

# MEASURING EXCHANGE MARKET PRESSURE IN MONGOLIA: EMP index<sup>\*</sup>

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## Abstract

The study estimates the exchange market pressure (EMP) in Mongolia over the period 2000-2010. EMP index measured as Siregar&Pontines (2007) methodology as the sum of exchange rate changes, reserve changes and policy rate changes. The study also, examined a threshold level for signal of currency crisis and macroeconomic fundamentals to determine EMP in Mongolia.

The results obtained suggest that (i) EMP index based on central bank's intervention in domestic FX market observes more pressure comparing to EMP index calculated by standard methodology, (ii) threshold level estimated by 3 sigma-rule and extreme value theory suggest that there was 5 signals of exchange market pressure during the study period, 3 of which were real currency crisis signal (end of 2008), (iii) the result of single-equation and structural vector auto-regression models (SVAR) provides evidence that exchange market pressure is consistent with Girton & Roper (1997) model which explained by change in domestic credit, government expenditure, real income, inflation and real interest rate differentiation.

JEL classification: F31, F41

Key words: Exchange market pressure index, exchange rate, currency crisis

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<sup>\*</sup>The views expressed in this paper are those of the staffs and to not necessarily represent position of Bank of Mongolia. Thus any error or mistakes belong to the staffs.

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## I. INTRODUCTION

Mongolia is expecting the world highest economic growth in coming decade. Its vast mineral deposits and stable investment opportunities are attracting massive foreign capital inflows in mineral sector and creating long lasting economic prosperity. As of 2010, net flow of FDI increased 2.8 times reaching USD 1.6 billion, portfolio investments rose 13.4 times amounting to USD758.4 million, and the outstanding of private sector debt doubled reaching USD 1.1 billion.

This influx of capital flows may increase our economic vulnerabilities to external shocks. Many empirical studies suggest that it has substantial risks to lead to unfavorable consequences such as further real exchange rate appreciation, loosened competitiveness of national producers in foreign and domestic markets, increased vulnerability of banking and financial sector, bubble price of real estate, increased inflation, and instability of nominal exchange rate due to the difference in productivity.

In this circumstances, it is required to implement sound macroeconomic policy that creates sustainable economic growth in medium and long run. In this framework, one of issues needed to examine and implement is to determine exchange market pressure with numerical values and to review opportunity to use it in exchange rate policy.

In international experience, pressure on domestic currency is expressed by “exchange market pressure (hereinafter “EMP”) index”. Griton&Roper (1977) calculated EMP index based on the balance of money market for the first time for Canada as the change in nominal exchange rate cannot fully demonstrate surplus supply and demand of exchange market for countries with high intervention of central bank in domestic exchange market. This monetary approach considers that decision makers regulate exchange market pressure through either the change in nominal exchange rate, or official foreign reserves of central bank, or the change in monetary policy of central bank, or combination of these.

The calculation of EMP index has following benefits. *Firstly*, to determine exchange market real pressure, to develop monetary and exchange rate policy that absorbs in economy at minimum cost, and to evaluate outcome of policy implementation. *Secondly*, to create opportunity to prevent currency crisis. *Lastly*, to study sustainability of regional macro-economy and negative impact of exchange market pressure of neighboring countries on the exchange rate of national currency.

This paper has three main objectives: (i) to calculate EMP index, (ii) to determine critical level of EMP index to prevent currency crisis, and (iii) to determine macro factors that explain EMP index. In other words, to calculate EMP index of Mongolia by the methodology as same as in member countries of SEACEN, to determine whether the index is below or higher than critical level that leads to crisis, and to look for opportunity to assume this criterion using main variables of macro economy in the future.

This approach is done in Mongolia for the first time. The paper does not cover other issues such as comparison of methods to calculate EMP index, its impact on monetary policy, methodology to make short term assumption, and impact on macro economy.

Next chapter of the paper presents research background of the topic; third chapter explains calculation of EMP index; fourth chapter explains the results of study on critical level to prevent currency crisis; last chapter determines macro-economic factors that determine EMP econometrics methodology, and the paper ends by conclusion and recommendation.

## II. THEORETICAL BACKGROUND

Economists calculate EMP index, which shows tendency of national currency to depreciate/appreciate and the equilibrium of domestic money market, because the change in exchange rate of national currency cannot fully demonstrate exchange market pressure. This index explains if exchange market pressure is absorbed either as appreciation/depreciation of nominal exchange rate, or increase/decrease in official foreign reserves, or increase/decrease in interest rate.

Exchange market pressure is absorbed by only the change of nominal exchange rate in countries with flexible exchange rate regime, by only the change of official reserves in countries with fixed exchange rate system, and by the changes of exchange rate and reserves in countries with managed floating regime.

As stated in the previous chapter, Griton&Roper (1977) calculated EMP for the first time based on monetary model of exchange rate as the sum of the changes in official foreign reserves and nominal exchange rate as follows.

$$EMP_t = e_t + r_t \quad (1)$$

Where,  $e_t$ -change in nominal exchange rate,

$r_t$  - change in official foreign reserves of central bank

Weymark (1997) included the criterion of the change in reserves into calculation of EMP index based on the model of small and open economy with price rigidity as follows.

$$EMP_t = \Delta e_t + \varphi \Delta r_t \quad (2)$$

where,  $\Delta e_t$  is change in nominal exchange rate,  $\Delta r_t$  is change in official foreign reserves of central bank,  $\varphi = -\frac{\partial \Delta e_t}{\partial \Delta r_t}$  is elasticity.

Following studies expanded above models by including response of monetary policy in EMP index calculation thus reflected the change in policy interest rate of central bank.

**Table 1. List of recent studies by chronological order**

| Research                      | Exchange rate | Official foreign reserve | Interest rate difference |
|-------------------------------|---------------|--------------------------|--------------------------|
| Griton & Roper (1977)         | *             | *                        |                          |
| Kaminsky & Reinhart (1999)    | *             | *                        |                          |
| Glick & Hutchison (2000)      | *             | *                        |                          |
| Edison (2003)                 | *             | *                        |                          |
| Khawaja (2007)                | *             | *                        |                          |
| Eichengreen (1995)            | *             | *                        | *                        |
| Nitithanprapas&Willett (2000) | *             | *                        | *                        |
| Bordo (2001)                  | *             | *                        | *                        |
| Bussiere & Fratzscher (2002)  | *             | *                        | *                        |
| Siregar & Pontines (2007)     | *             | *                        | *                        |

Specifically, Eichengreen (1995) emphasized the need to reflect significance of response of monetary policy during crisis and inserted policy interest rate into EMP index calculation. In other words, central bank can intervene directly through selling and buying foreign currency in the market, or indirectly through changing interest rate. EMP index is formulated in this approach as follows.

$$EMP_t = \Delta e_t + w_r \Delta r_t + w_l \Delta i_t \quad (3)$$

Where,  $w_r$  is ratio of change in reserves in EMP index,

$w_l$ - ratio of change in interest rate in EMP index  $w_r > 0, w_l > 0$

Above ratios are calculated by two methods. First method is based on structure model; specifically it applies estimation results of monetary approach of Girton&Roper (1977) and Weymark (1995) to determine exchange rate. The advantage of this method is the ratio of the indicator is well explained by economic theory.

Another method is method of the ratio to decrease variance used by Eichengreen (1996). This approach is widely used in the practice because of its advantage that each indicator does not overweigh in terms of variance and is easily calculated as it compares the variance of changes in reserves and interest rate to the variance of exchange rate. For instance, EMP calculation used in this paper is based on following formula of Kaminsky, Lizondo, and Reinhart (1999).

$$EMP_t = \frac{\Delta e_t}{e_t} - \frac{\sigma_e \Delta r_t}{\sigma_r r_t} \quad (4)$$

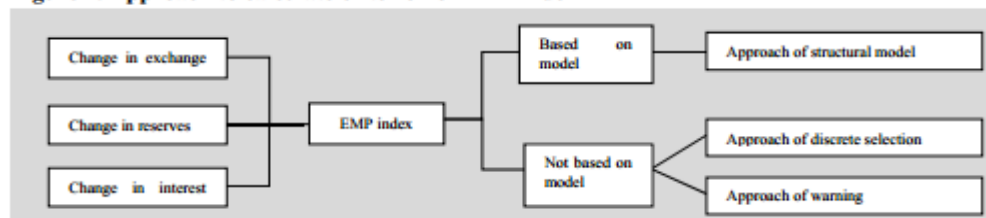
where,  $\sigma_e$ - standard deviation of exchange rate,  $\sigma_r$ -standard deviation of reserves

Regarding application of EMP index, it is significant to calculate the criterion that can lead to currency crisis. Researches done in this regard can be divided into two groups: based on model and not based on model, in general.

Previously explained formula of EMP index of Griton& Roper (1977) and Eichengreen (1996) is approach based on structural model. It is criticized for the fact that it cannot explain short term trend of exchange rate.

One way of another approach aims to determine probability of crisis, potential expenses and duration using econometrics method (Logit, Probit, VAR model) based on discrete data. Another way determines macro factors that can lead to currency crisis, and studies opportunity to prevent the crisis through calculation of their critical value.

**Figure 1. Approach to calculate criterion of EMP index**



Source: Chui (2002)

In Mongolia, it is first research on EMP index. However, studies that calculated sharp floating, which expresses instability in foreign currency market, taking only change in nominal exchange rate as exchange market pressure have been carried out in the past.

Ts. Munhbayar (2010) determined sharp floating as  $\pm 0.6$  in consecutive three days by calculating maximum floating using data for the period of 2006/01-2010/04 assuming announced exchange rate of togrog versus USD has Normal distribution. In other words, he considered that the condition for central bank to intervene exchange market will be created if daily floating of nominal exchange rate exceeds above limit.

S. Bilguun (2010) calculated critical value for the period of 2003/01-2010/08 using Extreme value theory as floating of nominal exchange rate of togrog against USD tends to have non-standard distribution. He concluded: (i) tails of distribution of floating follow Frenchent distribution, and (ii) emergency comes in the market when nominal exchange rate appreciates by 0.5% or depreciates by 0.4%.

### III. EMP INDEX CALCULATION

This paper uses following index of Siregar&Pontines (2007), which is calculated with three variables, in the calculation of EMP index.

$$EMP_t = \frac{\Delta e_t}{e_t} - \frac{\sigma_e}{\sigma_{nir}} \left( \frac{\Delta res_t}{res_t} \right) + \frac{\sigma_e}{\sigma_r} (\Delta I_t) \quad (5)$$

where:  $EMP_t$  – exchange market pressure index

$e_t$  nominal exchange rate of national currency against USD

$res_t$  foreign official reserves deducted by monetary gold

$i_t$  policy interest rate

$\sigma_e$  standard deviation of change in nominal exchange rate of togrog against USD

$\sigma_{nir}$  standard deviation of change in official foreign reserves

$\sigma_r$  standard deviation of change in policy interest rate

As seen in Equation (5), an increase of EMP index demonstrates the depreciation of nominal exchange rate of national currency, the decrease of official foreign reserves, or the increase of domestic interest rate. In other words, increased index will raise pressure of national currency to be sold.

Following data for 2000-2010 is used in the calculation of EMP index:

**Nominal exchange rate [ $e_t$ ]:** end-of-month nominal exchange rate of togrog/USD announced by Bank of Mongolia. Data is taken from monthly bulletin of Bank of Mongolia.

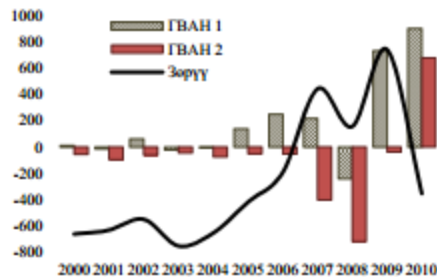
**Policy interest rate [ $r_t$ ]:** Bank of Mongolia has made interest rate of 7 day-bill of central bank as policy interest rate since July 2007. Therefore, dynamics of this criterion for 2000-2010 is represented by weighted mean of interest rate of 7 day-bill of central bank. Data is taken from monthly bulletin of Bank of Mongolia.

**Official foreign reserves 1 [ $res1_t$ ]:** Data on intervention in exchange market is missing in most countries. Therefore, number of intervention is represented by the change in official foreign reserves. Data is also missing in Mongolia. So, it is represented by the change in reserves. ( $res1_t$  is calculated as official foreign reserves minus monetary gold).

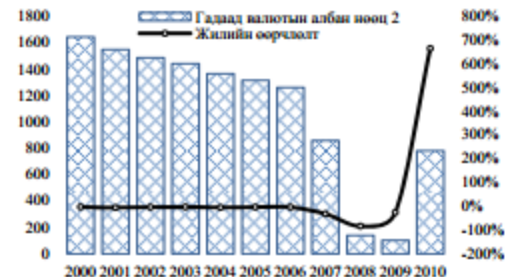
**Official foreign reserves2 [ $res2_t$ ]:** As report on flows of official foreign reserves shows, change in official foreign reserves differs from intervention amount by USD2.9 billion during 2000-2010 (Figure 2). Therefore, in order to make EMP index calculation realistic,

the balance<sup>8</sup> of official foreign reserves at the end of 1999 or beginning of 2000 is taken as USD1,700 million, and balances of following years adjusted by deducting or adding intervention amount. Dynamics of official foreign reserves reflected intervention is shown in Figure 3.

**Figure 2. Official foreign reserves /OFR/**



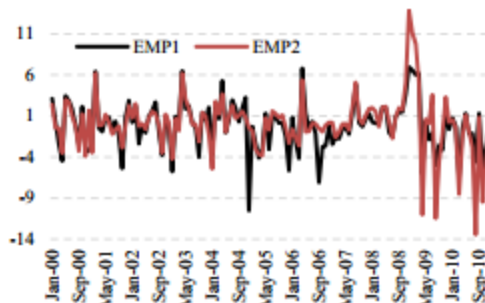
**Figure 3. Official foreign reserves 2**



Intervention amount of Bank of Mongolia is represented by USD spot trades done with commercial banks by Bank of Mongolia. In order to calculate data, statement of commercial accounts of foreign currency of Bank of Mongolia is taken from the system, and FX trade amount is consolidated.

When EMP index is calculated separately by two criteria of official foreign reserves, it turns out the result shown in Figure 4. As seen from Figure 4, statistics (Table 2) and distribution (Figure 5, 6) of EMP indices, EMP2 calculated by intervention is more stable in 2000-2008, and swung up during crisis of 2008/2009 and down during large flows of foreign currency in 2009-2010. In other words, EMP2 index better determines exchange market pressure. Therefore, EMP index is further represented by EMP2 index.

**Figure 4. EMP1, EMP2 calculation**



**Table 2. Statistics**

|              | EMP1      | EMP2      |
|--------------|-----------|-----------|
| Mean         | -0.182576 | 0.069536  |
| Median       | 0.110000  | 0.125689  |
| Maximum      | 6.940000  | 13.84258  |
| Minimum      | -10.52    | -13.43006 |
| Std. Dev.    | 2.960940  | 3.487162  |
| Skewness     | -0.143313 | -0.292796 |
| Kurtosis     | 3.938486  | 7.754218  |
| Jarque-Bera  | 5.296002  | 126.2003  |
| Probability  | 0.070793  | 0.000000  |
| Sum Sq. Dev. | 1148.499  | 1592.999  |
| Observations | 132       | 132       |

<sup>8</sup>Official foreign reserves flow consist of monetary gold, revenue, expense and financing of loan and aid of Government programs, transaction of Bank of Mongolia, and nostro replenishment of banks. So, beginning balance is taken at large amount and official foreign reserves are considered to be positive in terms of time series.

Figure 5. EMP1

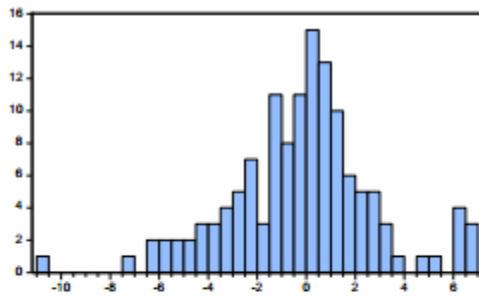
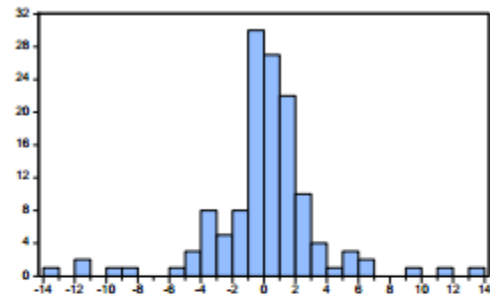


Figure 6. EMP2



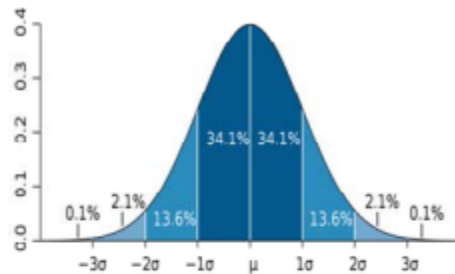
#### IV. MEASURING EMP INDEX THRESHOLD LEVEL

An application of EMP index is using it as early warning signal to prevent currency crisis. Therefore, this chapter estimates critical value of EMP index that leads to currency crisis using Three sigma rule and Extreme value theory.

##### 4.1 Three-sigma rule

The simplest way to answer this question is following statistical rule of Three-sigma (Figure 7). For instance, probability of 2 out of 7 days in daily series to fall within standard deviation from mean variable of that sample is 68%.

Figure 7. Three-sigma rule



$\mu \pm \sigma$  or 68.26% of distribution is within 1 standard deviation from the mean,

$\mu \pm 2\sigma$  or 95.44% of distribution is within 2 standard deviations from the mean,

$\mu \pm 3\sigma$  or 99.73% of distribution is within 3 standard deviations from the mean,

Currency crisis is defined as “when value of EMP index becomes larger than the mean of the sample plus standard deviation  $\delta$ ”, based on above rule of Knedlik (2006). In other words:

$$\text{Crisis} = \begin{cases} 1, & \text{if } EMP_{t,t} > \mu_{EMP} + \delta \cdot \sigma_{EMP} \\ 0, & \text{otherwise} \end{cases} \quad (6)$$

where:  $\mu_{EMP}$  – mean value of the sample of EMP index

$\sigma_{EMP}$  – standard deviation of the sample of EMP index

In international practice, the critical value of EMP index that leads to the crisis has been mainly calculated by 1-3 standard deviations (Table 3). Some researchers propose sharp depreciation of nominal exchange rate in addition to EMP index; for instance, Frankel &

Rose (1996) suggest additional condition of “nominal exchange rate to depreciate by 25% or more”.

**Table 3. Researches done on the topic**

| Sigma | Research papers  |
|-------|--|
| 1.500 | Eichengreen, Rose&Wyplosz (1996); Aziz, Caramazza&Salgado (2000)<br>Ahluwalia (2000); Bordo (2001) |
| 1.645 | Caramaza, Ricci&Salgado (2000); Bhundia&Ricci (2005)   |
| 1.700 | Kamin, Schindler&Samuel (2001)   |
| 2.000 | Eichengreen, Rose, Wyplosz (1994); Glick&Hutchinson (2001)   |
| 2.500 | Edison (2000)  |
| 3.000 | Kaminsky&Reinhart (1999); Berg and Patillo (1999); Bubula&Otker-Robe (2003)                        |

Following results turned out when crisis signal or EMP index exceeded the criterion is calculated for 2000-2010 by three-sigma rule.

**Table 4. Calculation of crisis criterion**

| Sigma | EMP   | Signal  | Date  | crisis or not   |
|-------|-------|---------|---|-----------------|
| 1.500 | 5.30  | 6 times | 2001/02 ; 2003/04; 2006/04; 2008/12; 2009/01; 2009/02 | 3/6 case (50%)  |
| 1.645 | 5.81  | 5 times | 2001/02 ; 2003/04; 2008/12; 2009/01; 2009/02          | 3/5 case (60%)  |
| 1.700 | 6.00  | 5 times | 2001/02 ; 2003/04; 2008/12; 2009/01; 2009/02          | 3/5 case (60%)  |
| 2.000 | 7.04  | 3times  | 2008/12; 2009/01; 2009/02                             | 3/3 case (100%) |
| 3.000 | 10.53 | 2 times | 2008/12; 2009/01                                      | 2/2 case (100%) |

Source: Estimation by researchers

First three signals in Feb 2001, Apr 2003, and Apr 2006 are associated with the change in interest rate of Central bank bill; remaining one demonstrates crisis of 2008.

**Table 5. Results of currency crisis**

| Nº | Date   | EMP index | Annual change in nominal exchange rate, % | Annual change in reserves, % | Change in interest rate, monthly | Inflation, annual | crisis or not |
|----|--------|-----------|---|------------------------------|----------------------------------|-------------------|---------------|
| 1  | Feb-01 | 6.2       | 0.5                                       | 10.5                         | 6.44                             | 13.2              | No            |
| 2  | Apr-03 | 6.2       | 2.7                                       | 36.8                         | 6.91                             | 6.4               | No            |
| 3  | Apr-06 | 5.4       | 1.4                                       | -1.3                         | 3.9                              | 4.3               | No            |
| 4  | Dec-08 | 13.8      | 8.3                                       | -30.0                        | -0.26                            | 23.2              | Yes           |
| 5  | Jan-09 | 11.1      | 17.9                                      | -33.9                        | -2.71                            | 21.0              | Yes           |
| 6  | Feb-09 | 9.8       | 25.5                                      | -40.4                        | -0.93                            | 17.2              | Yes           |

Source: Estimation by researchers

Therefore, the critical value of EMP index should be taken at 7.04 for  $\delta = 2.0$ .

Additional criterion for the depreciation of nominal exchange rate of national currency over 25% annually is applied to check whether currency crisis occurred or not. The result shows that the crisis occurred in Mongolia in Feb 2009.

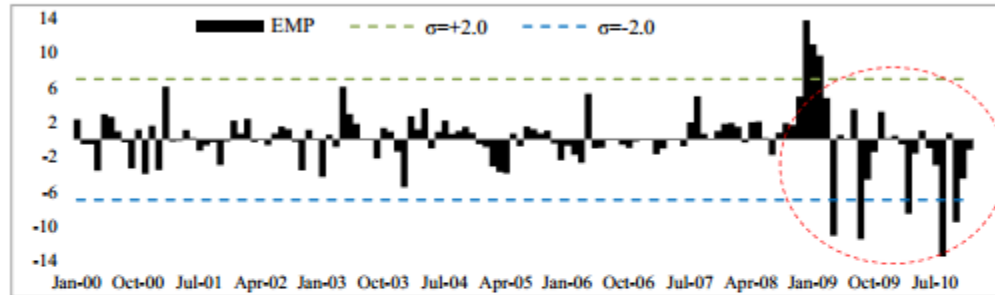
**Table 6. Annual change in nominal exchange rate of togrog against USD, %**

|  | 02/2001 | 04/2003 | 12/2008 | 01/2009 | 02/2009 |
|--|---------|---------|---------|---------|---------|
| Annual change in nominal exchange rate | 0.5     | 2.7     | 8.3     | 17.9    | 25.5    |

Source: Calculation based on reference rate of the Bank of Mongolia, [www.Bank of Mongolia.mn](http://www.Bank of Mongolia.mn)

If the criterion of EMP index is taken as asymmetry, value of  $\delta = 2.0$  goes below the criterion in Apr, Aug 2009 and Mar, Aug, Oct 2010, creating pressure for exchange rate of togrog against USD to sharply appreciate (Figure 9).

Figure 8. Criterion of EMP index



The long run trend of EMP index is represented by HP filter of Eviews-7 program, and there are stability or slight depreciation during 2000-2003, appreciation during 2003-2005, substantial depreciation during 2005-2008, and increasing pressure of appreciation since the later 2008. Therefore, when we calculated criterion of EMP index, we divided it into two groups by its trend to depreciate and appreciate: 2000/01-2009/06 and 2009/07-2010/12.

Figure 9. HP filter of EMP index

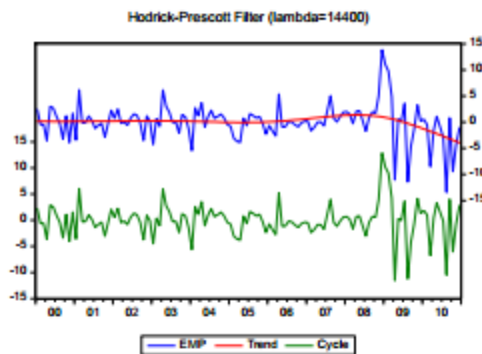
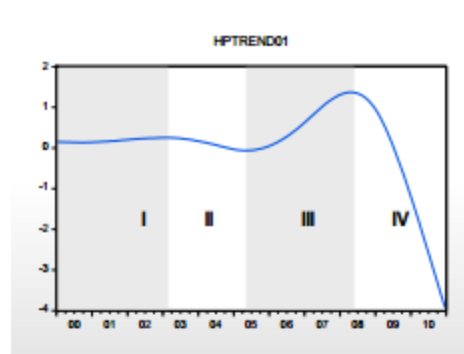


Figure 10. HP trend of EMP index



There is value of  $\delta = 1.5$  gives crisis signal 8 times when EMP index criterion is calculated for 2000/01-2009/06, the first or depreciation period trend. It can be said that crisis occurred in Aug 2007 and Nov 2008.

Table 7. Calculation of crisis criterion

| Sigma | EMP   | Signal  | Date   |
|-------|-------|---------|--|
| 1.500 | 5.30  | 8 times | 2001/02 ; 2003/04; 2006/04;2007/08; 2008/11; 2008/12; 2009/01; 2009/02 |
| 1.645 | 5.81  | 5 times | 2001/02 ; 2003/04; 2008/12; 2009/01; 2009/02                           |
| 1.700 | 6.00  | 5 times | 2001/02 ; 2003/04; 2008/12; 2009/01; 2009/02                           |
| 2.000 | 7.04  | 3times  | 2008/12; 2009/01; 2009/02  |
| 3.000 | 10.53 | 3times  | 2008/12; 2009/01; 2009/02  |

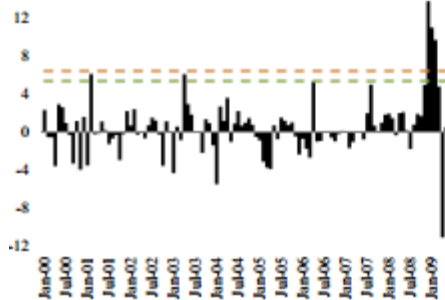
Source: Estimation by researchers

Newly arised signal of Aug 2007 is related to the depreciation of nominal exchange rate of togrog and increase of interest rate. In this summer time with international flight overload, demand for cash in FX market sharply increased due to interrupt of cash replenishment of foreign currency.

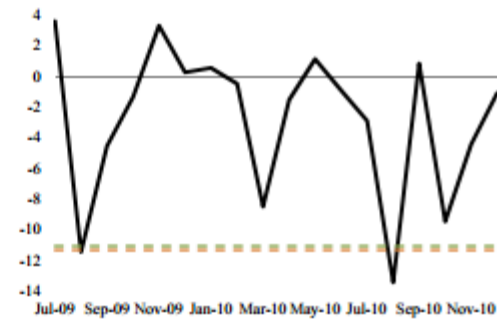
Nominal exchange rate of togrog against USD had depreciated by 16.7 togrog or 0.24% daily on average during 2007.08.06-13. Second signal was given in Nov 2008, the first month of currency crisis.

Therefore, threshold level of EMP index during depreciation trend turns out to be same with the criterion calculated for total period.

**Figure 11. Criterion of EMP index (01/00-06.09)**



**Figure 12. Criterion of EMP index (07/09-12/10)**



Second criterion of EMP index for the period of appreciation trend turns out over (-10.4) for value of  $\delta = 1.5$  twice and within the criterion for other values (Table 8).

**Table 8. Criterion of EMP index (2009.07-2010.12)**

| Date    | EMP criterion | EMP   | Monthly change in exchange rate | Intervention | Currency flow |
|---------|---------------|-------|---------------------------------|--------------|---------------|
| 2009.08 | -10.4         | -11.4 | -1.8%                           | \$41.5 M     | -4.6 M        |
| 2010.08 | -10.4         | -13.4 | -3.8%                           | \$157.7 M    | 196.5 M       |

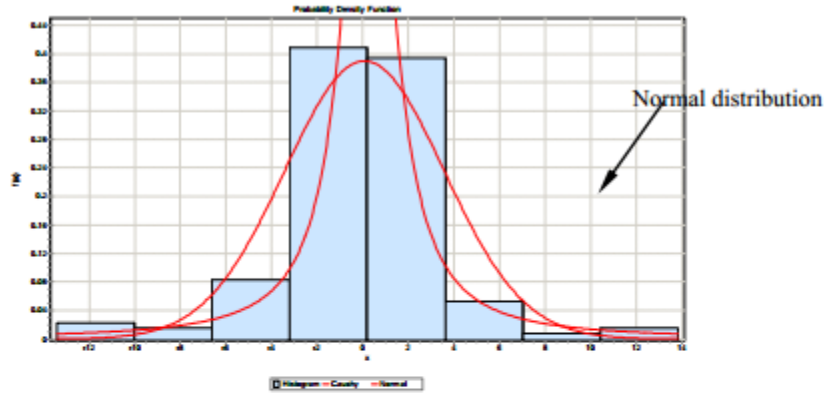
Conclusion drawn from the threshold level of EMP index calculated by three-sigma rule:

1. Critical value for depreciation period is 7.04;
2. Critical value for appreciation period is -10.4;
3. Currency crisis occurred during 2008/12-2009/02;
4. By additional criterion of depreciation of nominal exchange rate over 25%, crisis occurred only in Feb 2009;
5. Pressure for nominal exchange rate of togrog to sharply appreciate occurred in Aug of 2009 and 2010.

If series are assumed to be normally distributed and three-sigma rule is applied, above conclusion can be drawn.

However, in practice, financial indicators are mainly distributed abnormally. Therefore, we determined distribution of EMP index using EasyFit program and found distribution of Cauchy-Lorentz with mean 0.24 and variation 1.21. Figure 13 shows comparison of Cauchy-Lorentz and normal distributions of EMP index.

Figure 13. Distribution of EMP index



Accordingly, next sub section calculates the criterion of EMP index that can lead to the crisis using extreme value theory.

## 4.2 Application of extreme value theory

### 4.2.1 Explanation of extreme value theory

Extreme value theory is statistical methodology widely used in economy and is applied in measuring extreme event. Regarding EMP index, this theory has been applied widely since Koedjik (1990, 1992) and Hols & de Vries (1991) used it in the study of exchange market pressure.

Let's take series  $X_1, X_2, \dots, X_n$  of random measurement with ordinary distribution function. When we determined probability of maximum value  $M_n$  of first random number  $n$  to be below certain level  $x$ , distribution function turns out to be as follows as shown in (6):

$$M_n = \max(X_1, X_2, \dots, X_n), \quad n \geq 1 \quad (7)$$

$$P(M_n \leq x) = F_{(x)}^n \quad (8)$$

$$P(X_1 \leq x, \dots, X_n \leq x) = F_{(x)}^n, \quad x \in \mathbb{R}, n \in \mathbb{N} \quad (9)$$

In this case, extreme or maximum value of the series is located in upper part or right tail of the distribution. So, Generalized Extreme Value Distribution is defined as follows.

$$f_x^n = 1 - F_{(x)}^n = 1 - P(X_1 \leq x, \dots, X_n \leq x) \quad (10)$$

$$f_x^n = \begin{cases} 1 - \exp\left[-(1 + kx)^{\frac{1}{k}}\right] & \text{if } k \neq 0 \\ 1 - \exp[\exp(x)] & \text{if } k = 0 \end{cases} \quad (11)$$

where,  $k$  is a parameter which has function to direct property of extreme distribution tail, and  $\alpha = -1/k$  is called tail index.

Extreme distribution estimation can be done by two methods: parameter and non-parameter. Following section briefly explains estimation method of Hill (1975) used in this paper.

#### 4.2.2 Hill and HKKP estimations

Let's take sample of  $n$  positive series with undefined distribution. Let's assume  $x_{(i)}$  as "i"th number of the sample where  $x_{(i)} \geq x_{(i-1)}$ ,  $i = 2, \dots, n$ . Assuming  $k$  sample from right tail is taken into estimation, Hill (1975) offered following evaluation for  $\gamma$ :

$$\gamma_{(k)} = \frac{1}{k} \sum_{j=1}^k \ln(x_{n-j+1}) - \ln(x_{n-k}) \quad (12)$$

This is estimation method with maximum truth proportion and Pareto distribution that assumes number  $(k+1)$  as criterion. The difficulty with this estimation is the selection of value of  $k$ . In other words, undistorted evaluation of tail index largely depends on the selection of  $k$ . For small sample,  $1/k$  value substantially differs from zero, and evaluation value is distorted. Therefore, most researchers apply following estimation method of Huisman, Koedijk, Kool & Palm (2001) /hereinafter "HKKP"/ for small sample.

$$\frac{1}{\alpha} = \gamma_{(k)} = \gamma + \beta * k + \varepsilon_k \quad (13)$$

where,  $k=1, 2, \dots, K$        $\varepsilon_k$  is error

HKKP (11) demonstrated that the estimation is most optimal when value of  $K$  is approximately  $\frac{n}{2}$ . In practice,  $\gamma_{(k)}$  is calculated for value of 1 to  $K$ .

WOLS method is used to evaluate equation (11) by HKKP methodology. This has advantage to correct Heteroskedasticity error as deviation of  $\gamma_{(k)}$  is not constant at different  $k$ .

#### 4.2.3 HKKP estimation and its result

Using program Xtremes 4.1, we estimated the extreme value of EMP index by HKKP method based on method taught at Workshop on Extreme Exchange Market Pressure of the SEACEN Expert Group (SEG) by SEACEN.

**First step:** As to extreme value theory, ascending series of EMP index with positive numbers is created. EMP index is sorted in ascending order according to HKKP methodology and positive values are selected randomly.

**Second step:** Using program Xtremes 4.1, multivariate data is transferred to univariate data, and Hill (GP1) estimation method is applied to estimate value of Alfa index ( $\alpha$ ).

Figure 14. Hill estimation of Xtremes 4.1 program

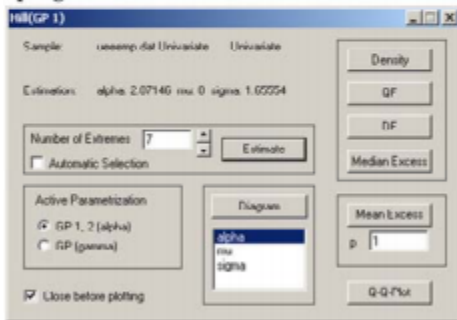
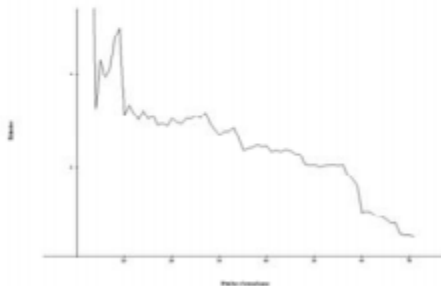


Figure 15. Estimation of Alfa index



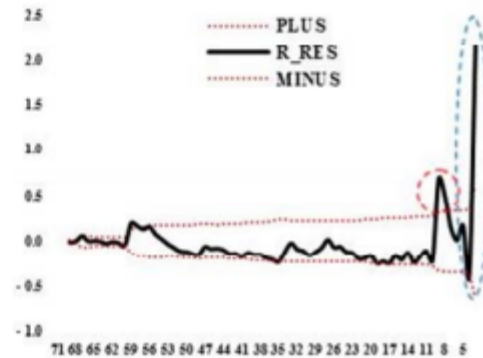
**Third step:** Value of Alfa index is sorted by order of sample where 70<sup>th</sup> value is at the beginning and 69<sup>th</sup> is next. Then, equation 11 is estimated using Weighted Least Squares method. Result of estimation is:

$$y_t = 2.178659 - 0.025228 * x_t + \varepsilon_t \quad (14)$$

Figure 16. Weighted Least Squares method

| Dependent Variable: Y      |             | Sample: 1 69              |             |       |
|----------------------------|-------------|---------------------------|-------------|-------|
| Method: Least Squares      |             | Included observations: 69 |             |       |
| Date: 02/23/11 Time: 10:30 |             | Weighting series: SQR(X)  |             |       |
| Variable                   | Coefficient | Std. Error                | t-Statistic | Prob. |
| C                          | 2.178659    | 0.038023                  | 37.07715    | 0     |
| X                          | -0.025228   | 0.001103                  | -21.08575   | 0     |
| Weighted Statistics        |             |                           |             |       |
| R-squared                  | 0.871397    | Mean dependent var        | 1.800351    |       |
| Adjusted R-squared         | 0.873537    | S.D. dependent var        | 0.292567    |       |
| S.E. of regression         | 0.169931    | Akaike info criterion     | -0.870282   |       |
| Sum squared resid          | 1.054727    | Schwarz criterion         | -0.613336   |       |
| Log Likelihood             | 25.46109    | Hannan-Quinn criter.      | -0.852081   |       |
| F-statistic                | 470.7937    | Durbin-Watson stat        | 0.822788    |       |
| Prob(F-statistic)          | 0           |                           |             |       |
| Unweighted Statistics      |             |                           |             |       |
| R-squared                  | 0.753817    | Mean dependent var        | 1.252932    |       |
| Adjusted R-squared         | 0.728844    | S.D. dependent var        | 0.606074    |       |
| S.E. of regression         | 0.311528    | Sum squared resid         | 6.66192     |       |
| Durbin-Watson stat         | 1.22652     |                           |             |       |

Figure 17. Omission of estimation



**Fourth step:** We estimated stability of estimation within error  $\pm 2$  limit using Stability test-Recursive estimates (OLS only) of EViews 7 program. It turns out that 9, 8, and 3<sup>th</sup> values of the sample are over the band thus extreme values.

**Fifth step:** Values of EMP index for above sample are firstly within value of Nov 2008 and next two are within 6 months. Therefore, extreme value theory shows financial crisis that started in late 2008 and stabilized in early 2009.

Table 9. Estimation of crisis criterion

| Date    | EMP value | Note               |
|---------|-----------|--------------------|
| 2008-11 | 5.042     | Month crisis begun |
| 2009-02 | 9.768     | Crisis continued   |
| 2009-03 | 4.871     | Crisis continued   |

Source: Estimation by researchers

**Result:** When we estimated the criterion of EMP index using extreme value theory, it shows that the currency crisis started in Nov 2008 and lasted for 5 months. Also, the criterion of EMP index that can lead to currency crisis is 5.04.

### 4.3 Comparison of the results of two methods

Looking at the results of above two methods, the result of extreme value theory explains better terms of start and end of currency crisis in 2008. Exchange market pressure during this period was absorbed by 40% depreciation of nominal exchange rate of togrog against USD, 39% decrease of foreign official reserves, and 2.3 unit increase of togrog interest rate (Table 9).

**Table 10. Crisis signal**

| Nº | Date   | EMP index | Annual change in nominal exchange rate, % | Annual change in reserves, % | Change in interest rate, monthly | Inflation, yearly | Crisis or not |
|----|--------|-----------|---|------------------------------|----------------------------------|-------------------|---------------|
| 1  | Nov-08 | 5.0       | 2.3                                       | -17.6                        | -0.68                            | 24.5              | Yes           |
| 2  | Dec-08 | 13.8      | 8.3                                       | -30.0                        | -0.26                            | 23.2              | Yes           |
| 3  | Jan-09 | 11.1      | 17.9                                      | -33.9                        | -2.71                            | 21.0              | Yes           |
| 4  | Feb-09 | 9.8       | 25.5                                      | -40.4                        | -0.93                            | 17.2              | Yes           |
| 5  | Mar-09 | 4.9       | 30.5                                      | -38.6                        | 2.45                             | 17.2              | Yes           |

As above results show, it is significant to use EMP index as a signal to prevent crisis but it is very difficult to make its assumption. In other words, big error can occur in assuming above three indicators then EMP index. Therefore, we tried to determine macro economic factors that determine EMP index in the next chapter.

## V. MACROECONOMIC DETERMINATION OF THE EMP INDEX

We applied widely used model of exchange market pressure of Girton& Roper (1997) in determining macro economic variables that define EMP index.

### 5.1 Girton & Roper model

This model was applied firstly in explaining exchange rate formation in free floating exchange rate regime in Canada during 1952-1962. Traditional approach considers that intervention by central banks in foreign currency market aims to protect exchange rate, whereas this model considers that intervention is designed for not only for stable exchange rate but also meeting the balance of domestic money market through exchange market pressure.

This monetarist model aims to show (i) how exchange market pressure is determined, and (ii) how money supply exceeded demand in free floating exchange rate regime affects exchange rate and official reserves. Main idea is based on idea that exchange market pressure of over money supply is absorbed in the depreciation of nominal exchange rate or decrease of official foreign reserves, or in both of them.

To explain the model simply as stated in Connolly&Silveira (1979):

$$\text{Traditional function of money demand: } M_t^d = kP_tY_t \quad (15)$$

where:  $k$ -surplus income or a constant,  $P$ -domestic price,  $Y$ -real income

$$\text{Function of money supply: } M_t^s = m_tB_t \quad (16)$$

where:  $m_t$ -money multiplier,  $B_t$ -base money ( $B_t = R_t + DC_t$ ), where  $R_t$ -net foreign assets of central bank,  $DC_t$ - net domestic assets

If it is assumed that money market and purchasing power are both balanced:

$$M_t^d = M_t^s \quad (17)$$

$$P_t = E_tP_t^* \quad (18)$$

where,  $P_t$ -domestic price,  $E_t$ - nominal exchange rate of national currency against foreign currency,  $P_t^*$ - foreign price

Substituting equation (18) in (15), equation (17) is:

$$kE_tP_t^*Y_t = m_tB_t \quad (19)$$

$$kE_tP_t^*Y_t = m_t(R_t + DC_t) \quad (20)$$

Following equation will come out when natural logarithm is taken from both sides of equation(6):

$$\ln k + \ln E_t + \ln P_t^* + \ln Y_t = \ln m_t + \ln(R_t + DC_t) \quad (21)$$

To differentiate both sides of above equation

$$0 + \frac{\frac{dE_t}{dt}}{E_t} + \frac{\frac{dP_t^*}{dt}}{P_t^*} + \frac{\frac{dY_t}{dt}}{Y_t} = \frac{\frac{dm_t}{dt}}{m_t} + \frac{\frac{dR_t+DC_t}{dt}}{R_t+DC_t} \quad (22)$$

$$\frac{\frac{dR_t}{dt}}{R_t+DC_t} - \frac{\frac{dE_t}{dt}}{E_t} = -\frac{\frac{DC_t}{dt}}{R_t+DC_t} + \frac{\frac{dY_t}{dt}}{Y_t} + \frac{\frac{dP_t^*}{dt}}{P_t^*} - \frac{\frac{dm_t}{dt}}{m_t} \quad (23)$$

$$r_t - e_t = -d_t + y_t + p_t^* - m_t \quad (24)$$

where,  $r_t$ -change in official foreign reserves,  $e_t$ -change in nominal exchange rate,  $d_t$ -change in share of domestic credit in money supply,  $y_t$ - change in domestic income,  $p_t^*$ -change in foreign price level,  $m_t$ -change in money multiplier

Equation (24) has proportional correlation which is, given foreign inflation and growth of domestic income, increase in domestic credit or money multiplier decreases reserves in fixed exchange rate regime, depreciates nominal exchange rate in floating regime, and causes decreased reserves and depreciation of exchange rate in managed floating regime.

Furthermore, increase of domestic income or foreign price has correlation to appreciation of national currency or increased inflow of foreign currency.

Girton & Roper (1977), Connolly& Silveira (1979), and Bahmani-Oskooee&Shiva (1998) inserted  $q_t = \frac{e_t}{r_t}$  into equation (24) and tried to show whether monetary policy absorbed exchange market pressure by change in nominal exchange rate or decrease of foreign reserves.

$$r_t - e_t = -d_t + y_t + p_t^* - m_t + q_t \quad (25)$$

coefficient before variable  $q_t$ :

- Reliability and positiveness in terms of statistics demonstrate exchange market pressure is absorbed mainly by depreciation of exchange rate ,
- Reliability and negativeness in terms of statistics demonstrate absorption mainly by decrease of reserves,
- Inreliability in terms of statistics demonstrates no response of EMP index to monetary policy.

Also, coefficient of variable  $q_t$  shows whether monetary approach of the balance of payments, on which exchange rate is formed, is implemented.

## 5.2 Empirical study

### Exchange market pressure index [ $emp_t$ ]

EMP index is represented by EMP2 index as described in chapter 3.

### Inflation [ $cpi_t$ ](+)

Domestic inflation rate reduces export income and raises exchange market pressure through the appreciation of real exchange rate. In Mongolia, increased inflation decreases real interest rate of togrog and creates trend for market participants to sell their assets in togrog and convert into USD, thus raising pressure for togrog to depreciate.

### Bank credit [ $bd_t$ ] (+)

High growth of domestic credit raises money supply and causes depreciation of national currency or increased exchange market pressure.

### Difference of interest rate [ $id_t$ ] (-)

Increased difference between domestic and foreign interest rates raises capital inflow and decreases EMP index. Especially, in situation when current exchange rate trend tends to continue and action of central bank is predictable, financial capital largely comes in to profit from interest rate difference.

### Terms of trade [ $fb_t$ ](-)

Improved terms of foreign trade upgrades trade balance, raises currency supply and decreases EMP index.

### Budget expenditure [ $feg_t$ ] (+)

State budget expenditure increases demand for imports through domestic demand and tends to raise EMP index. Particularly, the growth of demand in trade sector promotes imports if domestic industry is underdeveloped. Therefore, this indicator is represented by annual growth of state consolidated budget expenditure.

### Dummy 1 [ $dm1_t$ ]

Dummy variable is included in indicator of Aug 2007 in order to remove impact of EMP index due to interrupted cash replenishment of foreign currency.

**Table 11. Augmented Dickey-Fuller (ADF) Unit Roots Test**

| Variable | Without difference |           |                   | Difference of first order |           |                   | Integration rate |
|----------|--------------------|-----------|-------------------|---------------------------|-----------|-------------------|------------------|
|          | None               | Intercept | Trend & intercept | None                      | Intercept | Trend & intercept |                  |
| EMP      | 0.0000             | 0.0000    | 0.0000            |                           |           |                   | I (0)            |
| DDR      | 0.8152             | 0.6831    | 0.9993            | 0.0000                    | 0.0000    | 0.0000            | I (1)            |
| IRD      | 0.2939             | 0.1887    | 0.4192            | 0.0000                    | 0.0000    | 0.0000            | I (1)            |
| TOT      | 0.7900             | 0.7539    | 0.2268            | 0.0000                    | 0.0000    | 0.0000            | I (1)            |
| FEG      | 0.0473             | 0.0563    | 0.0812            |                           |           |                   | I (0)            |

Variables except  $emp_t$  and  $feg_t$  were unstable when we checked stability of variables; so, we stabilized by taking difference of first order.

### 5.2.1 Estimation of Single equation model

Following results are turned out when correlation of factors explaining EMP index is estimated by OLS\*\*.

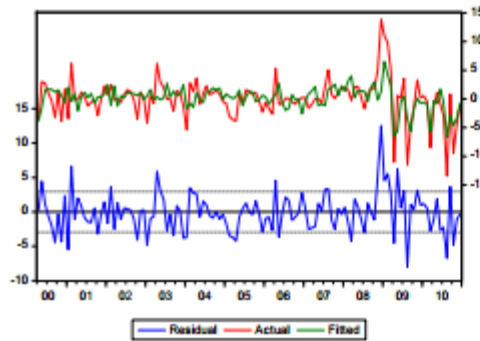
$$emp_t = 0.42 * EMP(-1)_t - 8.20 * TOT2(-2)_t + -0.46 * IRD(-1)_t + 0.53 * DOL2_t + 0.19 * DDR2(-2)_t - 3.77 * DUM_t + 0.0 * FEG(-3)_t + \epsilon_t \quad (26)$$

**Table 12. Estimation results**

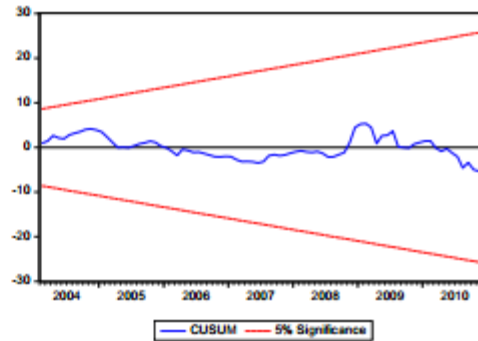
| Variable | Coefficient | Probability | Other indicators    |          |         |          |
|----------|-------------|-------------|---------------------|----------|---------|----------|
| EMP(-1)  | 0.418138    | 0.0000      | R <sup>2</sup>      | 0.327775 | SCI     | 5.214226 |
| TOT2(-2) | -8.202151   | 0.0312      | R <sup>2</sup> adj. | 0.294715 | HQ cri. | 5.122096 |
| IRD2(-1) | -0.464263   | 0.0061      | S.E.R.              | 2.957116 | LM      | 3.144903 |
| DOL2     | 0.535705    | 0.0022      | S.S.R.              | 1066.833 |         |          |
| DDR2(-2) | 0.196756    | 0.0477      | DW                  | 1.858043 |         |          |
| DUM2     | -3.773796   | 0.0003      | AIC                 | 5.059042 |         |          |
| FEG(-3)  | 0.017369    | 0.0352      |                     |          |         |          |

We checked above equation by coefficient test (Wald test, Ommitted variables test, Redundant variable test), estimation error test (LM test, Heteroskedasticity) and stabilization test (Chow, Ramsey, CUSUM test).

**Figure 18. Residual**



**Figure 19. Chow test**



At the result of estimation, EMP index is explained by credit balance of banks, the difference of interest rate, dollarization, government expenditure and terms of foreign trade<sup>††</sup>.

In other words, dollarization raises pressure for togrog to depreciate by 0.5 unit, increases of credit balance of banks and state budget expenditure raise the pressure after two months by 0.2 and 0.02 units. Improved terms of foreign trade and increased difference of interest rate raise the pressure of togrog appreciation in two months by 8.2 and 0.46 units.

### 5.2.2 SVAR method

In this section, we empirically check correlation between EMP index based on the balance of money market determined by Girton-Roper(1977) and factors that affect it by VAR method, which was firstly used by Tanner (1999, 2001, 2002).

\*\*Please see details in Appendix 1.

††Model excludes inflation as statistical estimation was unreliable.

Tanner (1999) showed that above mentioned EMP model of Girton-Roper (1977) based on the balance of money market can be studied using VAR method for currency crisis in Brazil, Chile, Mexico, Indonesia, Korea and Thailand. Main objective of the paper is to answer the question “What kind of means (domestic credit or NDA, or policy rate) of short term monetary policy can soften and remove EMP index?”.

In 2002, he tested again correlation between monetary policy and EMP index for 32 countries of east Europe and Asia. The empirical result of his study was consistent with expected or model value of Girton-Roper (1977) theory. Particularly, he showed that increase of domestic credit raises EMP index and pressures national currency to depreciate. Also, he emphasized that the effect of domestic credit growth on EMP index is stronger than the effect of the growth of interest rate difference. He considered application of VAR method in study of EMP index has following advantages over traditional estimation of OLSmethod:

- Can avoid distortion of Simultaneity problem through limitation.
- Can avoid endogeneity problem.
- Can estimate feedback between variables and allows determination of shock affect created by its deviation.

Based on data of three main indicators of monetary policy which are growth of domestic credit (NDA of banking system), difference between domestic and foreign interest rates (dif), and EMP index during Jan 2003-Dec 2010, we checked correlation between the variables using SVAR model.

#### ***A. Structure of model***

Model takes endogenous variables as follows.

$$x_t = \{EMP_t ; NDA\_G_t ; D\_DIF_t\}. \quad (27)$$

However, exogenous variables are represented by dummy variable of months of crisis or sudden shock. Where:

|                                 |  |
|---------------------------------|--|
| <b><i>EMP<sub>t</sub></i></b>   | -EMP index (estimated by non-parameter method of Siregar & Pontines (2007)); |
| <b><i>NDA_G<sub>t</sub></i></b> | -net domestic assets;  |
| <b><i>D_dif<sub>t</sub></i></b> | -difference of foreign and domestic interest rates                           |

Seasonal impact is removed by taking logarithm in above variables in modeling.

For most countries, EMP and SVAR model construction uses structural limitation or same time correlation between variables depending on characteristic of a country and frequency of data.

Considering Z statistics of model estimation, SVAR model uses limitation based on following assumption. We assume in this paper that EMP index and interest rate difference do not affect NDA within one month but NDA affects EMP index and interest rate difference. Appendix 1 shows estimation of SVAR model and matrix of limitation. Results of LR test show that limitation of same time correlation to transfer VAR model to semi structural model is fully consistent for data of Mongolia.

**B. Expected correlation between variables:**

- **Domestic credit (NDA) and EMP index.** In the model of Girton-Roper (1977) based on the balance of domestic money market, the growth of domestic credit is expected to increase EMP index. The reason is imbalance of payments demonstrates imbalance of money market; loss of the balance of payments is compensated by money supply exceeded its demand, whereas surplus is compensated by money demand exceeded its supply. Adjustment to above imbalance in fixed exchange rate regime is currency reserves; it is regulated by exchange rate in pure floating regime. In managed floating regime, exchange rate and reserves are used both. Then, it means that above mentioned growth of domestic credit is compensated by the depreciation of exchange rate or the decrease of foreign reserves. This depreciation of exchange rate and decrease of foreign reserves will raise EMP index.
- **Relationship between difference of interest rate and EMP index.** Theoretical relationship between EMP and interest rate is determined by money demand balance of interest rate (UIP condition). Monetarist and Keins approaches differently explain the relationship between interest rate and exchange rate. Monetarists think that the increase in domestic interest rate cuts money demand, thus causes depreciation of national currency. On the other hand, Keynesians explain that the increase of domestic interest rate promotes capital inflow and causes appreciation of national currency. However, in real economy, above two cases are observed both and either can dominate depending on economic condition of certain period .

Interest rate  $\uparrow \Rightarrow$  Real money demand  $\downarrow$  (Supply exceeded demand of money)  
 $\Rightarrow$  Foreign reserves  $\downarrow$  Depreciation of national currency  
 $\Rightarrow$  Change in EMP index

**B. Results of SVAR model estimation**

**Estimation of SVAR model.** Table 1 shows estimation of the model. Detailed estimation results are shown in Appendix 3.

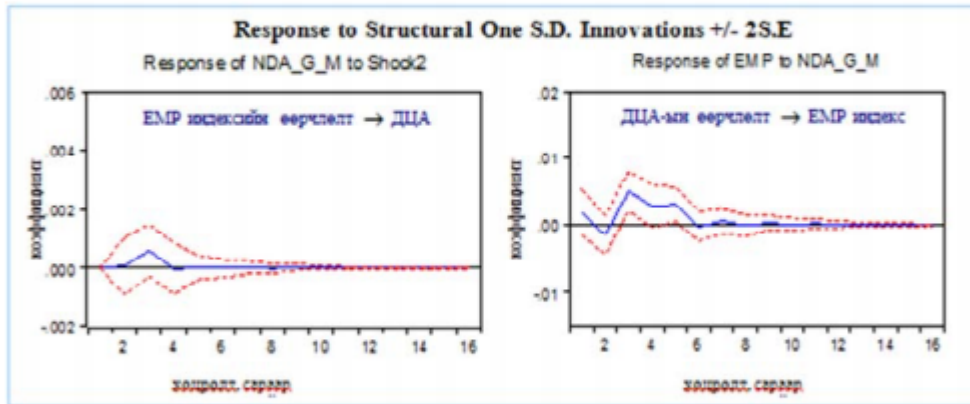
**Table 13. Estimation of SVAR model**

|        | NDA                 | EMP                | fference of interest rate |
|--------|---------------------|--------------------|---------------------------|
| $B_0=$ | 1                   | 0                  | 0                         |
|        | 0.39<br>(0.355921)  | 1                  | 0                         |
|        | -0.25<br>(0.244715) | 0.53<br>(0.085788) | 1                         |

Table 13 shows statistically that there is same time correlation between DNA, EMP index and the difference of interest rate. Also, it can be accepted statistically that EMP index has same time correlation with the difference of interest rate. Sign of these correlations is consistent with expected economic value. Standard error of estimated coefficients of matrix  $B_0$  is relatively small. Breakdown of response function and variation of SVAR model is shown below.

Impact of a certain factor in the model on inflation and other endogenous indicators is determined using response function. Figure 22 shows functions of the response between EMP index and NDA, whereas Figure 23 shows mutual response function of the difference of interest rate and EMP index. Appendix 2 shows the results of these and other response functions of the model.

**Figure 20. Response function: Response of NDA to shock of EMP index (1 standard deviation)**



Test results of granger cause show that EMP index is not granger cause of NDA and it is approved statistically NDA is granger cause of EMP index. When we estimated response function of SVAR model, it turns out that the change in NDA of that month raises EMP index in that same month and the biggest impact is observed after 3 months from shock occurrence. Above result is consistent with expected theoretical value and the growth of domestic credit causes depreciation of togrog exchange rate. On the other hand, the growth of EMP index of that month raises NDA in that same month and the biggest impact is observed in 3 months. This is consistent with the results of other studies (Tanner (2001, 2002) and Bautista & Bautista (2005)).

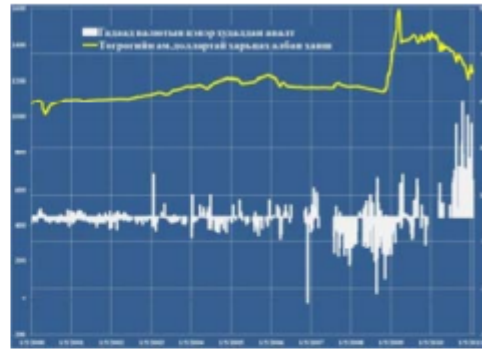
In theory, policy makers should withdraw togrog from the market or decrease NDA in order to reduce EMP for togrog depreciation. However, empirical studies (Tanner (2002) and Bautista & Bautista (2005)) emphasize that the growth of EMP index increases NDA, and explain it in relation to the fact that financing issued by central bank to banks goes up to support liquidity of banking system rather than restricting the growth of domestic credit when capital escapes from domestic economy and national currency depreciates sharply.

In Mongolia, also, during the crisis of 2008-2009, financing issued by central bank to commercial banks sharply rose to support liquidity of banks (Figure 21). Figure 21. EMP index, foreign and domestic net assets

**Figure 21. EMP index, foreign and domestic net assets**

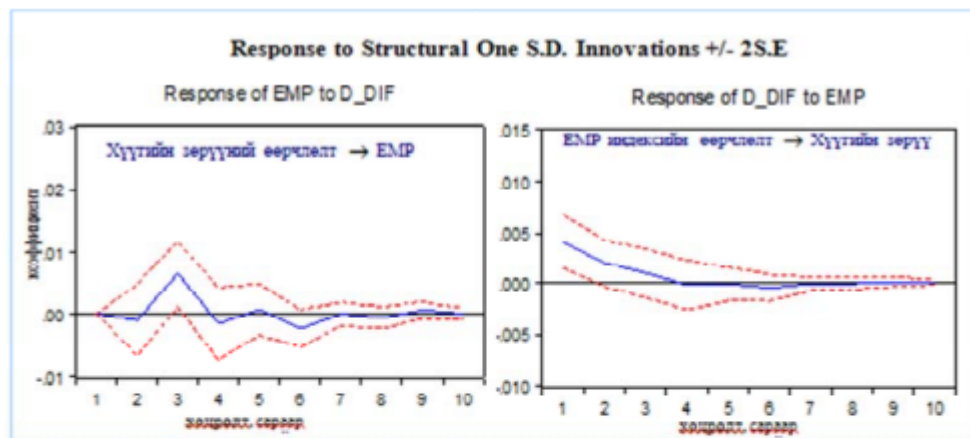


**Figure 22. Intervention of Bank of Mongolia**



**Difference of interest rate and EMP index:**As seen from the results of Granger cause test, EMP index is not granger cause of the difference of interest rate and it can be accepted at 80% probability that the difference of interest rate is granger cause of EMP index. However, the results of the response function of SVAR model, estimated total sample or data during 2003.01-2010.12, show that the change in the difference of interest rate of that month raises EMP index with 1 month lag and the biggest impact is observed after 4 months from the shock, while the growth of EMP index of that month increases the difference of interest rate in the same time. This is consistent with the results of other studies (Tanner (2001, 2002) and Bautista & Bautista (2005)).

**Figure 23. Response function: Mutual response of EMP index and difference of interest rate**

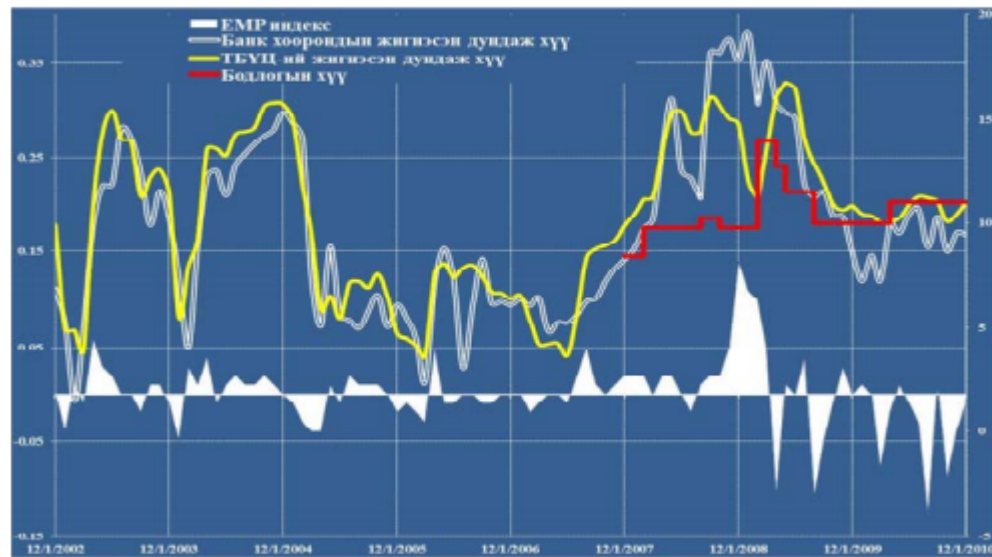


Above result is consistent with the value of Keynesian theory; increased domestic interest rate causes appreciation of togrog. It is related to sharp depreciation of togrog due to substantial decrease of official foreign reserves and foreign assets in banking system, and large foreign trade loss because of foreign economy crisis (Figure 21).

At that time, rise of interest rate by central bank against depreciation of togrog affected positive correlation between difference of interest rate and EMP index. As seen from response function of the model based on data during pre-crisis period (2003.1-2008.6), change in the difference of interest rate of that month decreases EMP index with lag of 2

months, and the biggest effect is observed after 4 months from shock. This result is consistent with the value of Keynes theory. Increased domestic interest rate promotes capital inflow thus leads to appreciation of togrög.

**Figure 24. EMP index and weighted average interest rate of Central bank bill**



## VI. CONCLUSION

In this paper, we calculated EMP index based on FX intervention for 2000-2010 and estimated its threshold level that leads to currency crisis using three sigma rule and extreme value theory.

Additionally, we examined macro factors which determine EMP index using single variable and multiple variable methods. We conclude as follows:

1. **Estimation of EMP:** Estimation of EMP index, that considers official international reserves only change by intervention amount taking beginning balance of foreign reserves as USD1.7 billion, precisely explains exchange market pressure. Therefore, further studies need to apply this indicator.
2. **Threshold level of EMP index that can lead to currency crisis:** Threshold level of EMP index which can lead to currency crisis was estimated using (i) three sigma rule, and (ii) extreme value theory. EMP index threshold is 5.8 during depreciation trend and -10.4 during current appreciation trend.
3. **Macroeconomic fundamentals that explain EMP index:** Factors that determine EMP index are estimated based on model of Girton & Roppen (1997) using OLS and VAR methods. The results are:
  - In Mongolia, it can be explained by the model of Girton & Ropper (1997).
  - EMP is directly related to the growth of bank credit, the difference of foreign and domestic interest rates, state budget expenditure and dollarization of banking system.
4. **Projection of EMP index:** We projected trend of EMP index for the first quarter of 2011 using above model as follows: In future, EMP index tends to decline or pressure for nominal exchange rate of togrog tends to rise as (i) market pressure is lower than the critical value, and (ii) interest rate difference is high.

Furthermore, based on above results, we recommend following policy proposals:

1. To estimate EMP index monthly and apply it in policy proposals,
2. To improve the frequency of EMP index and make its projection.

## REFERENCES

- Akcoraoglu, A. (2000 оны April). An Analysis of Exchange Market Pressure and Monetary Policy: Evidence from Turkey. *G.U.I.I.B.F. Dergisi*, p. 61-74.
- Bielecki, S. (2005). Exchange Market Pressure and Domestic Credit Evidence from Poland. *Working Paper Series Volume 5*.
- Feridun, M. (2006). ISE and Exchange Market Pressure. *Discussion Paper Series of Department of Economics*.
- Ghartey, E. E. (April 2009). The Mid 1990s Peso Crisis in Mexico: An Application of the Girton-Roper Model. *Frontiers in Finance and Economics Vol. 6 No.1*, p. 73-92.
- Jean-Louis Combes, Tidiane Kinda, and Patrick Plane. (January 2011). Capital Inflows, Exchange Rate Flexibility, and the Real Exchange Rate. *IMF Working Paper WP/11/9*.
- Khan, I. N. (June 2010). Exchange Market Pressure Index in Pakistan. *SBP Working Paper Series No.35*.
- Kim, I. (1985). Exchange Market Pressure in Korean: An Application of the Girton-Roper Monetary Model: Note. *Journal of Money, Credit and Banking*, 258-263.
- Lance Girton and Don Roper. (1981). Theory and Implications of Currency Substitution. *Journal of Money, Credit and Banking*, 12-30.
- Luo Dan-cheng and Yang Fang. (no date). Research of the Exchange Market Pressure during the Current Managed Float.
- M. Idress Khawaja and Musleh-Ud Din. (Winter 2007). Instrument of Managing Exchange Market Pressure: Money Supply or Interest Rate. *The Pakistan Development Review*, p. 381-394.
- Maria Socorro Gochoco-Bautista and Carlos C. Bautista. (January 10, 2009). Monetary Policy and Exchange Market Pressure: The Case of the Philippines. Quezon City, Philippines.
- McFarlane, L. (September 30, 2010). Exchange Market Pressure, Currency crises and Monetary Policy: Evidence from Jamaica. *Working Paper Series of Bank of Jamaica*.
- Michael Connolly and Jose Dantas da Silveira. (June 1979). Exchange Market Pressure in Postwar Brazil: An Application of the Girton-Roper Monetary Model. *The American Economic Review*, 448-454.
- Moreno, R. (December 7, 2000). Pegging and Macroeconomic Performance in East Asia. *Pacific Basin Working Paper Series*.
- Research and Training Centre, S. (2010). Extreme Exchange Market Pressure (EMP). *SEACEN Expert Group Workshop*. Kuala Lumpur: SEACEN.
- Richard C.K. Burdekin and Paul Burkett. (1990). A Re-Examination of the Monetary Model of Exchange Market Pressure: Canada, 1963-1988. *The Review of Economics and Statistics*, 677-681.

- Roberto Cardarelli, Selim Elekdag, and M. Ayhan Kose. (March 2009). Capital inflows: Macroeconomic Implications and Policy Responses. *IMF Working Paper Series WP/09/40*.
- Siregar, R. (2008). Exchange Rate Volatility, Exchange Market Intervention, and Reserves. *STI Training course* (p. 14). Singapore: IMF-STI.
- Stavarek, Daniel and Dohnal, Marek. (June 15, 2009). Exchange Market Pressure in Central Europe: An Application of the Girton-Roper Model. *Munich Personal RePEc Archive (MPRA)*.
- Stavarek, Daniel and Dohnal, Marek. (June 15, 2009). Exchange Market Pressure in Central Europe: An Application of the Girton-Roper Model. *MPRA Series*.
- Tatomir, S. (September). Exchange Market Pressure on the Croatian Kuna.
- Victor Pontines and Reza Siregar. (October 2004). The Yen, the US dollar and the Speculative Attacks Against the Thailand Baht. *CIES Discussion Paper No.0406*.

## VII. APPENDIX 1

### OLS estimation

Dependent Variable: EMP  
 Method: Least Squares  
 Date: 03/15/11 Time: 16:29  
 Sample (adjusted): 2000M04 2010M12  
 Included observations: 129 after adjustments

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.    |
|--------------------|-------------|-----------------------|-------------|----------|
| EMP(-1)            | 0.418138    | 0.092159              | 4.537144    | 0.0000   |
| TOT2(-2)           | -8.202151   | 3.762024              | -2.180249   | 0.0312   |
| IRD2(-1)           | -0.464263   | 0.166210              | -2.793236   | 0.0061   |
| DOL2               | 0.535705    | 0.171131              | 3.130373    | 0.0022   |
| DDR2(-2)           | 0.196756    | 0.098358              | 2.000413    | 0.0477   |
| DUM2               | -3.773796   | 1.017694              | -3.708184   | 0.0003   |
| FEG(-3)            | 0.017369    | 0.008153              | 2.130308    | 0.0352   |
| R-squared          | 0.327775    | Mean dependent var    |             | 0.060032 |
| Adjusted R-squared | 0.294715    | S.D. dependent var    |             | 3.521162 |
| S.E. of regression | 2.957116    | Akaike info criterion |             | 5.059042 |
| Sum squared resid  | 1066.833    | Schwarz criterion     |             | 5.214226 |
| Log likelihood     | -319.3082   | Hannan-Quinn criter.  |             | 5.122096 |
| Durbin-Watson stat | 1.858043    |                       |             |          |

## VIII. APPENDIX 2

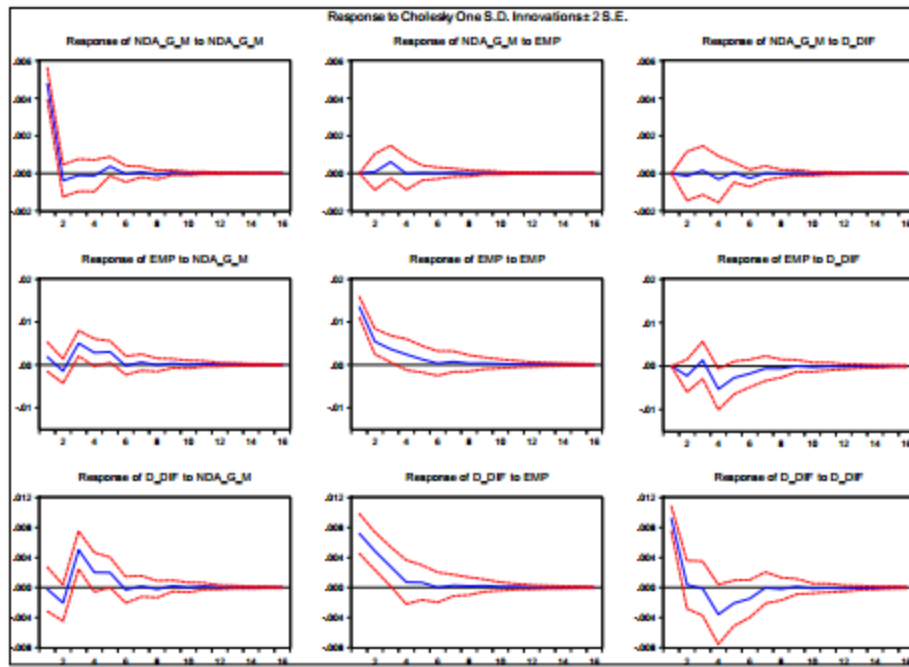
### Granger cause test

Date: 03/01/11 Time: 17:17  
 Sample: 2000M01 2010M12  
 Lags: 2

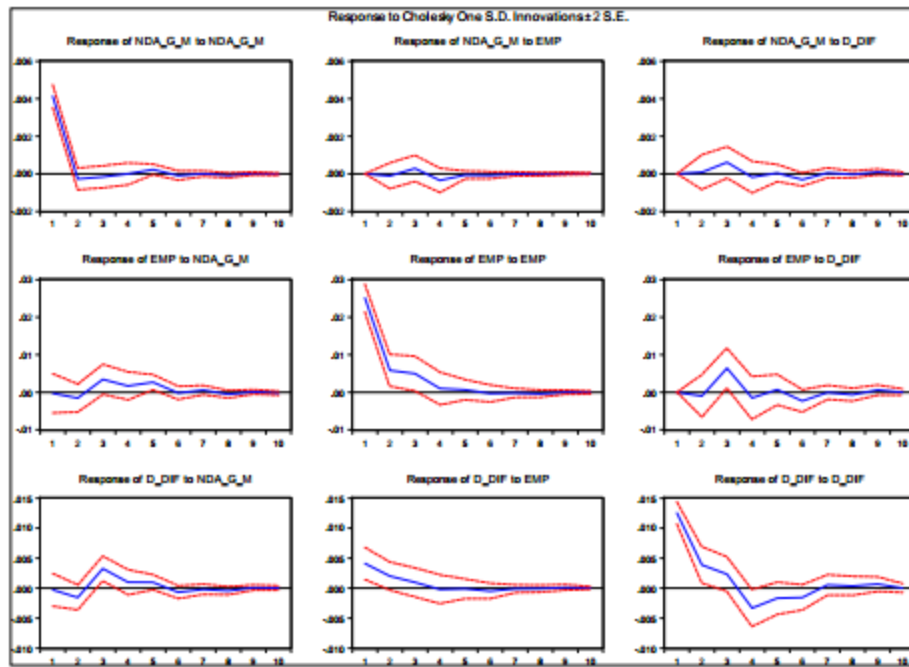
| Null Hypothesis:                            | Obs       | F-Statistic    | Prob.         |
|---|-----------|----------------|---------------|
| EMP does not Granger Cause NDA_G_M          | 128       | 0.83488        | 0.4364        |
| <b>NDA_G_M does not Granger Cause EMP</b>   |           | <b>2.93959</b> | <b>0.0566</b> |
| D_DIF does not Granger Cause NDA_G_M        | 94        | 0.48237        | 0.6189        |
| <b>NDA_G_M does not Granger Cause D_DIF</b> |           | <b>9.06090</b> | <b>0.0003</b> |
| <b>D_DIF does not Granger Cause EMP</b>     | <b>94</b> | <b>1.57033</b> | <b>0.2137</b> |
| EMP does not Granger Cause D_DIF            |           | 0.32363        | 0.7244        |

## IX. APPENDIX 3

Response function /2003.01-2008.06/



RESPONSE FUNCTION (2003.1-2010.12)



## X. APPENDIX 4

### Estimation of VAR model

Date: 03/02/11 Time: 14:27

Sample (adjusted): 2003M04 2010M12

Included observations: 93 after adjustments

Standard errors in ( ) & t-statistics in [ ]

|             | NDA_G_M                              | EMP                                  | D_DIF                                |
|-------------|--------------------------------------|--------------------------------------|--------------------------------------|
| NDA_G_M(-1) | -0.066759<br>(0.07014)<br>[-0.95174] | -0.373104<br>(0.42644)<br>[-0.87494] | -0.354236<br>(0.22372)<br>[-1.58339] |
| NDA_G_M(-2) | -0.040107<br>(0.07081)<br>[-0.56641] | 0.909940<br>(0.43048)<br>[ 2.11379]  | 0.898270<br>(0.22584)<br>[ 3.97745]  |
| NDA_G_M(-3) | 0.010126<br>(0.07503)<br>[ 0.13496]  | 0.518545<br>(0.45614)<br>[ 1.13681]  | 0.025795<br>(0.23930)<br>[ 0.10779]  |
| EMP(-1)     | -0.005540<br>(0.01450)<br>[-0.38205] | 0.245026<br>(0.08815)<br>[ 2.77952]  | 0.029204<br>(0.04625)<br>[ 0.63147]  |
| EMP(-2)     | 0.004238<br>(0.01483)<br>[ 0.28586]  | 0.054384<br>(0.09013)<br>[ 0.60341]  | -0.010525<br>(0.04728)<br>[-0.22259] |
| EMP(-3)     | -0.013489<br>(0.01457)<br>[-0.92593] | 0.008228<br>(0.08857)<br>[ 0.09290]  | 0.035716<br>(0.04647)<br>[ 0.76867]  |
| D_DIF(-1)   | 0.006285<br>(0.03713)<br>[ 0.16929]  | -0.078668<br>(0.22571)<br>[-0.34853] | 0.307644<br>(0.11842)<br>[ 2.59801]  |
| D_DIF(-2)   | 0.046834<br>(0.03513)<br>[ 1.33304]  | 0.558001<br>(0.21359)<br>[ 2.61246]  | 0.095031<br>(0.11206)<br>[ 0.84806]  |
| D_DIF(-3)   | -0.023483<br>(0.03429)<br>[-0.68483] | -0.388279<br>(0.20847)<br>[-1.86252] | -0.354070<br>(0.10937)<br>[-3.23739] |
| C           | -0.001412<br>(0.00096)<br>[-1.47466] | 0.006952<br>(0.00582)<br>[ 1.19397]  | -0.000848<br>(0.00305)<br>[-0.27756] |
| CRIS        | 0.068250<br>(0.04668)                | 1.084431<br>(0.28377)                | -9.89E-05<br>(0.14887)               |

|   |                                      |                                      |                                      |
|---|--------------------------------------|--------------------------------------|--------------------------------------|
|   | [ 1.46219]                           | [ 3.82156]                           | [-0.00066]                           |
| D0312                                   | 0.042723<br>(0.00424)<br>[ 10.0833]  | -0.025006<br>(0.02576)<br>[-0.97077] | -0.016570<br>(0.01351)<br>[-1.22620] |
| D0904                                   | -0.000622<br>(0.00501)<br>[-0.12435] | -0.140760<br>(0.03043)<br>[-4.62565] | -0.004198<br>(0.01596)<br>[-0.26296] |
| D1008                                   | -0.000482<br>(0.00426)<br>[-0.11324] | -0.136624<br>(0.02589)<br>[-5.27724] | -0.011763<br>(0.01358)<br>[-0.86608] |
| D0612                                   | -0.014435<br>(0.00429)<br>[-3.36782] | 0.003711<br>(0.02606)<br>[ 0.14241]  | 0.001989<br>(0.01367)<br>[ 0.14549]  |
| D0910                                   | -0.010055<br>(0.00481)<br>[-2.08990] | 0.002792<br>(0.02925)<br>[ 0.09544]  | -0.001984<br>(0.01535)<br>[-0.12929] |
| D0908                                   | -0.000752<br>(0.00460)<br>[-0.16354] | -0.127253<br>(0.02795)<br>[-4.55349] | -0.003275<br>(0.01466)<br>[-0.22341] |
| INF_US(-1)                              | 0.054346<br>(0.03134)<br>[ 1.73412]  | -0.234794<br>(0.19053)<br>[-1.23235] | 0.060321<br>(0.09995)<br>[ 0.60348]  |
| R-squared                               | 0.652293                             | 0.660722                             | 0.347120                             |
| Adj. R-squared                          | 0.573479                             | 0.583818                             | 0.199134                             |
| Sum sq. resids                          | 0.001281                             | 0.047353                             | 0.013033                             |
| S.E. equation                           | 0.004133                             | 0.025127                             | 0.013182                             |
| F-statistic                             | 8.276397                             | 8.591609                             | 2.345627                             |
| Log likelihood                          | 388.4924                             | 220.6354                             | 280.6267                             |
| Akaike AIC                              | -7.967579                            | -4.357749                            | -5.647885                            |
| Schwarz SC                              | -7.477398                            | -3.867569                            | -5.157705                            |
| Mean dependent                          | 0.000279                             | 0.001183                             | 0.000659                             |
| S.D. dependent                          | 0.006329                             | 0.038950                             | 0.014730                             |
| Determinant resid covariance (dof adj.) |                                      | 1.69E-12                             |                                      |
| Determinant resid covariance            |                                      | 8.88E-13                             |                                      |
| Log likelihood                          |                                      | 894.4987                             |                                      |
| Akaike information criterion            |                                      | -18.07524                            |                                      |
| Schwarz criterion                       |                                      | -16.60470                            |                                      |