Charles University in Prague

Faculty of Social Sciences
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MASTER THESIS

Exchange Rate Pass-Through in Mongolia

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, May 16, 2014

Signature

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Abstract

This thesis investigates the exchange rate pass-through to consumer prices, and its non-linearity and asymmetry effect in Mongolia. The recursive VAR model and non-linear econometric model are applied using monthly data from January 2000 to December 2013. We find that exchange rate pass-through is high and incomplete both in the short and in the long run in Mongolia. There is a statistically significant asymmetry effect, which states that impact of exchange rate depreciation on consumer price is higher than appreciation. However, we do not find an evidence of non-linearity in consumer price reaction to the large and small absolute changes of the exchange rate relative to its sample average and median as a threshold level. Additionally, we estimate the importance of the exchange rate shock for the consumer price variation using variance decomposition technique. In spite of this relatively high pass through, the exchange rate shocks explain a relatively small percentage of the variation in CPI inflation.

JEL Classification	E32, C01, C32, E31, E52, F31
Keywords	Monetary policy, transmission, exchange rate pass-through, asymmetry effect

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Acronyms

ADF Augmented Dickey Fuller

AIC Akaike information criterion

BOM Central Bank of Mongolia

CB Central Bank

CPI Consumer price index

ERPT Exchange rate pass-through

FPE Final prediction error

GDP Gross domestic product

HQ Hannan-Qwuinn information criterion

LR **S**equential modified test statistic

MNT Mongolian national currency “Tugrug”

NEER Nominal effective exchange rate

NSO National Statistical Office of Mongolia

REER Real effective exchange rate

SC Schwarz information criterion

VAR Vector Autoregression

Master Thesis Proposal

Author:	Bc. SanjidmaaBatmunkh
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Defense Planned:	June 2014

Proposed Topic:

Exchange Rate Pass-Through in Mongolia

Topic Characteristics:

My thesis will assess the monetary policy transmission through exchange rate in small open economies. Exchange rates are key variables in small open economies because of relatively high dependencies on international trade. Volatility in exchange rate influences the prices of not only imported goods but also cost of domestic finished goods and services through affecting imported inputs. It also affects price competitiveness of the economy, and thus the economic activity.

Mongolia is an import oriented small open economy that has a relatively high degree of openness to international trade. Inflation is imported from external price shocks due to a high share of imported products and inputs in Mongolia.

Using the case of Mongolia, we will identify the dynamic responses of consumer to the exchange rate volatility. Particularly, we will emphasize on the importance of the exchange rate channel as a transmission mechanism. We will determine the degree of exchange rate pass-through which is the important link for the transmission mechanism between exchange rate and inflation. Moreover, we will assess the asymmetry effect of exchange rate pass through to consumer prices.

I am going to use data from the National Statistical Report of Mongolia, reports of Bank of Mongolia.

Hypotheses:

1. Exchange rate pass-through to domestic prices is high and incomplete in Mongolia
2. There is an asymmetric effect of exchange rate change on consumer price inflation (ER appreciation/depreciation).
3. There is non-linear effect of exchange rate with respect to small and large absolute changes

Methodology:

We will employ a VAR model, which will allow us to measure exchange rate pass-through with an impulse response to a given shock and its magnitute and dynamics, and nonlinear model with dummy variables for measuring asymmetry effect of passthrough.

We will construct the econometric model according to the monetary transmission mechanism theory and related literatures.

Outline:

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3. Exchange rate regime in Mongolia
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   b) Defining the model
   c) Estimation
6. EmpiricalResults
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1 Introduction

The exchange rate is one of the important concerns of the monetary policy transmission mechanism, especially in small open economies because of relatively high dependence on international trade. Volatility in exchange rate influences the prices of not only imported goods, but also cost of domestic finished goods and services through affecting imported inputs. It also affects the price competitiveness of the economy, and thus the economic activity.

In the early 70s, the Breton-Woods system of fixed exchange rate collapsed and exchange rate of major currencies started to float freely against each other. However, prices, especially oil price, went up rapidly because of floating exchange rate, which facilitates adjustments to external shocks. Since the period of transition to floating exchange rate, there has been increased interest to investigate the effect of exchange rate volatility on domestic prices, namely, consumer prices, producer prices, and import prices.

The main focus of researches, examining effect of exchange rate movement on prices, changed throughout the years. In the early 70s, most of the ERPT studies focused on the macroeconomic implications, especially on trade balance and current accounts. In terms of theoretical approaches, exchange rate appreciation increases the export, thus improves the trade balance. However, researchers found that very volatile exchange rate does not result significant improvement on trade balance. Prices are not fully adjusted to the exchange rate movement because of price price elasticity of demand, substitutability of the goods, permanent changes of exchange rate volatilty, costly arbitrage, and pricing-to-market. Therefore, most of the exchange rate pass-through researches has been done with respect to microeconomic prespectives, especially firm plays main role in recent microeconomic based pass through analysis.

Fundamental theory for the effect of exchange rate on price level stems from the literature on Purchasing power parity theory of exchange rates (Cassel, 1918). The Mundell-Flemming model is also one of the major theories about the exchange

rate and price in an open economy. Impossible trinity principle of Mundell-Flemming model illustrates that fixed exchange rate, free capital movement and an independent monetary policy cannot be managed simultaneously. Other basic theoretical researches are “Industrial organization model” by Dornbusch (1987), “Pricing to market hypothesis” by Krugman (1986), and “macroeconomic model of price setting” by Taylor (2000). Based on the theoretical approaches, researchers more concentrated on empirical studies since 1990s in this area. For instance, Feinberg (1989), Knettler (1993), Choudhri, Faruqee, and Hakura (2005) empirically examined the price adjustment in terms of the degree of market concentration, relative market shares of imported and domestic products, import penetration and exchange rate fluctuations. Furthermore, as Goldberg and Knetter [1997] suggested, analysts started to focus on pass-through of an exchange fluctuation on domestic prices. Since then, a number of researchers have studied the exchange rate pass through an inflation in specific industries, or macroeconomic pass through of specific country or group of countries depending on their general characteristics, such as Woo 1984], Feinberg [1986; 1989], and Parsley and Popper [1998]. More specifically, studies are concentrated on determinants of exchange rate pass through. For instance, Choudhri and Hakura (2001), Gagnon and Igrig (2004), Bailliu and Fujii (2004) found that the higher inflation rate leads the higher pass through. Moreover, Campa and Goldber (2004), Taylor (2000), Frankel et.al (2011) considered exchange rate volatility as an important determinant of the pass through. Additionally, (Jeevan Kumar (2007)), McCarthy (1999), Feinberg (1989) found that degree of openness, import structure, international trade barriers are the important factors explaining the pass through.

What's more, (Barhoumi Karim, 2005), (Ca'Zorzi, Ellce, & Marcelo, 2007), (Ivohasina, 2012), (Goldfaij & Werlang, 2000) and (Lavern, 2009) examined the degree of exchange rate pass-through to consumer prices and import prices for emerging market and developing countries. These papers generally find incomplete pass-through, which is around 30 - 40 percent to consumer prices and 60 – 70 percent to import prices. Degree of ERPT for emerging and developing countries are considerably higher than developed countries. Moreover, exchange rate pass-through can have the asymmetric effect on prices depending on its appreciation/depreciation and absolute size of the volatility. (Ivohasina, 2012),finds that the pass-through coefficients are larger for the exchange rate depreciation than for the appreciation**.** On

the contrary, estimations by (Kumar & Khundrakpam, 2007), and (Przystupa & Wrobel, 2009) show that impact of exchange rate appreciation on consumer price is higher than depreciation. (Kumar & Khundrakpam, 2007) also find that pass though coefficients are higher for the large absolute exchange rate changes than small changes.

Exchange rate pass-through is theoretically defined as the percentage change of domestic prices resulting from a one percent change in the exchange rate between domestic and foreign countries. As (Karoro, 2007) and (Hyder, Shah 2004) proposed, the exchange rate movement transmits to inflation through direct and indirect channels. The direct channel is that exchange rate fluctuation changes the prices of imported inputs and goods, which are subsequently impacts on consumer prices. Indirect channel is that the exchange rate fluctuation directly affects on domestic prices due to price adjustment decisions of the firms based on pricing-to-market and other factors. (Hyder, Shah 2004).

According to the Kiptui (2005), it is important to understand exchange rate pass-through for the countries that have the inflation-targeting regime. The degree of exchange rate pass-through implies the level of international macroeconomic transmission and strength of the international market power of the foreign and domestic industries, and moreover, it helps to implement effective monetary policy.

The objective of the thesis is to assess the degree of exchange rate pass through and its asymmetric and nonlinearity effect in Mongolia. We will identify the dynamic responses of consumer price inflation to the exchange rate shocks in Mongolia, Particularly, we will emphasize on the importance of the exchange rate channel as a transmission mechanism. Moreover, we will determine the exchange rate pass-through, which is the important link for the transmission mechanism between exchange rate and inflation, and its asymmetry and nonlinearity effect.

Mongolia is an import oriented small open economy that has a relatively high degree of openness to international trade. In the last more than two decades, the economy has been experiencing high and very volatile inflation, which is recorded 31st highest inflation rate in the world (2012). In order to maintain low and stable inflation, it is important to determine the major factors contributing to inflation.

Inflation is imported from external price shocks due to a higher share of imported products and inputs in Mongolia. The trade balance of the country is mostly negative and about 60 percent of the trade turnover is accounted for import. Consumer price index of Mongolia measures the general price level of 329 different types of consumer goods (265) and services (64) purchased by households. In particular, the share of imported consumer goods in CPI basket is accounted for 50 percent. Moreover, 55 percent of the foodstuff, which is the largest percentage of the CPI volatility, in consumer basket is imported goods.

Mongolia has a floating exchange rate regime. Since 2008, volatility of domestic currency considerably increased and currency depreciated by 50 percent against the USD until the end of 2013. Thus, very volatile floating exchange rate and a large share of imported goods in CPI drew our attention to study the effect of exchange rate on consumer price inflation in Mongolia.

Historically, Mongolian economy was changed from a socialist to a free market economy during the 1989-1990. Subsequent years of transmission, the economy suffered from hyperinflation, unemployment and scarcity of food. However, GDP started growing at 6% in 1995 due to a sharp increase in copper prices and experienced about 3.5% percent growth in the next few years until 2000. Mongolian traditional economic activity used to base on livestock-based agriculture. However, nowadays, mining sector plays main role in the economy, and 80% percent of the exports are composed of minerals, which contribute 30 percent of the GDP.

We employ two econometric models; Firstly, the recursive VAR model which allows us to measure exchange rate pass-through with an impulse response. Secondly, Non-linear econometric model with dummy variables to measure the asymmetric and non-linear effect of exchange rate pass-through.

The rest of the paper is structured as follows: Chapter 2 presents a literature review on exchange rate and inflation linkage (Exchange rate pass through) Chapter 3 and 4 provide information about exchange regime and inflation rate in Mongolia. Chapter 5 states hypothesis, Chapter 6 explain empirical methodology; Chapter 7 and 8 interpret dataset and empirical results and Chapter 9 provides a conclusion. Finally, Appendixes give additional results for estimation results.

2 Literature review

In this chapter, we provide the empirical and theoretical literature reviews on exchange rate pass-through. Macroeconomic determinants of exchange rate pass-through, speed and magnitude of pass-through, asymmetry effect, and non-linear effects are discussed in cases of global, emerging markets, developing countries, and individual countries.

2.1 Theoretical literature review

2.1.1 Exchange rate pass-through defined

Theoretical definition of exchange rate pass-through is that the percentage change of domestic prices resulting from a one percent change in the exchange rate between domestic and foreign countries. (Campa, Goldberg 2002). All other researchers provide similar definition, for instance (Kiptui at al 2005) described that percentage change in import prices (expressed by local currency) is resulted from a one percent change in the exchange rate in which the change in domestic prices can be attributed to a preceding change in the nominal exchange rate.

The effect of exchange rate pass-through is mostly examined on domestic prices such as import price, export price, consumer price, and domestically produced price. Additionally, expression of exchange rate pass-through is also used to demonstrate how exchange rate volatility effects on investments and trade volumes. In this paper, we only focus on exchange rate pass-through into prices.

After the collapse of the Briton Woods system of fixed exchange, floating exchange regime spreads around the world. Initially, the policy makers applied floating exchange regime in order to provide efficient adjustment system into their economy (Menon, 1995), however, some countries experienced an abrupt increase in prices due to external shocks (increase in oil price was one of the main unexpected consequences of adoption of floating exchange rate), specifically, price adjustment from exchange rate volatility. Thus, economists need to explain this adjustment puzzle. Since then, many researchers have been motivated to study underlying

relationship between exchange rate volatility and prices of the internationally traded products.

The effect of exchange rate pass-through is mostly examined on domestic prices such as import price, export price, consumer price, and domestic product price. Additionally, expression of exchange rate pass-through is also used to demonstrate how exchange rate volatility effects on investments and trade volumes.

The theory for this study stems from the literature on Purchasing power parity (PPP) theory of exchange rates (Cassel, 1918). "The Law of One Price" basis on the PPP states that identical good must have same prices even in different places in terms of exchange rate. The purchasing power parity expresses that given amount of money has the same purchasing power not depending on to purchase directly from the market or convert it to another currency and then buy the same amount of identical goods. In other words, PPP rate is the amount of adjustment needed on the exchange rate to have a same purchasing power for countries. The real exchange rate is equal to one when purchasing power parity holds. However, this statement is not supported by estimations in practice both short and long run. On the contrary, relative PPP tends to hold in the long run, which is supported by world data. Relative PPP implies that the relationship between inflation rate and exchange rate volatility of two countries over the years are constant (in other words the real exchange rate is constant), but not essentially equal to one.

The real exchange rate can be defined as follows;

$$RER_{ppp} = e * \frac{P_f}{P}$$

Where, real exchange rate (RER) is expressed by the nominal exchange rate, which is adjusted by relative price levels of two countries. $P_f - foriegn\ price\ level,\ P - domestic\ price\ level.$

The real exchange rate can be constant when a change in the nominal exchange rate is equal to change in relative prices. If we assume foreign price level and real effective exchange rates are is constant, then the change in the domestic price level is fully affected by change in the nominal exchange rate. In this case, we can have the complete exchange rate pass-through in which nominal exchange rate is fully

reflected in domestic prices. Basically, there is partial or incomplete exchange rate pass through when the domestic price rises by less than one percent against one percent change in the exchange rate. In the case of incomplete pass through to import prices, exporters absorb the portion of the exchange rate change in order to compete with the prices of domestic products in order to keep their market share. The existence of the partial pass-through is the fundamental form of the "adjustment puzzle".

As (Rogoff, 1996) suggested that in the long run, incomplete pass-through occurs, not the complete pass through.

The Mundell-Flemming model is also one of the major theories about the exchange rate and price in an open economy. The model describes the long term relationship between the exchange rate, interest rate and output. Impossible trinity principle of Mundell-Flemming model illustrates that fixed exchange rate, free capital movement and an independent monetary policy cannot be managed simultaneously.

Furthermore, the existence of sticky nominal price, monetary policy shocks generate real and long run effect on output, unemployment, price levels, and interest rate. Consecutively, it influences the exchange and consequently the trade balance. Therefore, considerable policy implications arise with respect to nominal price sluggishness. It is involved the choice of exchange rate regime, optimal policy areas and coordination of international monetary policy. Moreover, If there is price sluggishness in the economy, the government would increase the inflation in order to decrease unemployment. (Hugh) Further, if this assumption is present, law of one price would hold even in the short term in the economy.

2.1.2 Channels and determinants of Exchange rate pass through

In this section, we discuss channels and the determinants of exchange rate pass through to domestic prices.

- **Channels of ERPT**

The exchange rate volatility passes into domestic prices in a direct and indirect way. The first channel is the direct channel through imported production inputs. The impact of exchange rate transmits via indirect channel, when a change in domestic price is influenced by change in imported inputs and capitals, which is resulted from exchange rate fluctuation. In other words, depreciation in domestic currency effects increase in prices of the imported products and inputs, and then higher cost of imported inputs and capitals subsequently influence on domestic prices to increase. The second channel is indirect channel. The exchange rate fluctuation indirectly affects on domestic prices due to mostly price adjustment strategy of the firms. (Hyder, Shah 2004). By way of explanation, exchange rate depreciation in domestic economy, gives an advantage to domestically produced products to have a lower price than imported products, in order to increase their market share. However, prices of locally produced products may have been increased due to increased demand of domestic products, and consequently it increases the profit margin of domestic producers.

On the other hand, If the local producers use imported raw materials, then the exchange rate transmission channels are merged. Thus, changes in exchange rate simultaneously affect the domestic prices and consumer prices. (Karoro, 2007)

We summarized the channels of exchange rate transmission into consumer prices as (Karoro, 2007) purposed.

Scheme 1

$$Exchange\ rate\ \downarrow \rightarrow\ Import\ price\ \uparrow \rightarrow Produced\ Price\ \uparrow \rightarrow Consumer\ price\ \uparrow$$

Scheme 2

$$Exchange\ rate\ \downarrow \rightarrow\ Import\ price\ \uparrow \rightarrow Consumer\ price\ \uparrow$$

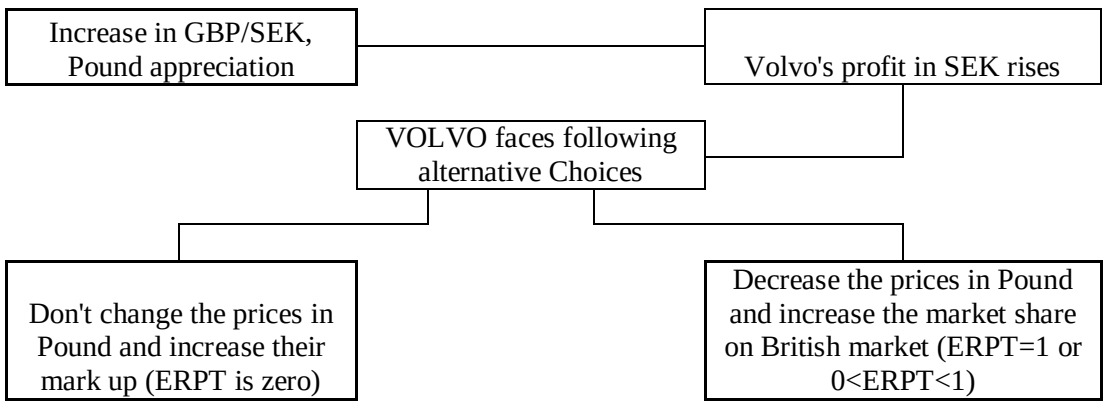
Scheme 3
$Exchange\ rate \downarrow \rightarrow Produced\ Price \uparrow \rightarrow Consumer\ price \uparrow$

Scheme 4
$Exchange\ rate \downarrow \rightarrow Consumer\ price \uparrow$

Where, scheme 1 and 2 exhibit direct transmission channels of pass-through where exchange rate volatility directly affects consumer prices through changes in both import price and produced price or only through change in import price. Scheme 3 and 4 show indirect transmission channels in which exchange rate indirectly affects consumer prices.

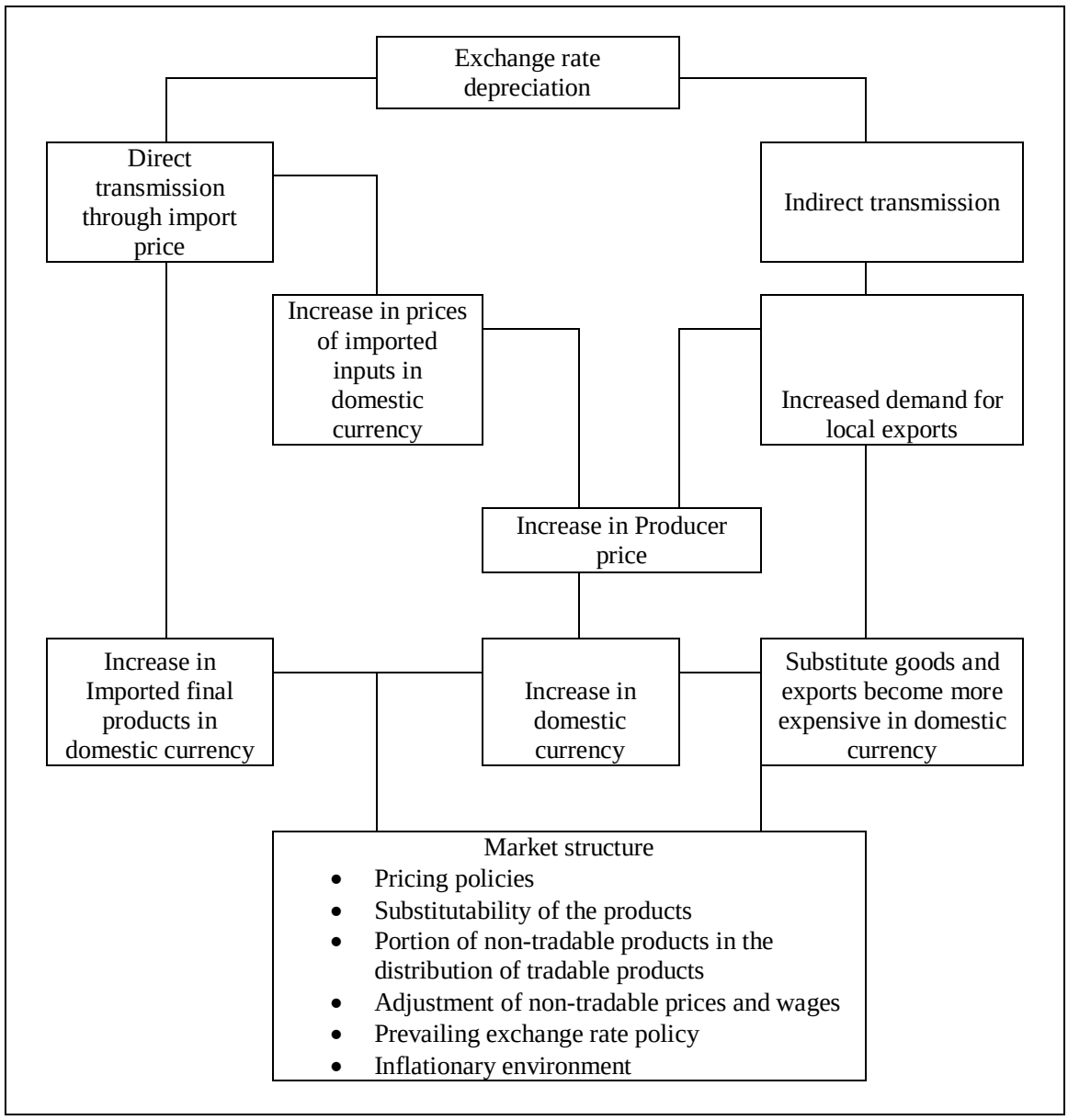
What's more, an exogenous exchange rate fluctuation along with sticky wage causes cost shock for the domestic producers. In terms of sticky wages, domestic currency appreciation leads labor costs. Thus, it results distortion of market equilibrium and requires price or quantity adjustments for an industry. (Campa, Goldberg 2002). Example of this mechanism is given by (Bax, 2004) which illustrates the exchange rate transmission in case of "VOLVO", a car producing company in Sweden. How the "VOLVO" would make a pricing decision on the British market in terms of appreciation of the British Pound.

Scheme 5 ERPT transmission based on "VOLVO"'s decision making



Source 1 (Bax, 2004)

Scheme 6 the transmission of Exchange rate pass-through



Source (Hyder & Shah, 2004) and (Karoro, 2007)

- ## Determinants of exchange rate pass through

This section reviews the theoretical models for exchange rate pass through and its determinants.

One of the well-cited theoretical researches in the area of ERPT is the paper by Dornbusch (1987) that applies industrial organization model and assumes the exchange rate as an exogenous variable. The paper illustrates that exchange rate

movement, in terms of sticky wages, will cause the cost shock. Hence, the firms adjust the prices and quantities in response to the cost shock. The proposed determinants of the ERPT are degree of market concentration, relative market shares of imported and domestic products, and import penetration. The price elasticity with respect to exchange rate change is described below based on Cournot oligopoly model.

$$\varphi = (n^*/N)\,(ew^*/p\,)$$

Where, n^* is number of foreign firms, N is total number of firms, and ew^*/p is ratio of marginal cost relative to prices in domestic currency. The elasticity of ERPT implies that degree of ERPT rises along with the number of foreign firms and marginal cost increases. Moreover, Dornbush (1987) finds that exchange rate fluctuation significantly reflects in prices of the industry, which has large import penetration and imperfect competition. Similar result is found by (Hyder & Shah, 2004) in which imperfect market competition leads high exchange rate pass through.

This argument is supported by (Goldberg, Knetter 1996) that developed the microeconomic framework of the price adjustment to the exchange rate volatility and violation of the law of one price. More specifically, literature is more focused on importance of competitive market structure on exchange rate pass through to prices. The following model is used based on textbook definition of ERPT regarding price changes to the exchange rate movement in between importing and exporting countries.

$$P_t = \alpha + \delta X_t + \gamma E_t + \varphi Z_t + \varepsilon_t$$

Where, t is time, p is import price in domestic currency, T is exporter's cost, E is the exchange rate of importing country's currency relative to the exporting country's currency, Z is a control variable for change in import demand. The coefficient γ expresses the degree of exchange rate pass-through. If γ is equal to one, pass through is complete. Conversely if γ is between zero to one, pass through is incomplete.

(Feenstra 1996) shows that incrase in market share may lead the decrease in ERPT elasticity in terms of weak assumption of the functional form of demand. The price adjustments to the exchange rate movement by exporting firms is low, if they

have small market share. On the other hand, exporting firms are willing to increase the prices response to the domestic currency appreciation as market share increases. Thus, large market share may lead high pass-through.

(Yang 1997) states that the substitution effect of the products negatively affects the degree of exchange rate pass through in the industry. Moreover, exporting firms do not differentiate the prices of the domestically produced products. If there is strong substitution effect between domestic and importing products, change in the exchange rate may not reflected in prices so that pass through is zero. Menon (1999) argue that in the short run, changes in exchange rate more likely to refect in profit margin rather than in prices.

Krugman (1986) suggested the pricing to market hypothesis as an additional factor of the exchange rate pass through. A nation specific market power and ability of market segmentation of the firm impact on its decision of mark up adjustments depending on destinations.

(Wickremasinghe, Silvapulle, 2004) studied the exchange rate of pass through depending on product differentiation and nature of competitions as a market or industry specific determinants. The model for the discussion is based upon the principles of the monetary approach. $PM = PX * E = (1 + \delta)C * E$, where, PM is the import price, PX is the exporters price, C is the cost of production, E is the exchange rate, and δ is the profit margin. From the model, profit mark-up can be expressed as $(1 + \delta) = \mu$. Alternatively, profit markup is computed as Mann(1989) proposed. $\mu = (PD/(C * E))^{\alpha}$, and it is substituted into the import price model.

$PM = \alpha PD + (1 - \alpha)c * + (1 - \alpha)E$, where, degree of pass through is expressed by $(1 - \alpha)$. ERPT is zero for the price takers in the market ($\alpha = 1$). The import prices in the domestic market is not influenced by exchange rate movement. On the contrary, ERPT is complete if the there is no competition between domestic and foreign producers. In this case, exporting firms fully adjust their prices to the exchange rate movement by keeping markups constant.

(Campa, Goldberg 2002) examined the determinants of exchange rate fluctuation into price. The model takes into account market integration and

segmentation, a role of market microstructure, and price discrimination power of the firm. The proposed model is shown below.

$$P_t^{M,j} = E_t P_t^{X,j} = E_t MAP_t^{X,j} \left(\frac{P_t^{M,j}}{P_t}\right) C^{\alpha,j}(C_t^j, Y_t E_t)$$

$$MAP_t^{X,j} = \left(\frac{P_t^{X,j}}{C_t^{x,j}}\right)$$

Where, X is foreign exporting country, M is domestic importing country, $P_t^{M,j}$ is import price in domestic country, E is the nominal exchange rate, C is the marginal cost function, and MAP is the mark up of the prices. Markup rate is the industry specific and depends on demand which expressed by $\frac{P_t^{M,j}}{P_t}$.

The formula implies that price adjustment of the exporting firm is depends on mark up of the demand and marginal costs.

(Bailliu and Fujii (2004) formulated the model for pass through considering simple static profit maximization problem. In this model, foreign firm exports product to the importing country referred as domestic country as well. The firms input cost is assumed to be dominated in the currency of the exporting country.

$Max\pi = e^{-1}PQ - C(Q)$ – The profit maximizing behavior

Where, π, e, and P are profits in domestic currency (exporting firm's currency), exchange rate of domestic currency relative to currency of an exporting firm, and price in domestic currency respectively and C() is a cost function expressed by the quantity demanded (Q).

The firm solves the profit maximization problem as follows;

$P = eC_q\mu$ – The first order condition maximization

Where, C_q is the marginal cost and μ is the mark-up over marginal cost which depend on the price elasticity of demand of the good. $\mu = \gamma/(1-\gamma)$, where, γ is the price elasticity of the demand. Hence, exchange rate movement, marginal cost and mark up cause price change in domestic currency. Specifically, marginal cost changes due to

domestic input cost and mark up changes depending on demand factors in domestic economy. Therefore, we can write the price equation in following way.

$P = \alpha_0 + \alpha_1 e_t + \alpha_2 P_t^* + \alpha_3 Y_t + \varepsilon_t$ – The reduced form of price equation

*P** is the marginal cost of foreign firm and '*Y*' is demand condition. (Goldberg and Knetter (1996)). Consequently, α_1 measures the degree of ERPT.

Moreover, (Goldberg, Knetter 1996) findings suggest that violation of law of one price and incomplete pass through are resulted from third degree price discrimination. Gaulier (2006) stated that optimal mark-up negatively by price elasticity of demand and positively by market share of the exporters in the destination market. Hence, price adjustment to exchange movement is determined by pricing-to-market argument.

(Kara & Nelson, 2003) examined the relationship between inflation and exchange rate using alternative open economy models such as 'monetary approach', pricing-to-market approach; New Keynesian open-economy model, and the traditional backward-looking open economy Phillips curve. Here, we review the models, which are not presented in the previous litertures.

Simplified New Keynessian Phillips curve assumes that there is a sticky price for the domestic products while price is flexible for the imported products. Also, model assumes there are no imported inputs in the domestic economy. Further, exogenous disturbance is considered. Hence, Phillips curve is as follows.

$P_t^D = \beta E_t P_{t+1}^D + \alpha L_t + u_t$

Above in the equation, P_t^D is domestic price index, β is discount factor, $\alpha > 0$ and L_t is the labor cost. And then, complete pass through assumption is substituted into the equation of Phillips curve.

$P_t^D = P_t - s_m \Delta q_t$

$P_t = \beta E_t P_{t+1} + \alpha mC_t + \varphi(\Delta q_t - \beta E_t P_{t+1}^D) + u_t \ , \varphi > 0$

Where, P_t is the consumer price inflation, s_m is the share of import, mc is the marginal cost, and $(\Delta q_t - \beta E_t P_{t+1}^D)$ represents depreciation of domestic currency.

Backward looking Phillips curve considers lagged inflation rate, demand in the domestic market, and real exchange rate movement does not concern optimization behavior and rational expectations. (Kara & Nelson, 2003)

Conditions for the complete ERPT:

As we discussed above, there is a complete pass-through if one percent exchange rate change leads one percent change in domestic prices. Complete exchange rate pass-through is present if following two assumptions are fulfilled. First of all, mark ups of price in domestic currency are constant. In terms of perfect competition, mark ups over the cost are zero. Secondly, marginal costs in domestic currency are constant. For instance, if the exporting firms want to maintain their markup in domestic currency, export prices in domestic currency must be constant. Thus, depreciation in domestic currency would increase the exporter's profits expressed in foreign currency (currency of the exporting firm). (Bax, 2004)

Reasons for the incomplete ERPT:

The incomplete exchange rate pass through is a micro-economic phenomenon, which leads significant macroeconomic consequences (Gaulier at al 2006). The adjustments of domestic prices to the exchange rate fluctuations are explained by a number of determinants. Here, we discussed several reasons of the partial pass-through.

Firstly, we assume the assumptions of the complete pass through do not hold. If the marginal costs are not constant, changes of prices in the domestic currency would be affected by changes in demand. Further, if there is a simultaneous change in quantity and marginal cost, markups can be constant even though exchange rate movement are not fully reflected in prices.

The second reason is related to the outsourcing cooperated with manufacturing facilities of other countries. By way of explanation, marginal costs of the exporters' might come in currency of the exporting country or other countries. Hence, the importance of the marginal cost in the explanation of exchange rate pass through is notably depend on the invoiced currencies, whether it is expressed in exporter's, in importers' or in third country's (Freiberg 1998). If we assume that all the revenues and inputs are expressed in domestic currency, firms make pricing decisions in spite

of exchange rate changes in exchange rate. Thus, it may lead no exchange rate pass through. (Bax, 2004)

The third reason is accounted for price elasticity of demand and substitutability of the products. The pricing decisions by manufacturing firms may depend on the demand curve and its elasticity. If the price elasticity of demand is high, producers (exporters) are not willing to change the price in terms of currency depreciation of the importing country. Hence, the mark ups of the producer declines and prices are slightly adjusted to the exchange rate. On the other hand, if the price elasticity is low, changes in price do not largely influence on decrease in demand. Therefore, producers are more likely to change the prices along with changes in exchange rate. Thus, low price elasticity of demand is associated with the high exchange rate pass through. An another factor for the imcomplete pass through is substitution effect of the products in the domestic market relative to the foreign market. Large substitution effect between domestic and foreign products tends to lead high small pass through. For instance, when the currency of the importing country appreciates, exporting firms are willing to lower the prices in order to increase their price competitiveness in the market with respect to large substitution effect. (Markusen 1995).

Fourthly, there is a greater incentive to adjust prices for the manufacturers during the periods when high and permanent exchange rate changes are expected. Desire of the exporters to increase market share in the domestic market, would lead higher, but incomplete pass through (Markusen 1995).

Fifthly, costly arbitrage, home bias and regulations influence the effect of exchange rate pass through to be incomplete.

Finally, pricing-to-market phenomenon explains that import prices in the market are set same price level as domestic products. The prices are not reflected by changes in exchange rate so that there is no pass through to the prices. (Kara, Nelson 2003).

- ## Models for the asymmetry of exchange rate pass-through

This section reviews the theoretical explanations for the asymmetric response of trade prices to exchange rate changes.

Binding quantity constraints: A depreciation of the home currency gives a choice of a foreign firm to choose either to decrease their makeup, keeping import prices fixed in the home country, or to maintain their markup by increasing the price in the home country, which may lead to a decrease in market share of the firm, or to combine the both implementations. There is no pass through when firm keeps a price constant in importing country and keeps a market share, however, it decreases the firm's profit margin. On the other hand, pass through is complete when the firm increases the import price by reflecting fully the depreciation. During the complete pass through sales in importing country will decrease and it will cause to reduce the profit. In case of partial pass-through, sales and price decrease with the corresponding decline in profit. Thus, pass through is higher during the exchange rate depreciation than appreciation (Pollard and Coughlin (2003)).

Market share objective: Exchange rate appreciation of the importing country allows foreign firms to increase their market share at the same time keeping the markup. However, during the depreciation, foreign firms face difficulties to decrease their markup in order to keep their market share. Thus, exchange rate appreciation leads higher pass-through than depreciation. (Knetter (1994))

Pricing-to-Market adjustment: Knetter (1994) suggests that trade restrictions may affect asymmetry in price adjustment of the domestic and foreign firms to the exchange rate movement in terms of pricing-to-market. In other words, the appreciation of the domestic currency may lead higher pricing-to-market adjustment than during the depreciation.

Production input switching: In order to explain production switching as Ware and Winter (1988) suggested, we should consider a price-taking firm which uses inputs produced in domestic country or abroad and sells their products in a domestic and an export market. Having an operation in two markets allows the firm to shift the production technology depending on exchange rate fluctuation. More specifically, during the exchange rate appreciation, firm can choose their domestically produced inputs for the production procedure while during the depreciation, firm uses inputs imported from abroad. Hence, the fact that there is no change in output and price, leads zero pass-through. Webber (2000) formulates the asymmetric effect of pass-through using production switching model. A dual profit functions are shown below.

$\pi^D = P^D(Q)Q/E - P^{iM}i^M/E$ Depreciation phase

$\pi^A = P^D Q/E - P^i i$ Appreciation pjase

Where, $P^D(Q)$ is the inverse of the import demand curve, expressed by in domestic currency, E is the exchange rate, i and i^M are the quantity of the domestic and imported input respectively, Q is the quantity of export output, P^{iM} and P^i are price of importers and domestic's respectively. In the model that we provided above assume that there is perfect input switching from one production technology to another production technology without any cost. Specifically, domestic currency appreciation would lead increase in marginal revenue by same amount keeping a marginal cost constant, for a given domestic price. If domestic price of the firm declines, output will increase. Thus, it would lead partial pass through. On the contrary, during the exchange rate depreciation, marginal revenue and cost of the firm will decline by same amount as depreciation. Hence, output and price do not change and there is no exchange rate pass through during the depreciation. As a result, pass through is higher during the appreciation than depreciation.

Menu cost: Change in exchange rate may reflect asymmetrically (non-linearity) to the price due to presence of menu cost. Firms respond to the large and small exchange rate changes depending on the cost of changing prices. A significant way for firms to change their price resulting from exchange rate volatility is only when change in exchange rate exceeds certain threshold. If invoice currency is the importers' currency, firm doesn't need to change the price due to small change in exchange rate and absorb the effect of pass through on price. There is no pass through in this case. If, however, invoice currency is the exporters' currency (foreign currency), small change in exchange rate doesn't affect the invoice price of imports in exporter's currency, but fully affects import prices in domestic currency. In this case exchange rate pass through is complete. The presence of menu cost, large change in exchange rate makes it worthwhile for foreign investors to change the invoice price in exporter's currency. It leads decrease in pass-through of large exchange rate changes because firms absorb the price variation in domestic currency. (Pollard and Coughlin (2003)).

Overall, market share objective and production input switching models state that exchange rate appreciation may lead higher pass through than depreciation. However, in terms of sticky price or binding quantity constraints, asymmetry effect is found in different direction, which is higher for the depreciation than appreciation.

According to the menu cost, an absolute change of the exchange rate compared with threshold level and currency denomination of invoice determine the asymmetry of the exchange rate pass through. In following two cases, pass-through is larger; (1) absolute changes in exchange rate are higher than threshold level associated with currency denomination of the invoice is expressed in foreign currency; or (2) absolute exchange changes are smaller than threshold level when currency denomination of the invoice is expressed by domestic currency. Even though most of the models explained above examined the asymmetry effect of pass-through into import prices, there are same price adjustment strategies for the domestic producers. Exchange rate shocks to the import price is eventually reflected in domestic prices and consumer prices which implies the indirect transmission mechanism of the ERPT (Karoro, 2007)

Factors for the asymmetry	Pass-through effect
Market share objective	Appreciation>Depreciation
Production input switching	Appreciation>Depreciation
Binding quantity constraints	Depreciation>Appreciation
Menu cost:	
(denomination of the invoice is domestic currency)	Larger pass-through associated with large absolute exchange rate changes
(denomination of the invoice is foreign currency)	Larger pass-through associated with small absolute exchange rate changes

Source (Karoro, 2007)

2.2 Empirical literature review

This section reviews empirical literatures.

The early papers that we povided are mostly theoretical studies of exchange rate pass-through. Since 1990s, researchers more focused on empirical studies of ERPT. During the Asian crisis in the late 1990s, many industrialized economies experienced deflation due to fall in import price. Especially, deflation in the UK and US is resulted from exchange rate depreciation and fall in import price. Since then, many more studies pointed out the relationship between inflation and exchange rate as an important factor of the inflation. The researchers studied exchange rate pass-through to price developments in specific industries, specific country, or group of countries depending on their general macroeconomic characteristics.

Feinberg (1989) does one of the early empirical studies based on industrial organization model. The paper empirically examined the exchange rate pass through on domestic producer prices depending on its domestic industries in case of USA and Germany from 1974 to 1987. In particular, the paper finds that the higher exchange rate pass through on domestic price in import oriented industries, while lower pass through in capital intensive and less import penetration industries. Further, empirical study by Mann (1986) provided evidence that exporting firms are more likely to change their exporting prices to adjust the profit margin corresponding with more frequent exchange rate volatility. Thus, it leads less pass though in greater exchange rate volatility countries.

An empirical study of Krugman (1986) was empirically done by Knettler (1993) in case of Japanese transport and electrical machinery industries. Paper investigated the relationship between export prices in yen and domestic price of the exporting products and found that there is a substantial change in export price comparing to domestic prices resulted from exchange rate variation.

Knettler (1993) analyzed the degree of price discriminations depending on export destinations, source countries, and within industries. The paper finds that export destination, exchange rate volatility, and industrial composition matters for the pass though and it differs across the counties. In addition, high pass-through may occur due to weak pricing to market adjustment in which firms do not concern

enough about the pricing policies in small markets. In addition, Goldberg and Knetter (1997) investigated the exchange rate pass through to import prices within the market segmentations, and explained the incomplete pass-through as a result of third degree price discrimination. Taylor (2000) developed a microeconomic model of price setting to show that lower persistence of cost changes leads to lower pass through. Simulations of an empirical model showed a positive relationship between persistent exchange rate shock and import prices. Hence, pass through is higher for the countries with higher persistent of exchange rate fluctuations. Furthermore, for the larger economy, exchange rate pass through to consumer prices is more likely to be incomplete due to counteracting change in world price. On the contrary, in small open economies, the inflationary effect of exchange depreciation would be a complete because they do not influence the world price.

The panel study by Goldfajn and Werlang (2000) investigated the effect of exchange rate on inflation using a sample of 71 countries in a period of 1980 – 1998. Initial real exchange rate overvaluation, the initial rate of inflation, the degree of openness and GDP deviation played main role in determining the effects of the pass through. However, importance of determinants differs among the countries. For instance, the real exchange rate is the most significant determinant to get a better inflation prediction in emerging countries, while initial inflation is considered as an important factor to access inflation in the developed countries. Moreover, pass through increases till its peak at 12 months and gradually decreases.

Choudhri and Hakura (2001) tests a hypothesis by Taylor (2000) and finds that strong positive dependence between mean inflation rate and pass through across 71 countries in the period of 1979 – 2000. The result implies that low inflationary environment leads to the low exchange rate pass through to import prices. Similar empirical evidence, done by Devereux and Yetman (2003) in a sample of 122 countries, also finds that exchange rate pass-through significantly and positively depends on the average inflation rate.

Gagnon and Igrig (2004) developed the theoretical model to investigate the question of whether a change in the pass through is explained by inflation stabilization by central banks. The hypothesis, based on the model is empirically tested on 20 industrialized countries during 1971-2003. They find a significant

relationship between exchange rate volatility and estimated rates of pass through. The countries with a stable inflation rate tend to have a low exchange rate pass through into the prices. However, estimated monetary policy parameters are not found statistically relevant to the pass through. On the contrary, Bailliu and Fujii (2004) find a significant effect of monetary policy regime on exchange rate pass-through using 11 industrialized countries in the period of 1977-2005. In particular, change in monetary policy regime leads to lower exchange rate pass through.

Cross country and time series evidence of Campa and Goldber (2004) in 23 OECD countries provided that composition of the import is the important aspect for explaining pass through across the countries. Additionally, pass through elasticity is high in countries with high exchange rate fluctuations and it is closer to one in the long run. Furthermore, as Frankel et.al (2011) investigated, per capita incomes, bilateral distance, tariffs, country size, wages, long-term inflation, and long-term exchange rate variability are the significant determinants of the pass through.

ERPT estimation using a VAR framework

The empirical analysis of exchange rate passes through on import prices and inflation is mostly done under the recursive VAR framework by assessing impulse responses and variance decomposition.

McCarthy (1999) used VAR methodology along with distribution chain obtained from shocks to exchange rate and import prices to examine the ERPT for six industrialized countries. Impulse response and variance decompositions show that shocks have a modest effect on inflation and pass through is stronger in more open countries with higher import share.

Many similar researches have used the recursive VAR model in case of particular countries and they usually find consistent results depending on their common characteristics of the countries. Bhundia (2002) finds that decline in inflation rate leads the low exchange rate pass-through in South Africa. Using a case of Brazil Belaisch (2003) finds similar results. Moreover, Leigh and Rossi (2002) for Turkey find that pass through lasts about from 4 months to 1 year and complete in the short run and larger than other emerging countries. In euro area, according to Campa and Goldberg (2005)’s analysis, the pass through to import prices is high, although

incomplete in the short run while it is relatively higher and close to one in the long run. Introduction of euro did not cause significant structural change in exchange rate transmission. However, industries within countries experienced lower pass through to import prices.

ERPT in emerging market and developing countries

Furthermore, many studies examined the degree of pass-through into domestic prices for emerging and developing countries. (Barhoumi Karim, 2005) estimated the exchange rate pass though into import prices for 24 developing countries using non stationary panel approach. The paper finds that degree of pass-through is heterogeneous in developing countries in the long run. It can depend on the macroeconomics situations such as monetary policy, exchange rate regime, and trade policy of the individual countries. The estimation result shows that the highest long run pass through coefficient is 203 percent for Costa Rica and the smallest one is 27 percent for Iran. On average, paper obtained, long run pass through to import price is 77.25 percent across the countries. (Ca'Zorzi, Ellce, & Marcelo, 2007) studied the exchange rate pass through into both consumer and import prices for 12 emerging market countries in Asia, Latin America, Central and Eastern Europe using VAR framework. As outlier countries, Turkey and Argentina are excluded from the analysis. The paper finds that pass-through coefficients are always higher in emerging countries than developed countries. Moreover, the countries with low inflation level (one digit inflation) have a relatively low degree of pass-through which is generally less than 10 percent. For the countries with a relatively high inflation rate, between 10 and 20%, estimated pass through coefficients are about 40 percent which is considerably higher than in low inflation countries.

Another similar estimation is done by (Lavern, 2009). The paper examined ERPT to import prices (first stage) and then the subsequent effect of import price on consumer prices (second stage) for four emerging market economies (Jamaica, Mexico, Brazil, Trinidad and Tobago) using a stochastic volatility model with time-varying parameters. The paper finds that degree of pass-through significantly declines over the years from mid 2000 to 2008. The main findings are that first stage pass-through has fallen from 29 percent to 3 percent for Jamaica, from 160 percent to 10 percent for Trinidad & Tobago, but for Mexico degree of pass through is increased from -28

percent to 3 percent. Moreover, for the second stage, pass through has declined from 153 percent to 30 percent and from 100 percent to -3 percent in Brazil and Mexico respectively. Conversely, there is an increase in the second stage pass through for Trinidad and Tobago from -20 percent to 0 in 2008. Moreover ERPT to domestic prices and its determinants for sub-Saharan African countries are examined by (Ivohasina, 2012). The paper finds incomplete and asymmetric pass through to domestic prices. In those countries, about 40 percent of the exchange rate volatility reflects in domestic prices and full impact generally takes place in the first four quarters. The pass-through coefficients are larger for the exchange rate depreciation than appreciation. Furthermore, flexible exchange rate regime, higher income, low inflation environment, a prudent monetary policy and a sustainable fiscal policy lead to lower exchange rate pass through. (Goldfaij & Werlang, 2000) examined how exchange rate depreciations impacts on inflation using 71 countries in the period 198-1998. In this estimation, sample is divided by geographical criteria and its membership status. Estimated exchange rate pass-through coefficients are 39.4 percent for emerging markets, 34 percent for developing countries, 24.5 percent for developed countries, 11.3 percent for OECD countries, and 47.1 percent for non OECD members.

Asymmetry in pass through

Many studies assume that pass through vary depending on exchange rate appreciation or depreciation and magnitude of the changes. We briefly summarize the empirical explanations for the asymmetric response of trade prices to exchange rate changes, as studies suggested in the asymmetry area.

Asymmetry is supported by many empirical researches and they usually test asymmetry in two different approaches. Firstly, researchers look at the volatility of pass through depending on periods of depreciation and appreciation. Secondly, they use dummy variables to identify asymmetry in each time. (Ratricia and Polland (2003)). There is no consensus whether exchange rate depreciation or appreciation leads to higher pass through. Direction of the asymmetry effect differs among the countries.

Mann (1986) examined the asymmetry during the period of overall depreciation between 1977 and 1980 and period of overall appreciation between 1981 and 1985 in US. The paper finds that higher pass through into import prices during the periods of exchange rate appreciation than periods of depreciation. In contrast, Webber (2000) ‘s empirical study finds the higher pass through during the depreciation than during the same magnitude of the appreciation by assessing asymmetry in seven Asian countries. After the Asian crises, however, many strong currencies were recovered back; import price did not change back to its previous price level. Asymmetry effect, at the industry level, l is examined by Goldberg (1995) for the automobile industry in the US, Oivei (2002) for the nine different US industries, Kadiyali (1997) in the photographic industry and they find that pass through is higher during the depreciation than appreciation.

(Kumar & Khundrakpam, 2007) examined the degree of exchange rate pass through to domestic prices, asymmetry effect, and its determinants for India during the post economic reforms since 1991. The paper finds that lower trade restriction, higher import penetration, more open economy is associated with the lower pass-through. Estimated pass-through coefficients are 6.3 percent in the short run and 9 percent in the long run. Furthermore, paper investigated the asymmetry effect of the pass through depending on appreciation/ depreciation and its absolute change in exchange rate. The impact of exchange rate appreciation on consumer price is higher than depreciation. The result shows that about 14 percent (in the short run), and 20 percent (in the long run) of the appreciation reflects in consumer price inflation, while it is 3 percent in the short run and 5 percent in the long run for the depreciation. Moreover, estimated pass though coefficients are higher, about 5 percent, for the large absolute exchange rate changes than small changes, which is about 14 percent.

(Przystupa & Wrobel, 2009) studied the asymmetry effect of exchange rate pass-through to import and consumer prices in case of Poland. The paper finds that degree of ERPT to consumer prices tends to change along with business cycle and lower exchange rate volatility is associated with higher exchange rate volatility. The asymmetric effect of pass-through is found that coefficients are higher during the appreciation than depreciation. However, during the regular economic fluctuations, pass-through coefficients are relatively on average than asymmetric.

Empirical literature on Mongolia

(Doojav, 2009) examined the impact of exchange rate movement on inflation using Recursive VAR model and data from 1998 to 2000. The paper finds high ERPT and low persistence of volatility of exchange rate. Estimated pass through coefficient is 55 percent, in which 55 percent of the depreciation shock is eventually reflected in consumer prices after 9 months of the shock. Moreover, exchange rate explains about 7-8 percent of the inflation volatility.

Determinants of pass through

We briefly summarized above mentioned empirical literatures and determined the important factors explaining the pass through.

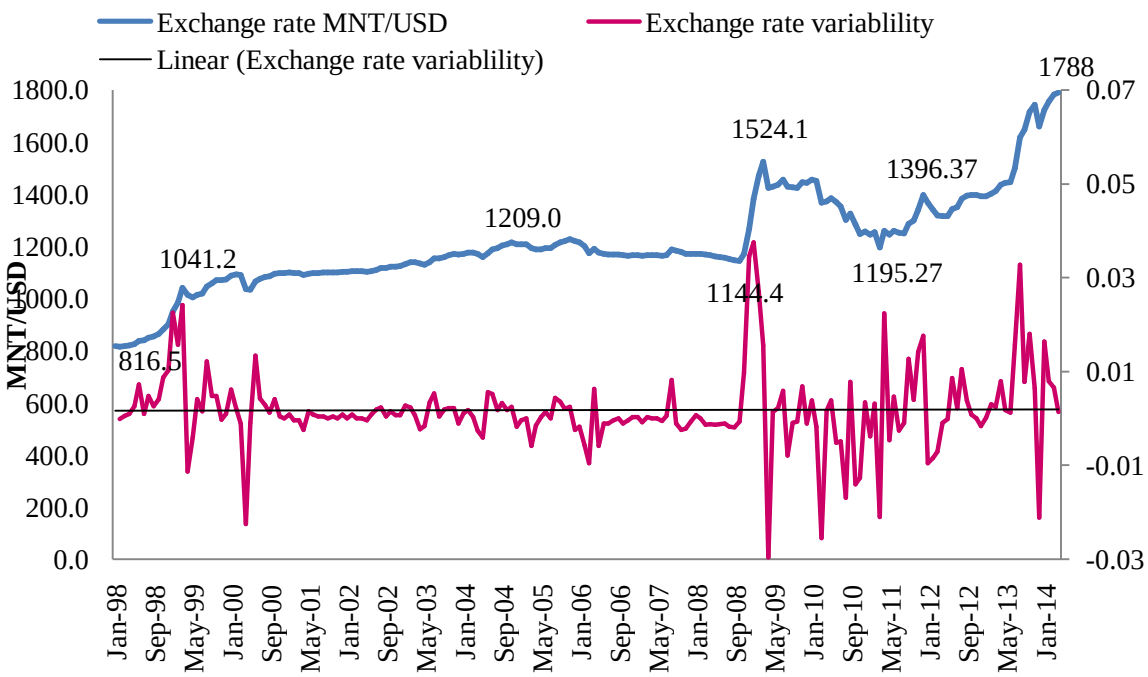
1. Inflation volatility: The higher inflation rate leads the higher pass through.
2. Exchange rate volatility: There is no consensus about effect of exchange rate volatility on pass through
3. Degree of openness: A greater Import share of consumption and inputs in production leads the higher pass through. Hence, countries or industries with a high degree of openness tend to have greater exchange rate pass through.
4. Import structure: Pass through varies among the importing industries. Energy and raw material industries tend to have more pass through than manufactured products. (Jeevan Kumar (2007))
5. International trade barriers (tariffs and quantitative restrictions): The barriers allow the arbitrage opportunities for international trade and affect pass through to be low
6. Asymmetry effect: Pass through may differ depending on exchange rate appreciation or depreciation.

3 Exchange rate regime in Mongolia

The exchange rate regime in Mongolia is defined floating exchange rate regime. However, as an import oriented small open economy, central bank of Mongolia intervenes to smooth excessive exchange rate volatility in order to maintain the exchange rate considerably stable.

Figure1 shows the exchange rate development and variability from 1998 to 2013 and figure 2 shows the foreign currency reserve in Mongolia. Figure 1 shows that the exchange rate had relatively smooth fluctuations from 2000 to October 2008, though during the global financial crisis exchange rate variability increased significantly and Mongolian currency (MNT) depreciated by 30 percent against the USD. Last three months of 2009, central bank of Mongolia sold reserves of 280 million USD which was about 10 of the foreign exchange rate reserves to stabilize the exchange rate volatility at 1400.

Figure 1 Exchange rate MNT/USD and exchange rate variability (1998-2013)



In 2010, due to increased foreign investments in mining sector, Mongolian economy started to recover and MNT appreciated by 22 percent which was close to the level

before crisis. However, in 2011, resulting from high economic growth (17 percent) and sharp increase in USD demand for the heavy development of mining operations from public and government, MNT depreciated by 16 percent. Therefore, end of the 2011, central bank of Mongolia intervened to decrease excessive exchange rate volatility and foreign currency reserve declined to 2.27 billion USD from 2.46 billion USD. According to the IMF report in 2011, dramatic growth in spending overheated the Mongolian economy, leading to high inflation, rapid increase in imports of both merchandise and cervices led excessive demand for USD, and macroeconomic uncertainty were influencing the exchange rate.

Even though, MNT appreciated for a few months after the interventions by CB at the end of 2011, MNT has been depreciated since May, 2012 until (now) April 2014. The decline in foreign direct investment and weak mineral exports led external imbalances and it puts pressure on balance of payment and foreign exchange reserves. Moreover, foreign currency reserve has declined by 40 percent in 2013.

Figure 2 Foreign currency reserve

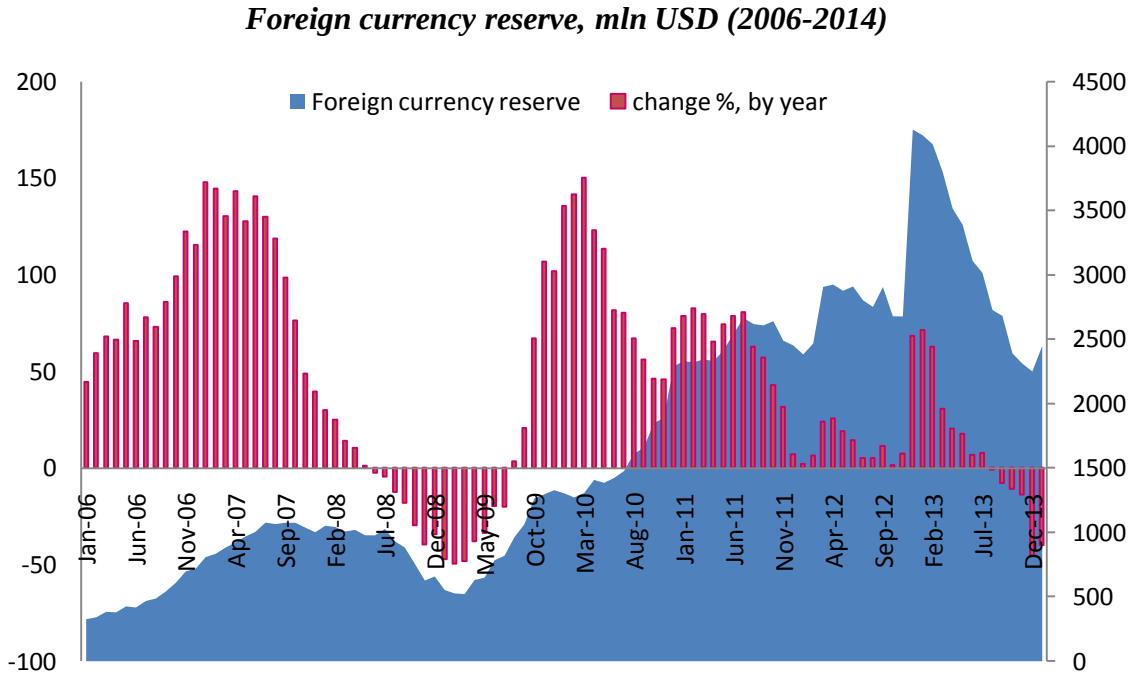
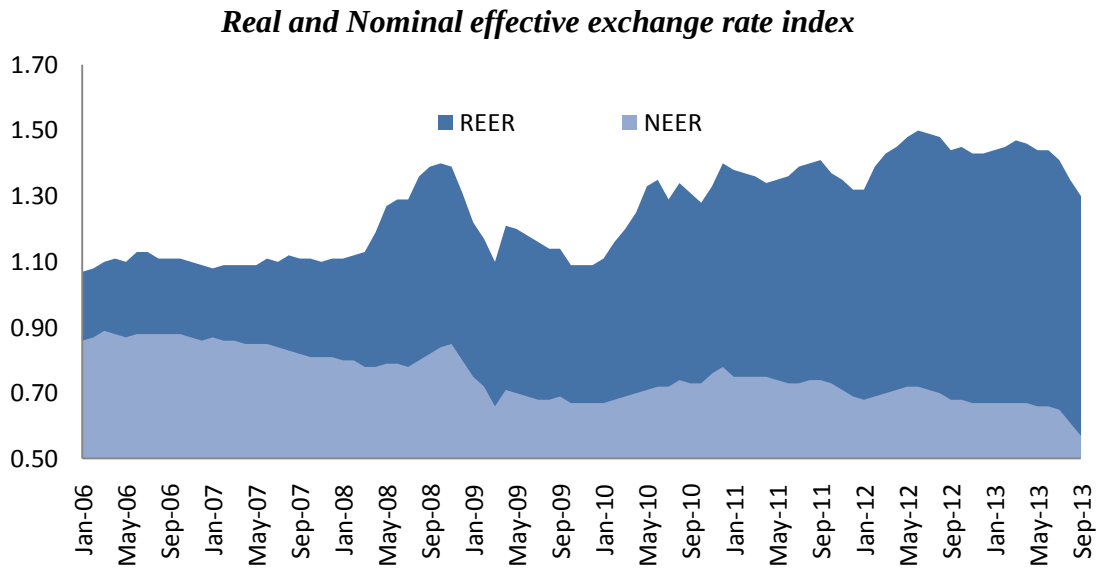


Figure 3 NEER and REER

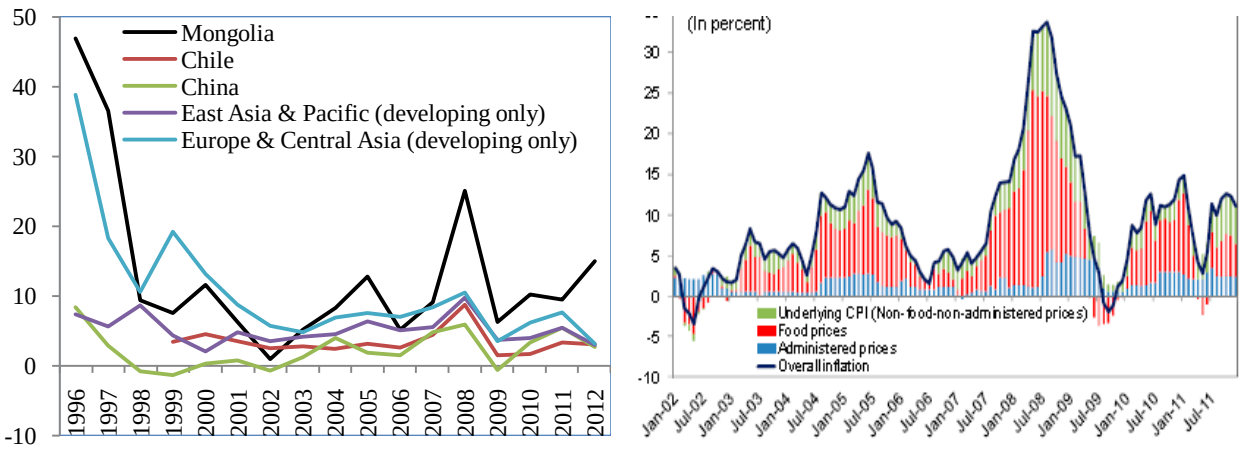


4 Inflation in Mongolia

Inflation rate in Mongolia is recorded as 31st highest inflation in the world (12.5 percent in 2013). Mongolia is facing high and very volatile inflation rates along with high economic growth, which is 2013 (11.7%) and 2013 (17.6%) since transition in 1990 from a socialist to a free market economy. One of the crucial objectives of the Central bank of Mongolia is to maintain price stability and calibrates monetary policy. In order to conduct monetary policy successfully for low and stable inflation, it is important to understand driving factors of inflation. As a landlocked small open economy, Mongolian economy is largely driven by supply and demand shocks such as oil price, copper price and coal price (demand shock) and large transportation cost due to geographically large territory (supply shock).

An average inflation rate in Mongolia is 13.25 from 1996 to 2012, reaching its highest rate 46.8 percent in 1996 and lowest rate 0.9 percent in 2002 (Figure 4).

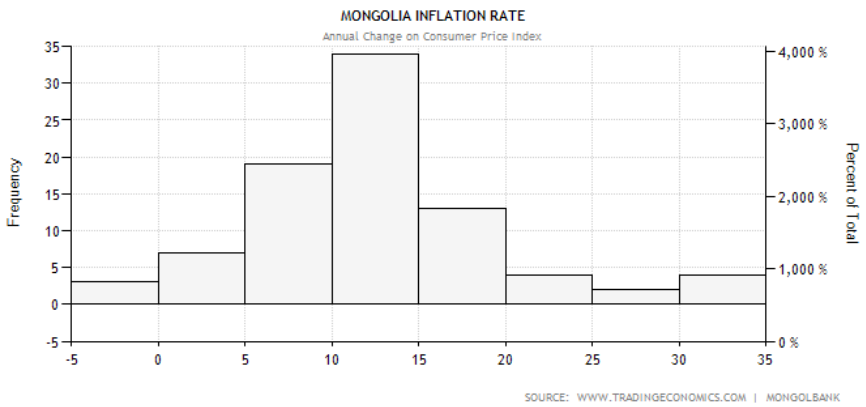
Figure 4 Inflation rate (CPI) and inflation contributions



Food prices are major contributions of the Consumer Price index which accounts for 40 percent in average and more volatile than other contributors. There is large seasonal and monthly effect in Mongolia's economy because of extreme weather condition. Seasonal volatility of the economic performance is resulted from exports (main exporting product) only in summer and in the first few months of autumn and downturn of agriculture sector in winter. During the years with severe winters, that large number of livestock dies due to cold and starvation causes a large increase in food price. Therefore, Food price volatility is mostly affected by agricultural shocks in Mongolia.

Furthermore, Consumer price index of Mongolia measures general price level of 329 types of consumer goods (265) and services (64) purchased by households. In particular, share of imported goods in consumer goods in CPI basket is accounted for 62 percent. Moreover, 55 percent of the foodstuffs in consumer basket are imported goods. Thus, the role of exchange rate volatility can be important factor of consumer price inflation in Mongolia.

Figure 5 Histogram



5 Hypothesis

Based on provided literature review and introduced motivation we have stated the following hypothesis.

Hypothesis 1: Exchange rate pass-through to consumer price is high and incomplete in Mongolia

Campa and Goldber (2004), Taylor (2000), Frankel et.al (2011), Mann (1986) examined that countries with high exchange rate volatility have high exchange rate pass through. Moreover, Frankel et.al (2011) find that exchange rate pass through is higher and faster in developing countries than in high-income countries. Furthermore, (Barhoumi Karim, 2005), (Ca'Zorzi, Ellce, & Marcelo, 2007), (Ivohasina, 2012), (Goldfaij & Werlang, 2000) and (Lavern, 2009) find incomplete pass-through which is around 30 - 40 percent to consumer prices and 60 – 70 percent to import price for emerging market and developing countries.

Therefore, we expect the relatively high exchange rate volatility, high initial inflation, a large share of import penetration, and as an emerging and developing country, Mongolia could have high and incomplete pass though.

Hypothesis 2: There is an asymmetric effect of exchange rate change on consumer price inflation (ER appreciation/depreciation).

Hypothesis 3: There is a non-linearity effect of exchange rate with respect to small and large absolute changes

Ratricia and Polland (2003), Mann (1986), Webber (2000) empirical studies of asymmetry of pass though find that appreciation leads higher pass through than depreciation. Estimations by (Kumar & Khundrakpam, 2007), and (Przystupa & Wrobel, 2009) show that impact of exchange rate appreciation on consumer price is higher than depreciation because of their considerably small share of import goods in CPI basket which is contrary to case of Mongolia. (Kumar & Khundrakpam, 2007) also find that pass though coefficients are higher for the large exchange rate absolute changes than small changes.

Thus, we expect asymmetry effect, in particular, higher ERPT during the exchange rate depreciation than appreciation. Additionally, non-linearity effect of exchange rate pass-through is expected in Mongolia

6 Methodology

6.1 VAR model

We use VAR framework to investigate the pass through of exchange rate fluctuations to consumer prices. Exchange rate pass through will be evaluated using a five-variable recursive VAR approach. The methodology draws on McCarthy (2000) and has the following ordering for the variables:

$$X_t = \{\pi_t^{oil} \longrightarrow \Delta y_t \longrightarrow \Delta e_t \longrightarrow \pi_t^{cpi} \longrightarrow \Delta M1_t\}$$

Where, π_t^{oil} is oil price inflation, Δy_t is growth in Monthly GDP, Δe_t is change in nominal exchange rate, π_t^{cpi} is consumer price inflation, $\Delta M1_t$ is growth in narrow money.

In this framework, the system allows trace dynamic effect of an exchange rate shock on consumer prices along the distribution chain. According to McCarthy (2000) consumer price inflation at each stage are comprised of five components. The first component is that expected inflation which is on information available at period t-1. The effects of domestic supply and demand shocks to inflation at the stage are used as a second and third component in period t. The fourth component is the effect of exchange rate shocks on inflation. The next component includes the effects of shocks to inflation at the previous stages of the chain. The last component includes the effect of all stage's shock in the distribution chain.

Structural shocks are recovered from the VAR residuals using a Cholesky decomposition of variance- covariance matrix. π_t^{oil} (oil price inflation) is used as a supply shock and Δy_t (output growth) is used as a demand shock. Furthermore, model includes M1 money as a monetary policy variable that responds to all the other variables via a reaction function.

Under these assumptions, shocks in the VAR system can be represented with a recursive VAR in the following manner:

$$\pi_t^{oil} = E_{t-1}\left[\pi_t^{oil}\right] + \varepsilon_t^{oil}$$

$$\Delta y_{\mathrm{t}} = E_{t-1}[\Delta y_{\mathrm{t}}] + \alpha_1 \varepsilon_t^{oil} + \varepsilon_t^{\Delta y}$$

$$\Delta e_{\mathrm{t}} = E_{t-1}[\Delta \mathrm{e_t}] + \lambda_1 \varepsilon_t^{oil} + \lambda_2 \varepsilon_t^{\Delta y} + \varepsilon_t^{\Delta e}$$

$$\pi_t^{cpi} = E_{t-1}\left[\pi_t^{cpi}\right] + \gamma_1 \varepsilon_t^{oil} + \gamma_2 \varepsilon_t^{\Delta y} + \gamma_3 \varepsilon_t^{\Delta e} + \varepsilon_t^{cpi}$$

$$\Delta M1_t = E_{t-1}[\Delta M1_t] + \beta_1 \varepsilon_t^{oil} + \beta_2 \varepsilon_t^{\Delta y} + \beta_3 \varepsilon_t^{\Delta e} + \beta_4 \varepsilon_t^{cpi} + \varepsilon_t^{\Delta M1}$$

Where, ε_t^{oil} is supply shock, $\varepsilon_t^{\Delta y}$ is demand shock, $\varepsilon_t^{\Delta e}$ is exchange rate shock, ε_t^{cpi} is consumer price inflation shock, and $\varepsilon_t^{\Delta M1}$ is money supply shock.

$E_{t-1}[]$ shows expectations of the variables based on information set at the end of period t-1, where, the time period t expresses one month. The conditional expectation equations can be replaced by linear projections based on lags of the five endogenous variables. (Gan-Ochir, 2009)

We will provide the impulse responses of consumer price inflation to the orthogonalized shocks of exchange rate. In addition, identifying shocks by using Cholesky decomposition arises the issue which is related to identification of aggregate demand and supply shocks. Here, we assume that shocks are serially uncorrelated and also uncorrelated with one another within a period.

6.2 Model for asymmetric effect

The model we employed for analyzing asymmetry effect of exchange rate pass-through to consumer price is based on the papers (Bailliu and Fujii (2004) and (Kumar & Khundrakpam, Feb 2007). The empirical model follows the profit maximization model.

$Max\pi = e^{-1}PQ - C(Q)$ – The profit maximizing behavior

Where, π, e, and P are profits in domestic currency (exporting firm's currency), exchange rate of domestic currency relative to currency of an exporting firm, and price in domestic currency respectively and C() is a cost function expressed by the quantity demanded (Q).

$P = eC_q\mu$ – The first order condition maximization

Where, C_q is the marginal cost and μ is the mark-up over marginal cost which depend on the price elasticity of demand of the good. Hence, price volatility in domestic currency is caused by changes in exchange rate, marginal cost and mark up. Specifically, marginal cost changes due to domestic input cost and mark up changes depending on demand factors in domestic economy. Therefore, we can write the price equation in following way.

$P = \alpha_0 + \alpha_1 e_t + \alpha_2 P_t^* + \alpha_3 Y_t + \varepsilon_t$ – The reduced form of price equation

Where, 'P*' is the marginal cost of foreign firm and 'Y' is demand condition. (Goldberg and Knetter (1996)).

Based on this theoretical approach, our main specification for analyzing exchange rate pass through and its asymmetry effect is determined in following manner. (Pollard and Coughlin (2004)). In this model, lagged effects of the variables and oil price shock are taken into account.

Model1:

$$\pi_t^{cpi} = \alpha_0 + \alpha_1 \sum_{i=0}^{n} \Delta e_{t-i} + \alpha_2 \sum_{i=0}^{n} \Delta P_{t=i}^* + \alpha_3 \sum_{i=0}^{n} Y_{t-i} + \alpha_4 \sum_{i=1}^{n} \pi_{t-i}^{cpi} + \alpha_5 \sum_{i=0}^{n} \pi_{t-i}^{oil} + \varepsilon_t$$

Where,

α_2 –is the coefficient of short run pass-through, $^{\alpha_2}/_{1-\alpha_1}$ – is the coefficient of long run pass through. The lagged inflation term can express the speed of pass through to inflation. (Kumar & Khundrakpam, Feb 2007)

Asymmetry

We employed the dummy variables additionally to the specification for measuring asymmetry effect relative to appreciation and depreciation of exchange rate as well as non-linearity of exchange rate change. (Pollard and Coughlin (2004)) and (Kumar & Khundrakpam, Feb 2007)

Exchange rate appreciation and deprecation effect

The dummies for exchange rate appreciation and depreciation, respectively

$$D_A = \begin{cases} 1 \text{ for } \Delta e > 0 \\ 0 \text{ otherwise} \end{cases} \quad \text{and} \quad D_D = \begin{cases} 1 \text{ for } \Delta e < 0 \\ 0 \text{ otherwise} \end{cases}$$

Model2:

$$\Delta P_t = \alpha_0 + \alpha_{1A} D_A \sum_{i=0}^{n} \Delta e_{t-i} + \alpha_{1D} D_D \sum_{i=0}^{n} \Delta e_{t-i} + \alpha_2 \sum_{i=0}^{n} \Delta P^*_{t=i} + \alpha_3 \sum_{i=0}^{n} Y_{t-i} +$$

$$+ \alpha_4 \sum_{i=1}^{n} \Delta P_{t-1} + \alpha_5 \sum_{i=0}^{n} oilshock_{t-1} + \varepsilon_t$$

Where, α_{1A} and α_{1D} are the pass through coefficients for appreciation and depreciation.

Size of exchange rate change effect

The dummies for absolute large and small exchange rate change:

$$D_L = \begin{cases} 1 \text{ for } \Delta e > threshold \\ 0 \text{ otherwise} \end{cases} \quad \text{and} \quad D_s = \begin{cases} 1 \text{ for } \Delta e < threshold \\ 0 \text{ otherwise} \end{cases}$$

Model3:

$$\Delta P_t = \alpha_0 + \alpha_{1L} D_L \sum_{i=0}^{n} \Delta e_{t-i} + \alpha_{1S} D_S \sum_{i=0}^{n} \Delta e_{t-i} + \alpha_2 \sum_{i=0}^{n} \Delta P^*_{t=i} + \alpha_3 \sum_{i=0}^{n} Y_{t-i} +$$
$$+\alpha_4 \sum_{i=0}^{n} \Delta P_{t-1} \, \alpha_5 \sum_{i=0}^{n} oilshock_{t-1} + \varepsilon$$

Where, α_{1L} and α_{1s} are pass through coefficients for large and small exchange rate change.

The variables that we used in the model of asymmetry and non-linearity are following: Consumer Price Index (P), exchange rate (e), GDP (proxy is industrial production) (Y), and Trade weighted foreign prices (P*). The trade weighted foreign prices will be calculated as *P* = (NEER × CPI) ÷ REER*. Where, REER - real effective exchange rate, NEER – nominal effective exchange rate

7 Data

The sample of monthly data, which is used in VAR analysis includes 168 observations from January 2000 to December 2013. All the data were collected from publicly available reports and database of Central Bank of Mongolia (BOM) and National Statistical Office of Mongolia (NSO). The source for the data of international oil price is Official Energy Statistics from the US government..

Dataset includes variables such as real Gross Domestic Product (GDP), Consumer price index (CPI), M1, nominal exchange rate of US dollar against Tugrug, (Mongolian national currency), crude oil, Nominal effective exchange rate (NEER), and Real effective exchange rate (REER).

Additionally, we calculated trade weighted foreign prices (P*) in our dataset.

$$P^* = (NEER \times CPI) \div REER.$$

Since real GDP is given on quarterly basis only, we used real gross industrial output as a proxy of GDP in monthly database.

Summary Statistics

	Output	M1	Exchange rate	Oil price	CPI	NEER	REER
Mean	77,659.11	631,474.60	1,235.63	62.66	127.70	81.07	118.47
Median	74,198.00	338,796.90	1,180.90	62.48	105.98	81.88	111.62
Maximum	167,814.20	2,083,310.00	1,741.71	133.88	239.57	104.61	150.61
Minimum	29,879.74	94,954.80	1,032.70	19.39	68.55	47.69	98.77
Std. Dev.	25,354.03	576,213.90	139.21	28.90	49.95	14.56	15.12
Skewness	0.55	1.13	1.23	0.22	0.62	(0.22)	0.62
Kurtosis	3.43	2.84	4.27	1.92	2.09	2.30	1.96
Jarque-Bera	8.98	35.74	53.49	9.50	16.64	4.74	16.98
Probability	0.01	-	-	0.01	0.00	0.09	0.00

8 Estimation results

8.1 ERPT estimation using VAR model

We estimate a VAR model consisting of following five variables as we discussed above using monthly data from 2000 to 2013: Δy_t is growth in Monthly GDP, Δe_t is change in nominal exchange rate, π_t^{cpi} is consumer price inflation, $\Delta M1_t$ is growth in narrow money.

8.1.1 Stationarity

To specify and define proper VAR model, some commonly used procedures, namely stationarity and cointegration tested to explore the data properties.

First, the series are checked for stationarity by using Augmented Dickey – Fuller (ADF) test. Table (1) shows ADF statistics for all endogenous variables in system.

Table 1 Unit Root Tests

Variables	ADF statistic	Probability	Order of integration
Variables (at level)			
oil	-1.739615	0.4097	I(0)
er	-1.302906	0.6281	I(0)
CPI	1.373251	0.9989	I(0)
m1	-0.16644	0.9390	I(0)
gdp	1.898469	0.9998	I(0)
P*	0.504623	0.9864	I(0)
Variables (first log difference)			
d_oil_l (doil)	-10.75482	0.0000	I(1)
d_er_l (dex)	-9.828126	0.0000	I(1)
d_mpi_l (dmpi)	-12.73843	0.0000	I(1)
d_cpi_l (dcpi)	-8.361344	0.0000	I(1)
d_gdp_l(gdp)	-2.876591	0.0500	I(1)
d_P*_l	-9.286606	0.0000	I(1)

The ADF test is performed up to 13 lags chosen by SIC criteria with a constant. Our dataset is not stationary supported by the ADF-test according to existence of unit root

process. Values of test statistic are smaller than Critic value /-2.87/ at 95% confidence level. We can't reject the existence of unit root and series are not stationary. Thus we transformed our data to stationary by taking first log difference. From the ADF test, the values of test statistics are higher than critical values /-2.87/ at 95% confidence level (Table1). That means that there is no unit root. Thus, the process is stationary after transformation of the data and we estimate a VAR model with variables in first differences.

8.1.2 Lag selection

In order to choose proper lag length for our VAR estimation, we performed several tests which are sequential modified LR test statistic, lag exclusion Wald test, Hannan-Qwuinn information criterion (HQ), Akaike information criterion (AIC), Schwarz information criterion (SC) and Final prediction error (FPE). The VAR model with proper lag tries to balance following extremes in the model. Firstly, it avoids model to over fit by limiting the length of lags in the short sample. Secondly, it minimizes model misspecification by not selecting too small lag length.

The lag length criteria tests are shown in Table 2. Sequential modified LR test (LR), Final prediction error (FPE) and Akaike information criterion (AIC) suggest us to use VAR(3) model. AIC is usually suggested to use for daily and monthly data. Thus VAR model is estimated with three lags in our study.

Table 2 lag selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-448.5837	NA	1.07e-05	5.577714	5.691595*	5.623948
1	-358.3343	172.7474	5.48e-06	4.912077	5.709240	5.235716*
2	-327.6259	56.51850	5.85e-06	4.977005	6.457450	5.578049
3	-280.4828	83.29573*	5.13e-06*	4.840280*	7.004007	5.718730
4	-251.9271	48.35202	5.67e-06	4.931621	7.778630	6.087476

** indicates lag order selected by the criterion (each test at 5% level)*

VAR Lag Exclusion Wald Tests is performed in Table3 to check whether lags with significant information content are not excluded from the model. Three lags in the VAR system are jointly significant by Wald test. Moreover, VAR residual serial correlation Lagrange Multiplier (LM) test is performed with the null hypothesis of no

serial correlation at lag order three. Table 4. Null hypothesis can't be rejected and there is no serial correlation in our system.

Table 3 Wald test

VAR Lag Exclusion Wald Tests

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	DOIL	OUTPUT	DEX	DCPI	DMPI	DM1	Joint
Lag 1	16.67111	10.06967	19.28017	42.94523	4.700514	32.47692	164.0286
	[0.010571]	[0.121748]	[0.003716]	[1.20e-07]	[0.582757]	[1.32e-05]	[0.000000]
Lag 2	3.463901	14.75334	15.06202	7.89754	11.43506	8.750511	70.27497
	[0.748766]	[0.022264]	[0.019780]	[0.245706]	[0.075826]	[0.188103]	[0.000544]
Lag 3	17.50196	23.95909	6.691657	12.79328	15.64239	15.92708	91.08918
	[0.007605]	[0.000531]	[0.350306]	[0.046439]	[0.015808]	[0.014151]	[1.14e-06]
df	6	6	6	6	6	6	36

Table 4 Serial correlation LM test

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Lags	LM-Stat	Prob
1	40.32654	0.2848
2	32.94181	0.6148
3	43.41436	0.1309
4	37.41986	0.4038
5	44.76605	0.0533

Probs from chi-square with 36 df.

8.1.3 Cointegration test

We test the cointegration between variables for the VAR(3) model using Johansen cointegration test shown Table5. Both tests show that there is no cointegration relationships among the variables in VAR(3) at the 5% confidence level. Thus we use unrestricted VAR model.

Table 5 Cointegration test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.335179	187.0435	95.75366	0.0000
At most 1 *	0.264122	124.9914	69.81889	0.0000
At most 2 *	0.259872	78.37445	47.85613	0.0000
At most 3 *	0.100601	32.63270	29.79707	0.0230
At most 4 *	0.061030	16.51639	15.49471	0.0350
At most 5 *	0.044661	6.944740	3.841466	0.0084

Trace test indicates 6 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

8.1.4 Results and analysis

This section presents empirical results for the exchange rate shocks' pass-through to the prices. The dynamic impulse responses trace out responsiveness of consumer to one standard deviation shocks to the error term in the VAR model. The dashed lines show 95% confidence interval, reflecting uncertainty of the estimated coefficients.

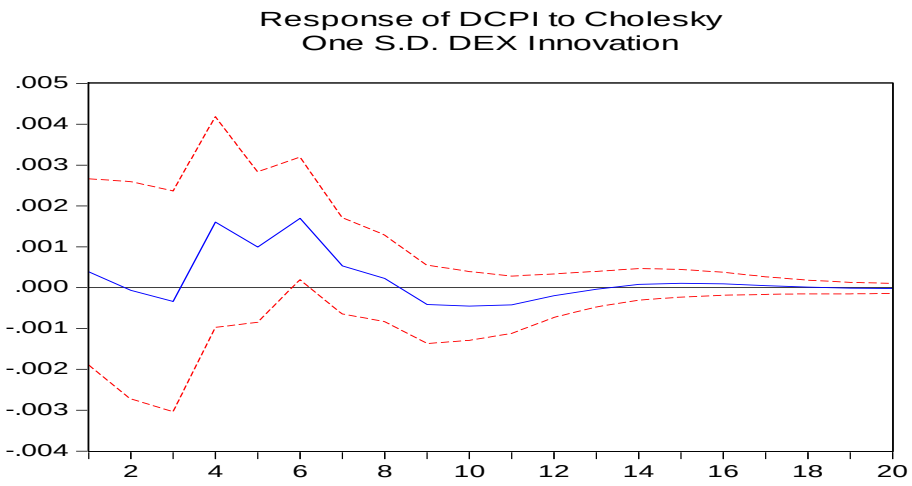
Responses to exchange rate shocks

In our model exchange rate shock is estimated given all the variables at preceding period and oil price inflation, and output values in current period. Figure 6 displays the responses of consumer price indices to an exchange rate shock.

- Figure6 displays the responses of the consumer price index to a exchange rate depreciation shock. Unexpected positive shock in exchange rate, i.e. depreciation of the domestic currency, has a small insignificant negative effect for the first three months and a positive effect on consumer prices with the maximum effect occurring in the fourth-to-six months of the

shock (which is statistically significant for the six-month lag). The impact of exchange rate shock on consumer prices turns to insignificantly negative values after eight months, which can express the partial adjustment process to the shock by consumers in the domestic economy, and then impact of the shock dies out afterwards.

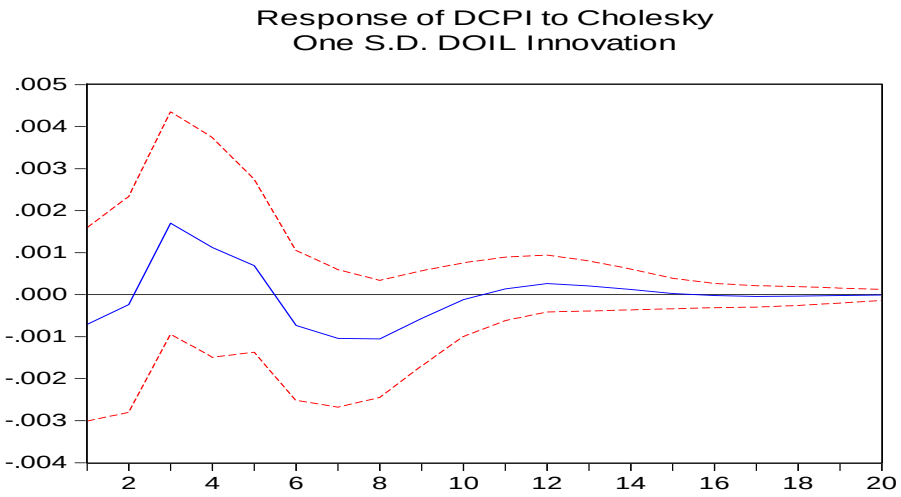
Figure 6. Impulse response of consumer prices to exchange rate shock



Responses to the oil price shock

In addition, we displayed the responses of consumer prices to a positive oil price shock (figure7).

Figure 7. Impulse response of consumer prices to oil price shock



- An oil price shock has an immediate and positive impact on consumer prices in Mongolia. The shock has a maximum effect during the first three months of the shock. The responses of consumer prices to the oil shock turn out insignificantly negative for the 8-10 months and dwindle away gradually.

Pass through coefficients

Using impulse response function, the cumulative pass through coefficients are computed by dividing the cumulative impulse responses of prices after *m* months by the cumulative impulse response of exchange rate to the exchange rate shock after *m* months. Thus the exchange rate pass through (ERPT) at time t is defined as:

$$ERPT_t = {Price\ index_{t,t+m}}\Big/{Exchange\ rate_{t,t+m}}$$

Where, P and E are respectively the change in cumulative price and change in cumulative exchange rate after m periods. (Matthew Kofi, 2009)

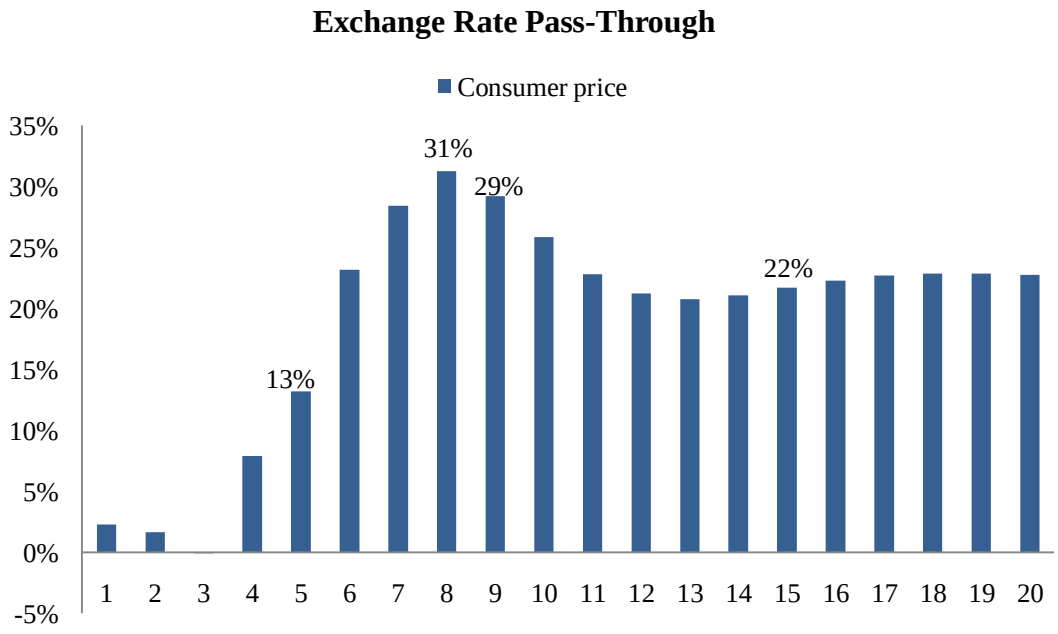
Table 6 exhibits calculated ERPT consumer prices in 20 months horizon. The pass through of exchange rate to consumer price rises from 7.9 percent in the fourth month to 31.3 percent in the eight months after the depreciation shock.

Overall, transmission of exchange rate movement to consumer prices is incomplete. About 22 percent of the exchange rate depreciation is eventually reflected in consumer prices after 12 months of the shock.

Table 6 ERPT coefficients

Period	Consumer price
After 1 months	0.023
After 2 months	0.017
After 4 months	0.079
After 5 months	0.132
After 8 months	0.313
After 10 months	0.259
After 15 months	0.217
After 20 months	0.228

Figure 8 ERPT coefficients

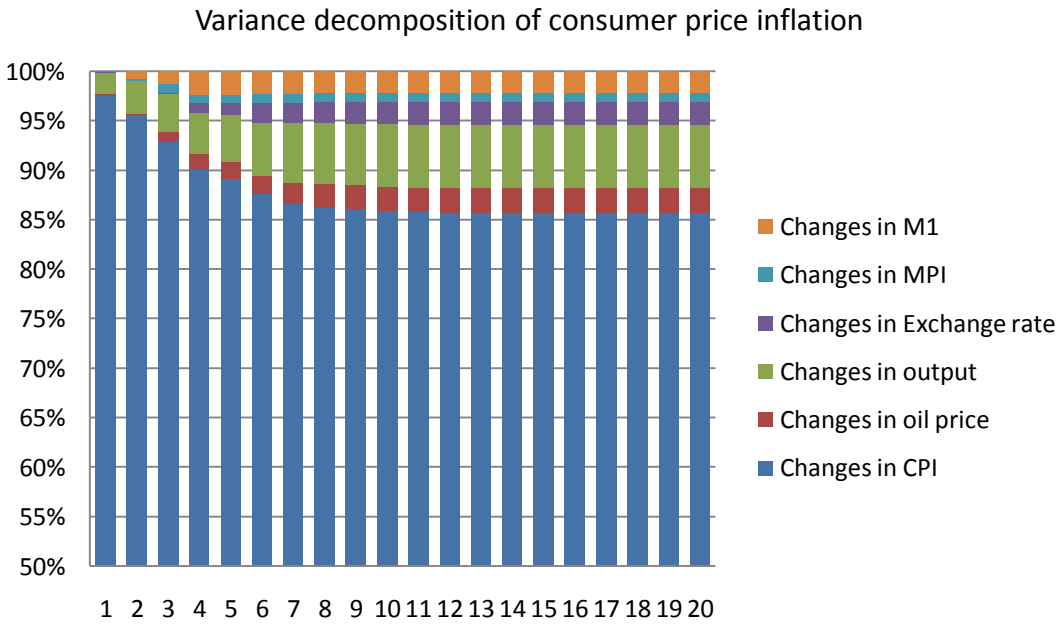


8.1.5 Variance decomposition

A small exchange rate volatility could lead large pass-through; however, same magnitude of exchange rate volatility may have little influence on consumer price inflation forecasting. Because the impulse responses asses only the extent of pass-through to prices, and they don't investigate the importance of the shock. The variance decomposition basically illustrates the proportion of the movements of the shocks to other variables in VAR system. In order to indicate the importance of the exchange rate shocks in domestic price inflation fluctuations, we examine the variance decomposition of the consumer prices.

For consumer prices (Figure 9), the effect of exchange rate on CPI variance is small, ranging from 2 to 3 percent of the variance of CPI. Main variation of the consumer price inflation is (besides the shocks to the CPI itself) explained by output growth shocks which account for about 7 percent of the variation. Thus, we can conclude that high exchange rate pass through doesn't imply high significance of exchange rate explaining the consumer price inflation volatility and forecasting.

Figure 9 Variance decomposition of consumer price inflation



8.1.6 Robustness

In this section we check the robustness of the results by assessing sensitivity of the results to different Cholesky ordering. We re-estimated the model with two alternative orderings.

- The first considered alternative model has the following Cholesky ordering: $X_t = \{\pi_t^{oil} \longrightarrow \Delta y_t \longrightarrow \Delta M1_t \longrightarrow \Delta e_t \longrightarrow \pi_t^{cpi}\}$
  where M1 variable is placed after output. This ordering allows central bank policy to influence prices and to appease the exchange rate fluctuations, as proposed for example by (Zulfiqar Hyder, 2004).

- The second alternative model to the baseline case has following Cholesky ordering where M1 is placed before the output growth

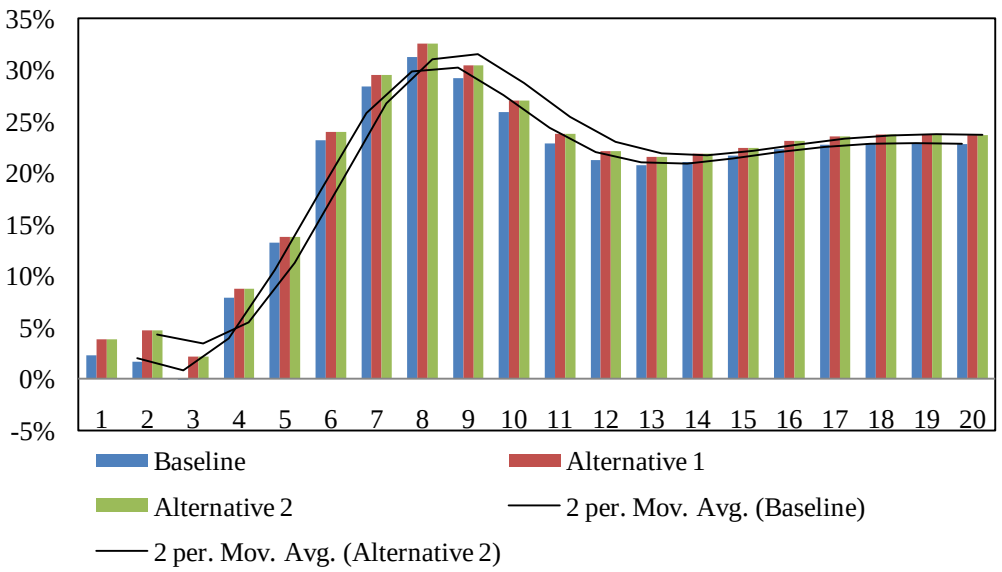
  $X_t = \{\pi_t^{oil} \longrightarrow \Delta M1_t \longrightarrow \Delta y_t \longrightarrow \Delta e_t \longrightarrow \pi_t^{cpi}\}$. This ordering assumes a contemporaneous response of exchange rate to changes in monetary policy variable M1.

Estimated coefficients and impulse response functions are presented in Figure 10. Degrees of ERPT to consumer prices using the first and second alternative ordering are equal. We don't find any difference between two alternative models. However,

However, alternative estimates of ERPT to consumer prices increases slightly. The coefficients are about 1-2 percentage point lower than estimates of initial ordering.

In conclusion, estimates of ERPT to domestic prices under two different Cholesky ordering are not materially different from those of baseline models.

Figure 10 ERPT coefficients using alternative VAR Cholesky ordering



8.2 Asymmetry of ERPT estimation

We will use same dataset as we used in VAR estimation. Additionally we calculated the trade weighted foreign price (P*). Our dataset is stationary shown in table1, supported by ADF test. The number of lags in our estimation is chosen using general to specific method. We estimated the model with up to 11 lags (monthly data) and then progressively excluded the insignificant lags.

Before analyzing asymmetry effects of pass-through, we estimated general pass-through coefficients to consumer prices using Model1. (Appendix Table 12)

Model1: $\pi_t^{cpi} = \alpha_0 + \alpha_1 \sum_{i=0}^{n} \Delta e_{t-i} + \alpha_2 \sum_{i=0}^{n} \Delta P^*_{t=i} + \alpha_3 \sum_{i=0}^{n} Y_{t-i} + \alpha_4 \sum_{i=1}^{n} \pi_{t-i}^{cpi} + \alpha_5 \sum_{i=0}^{n} \pi_{t-i}^{oil} + \varepsilon_t$

Table 7 Estimation result of model 1

Model1: Dependent Variable: $\boldsymbol{\pi_t^{cpi}}$

Variable name		Coefficient	t-Statistic[1]	
Constant	const	0.0027	1.8225	*
Exchange rate MNT/USD	e	0.0927	1.6666	*
	e(-3)	0.0922	1.6611	*
	e(-5)	-0.1058	-1.7684	*
Trade weighted foreign price	P*	0.2977	1.9009	**
Output	Y(-3)	-0.0208	-4.1959	***
Inflation (CPI)	$\pi_t^{cpi}(-1)$	0.4561	6.8916	***
	$\pi_t^{cpi}(-4)$	-0.1719	-2.6108	***
Oil price shock	$\pi_t^{oil}(-2)$	0.0347	2.6607	***
R-squared	***0.42118***	***DW***	***2.1737***	

The coefficients are calculated as a summation of coefficients of individual lags

Exchange rate ($\boldsymbol{\alpha_1}$)	0.0791
(neer × cpi) ÷ reer ($\boldsymbol{\alpha_2}$)	0.2977
Output ($\boldsymbol{\alpha_3}$)	-0.0208
Inflation ($\boldsymbol{\alpha_4}$)	0.2842
Oil price shock ($\boldsymbol{\alpha_5}$)	0.0347

[1] * 90 percent, ** 95percent, *** 99 percent confidence interval

Exchange rate pass-through coefficients to consumer prices in short and long run

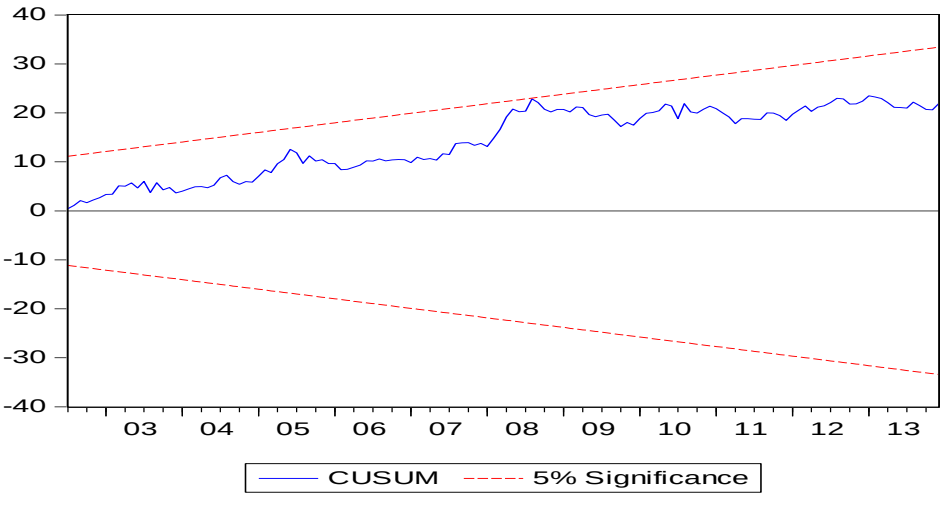
Short run (α_2)	**29.8%**	**Long run ($^{\alpha_2}/_{1-\alpha_1}$)**	**32.3%**

All variables are statistically significant. We find that short-run pass through to consumer price is 29.8 percent in the 3 months after the shock while long-run pass through is 32.3 percent. Next, we check whether estimated pass-through coefficients using model1 are statistically different from those which we estimated using recursive VAR framework in previous section. Using a Wald test, we can't reject the null hypothesis that coefficients aren't different (restrictions $\alpha_2 = 13\%, 23\%, and\ 31\%$ in short run $\left(^{\alpha_2}/_{1-\alpha_1}\right) = 22\%$, in long run), shown in Appendix Table19, 20. Thus, pass-through coefficients to consumer prices obtained using these two methods are not statistically different both in short and long run.

Moreover, we test whether pass through is complete (restriction$\alpha_2 = 1$, $(^{\alpha_2}/_{1-\alpha_1}) = 1$) using Wald test. This hypothesis is rejected at the 1 percent confidence level. Hence, there is incomplete exchange rate pass-through in Mongolia which is statistically confirmed (Appendix Table18).

We performed CUSUM test which finds parameter instability if the cumulative sum of recursive residuals exceeds 5 percent critical line. As with the CUSUM test, shown in figure (11), movement inside the critical lines represents that our parameters are relatively stable, even though it hits critical line in 2008. Additionally, Serial correlation LM test is performed in Table(17). The null hypothesis that there is no serial correlation is not rejected with F-statistic=1.13062, Prob. F(2,138)= 0.3258.

Figure 11 CUSUM test



8.2.1 Asymmetry effect

We examined how changes in exchange rate are transmitted to consumer prices depending on appreciation/depreciation and size of the changes. The results are shown in Table 8.

Model2: we found statistically significant asymmetry effect of pass through with respect to direction of the exchange rate change (Appendix table13). The 24.3 percent of the exchange rate depreciation positively and 12.3 percent of the appreciation negatively reflects in consumer price inflation respectively. Therefore, we conclude that there is an asymmetry effect, which is higher for the depreciation than appreciation as we expected in the Mongolian case. The asymmetry effect is supported by Wald test Table (8). We rejected the null hypothesis of coefficients of two dummy variables are equal at the 99 percent confidence level.

Table 8 Wald test for asymmetry effect

Wald Test:			
Equation: EQ01ASYM			
Test Statistic	Value	df	Probability
F-statistic	8.60426	(1, 144)	0.0039
Chi-square	8.60426	1	0.0034
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
C(1) - C(2)		0.366405	0.124912

Restrictions are linear in coefficients.

In Mongolia, 62 percent of the consumer goods in CPI basket is imported due to inadequate development of manufacturing industry. Thus, when the domestic currency appreciates, importing firms don't tend to lower their prices as much as they increased during the depreciation in order to increase their mark up.

Table 9 Asymmetry and non-linearity in Pass-Through

Asymmetry and non-linearity in Pass-Through				R-squared
Model2: Direction		Depreciation	Appreciation	
		0.2433	-0.1231	*33.02%*
		(3.32)	(1.94)	
Model3: Size		Large	Small	
	> sample average	0.2004	0.2035	*32.51%*
		(2.74)	(1.90)	
	> median	0.2171	0.1379	*32.64%*
		(3.21)	(1.02)	

Note: Figures in brackets are t-statistics

8.2.2 Non-linearity effect

Model 3: There is no criterion to choose threshold levels, which determine the large and small absolute exchange rate changes. As (Pollard and Coughlin (2004) suggested, we have chosen the sample average and median of the absolute exchange rate changes as a threshold level.

The result shows that we cannot reject linearity of the exchange rate pass-through between large and small absolute changes compared with sample average as a threshold. The estimation result is shown in the (Appendix Table 14). The linearity effect is supported by Wald test (Table 10). We can't reject the null hypothesis which states that coefficients of dummy variables are equal C(1)=C(2) at the 98 percent confidence level. Thus, pass-through coefficients for small changes are same as for large the changes. In this case, not depending on the size, 20 percent of the exchange rate variation passes to consumer prices.

Table 10 Wald test for testing linearity (Mean as a threshold)

Wald Test:
Equation: EQ02ASYM

Test Statistic	Value	df	Probability
F-statistic	0.000573	(1, 143)	0.9809
Chi-square	0.000573	1	0.9809

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1) - C(2)	-0.003092	0.129198

Restrictions are linear in coefficients.

On the other hand, the estimation, using median as an alternative threshold level, provides the linearity effect as well. We cannot reject the hypothesis of linearity using a Wald test with 60 percent probability. However, pass-through coefficients are statistically significant and higher for large changes than small changes, which is statistically insignificant. Specifically, 22 percent of the large and 14 percent of the small exchange rate changes reflects in consumer prices respectively. Estimation result is shown in the (Appendix Table 15).

Table 11 Wald test for testing linearity (median as a threshold)

Wald Test:
Equation: EQ03ASYM

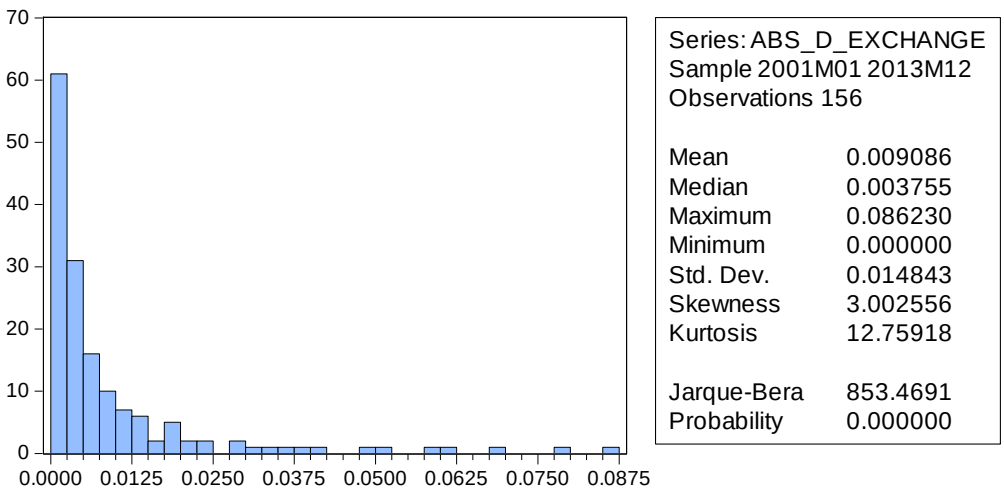
Test Statistic	Value	df	Probability
F-statistic	0.276012	(1, 143)	0.6001
Chi-square	0.276012	1	0.5993

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1) - C(2)	0.079201	0.150753

Restrictions are linear in coefficients.

In conclusion, we find an asymmetry effect with respect to appreciation and depreciation while do not find non-linearity effect for both estimations using a two different threshold level. However, the estimations, using two alternative threshold levels, provide us slightly different effect of non-linearity. This effect is resulted from very skewed distribution of the absolute changes in exchange rate.



9 Conclusion

This paper finds that transmission of exchange rate movement into consumer price is incomplete in Mongolia. Using impulse response functions and variance decompositions derived from a recursive VAR model, the paper finds that exchange rate pass through to consumer price rises from 7.9 percent in the fourth month to 31.3 percent in eight months after the depreciation shock and 22 percent in the long run. Overall, the bulk of the pass through to consumer price occurs in the first eight months after the shock.

Alternatively, we estimate the degree of ERPT to consumer prices using the non-linear econometric model. Estimated pass trough coefficients are 29.8 percent in the short run and 32.3 percent in the long run. Using a Wald test, we find that pass-through coefficients that we obtained using these two methods are not statistically different. Our findings are consistent with other papers, for example, (Zorzi, Hahn, & Sánchez, 2007), (Barhoumi Karim, 2005), , (Ivohasina, 2012), (Goldfaij & Werlang, 2000) and (Lavern, 2009) found that ERPT to consumer prices is considerably higher, about 30 – 40 percent, in emerging and developing countries than in developed countries.

In spite of this relatively high pass through, the exchange rate shocks explain a relatively small percentage of the variation in CPI inflation. Main variation of the consumer price inflation is explained by shocks to the CPI itself, and then by output growth shocks which account for about 7 percent of the variation. Thus, we can conclude that the relatively high exchange rate pass through does not imply high significance of exchange rate for explaining the consumer price inflation volatility and forecasting.

Furthermore, we find a statistically significant asymmetry effect of pass through with respect to the direction of the exchange rate change. ERPT to consumer prices is higher for the depreciation (24.3%) than appreciation (12.3%) as we expected in case of Mongolia. In Mongolia, most of the goods in the consumer price basket are imported due to inadequate development of manufacturing industry. Thus,

when the domestic currency appreciates, importing firms don't tend to lower their prices as much as they increased during the depreciation in order to increase their mark up.

Finally, estimation for assessing non-linearity using both alternative threshold levels, do not provide a non-linearity effect of pass-through with respect to large and small absolute changes of exchange rate. In this case, not depending on the absolute size of the change, 20 percent of the exchange rate variation passes to consumer prices. On the other hand, the estimations, using two alternative threshold levels, provide us slightly different effect of non-linearity. This effect is resulted from very skewed distribution of the absolute changes of the exchange rate.

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10 APPENDIX

Table 12 Model 1Estimation result of exchange rate pass through using non-linear model

Dependent Variable: INF_CPI
Method: Least Squares
Date: 05/05/14 Time: 19:28
Sample (adjusted): 2001M07 2013M12
Included observations: 150 after adjustments
INF_CPI=C(1)+C(2)*E+C(3)*PSTAR+C(4)*INF_CPI(-1)+C(5)*INF_CPI(
-4)+C(6)*DOIL(-2)+C(7)*E(-3)+C(8)*E(-5)+C(9)*Y(-3)+C(10)
*PSTAR(-2)+C(11)*PSTAR(-3)+C(12)*PSTAR(-4)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.002749	0.001508	1.822478	0.0705
C(2)	0.092667	0.055603	1.666568	0.0979
C(3)	0.297676	0.156593	1.900946	0.0594
C(4)	0.456089	0.066180	6.891608	0.0000
C(5)	-0.171926	0.065851	-2.610819	0.0100
C(6)	0.034690	0.013038	2.660676	0.0087
C(7)	0.092164	0.055483	1.661103	0.0990
C(8)	-0.105837	0.059850	-1.768385	0.0792
C(9)	-0.020801	0.004957	-4.195893	0.0000
C(10)	0.188359	0.152362	1.236260	0.2185
C(11)	0.270537	0.150820	1.793774	0.0750
C(12)	0.237356	0.155127	1.530072	0.1283

R-squared	0.421180	Mean dependent var	0.007426
Adjusted R-squared	0.375042	S.D. dependent var	0.015613
S.E. of regression	0.012343	Akaike info criterion	-5.874818
Sum squared resid	0.021025	Schwarz criterion	-5.633967
Log likelihood	452.6113	Hannan-Quinn criter.	-5.776968
F-statistic	9.128741	Durbin-Watson stat	2.173652
Prob(F-statistic)	0.000000		

Table 13 Model2 Asymmetry effect between appreciation and depreciation

Dependent Variable: INF_CPI
Method: Least Squares
Date: 05/06/14 Time: 01:10
Sample (adjusted): 2001M06 2013M12
Included observations: 151 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
E*E_D	0.243281	0.073276	3.320047	0.0011
E*(1-E_D)	-0.123124	0.063521	-1.938314	0.0576
Y(-3)	-0.019374	0.005321	-3.641024	0.0004
INF_CPI(-1)	0.489859	0.064904	7.547445	0.0000
INF_CPI(-4)	-0.165122	0.065822	-2.508611	0.0132
DOIL(-2)	0.038731	0.013931	2.780310	0.0062
PSTAR(-3)	0.344018	0.152637	2.253840	0.0257

R-squared	0.330216	Mean dependent var	0.007128
Adjusted R-squared	0.302308	S.D. dependent var	0.015986
S.E. of regression	0.013353	Akaike info criterion	-5.748923
Sum squared resid	0.025675	Schwarz criterion	-5.609049
Log likelihood	441.0437	Hannan-Quinn criter.	-5.692099
Durbin-Watson stat	1.995451		

Table 14 Model3 Asymmetry effect depending on size (sample average)

Dependent Variable: INF_CPI
Method: Least Squares
Date: 05/06/14 Time: 03:15
Sample (adjusted): 2001M06 2013M11
Included observations: 150 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ED*SIZE_D1	0.200409	0.073240	2.736341	0.0070
ED*(1-SIZE_D1)	0.203501	0.107256	1.897342	0.0598
INF_CPI(-1)	0.480011	0.065726	7.303270	0.0000
INF_CPI(-4)	-0.160339	0.066320	-2.417640	0.0169
DOIL(-2)	0.035693	0.014023	2.545369	0.0120
Y(-3)	-0.019355	0.005384	-3.594891	0.0004
PSTAR(-3)	0.333848	0.153445	2.175690	0.0312

R-squared	0.325124	Mean dependent var	0.007089
Adjusted R-squared	0.296807	S.D. dependent var	0.016033
S.E. of regression	0.013444	Akaike info criterion	-5.734962
Sum squared resid	0.025848	Schwarz criterion	-5.594465
Log likelihood	437.1221	Hannan-Quinn criter.	-5.677882
Durbin-Watson stat	1.980866		

Table 15 Asymmetry effect depending on size (Median)

Dependent Variable: INF_CPI
Method: Least Squares
Date: 05/06/14 Time: 03:13
Sample (adjusted): 2001M06 2013M11
Included observations: 150 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ED*SIZE_D2	0.217096	0.067701	3.206709	0.0017
ED*(1-SIZE_D2)	0.137895	0.135255	1.019518	0.3097
INF_CPI(-1)	0.488281	0.066332	7.361118	0.0000
INF_CPI(-4)	-0.162374	0.066358	-2.446961	0.0156
DOIL(-2)	0.037013	0.013894	2.663881	0.0086
Y(-3)	-0.019584	0.005371	-3.646373	0.0004
PSTAR(-3)	0.337204	0.153361	2.198762	0.0295

R-squared	0.326421	Mean dependent var	0.007089
Adjusted R-squared	0.298159	S.D. dependent var	0.016033
S.E. of regression	0.013431	Akaike info criterion	-5.736886
Sum squared resid	0.025798	Schwarz criterion	-5.596390
Log likelihood	437.2664	Hannan-Quinn criter.	-5.679807
Durbin-Watson stat	1.982102		

Table 16 Serial correlation LM test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.130627	Prob. F(2,138)	0.3258
Obs*R-squared	2.418259	Prob. Chi-Square(2)	0.2985

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/06/14 Time: 22:42
Sample: 2001M07 2013M12
Included observations: 150
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000919	0.001568	-0.585636	0.5591
E	0.009646	0.056399	0.171036	0.8644
PSTAR	-0.010324	0.150979	-0.068383	0.9456
INF_CPI(-1)	0.144951	0.128695	1.126318	0.2620
INF_CPI(-4)	-0.002261	0.066499	-0.033993	0.9729
DOIL(-2)	-0.003535	0.013586	-0.260207	0.7951
E(-3)	-0.010403	0.056568	-0.183905	0.8544
E(-5)	-0.008864	0.061017	-0.145274	0.8847
Y(-3)	-0.001068	0.005076	-0.210318	0.8337
PSTAR(-2)	-0.015832	0.149954	-0.105579	0.9161
RESID(-1)	-0.229446	0.160742	-1.427416	0.1557
RESID(-2)	-0.038881	0.106770	-0.364162	0.7163

R-squared	0.016122	Mean dependent var	-2.08E-19
Adjusted R-squared	-0.062303	S.D. dependent var	0.012128
S.E. of regression	0.012500	Akaike info criterion	-5.849486
Sum squared resid	0.021564	Schwarz criterion	-5.608635
Log likelihood	450.7114	Hannan-Quinn criter.	-5.751635
F-statistic	0.205568	Durbin-Watson stat	1.975051
Prob(F-statistic)	0.997045		

Table 17 Wald coefficient test for incomplete pass through

Wald Test:
Equation: MODEL3IIN2

Test Statistic	Value	df	Probability
F-statistic	20.11541	(1, 138)	0.0000
Chi-square	20.11541	1	0.0000

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-1 + C(3)	-0.702324	0.156593

Restrictions are linear in coefficients.

Table 18 Wald coefficient test between VAR and non-linear model in the short run

Wald Test:
Equation: MODEL3IIN2

Test Statistic	Value	df	Probability
F-statistic	1.146549	(1, 138)	0.2861
Chi-square	1.146549	1	0.2843

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-0.13 + C(3)	0.167676	0.156593

Restrictions are linear in coefficients.

Wald Test:
Equation: MODEL3IIN2

Test Statistic	Value	df	Probability
F-statistic	0.006194	(1, 138)	0.9374
Chi-square	0.006194	1	0.9373

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-0.31 + C(3)	-0.012324	0.156593

Restrictions are linear in coefficients.

Wald Test:
Equation: MODEL3IIN2

Test Statistic	Value	df	Probability
F-statistic	0.186774	(1, 138)	0.6663
Chi-square	0.186774	1	0.6656

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-0.23 + C(3)	0.067676	0.156593

Restrictions are linear in coefficients.

Table 19 Wald coefficient test between VAR and non-linear model in the long run

Wald Test:
Equation: MODEL3IIN2

Test Statistic	Value	df	Probability
F-statistic	0.382500	(1, 138)	0.5373
Chi-square	0.382500	1	0.5363

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-0.22 + C(3)/(1 - C(2))	0.108077	0.174751

Delta method computed using analytic derivatives.

Wald Test:
Equation: MODEL3IIN2

Test Statistic	Value	df	Probability
F-statistic	0.314992	(1, 138)	0.5755
Chi-square	0.314992	1	0.5746

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-0.23 + C(3)/(1 - C(2))	0.098077	0.174751

Delta method computed using analytic derivatives.

Figure 12 Impulse responses to exchange rate shock

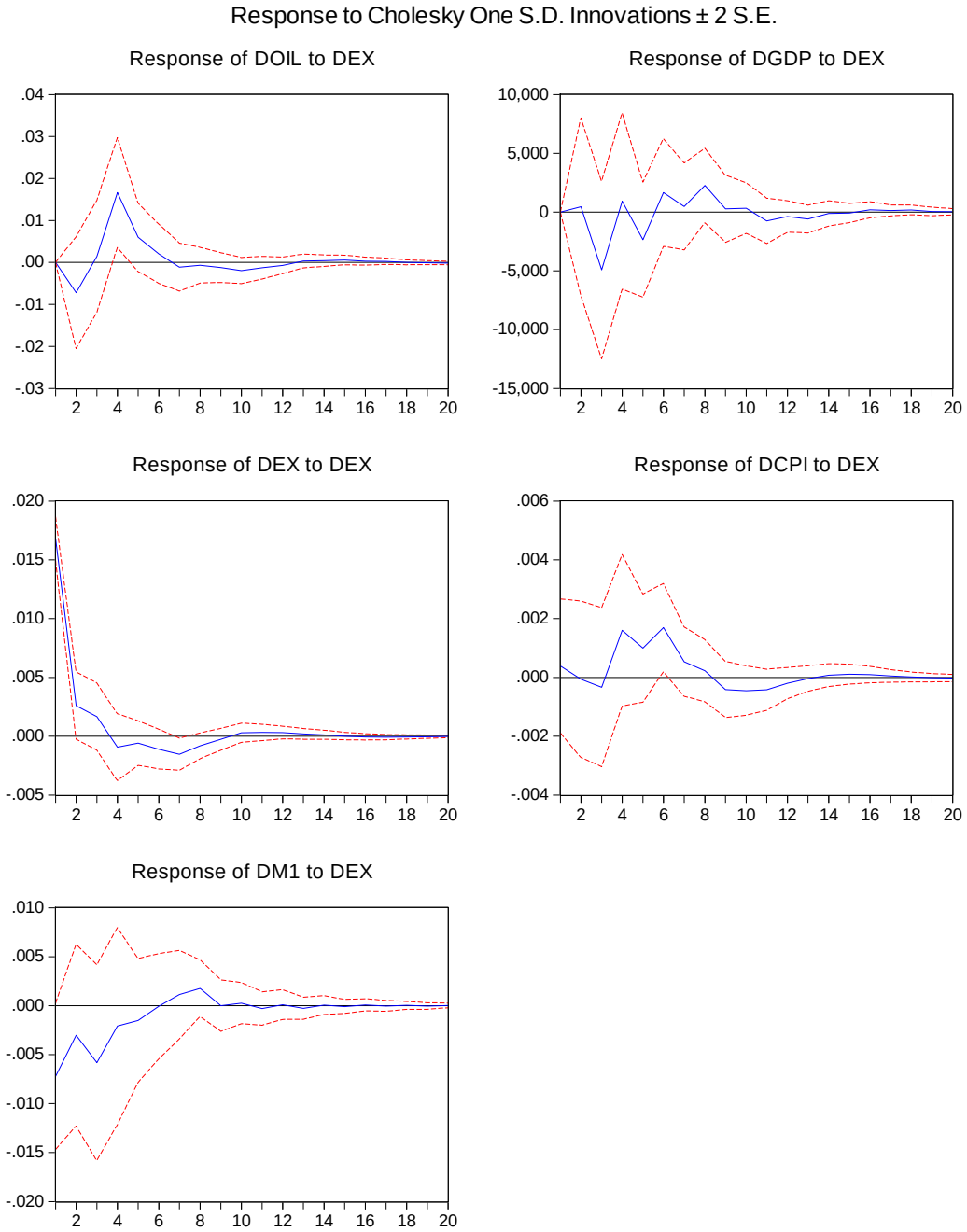

Figure 13 Cumulative impulse responses to exchange rate shock

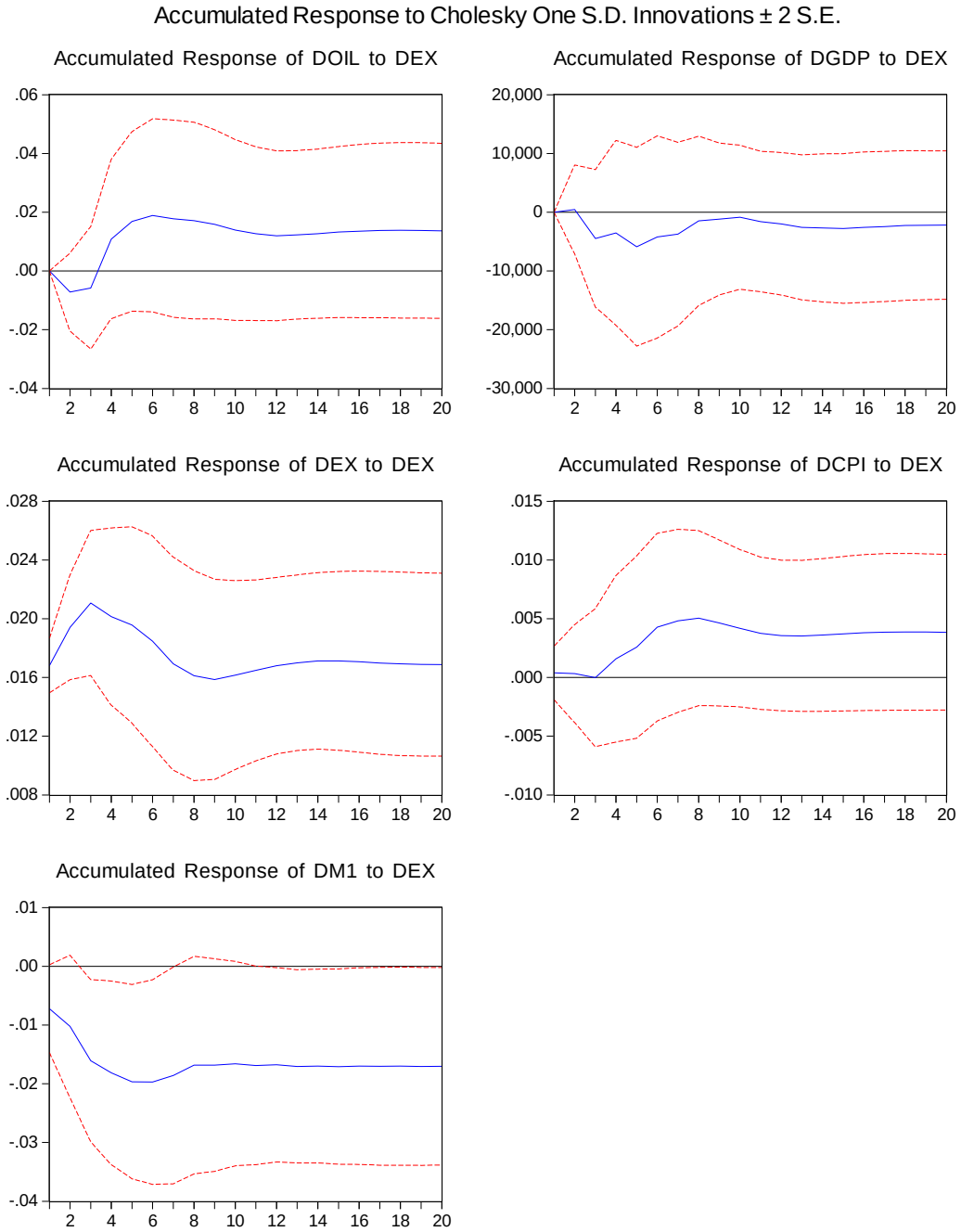

Figure 14 Alternative Cholesky ordering 1

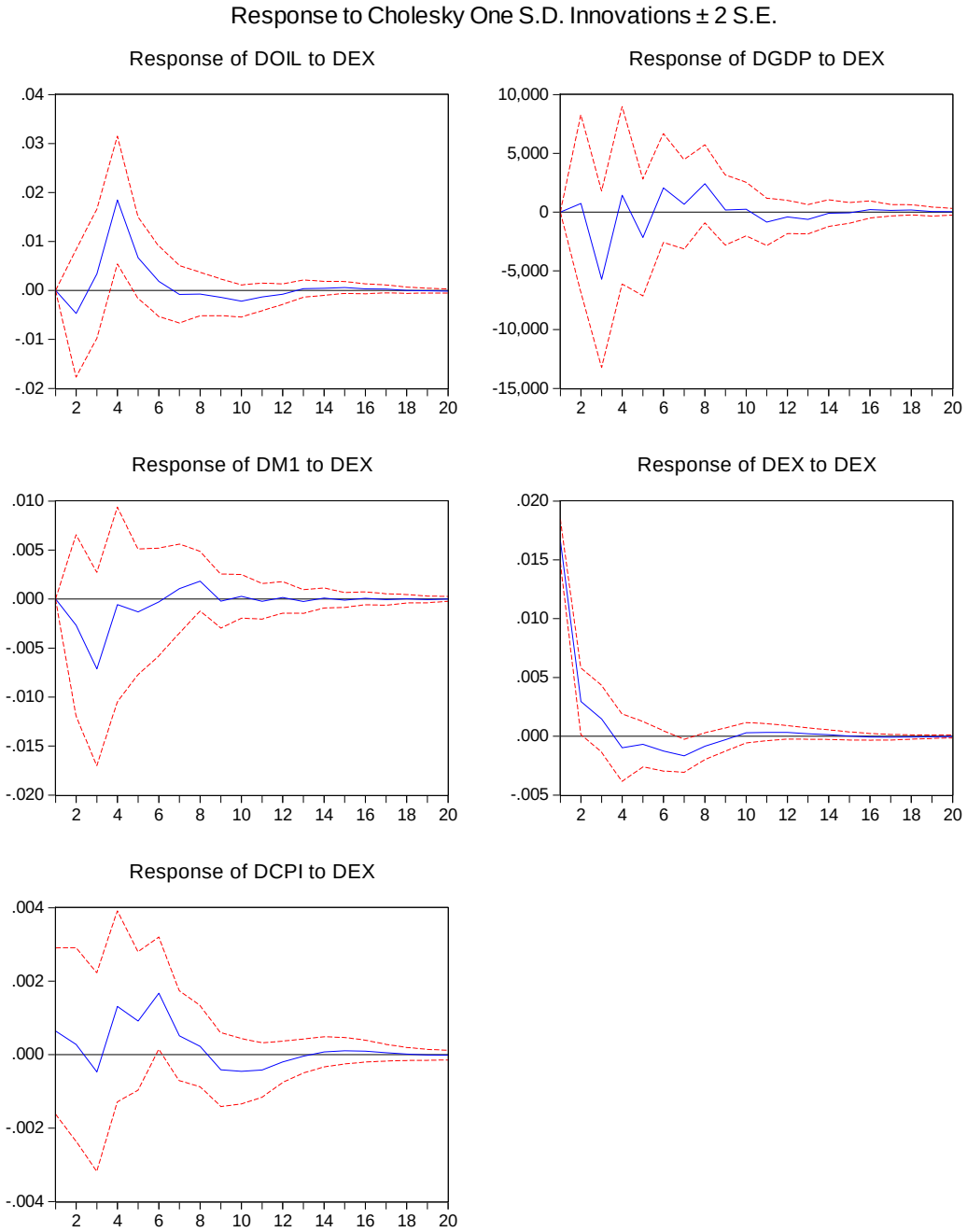

Figure 15 Alternative Cholesky ordering 2