Currency Substitution Theory, a New Chanel to Enter the Exchange Rate as the Monetary Transmission Mechanism

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Abstract

This paper examines whether in analysis of the impact of monetary policy, the exchange rate can play a role along with the interest rate as a transmission mechanism of monetary policy effects on economic variables or not? For this purpose, the general dynamic stochastic equilibrium models were used in the form of a New Keynesian small open macro-economy. This model was designed for Iran's economy by considering oil-based economy's and the currency substitution Existence. Then, its calibration and simulation was conducted with Iran's economic data for the period of 1995-2011. The results from model validation, univariate and multivariate recognition of Markov Monte Carlo chain and analysis of the model impulse responses showed that in Iran's economy, the exchange rate plays a role along with the interest rate as a monetary transmission mechanism.

Resumen

Este documento examina si en el análisis del impacto de la política monetaria, el tipo de cambio puede jugar un papel junto con el tipo de interés como mecanismo de transmisión de los efectos de la política monetaria sobre las variables económicas o no. Para ello, los modelos de equilibrio general de estocásticos dinámicos fueron utilizados en la forma de una nueva keynesiana pequeña macro-economía abierta. Este modelo fue diseñado para la economía de Irán teniendo en cuenta la sustitución de moneda existencia y de la economía a base de aceite. Luego, su calibración y simulación se llevó a cabo con los datos económicos de Irán para el período 1995-2011. Los resultados de la validación de modelos, el reconocimiento univariante y multivariado de la cadena de Markov Monte Carlo y el análisis de las respuestas de impulso modelo mostraron que en la economía iraní, el tipo de cambio juega un papel junto con la tasa de interés como mecanismo de transmisión monetaria

Keywords: New Keynesian small open macro-economy, dynamic stochastic general equilibrium model, Exchange rate, monetary transmission mechanism,

JEL Classification: E12, E52, F31

1. Introduction

In most economies in the world, small changes in interest rates will lead to dramatic and significant changes in the economic situation and economic variables. For example, many economists in the world know a slight fluctuation of interest rates as one of the causes of the recent financial crisis (IMF, 2009). But, the situation is different in Iran and other developing countries. Investment and money supply and demand are not so sensitive to interest rate changes due to existing economic and structural problems such as high inflation rates. Therefore, applying the monetary policy and the expected impact on the economy do not seem efficient by changing interest rates and influencing the investment demand and money supply and demand in the current IS-LM models in these countries, unless there is another channel alongside the interest rate that can justify the applying of monetary policy. The proposed channel by this research besides the interest rate channel, in an open economy, is the exchange rate.

This study sought to explore the possibility of contributing the exchange rate channel alongside the interest rate channel in the monetary policies influence on economy. To examine the research main hypothesis, the dynamic stochastic general equilibrium (DSGE) models were used within the framework of New Keynesian School teachings.

2. Statement of the Problem

To control macroeconomic variables such as economic growth, inflation control, etc. the central bank adopt monetary policies through the tools at its disposal. These policies influence the real sector or monetary of the economy via changes in interest rates, exchange rate or return rates of other assets. In other words, the monetary policies affect the economy through these three channels. But, the existence or degree of influence of each of these channels in each economy is different; however, given the circumstances and characteristics of each country, some of these channels may not work properly. In economies with high inflation and in countries lacking real data on the interest rates, such as Iran's economy, the interest rate channel does not work well .The hypothesis of this study is that the exchange rate channel could be a good alternative for the interest rate channel. It should be also noted that the succession of exchange rate rather than interest rate is an incomplete successor. In other words, the purpose of research was not the complete removal of the interest rate mechanism and absolute succession of the exchange rate mechanism instead. Rather, the objective was merely to test the exchange rate mechanism in the transfer of monetary policies effects to the economic variables. Evaluating the effectiveness or non-effectiveness of monetary policies was not also among the study purposes. Rather, it was to assess a new mechanism in monetary policies influence on economic variables.

Figure (1) was used to express the problem of research more clearly:

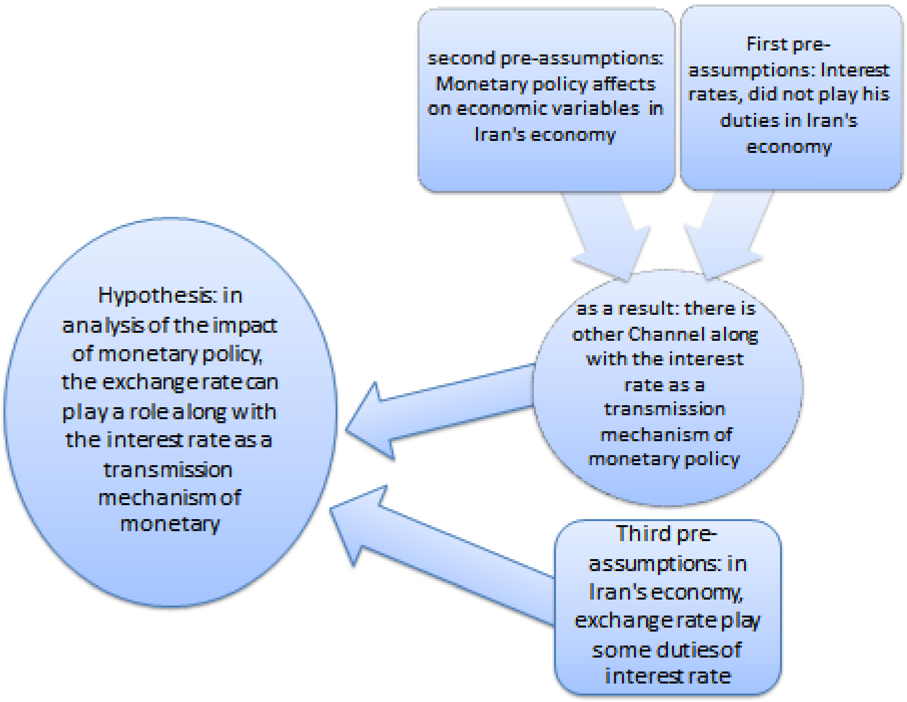


Figure1. Extraction Process of the Research Hypothesis

3. Study the Interest Rate Performance in Economic Theories and in Iran's Economy

In economics, the impact of interest rates on the economy occurs in the context of two money and capital markets. The majority of interest rates theories in the context of money market involve different approaches to the interest rate on the role playing in money demand. For example, Johan Gustaf Knut Wicksell (1851-1926), the Swedish economist, whose theories later inspired Keynes, entered the interest rate into the money market for the first time in 1898 in his study entitled as "Interest rates and prices". For him, equality of the interest rates of money market and capital market is a channel to balance out the economy, or according to Keynes, the interest rate has been selected as a lost reward in money market instead of assets. Friedman sees the interest rate as the expected rate of assets, or Tobin recognized the interest rate as risk reduction price in financial transactions.

But, in classical economics, capital markets are the place for formation of the theory of setting interest rates. Based on the analysis of the classical economists, the interest rate in this market is determined by two forces of investment demand and the supply of savings. Investment demand or savings demand for investment is the inverse function of the interest rate. According to this theory, when the interest rates rise, under identical conditions, the amount of investment demand would decrease. On the contrary, by reducing the interest rate, the amount of investment will increase

(Snowden, Vienna and Vinarkovich, 2005), but in the context of capital market, Keynes considers the interest rate as the final return or outcome of investment (Shakeri, 2009).

In conclusion, we can say that various economists have different approaches to interest rates depending on theorizing in within what mindset. For example, in the Keynes mindset and through the Great Depression period, where interest rates are so low that it is not likely to go lower and everyone is waiting for its increase so that the bond prices would decrease, and thus all people keep their money in cash (liquidity trap), the interest rate is the opportunity cost of holding cash, while Friedman sees it as the expected rate of financial assets. In the new Keynesians uncertainties, Tobin knows the interest rate as the cost of risk reduction in financial transactions. The classics, due to considering the importance for the role of investment in their analyses, would see it as the capital price, etc. Despite all the differences of these economists in their approaches to interest rates, the common point of all of them is to consider the interest rate as an input channel to economic monetary changes. Therefore, due to its role in money demand and investment, the interest rate can affect the macroeconomic variables, and hence, it can also act as a channel of monetary policy effectiveness.

Now, the question is, despite its importance, whether the interest rate channel can play its role properly or not. There is a consensus in most of empirical studies developed about the economy of developing countries that the interest rate does not play its role well as the impacting channel of monetary policies on the economy, and thus, they have introduced substitutes for the opportunity cost of holding money. In this context, due to lack of development of financial markets, determination of interest rates by the monetary authorities and lack of access to information related to interest rates, some studies have considered the inflation rate as the opportunity cost variable in the money demand function. Some of these studies include Bahmani Oskouei and Rahman (2005), Jafari Samimi et al. (2007), Mostafavi and Yavari (2008), Hsahrestani and Sheriff Renani (2009) and Hamzeh (1996) studies. Some other studies have also used other variables as the successor of interest rate, such as Bahmani Oskouei (2002), using the exchange rate on the black market, Emadzadeh (1991), using the government budget to budget deficit ratio, Sameti and Yazdani (2009), using the interest rate on long-term loans to the private sector and Sameti et al. (2010), using the final productivity of capital, as the opportunity cost of holding money variable because of shortcomings in the process of setting interest rates.

Another factor can be named as an evidence of interest rate inefficiency in some countries is insensitivity of investment demand to the interest rate. Some of these studies indicating investment is not sensitive to interest rate in Iran's economy include Kamijani research (1996), who identified the problem mostly due to high risk and uncertainty of investors in the private sector, and the studies by Rezai, Bahmani and Hirad (2009).

According to the above and given that the impacting mechanism functions on real economic variables mainly through reducing the interest rate and decreasing the cost of investment, despite economic constraints as well as high risks of investing in Iran, it seems that the interest rate channel does not work as a monetary transmission mechanism (Bidabad, 2005).

money transfers to economic variables. The research hypothesis implies that the exchange rate channel is a more appropriate channel in monetary policies.

4. The Impact of Monetary Policies Applied on Iran's Economy and the Role of Exchange Rates in the Money Demand Function

There are many studies on the impact of monetary policies on Iran's economy that show monetary policies can affect Iran's economy, the studies by Heidari (2009), Jalaiee and Shirafkan (2010), Khoshakhlagh, Dallali Esfahani and Mousavi Mohseni (2010), and Sharifi Renani, Honarvar, Daie Karimizadeh and Amrollahi Pourshariati (2010). Since the interest rate has not the required effectiveness, an alternative variable should be found that can afford some tasks of this variable in applying monetary policies. According to the hypothesis of this study emerged from the previous studies in this regard, this variable is the exchange rate.

Therefore, in this part, we review the studies that have discussed the role of other variables except for conventional variables in the monetary theories affecting the demand for money. Some of these studies include the exchange rate in black market in a study by Bahmani Oskouei (2002) and Jafari Samimi, Elmi and Sadeghzadeh Yazdi (2007), the variable of exchange rate in the study by Shahrestani and Sharifi Renani (2009) and Sameti, Dallali Esfahani, Khoshakhlagh and Shirani Fakhr (2010), Sharifi Renani, Honarvar, Daie Karimizadeh and Amrollahi Pourshariati (2010), Sameti and Yazdani (2009), Bafandeh Imandoost and Ghasemi (2012) and Izadi Dahmardeh (2013). The foreign studies that have considered the opportunity cost of holding money such as exchange rate in the money demand function include studies by Ariz (1994), Choodhori (1997), Tan (1997), Ariz and Suif (1998), Khalid (1999), Pozo and Wheeler (2000), Ebrahim (2001) and Bahmani Oskouei and Tanco (2006).

These studies confirmed the hypothesis that the exchange rate plays an important role in the money demand function. But, there is another group of studies that besides the effectiveness of the exchange rate in the money demand function, have also particularly confirmed the role of this variable as the transmission channel of economic policies effects on the macro variables. In Iran, very few studies have been done on monetary transmission mechanism, but some of them include Moshiri and Vashghani (2011) and Vasheghani, Pedram and Beghzian (2013). The foreign studies are as follows: Tanzi and Beljer (2004), Mantil (1991), Calvo and Vegh (1992), Egnor and Khan (1996), Cottner and Moser (2002), Ledook and Keith (2004), Medina and Soto (2006), (Aslan and Koorap (2007), Munoz et al. (2007), Olalkan and Akinloo (2008), Feizi (2009), Lee White and Pefav (2009), Tovar (2009), Mishra et al. (2010), Bhattacharya and Mokhrejeh (2011), and Bhattacharya et al. (2011).

However, none of the studies in the field of applying monetary policy through the exchange rate channel, especially in Iran's economy, have followed a CGE approach to the issue. In this study, we evaluated the hypothesis of succession of (partial) exchange rate instead of interest rates in applying monetary policies using the Dynamic Stochastic General Equilibrium (DSGE) Models within the framework of New Keynesian open small macroeconomics.

Some of studies that have estimated the dynamic stochastic general equilibrium (DSGE) models within the framework of the New Keynesian open small macroeconomics are as follows: Heider and Khan (2008) study, Pakistan, Dip, Gamoodi and Moran (2008) study, Canada, Sadegh (2008) study, transition countries of Central Europe, Kolaska (2008) study, Poland, Bankik and Maleki study (2008), Australia, Disesiou and Nelson (2007) study, UK, Pieres and Sagsegard (2007) study, low-income countries (Mozambique), Liu (2006) study, New Zealand and Dasilveria (2006) study, Brazil.

5. Model

In this study, a two-block model was used, which has been founded based on the original model introduced in Walsh (2010). However, it has been changed and evolved according to Iran's economy, its properties, the money substitution theory and the research main hypothesis. As mentioned earlier, the research model is in the category of New Keynesian policy models. The internal block is consisted of an IS equation, a Phillips curve and the Uncovered Interest Parity (UIP) Condition[5]. As Europe has the largest share of trade with Iran, the Euro area was considered as a proxy for the economy of the foreign world. The external block is Exogenous than to the internal block. The framework followed in this study was the framework of New Keynesian models on small open economies to which the foundations of microeconomics were added in this study.

In these models, the behavioral equations are explicitly extracted from intertemporal optimization of private sector representative with rational expectations, various real and nominal rigidities and under institutional constraints of budget and technology such as financial market failure, commodity market and the factors market. In this context, the macroeconomic fluctuations can be considered as an optimal response of the private sector to supply and demand shocks in different markets with the restrictions listed above.

5 Uncovered Interest Parity (UIP) Condition is a condition in which the interest rate differences between the two countries are equal to the expected changes in the exchange rate between the two countries. If there is no equality without interest coverage, the profit opportunity would occur. $(i_1 - i_2) = E(e)$

5.1. Domestic Economy

- **Households (Based on Currency Substitution Theory)**

The topic of currency substitution occurs in the field of macroeconomics, money economy and the international economy. The currency substitution literature originates from domestic monetary economy as well as the international monetary economy. For, the currency substitution phenomenon is influenced by macroeconomic variables and international and variables monetary, and some of them affect these variables.

In general, the main three functions of money in economic are distinguished as: a medium of exchange; a unit of account; a store of value. If the national currency of a country fails to perform its duties well for various reasons, including inflation, devaluation of the national currency and economic instability, and the foreign money has taken all or part of these duties, one can says that the economy has been dollarized or currency substitution has occurred. so that one or more foreign currencies have replaced the national currency. The currency substitution phenomenon has different effects on the economy of different countries. Experimental studies have shown that this phenomenon, whether formally with the government will or informally and without the government will weakens the national currency in the country and abroad. The issue of currency substitution has entered the economy literature for nearly four decades. The currency substitution phenomenon in Iran has been confirmed in various periods. Among studies that have examined the currency substitution in Iran and confirmed it at various time intervals in Iran, the following can be mentioned:

Studies by Khalatbari (1991), Yazdanpanah and Khiabani (1997), Farzinvash and Lashkari (2004), Lashkari (2004), Lashkari and Arabmazar (2005), Lashkari (2008), Sameti and Yazdani (2011), Tehranchian, Norrozi and Bayrami (2012), and Daie Karimzadeh, Mahmoodeh and Sameti (2014). The model designed for the household sector is as follows:

The representative households with an infinite life decide optimally about their composite consumption good (C_t), the time devoted to market employment (N_t) and real money balances ($\frac{M_t}{P_t}$):

$$E_t \sum_{i=0}^{t=\infty} \beta^i \left[\frac{C_{t+1}^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-b}\left(\frac{M_{t+i}}{P_{t+i}}\right)^{1-b} - \chi \frac{N_{t+1}^{1+\eta}}{1+\eta} \right] \qquad (1)$$

Where,

σ : Inverse of intertemporal elasticity of substitution

η : Inverse of elasticity of working hours to real wage

β : Subjective discount factor

The exchange rate effects on the opportunity cost of domestic money, especially in countries with high inflation (such as Iran). According to currency substitution theory, the household budget constraints would change.

$$C_t + \frac{M_t}{P_t} + \frac{M_t^*}{P_{t-1}^*}\frac{P_{t-1}^*}{P_t^*}\frac{P_t^*}{P_t} + \frac{B_t}{P_t} = \frac{W_t}{P_t}N_t + \frac{M_{t-1}}{P_{t-1}} + \frac{M_{t-1}^*}{P_{t-1}^*}\frac{P_{t-1}^*}{P_t^*}\frac{P_t^*}{P_t} + \left(1 + \frac{r_{t-1}[\,])B_{t-1}}{P_t} + \Pi\right]_t$$

(2)

Where,

M_t^*: The amount of foreign currency held to preserve the value of money in economies with high inflation

P_t^*: Foreign prices index

P_t: Domestic prices index

$W_t N_t$: Nominal wage

Π_t: Real profits received from firms

Using the first order condition optimization, Euler equation is derived as follows:

$$C_t^{-\sigma} + s_t = \beta E_t\left[C_{t+1}^{-\sigma} + \frac{1+r_t}{\pi_{t+1}} + \frac{s_{t+1}}{\pi_{t+1}^*}\right] \qquad (3)$$

Where,

$s_t = \frac{P_t^*}{P_t}$: Real exchange rate[6]

$\pi_t = \frac{P_t}{P_{t-1}}$: Inflation rate

When the above equation is turned linear around a stable equilibrium position (zero inflation: SS), it will result in a different curve of IS as follows:

$$y_t = E_t y_{t+1} - \frac{1}{\sigma}\left(r_t + E_t \Delta s_{t+1} - E_t \pi_{t+1}^*\right) + s_t^y \qquad (4)$$

6 The exchange rate refers to the indirect exchange rate, which is defined as the number of foreign currencies needed to purchase a domestic currency, and is obtained by dividing the index of foreign prices on the domestic price index.

We assume that the purchasing power parity theory is established in Iran. In this case, the previous IS curve turns into a new curve as follows:

$$y_t = E_t y_{t+1} - \frac{1}{\sigma}(r_t + E_t \Delta q_{t+1} - \pi_{t+1}) + \varepsilon_t^y \qquad (5)$$

Where,

q : Nominal exchange rate

y_t: Production gap

ε_t^y : White noise shock of the IS curve

To manage this IS curve for an open economy, the foreign production gap and exchange rate can be added to the equation:

$$y_t = E_t y_{t+1} - \delta_1(r_t + E_t \Delta q_{t+1} - \pi_{t+1}) + \delta_2 y_t^* - \delta_3 q_{t-1} + \varepsilon_t^y \qquad (6)$$

In the above equation, "y_t^*" is the foreign production gap. Putting the foreign production gap and nominal exchange rate in the above equation indicates the transmission channels of external shocks to the domestic economy. In specification of the monetary policy reaction function, the studies of Klider et al. (1999) and Svensson (2000) were used. They argue that the Taylor rule[7], which only

7 Taylor rule recommends the use of money market instruments, i.e., changes in short-term interest rates as a mechanism to reduce inflation in the short run. This rule implies that if the inflation was higher than the desired amount, the interest rate should be increased, and if it was lower than the targeted level, the interest rate needs to be reduced to increase the inflation. In other words, Taylor rule says that the short-term interest rate and inflation move in opposite directions to one another. Taghinejad Omran and Bahman (2013) state that using the Taylor rule in Iran has two problems: First, this rule has not microeconomic basis. Second, especially in the short term, the monetary base in Iran instead of the interest rate is the variable of monetary policy. In this study, first, explaining the microeconomic basis, the Taylor rule is extended in such a way that uses an alternative monetary base variable instead of the interest rate. Their results show that the response of the monetary authorities to diversion in production is compatible with the extended Taylor rule. Thus, in the present study, the principles used in the expanded Taylor monetary policy rule were used. Then, the interest rate was borrowed from the article by Shahmoradi, Kavand and Nadri (2011). They have tried to estimate the time series of equilibrium real interest rate with potential production for Iran's economy by using quarterly data (1990-2008). For this purpose, the summarized structural form of the general equilibrium compatible with Iran's economy was designed, and using the Kalman filter approach, the unobservable variables were estimated.

takes the domestic production gap and domestic inflation into consideration, is also optimized for an open economy, and this is a strong rationale for the structure of different models. Thus, the general form of the monetary policy rule is intended as follows:

$$r_t = \varphi_1 E_t \pi_{t+1} + \varphi_2 y_t + \varepsilon_t^r \qquad (7)$$

Where,

r_t : Domestic interest rate

φ_π & φ_y : Policy factors

ε_t^r : White noise shock of the monetary policy

To be able to close the model, we need to specify the evolution of the real exchange rate against the uncovered interest parity (UIP) condition. This equation is one of the main equations of open economy. To do so, the International Monetary Fund (IMF) method of Berg and other (2006) for emerging economies was used, which is as follows:

$$q_t = \delta E_t q_{t+1} + (1-\delta) q_{t-1} + (r_t - E_t \pi_{t+1}) - (r_t^* - E_t \pi_{t+1}^*) + \varepsilon_t^q \qquad (8)$$

Where,

δ : Set value is equal to 0.5

ε_t^q : White noise error component

The exchange rate will affect the inflation as well as the production gap through the effect on net exports, domestic prices (via importing prices) and the interest rates (via exchange rates). Kia (2006) found that in the long run, higher exchange rate (less valuable domestic currency) has led to higher prices in Iran. By identifying the long-term equilibrium condition in the money market, Clawson

However, the noteworthy in their study is that Shahmoradi et al. estimated the equilibrium interest rate in Iran's economy in a balance system based on the rate of changes in volumes of money. They argue that given the effectivity nature of the majority of inflation rates from the changes in money supply in Iran's economy (whether due to government debts to the central bank because of the settlement of public budget deficits or due to the increase in the monetary base due to rising foreign assets of the Central Bank as a result of severe increase in oil prices), it seems that the liquidity growth rate and its disruptions could have a significant effect on inflation rate. Thus, borrowing the balanced interest rate from Shahmoradi, Kavand and Nadri (2011) that estimate the interest rates based on changes in money supply will actually solve the problems of the Taylor rule in Iran's economy, and the results are consistent with the findings of Taghinejad Omran and Bahman (2013) in calculating and estimating the expanded Taylor monetary policy rule.

and Goswami (2002) found the strong effect of the currency and exchange rates in the short-term inflation equation.

- **Firms (Under conditions of natural resource-exporting countries)**

The Phillips curve is an equation that describes the dynamics of inflation in the domestic economy:

$$y_t = -b_1\rho_t + b_2\left(\pi_t - E_{t-1}\pi_t\right) + e_t \qquad (9)$$

But the question is whether the Phillips curve will be again the case or not for countries such as Iran that are highly dependent on exports, such as oil, gas and raw materials. Oil and gas make up 70 percent of Iran's exports, and the exports of finished goods produced in the country are very poor. This feature has led us to design a Phillips curve based on the exchange rate. The Phillips curve has been designed based on previous studies of the authors of this study (Shahraki and others, 2016). According to this study, an equation describing the dynamics of inflation in Iran's domestic economy has been modeled by the following Phillips curve:

$$\pi_t = E_t\pi_{t+1} + \lambda_1 y_t + \lambda_2 q_t + \varepsilon_t^{\pi} \qquad (10)$$

Where,

π_t: Consumer Price Index (CPI)

ε_t^{π} : White noise shock of the Phillips curve

The evidence on the above curve implies that as the export of finished goods produced inside Iran is very weak and oil and gas make up the majority of Iran's exports, and assuming that the economy has a constant inventory of natural resources that are sold in international markets at random international prices, one can say that the export earnings are largely an exogenous variable than to domestic economic conditions, and exchange supply in Iran is constant, and changes in exchange rate only affects the demand for exchange and the rate of import and the prices of imported goods. Therefore, on one hand, the changes in exchange rate would change the optimized price of the manufacturer through the optimization function of the manufacturer's profit due to rising prices of imported inputs used in the production. On the other hand, it changes the ratio of using the workforce to the imported inputs, leading to changes in optimal rates of hours of the work force through the production function. Also, through optimization functions of consumer utility, it will change his utility.
Equation (6), (7), (8) and (10) represent the domestic sector (block) of the model.

5.2. Foreign Economy

Modeling the foreign sector economy according to Walsh (2010) is as follows:

$$y_t^* = E_t y_{t+1}^* - \delta^*\left(r_t^* - E_t \pi_{t+1}^*\right) + \varepsilon_t^{y^*} \qquad (11)$$

$$\pi_t^* = E_t \pi_{t+1}^* + \lambda^* y_t^* + \varepsilon_t^{\pi^*} \qquad (12)$$

$$r_t^* = \varphi_1^* E_t \pi_{t+1}^* + \varphi_2^* y_t^* + \varepsilon_t^{r^*} \qquad (13)$$

Thus, the research model is determined by seven equations of (6), (7), (8), (10), (11), (12) and (13).

6. Model Estimation Methodology & Results

The Dynare toolbox in the form of MATLAB software is used to solve the DSGE models. It is noteworthy that the software is able to make the relations linear, in which case, we need to have the stable values of the variables. However, due to the difficulty of finding these values and challenges in method of obtaining them, it is preferred that we make the model linear by ourselves. In this case, we should have the ratio of the steady state of some variables to each other. These ratios can be calculated by using the mean of their long-term trend. When the growth rate of all variables is equal to zero, the variables are stable and have balanced growth rate. For making the variables stationary and elimination of their long-term trends, usually, all variables will be as so-called trend-eliminated or made stationary. For this purpose, the trend-eliminated variables are considered as the new variables of the model, and all analyzes will be performed on the trend-eliminated variables: The linear-made model after making the variables stationary would be as follows:

$$y_t = \rho_y E_t y_{t+1} + (1-\rho_y) y_{t-1} - \delta_1\left(E_t q_{t+1} - q_t - E_t \pi_{t+1} + r_t\right) + \delta_2 y_t^* - \delta_3 q_{t-1} + \varepsilon_t^y \qquad (14)$$

$$\pi_t = \rho_\pi E_t \pi_{t+1} + (1-\rho_\pi)\pi_{t-1} + \lambda_1 y_t + \lambda_2 q_t + \varepsilon_t^\pi \qquad (15)$$

$$r_t = \varphi_1 E_t \pi_{t+1} + \varphi_2 y_t + \varepsilon_t^r \qquad (16)$$

$$q_t = \delta E_t q_{t+1} + (1-\delta) E_t q_{t-1} + \left(r_t - E_t \pi_{t+1}\right) + \left(r_t^* - E_t \pi_{t+1}^*\right) + \varepsilon_t^q \qquad (17)$$

$$y_t^* = \rho_y^* E_t y_{t+1}^* + \left(1-\rho_y^*\right) * y_{t-1}^* - \delta^*\left(r_t^* - E_t \pi_{t+1}^*\right) + \varepsilon_t^{y^*} \qquad (18)$$

$$\pi_t^* = \rho_\pi^* E_t \pi_{t+1}^* + (1-\rho_\pi^*)\pi_{t-1}^* + \lambda^* y_t^* + \varepsilon_t^{\pi^*}; \qquad (19)$$

$$r_t^* = \varphi_1^* E_t \pi_{t+1}^* + \varphi_2^* y_t^* + \varepsilon_t^{r^*} \qquad (20)$$

The Bayesian approach was used in this study to obtain the estimates of parameters and conclusion in this model. Also, the Dynare 4.4.3 was used, which is a general and suitable tool for Bayesian estimation in the context of dynamic stochastic general equilibrium models.

Calibration is one of the most important stages of empirical evaluation of DSGE models in both real business cycles and New Keynesian schools. To calibrate, using the existing data as well as some studies done on some of the parameters in the country, the parameters' values were set. The standard values used in international literature were used for some of the parameters not found in the domestic studies. However, the parameters that their values are not ensured completely can be assessed by the consistency standard between the model predicted moments and the actual moments. The Inverted Gamma Distribution and Non Informative Normal Distribution were respectively selected for standard deviation and for the remaining parameters. The previous final distributions for the model parameters are summarized in Table 1.

The profiles of the exogenous shocks reported in Table were also extracted by using the Central Bank statistics in the mentioned years and by the least squares method. It is noteworthy that according to the literature of these models, the cyclic part of the data must be used for estimation, since these models stress on deviations percentage of the variables from the stable situation. Thus, here, using the Hedrick-Prescott filter, the variables trends were extracted.

7. Results

Model-solving by using the Dynare toolbox is based on the Blanchard-Kahn method. In the first stage, the steady state results of the model were examined. Since the equations have been entered the software in linear form, the model steady state of all of them is equal to zero. According to Dynare estimates, this model has 10 eigenvalues that five of them are larger than 1. Since the model has five forward-looking variables, thus, based on the order and Blanchard-Kahn conditions, the presence of a sustainable path in the model is guaranteed. Then, the model summary is shown. The present model has seven variables, three state variables and two static variables.

We needed data for estimation process. Since the model designed in this study had two domestic and foreign economy blocks, we needed two data sets, domestic economy data and foreign economy data. For foreign economy, the data of the euro zone for inflation by using the CPI index, GDP and the interest rates in the period of 1995-2011 were used. The data were obtained from the database of "New Area Wide Model (NAWM)" of the European Central Bank. The domestic economy data also included GDP, Consumer Price Index and the exchange rate, which were achieved from Iran's central bank economic time series database. The data on domestic interest rate were extracted from Shahmoradi (2011) study. The domestic and foreign production gaps were obtained from subtracting the permanent component (which is filtered by Hodrick Prescott Filter) from the GDP quarterly data. Since the data on exchange rates (Euro rate) for the period of 1993-2007 were not available, the Kalman Filter was used to generate the missing data. The procedure was the same for the interest rate data. These data are available in the range of 1996-2008, and after that, the data have not been generated. Therefore, the Kalman filter was used to produce them as well.

8. Model Validation

Evaluating the credibility and success of dynamic stochastic general equilibrium models are usually done with assessment the proximity of produced moments from the calibration of the constructed model with the moments of the real world. Unfortunately, no test has so far suggested for comparing the results of the model moments with the economic reality, and the related studies have only mentioned the numerical proximity of these variables. In this study, to evaluate the model, we used the comparison of the main variables simulated in the model and their values in the real world. Table 1 has compared these values.

The results showed that there is a significant part of the information contained in the data that can be used for updating our prior distributions on the model parameters. In other words, we have informative data for most of the estimated parameters. This means the posterior distributions have clear differences with the prior distributions. Comparing the obtained prior and posterior distributions showed that the model designed has been confirmed with the assumption that the exchange rate alongside the interest rate can be used as a mechanism for transfer the effects of monetary policies.

8.1. Monte Carlo Markov Chain (MCMC) Univariate and Multivariate Diagnostics

The Monte Carlo Markov Chain (MCMC) univariate diagnostics is the main source of feedback to gain confidence, or spot a problem, with result. In this model, there are two chains of 30,000 draws that 20% of each chain was discarded as losses in the sample to remove the effects of the initial values. Then, we had finally 24,000 draws. In addition, the Current acceptance ratio of both chains are closer together (0.2523 and 0.2499), which indicates the ability of the model. However, such an assessment is also carried out based on the charts. If the results from one chain are sensible, and the optimizer did not get stuck in an odd area of the parameter subspace, two things should happen. First, results within any of the however many iterations of Metropolis-Hastings simulation should be similar. And second, results between the various chains should be close. This is the idea of what the MCMC diagnostics track. The black bold lines and the dotted lines on the graphs represent specific measures of the parameter vectors both within and between chains. The dotted shows the 80% interval/quantile range based on the pooled draws from all sequences, while the black shows the mean interval range based on the draws of the individual sequences. For the results to be sensible, these should be relatively constant (although there will always be some variation) and they should converge. Dynare reports three measures: \interval", being constructed from an 80%

confidence interval around the parameter mean, \m2", being a measure of the variance and \m3" based on third moments (Mancini Griffoli, 2008). sensible results in the Monte Carlo Markov Chain univariate and multivariate diagnostic suggest the sensibility of the model with the assumption that the exchange rate alongside the interest rate is an appropriate mechanism for transmitting the effects of monetary policies.

8.2. Analysis of the Model Impulse Responses

Standard deviations of the shock applied to the variables of exchange rate, interest rate, demand and supply are respectively shown in Figures (5), (6), (7) and (8). The vertical axis of the graph shows the percentage of changes in variables from their steady state, while the horizontal axis shows the courses (here, every period is a season). The paths plotted on each chart explain the returning path of each variable to its steady state.

As can be seen in the charts, a positive shock to the equations mentioned can change the variables by 10%. However, all variables returned to their original state after a maximum of three years. Thus, the theoretical model developed is a sustainable model.

The real exchange rate is variable is the most reactive variable to the shocks. This confirms the research hypothesis stating that the exchange rate can be considered as a transmission mechanism of shocks on economic variables. After the shock applied to the exchange rate, the interest rate shock is the most effective shock on the exchange rate. The interest rate shock after changing the interest rate will changed the exchange rate through the uncovered interest parity (UIP) rule. This equation is one of the main equations of economy, and represents a condition in which the interest rate differences between the two countries are equal to the changes expected in the exchange rate between the two countries. If there is no equality without interest coverage, the profit opportunity would occur. Therefore, the exchange rate will change through these changes. However, after the interest rates, the exchange rates show the greatest response to the demand shock.

A demand shock to the economy changes the demand gap in the economy by changing the optimization of consumers' utility. This change affects the exchange rate in two ways. On one hand, by changing the interest rates by the central banks response to changes in demand gap, due to facing the inflation rate, the interest rate would change, and then again, leads to changes in the exchange rate through the uncovered interest parity (UIP) rule in an open economy. Thus, if the shock raises the interest rates, in a small open economy, the capitals will be withdrawn from the economy, which leads to increased demand for the currency and increases the exchange rate. This increase continues until that changes in interest rates and exchange rates become equal. The second way of the demand shock influence on the exchange rate after the change of aggregate demand in the economy occurs through the Phillips curve and change in the inflation gap. Changes in the real exchange rate in a country with a fixed inventory of natural resources, which are sold in international markets at random international prices, would lead to changes in the price of imported inputs with increasing the cost of production on one hand, and by changing the ratio of using the labor input and intermediate imported inputs on the other hand, which finally cause changes in prices and production levels in the economy (rate of changes in production and inflation depends on the production flexibility compared to changes). This change is summarized on the currency-based Phillips curve. After the change of inflation, the exchange rate will again change through changing the real interest rate in the uncovered interest parity relationship.

9. Policy Suggestions and Recommendations

The model presented in this paper is the simplest possible mode. Other assumptions can be added to the model to enrich and make it more complex at the same time. Other different methods can be considered for the process of the evolution of shocks in the model. There are also other modeling approaches in economic literature that can be used. The fact that Riba is forbidden in Iran does not mean that it really does not exist. As far as the economy is concerned, people use other alternatives for the interest rate (rate of return in the housing market) in Iran that can be used as a tool for monetary policy, and other alternatives are used for it in modeling.

Finally, in this research, the possible use of the exchange rate mechanism besides the interest rate mechanism was merely investigated. A model can be designed, in which the share of each of the interest rate and exchange rate mechanisms in Iran's economy can be obtained and analyzed in affecting the policies.

Appendix

Table1. Comparison the Moments Obtained From the Model With the Real World Moments

Equation	Parameter	Prior distribution	Mean of Posterior distribution	Confidence distance at 90%
Domestic IS curve	Inverse of intertemporal elasticity of substitution of domestic consumption	$\delta_1 \sim N(0.25,0.1)$	0.1772	(0.1656,0.1891)
	Coefficient of foreign production Gap in domestic IS curve	$\delta_2 \sim N(0.25,0.1)$	0.2332	(0.2589,0.2676)
	Coefficient of the real exchange rate in the previous period in domestic IS curve	$\delta_3 \sim N(0.1,0.1)$	0.1699	(0.1552,0.1796)
	Weight of the expected production gap of the future period in domestic IS curve	$\rho_y \sim B(0.5,0.25)$	0.4969	(0.4687,0.5238)
Domestic Philips curve	Coefficient of the production gap in domestic Philips curve	$\lambda_1 \sim N(0.1,0.1)$	0.092	(0.051,0.123)
	Coefficient of the real exchange rate in domestic Philips curve	$\lambda_2 \sim N(0.01,0.01)$	0.1066	(0.1061,0.1072)
	Weight of the expected inflation of the future period in domestic Philips curve	$\rho_\pi \sim B(0.75,0.35)$	0.0799	(0.0296,0.1116)
Domestic monetary policy rule	Coefficient of the expected inflation of the future period in domestic monetary policy rule	$\psi_1 \sim N(1.5,0.3)$	1.4164	(0.3839,1.4434)
	Coefficient of the production gap in domestic monetary policy rule	$\psi_2 \sim N(0.25,0.1)$	-0.0002	(-0.0115,0.0089)
Evolution of the real exchange rate in uncovered interest equity	Coefficient of the expected real exchange rate of the future period in the evolution equation of the real exchange rate in uncovered interest equity	$\delta \sim B(0.5,0.25)$	0.4146	(0.3911,0.4308)
Foreign IS curve	Inverse of intertemporal substitution elasticity of foreign consumption	$\delta^* \sim N(0.1,0.1)$	0.1523	(0.1471,0.1590)
	Weight of the expected production	$\rho_{y^*} \sim B(0.25,0.15)$	0.3176	(0.3094,0.3257)

	gap of the future period in foreign IS curve			
Foreign Philips curve	Coefficient of the production gap in foreign Philips curve	$\lambda^* \sim N(0.1,0.1)$	0.0000	(0.0000,0.0000)
	Weight of the expected inflation of the future period in foreign Philips curve	$_{\pi^*} \sim B(0.25,0.15)$	0.30087	(0.2887,0.3161)
Foreign monetary policy rule	Coefficient of the expected inflation of the future period in foreign monetary policy rule	$\psi_1^* \sim N(1.75,0.3)$	1.6857	(1.611,1.7436)
	Coefficient of the production gap in foreign monetary policy rule	$\psi_2^* \sim N(0.1,0.1)$	0.1032	(0.0929,0.1183)
Shocks applied to domestic IS curve	Shocks applied to domestic IS curve (like domestic taste shock)	$\varepsilon_t^y \sim inv\Gamma(0.1, \infty)$	0.1061	(0.0879,0.1621)
Shocks applied to domestic Philips curve	Shocks applied to domestic Philips curve (like cost shocks or inflation shocks)	$\varepsilon_t^\pi \sim inv\Gamma(1,1)$	0.8441	(0.6277,1.1191)
Shocks applied to domestic monetary policy rule	Shocks applied to domestic monetary policy rule	$\varepsilon_t^r \sim inv\Gamma(0.1, \infty)$	0.1231	(0.0523,0.1582)
Shocks applied to exchange rate equation	Shocks applied to exchange rate equation	$\varepsilon_t^q \sim inv\Gamma(0.1, \infty)$	0.8585	(0.5085,1.1352)
Shocks applied to foreign IS curve	Shocks applied to foreign IS curve (like foreign taste shock)	$_t^{y^*} \sim inv\Gamma(0.01, \infty)$	0.096	(0.022,0.0976)
Shocks applied to foreign Philips curve	Shocks applied to foreign Philips curve (like cost shocks or inflation shocks)	$\varepsilon_t^{\pi^*} \sim inv\Gamma(0.1,1)$	0.1103	(0.0362,0.1824)
Shocks applied to foreign monetary policy rule	Shocks applied to foreign monetary policy rule	$\varepsilon_t^{r^*} \sim inv\Gamma(5, \infty)$	7.9476	(7.1831,8.4979)

Figure 2. The Prior and Posterior Distributions of the Model Parameters

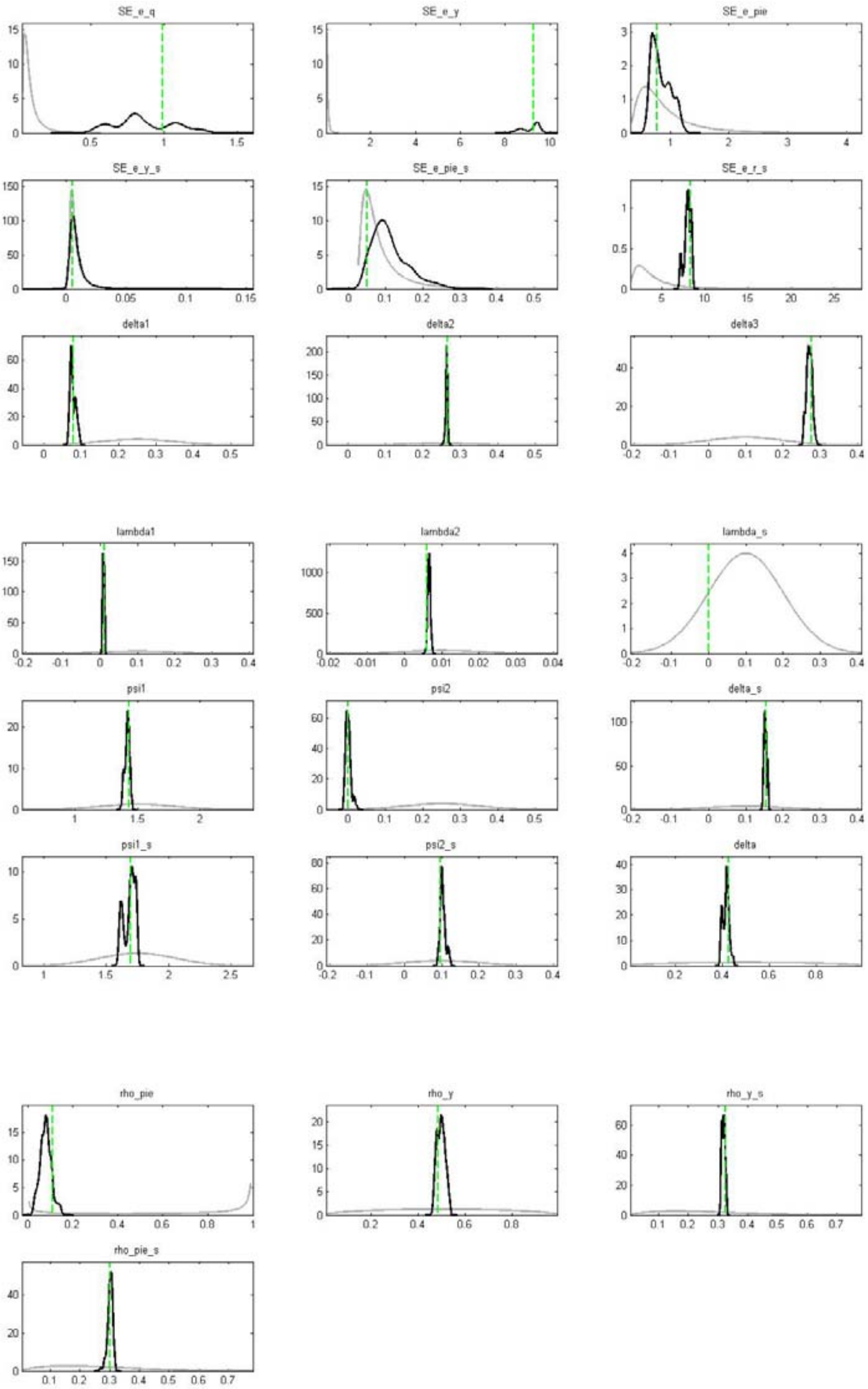
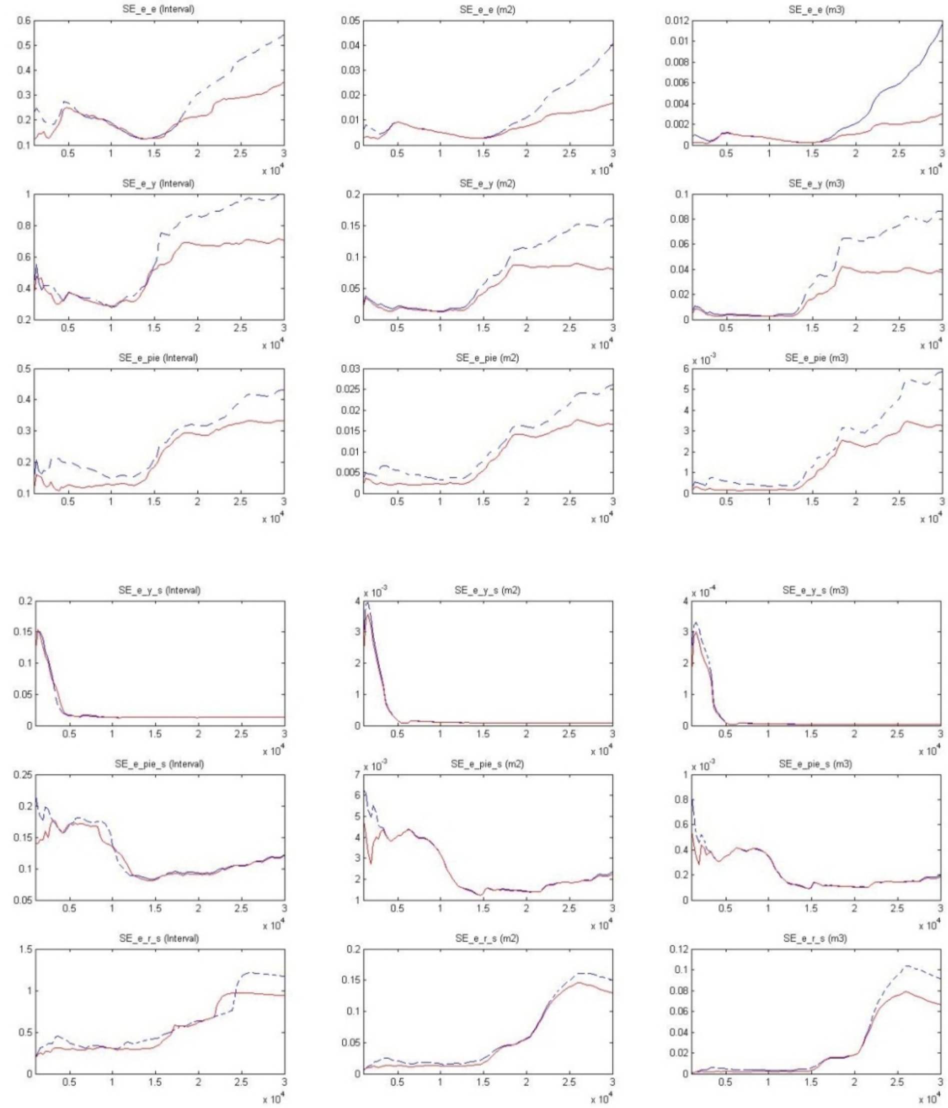
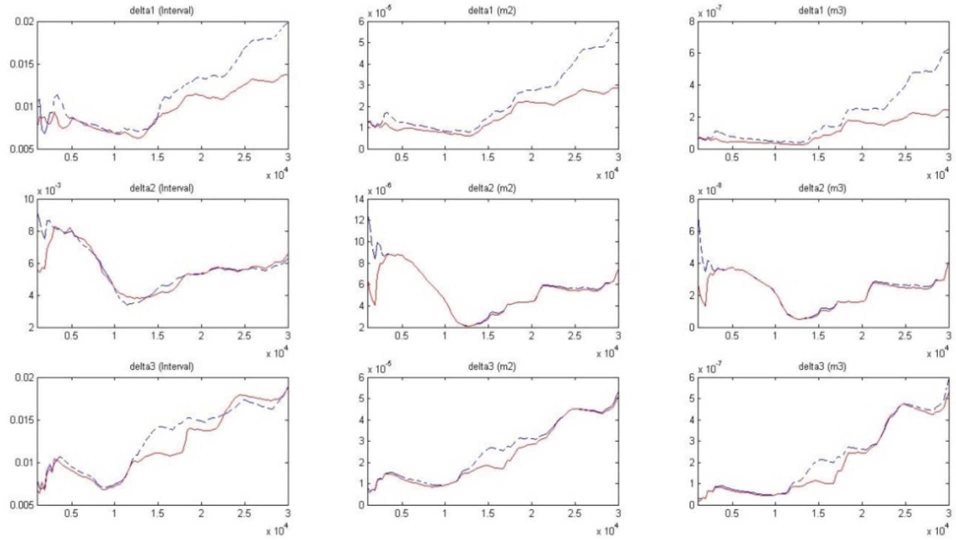
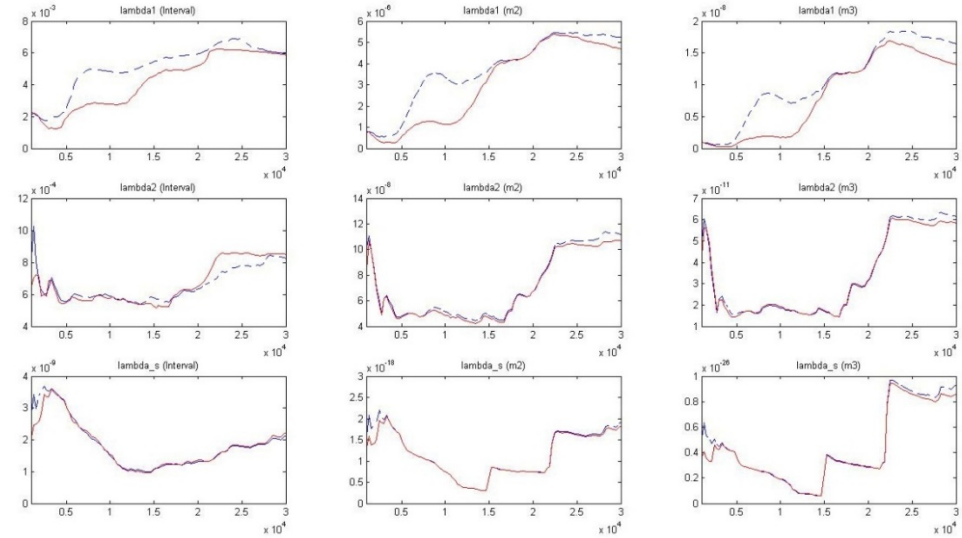
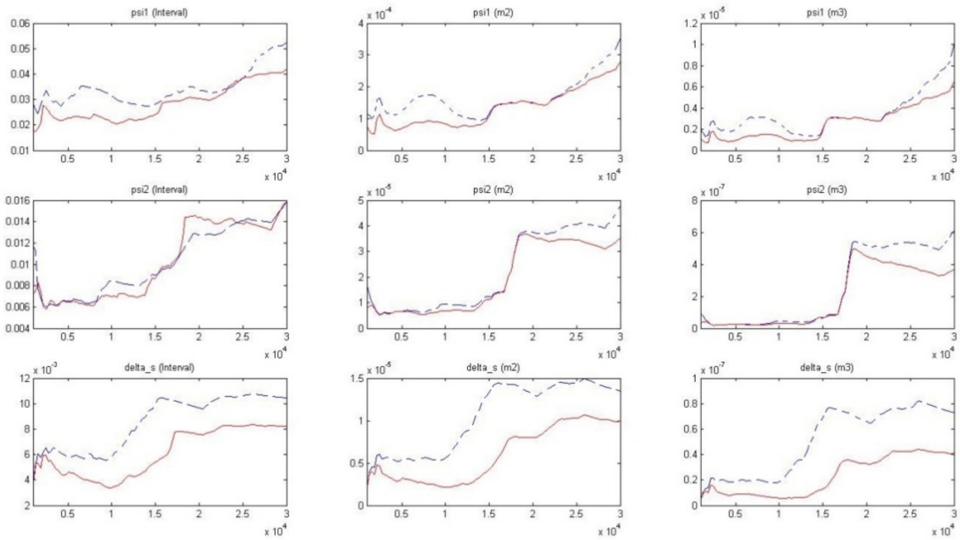


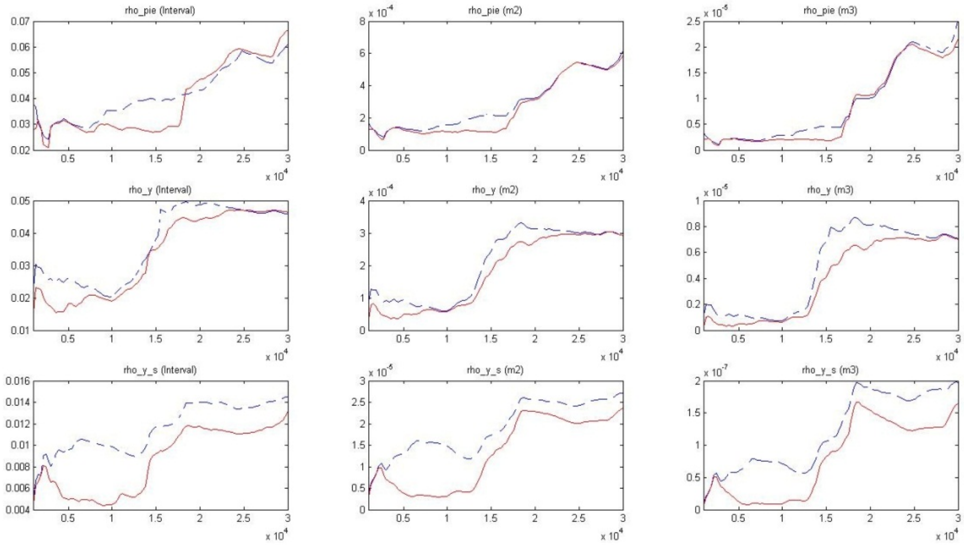
Figure 3. Monte Carlo Markov Chain (MCMC) Univariate Diagnostics

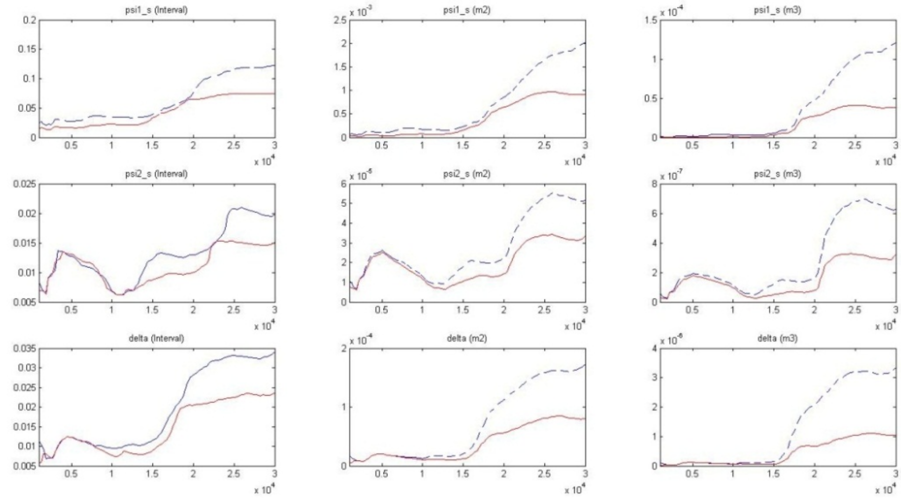



delta1 (Interval)
delta1 (m2)
delta1 (m3)
delta2 (Interval)
delta2 (m2)
delta2 (m3)
delta3 (Interval)
delta3 (m2)
delta3 (m3)


lambda1 (Interval)
lambda1 (m2)
lambda1 (m3)
lambda2 (Interval)
lambda2 (m2)
lambda2 (m3)
lambda_s (Interval)
lambda_s (m2)
lambda_s (m3)


psi1 (Interval)
psi1 (m2)
psi1 (m3)
psi2 (Interval)
psi2 (m2)
psi2 (m3)
delta_s (Interval)
delta_s (m2)
delta_s (m3)


rho_pie (Interval)
rho_pie (m2)
rho_pie (m3)
rho_y (Interval)
rho_y (m2)
rho_y (m3)
rho_y_s (Interval)
rho_y_s (m2)
rho_y_s (m3)


psi1_s (Interval)
psi1_s (m2)
psi1_s (m3)
psi2_s (Interval)
psi2_s (m2)
psi2_s (m3)
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delta (m2)
delta (m3)

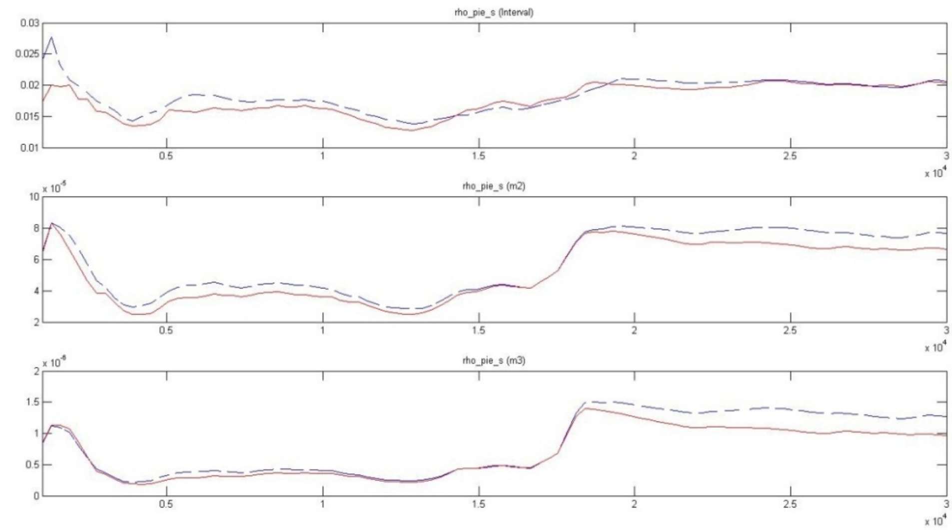

rho_pie_s (Interval)
rho_pie_s (m2)
rho_pie_s (m3)

Figure 4. Monte Carlo Markov Chain (MCMC) Multivariate Diagnostics

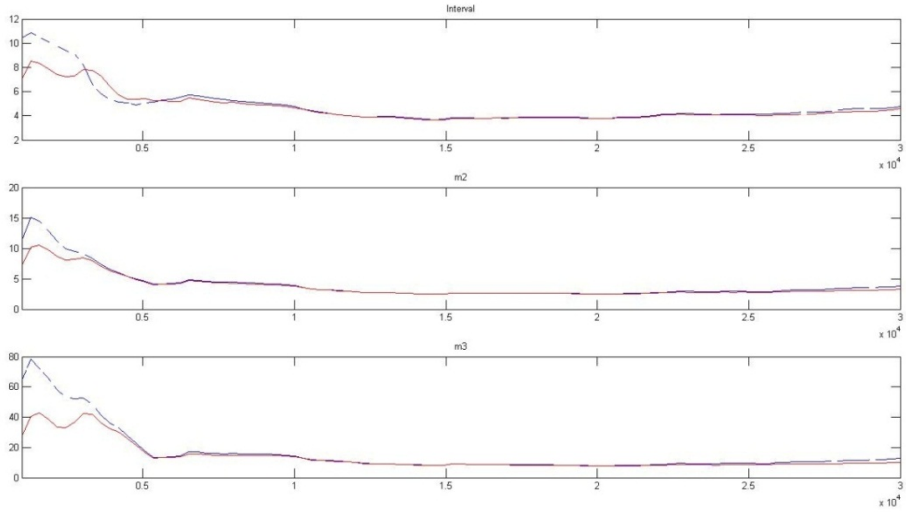


Figure 5. A Standard Deviation of a Shock Applied to the Exchange Rate

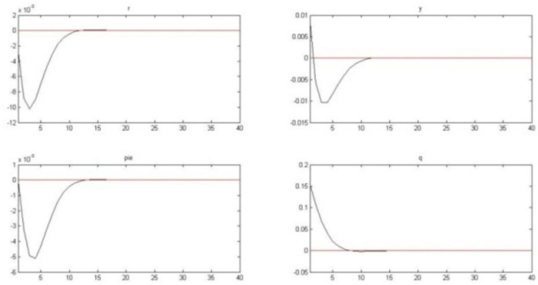


Figure 6. A Standard Deviation of a Shock Applied to the Interest Rate

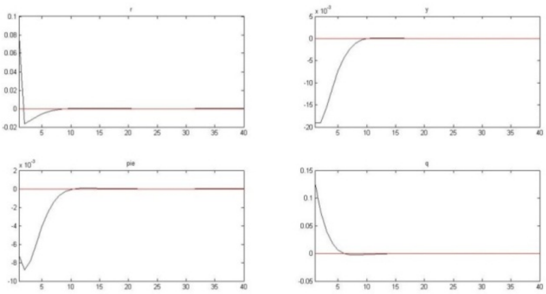


Figure 7. A Standard Deviation of a Shock Applied to the Equation IS

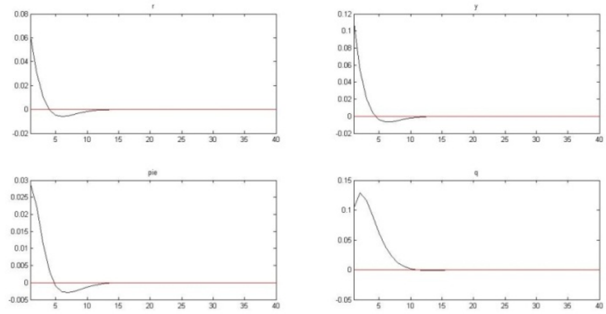
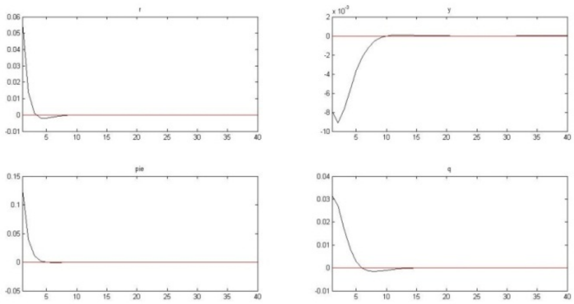


Figure 8. A Standard Deviation of a Shock Applied to the Aggregate Supply Equation



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