The Dynamics of the Exchange Rate and Extension of Monetary Trilemma (Iran Economy Case Study)**

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Abstract

Simultaneous making policy of interest rates, exchange rates and capital accounts can be extended to trilemma theory, contrary to its earlier theories, provided that the imbalances of the private sector, the government and the capital account adjusted through the policy variables such as the government expenditures, the interest rates on domestic deposits, the interest rates on domestic loans, effective exchange rates, foreign prices and foreign interest rates. On the other hand, the components of the extension of trilemma theory in the form of internal and external imbalances affect the exchange rate. In other words, if the real sector markets of the economy are not cleared through the aforementioned trilemma components, and policy variables, internal and external imbalances will be affected by opposite direction of net domestic assets (ΔNDA) and net foreign assets (ΔNFA) of the banking system. This is in accordance with the fundamental principles of the monetary approach balance of payments and exchange rate. Policy variables do not put pressure on the unofficial exchange rate as long as they have the same effect on the net changes in the domestic and foreign assets of the banking system. The purpose of this study is to consider the effect of internal and external imbalances on exchange rate through the simultaneous equations system, generating impulses in policy variables, and examining reactions in Iranian economy. In this paper, the monetary exchange rate determination model is analyzed and examined by using the extension of trilemma theory for macroeconomic data of Iran in the form of internal and external imbalances. The results of this study suggest that policy variables can stabilize the unofficial exchange rate (with other conditions being constant) through trading off internal and external imbalances. Thus, the economic policymaker can, while independently policing interest rates, capital accounts and government expenditures and other policy variables in this research, maintain exchange rate stability as a strategic variable and anchor the general level of prices.

Keywords: Trilemma, Internal and External Equilibrium, Policy Variables Trade-Off, Iran.

JEL Classification: F31, F32, F3.

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1. Introduction

The impossibility of simultaneously policing of the exchange rate, the capital account, and the interest rate in a small economy is called Trilemma theory. Assuming that policymaking for each of the aforementioned variables in the small assumed economy does not affect other countries (in case of being ceteris paribus), the key question is how the transitional mechanism of internal and external imbalances in the real and monetary sectors will effect on the exchange rate? What are the triggers on the exchange rate in the context of trilemma? Most studies in the field of trilemma emphasize on these three policy indicators, but policy indicators have been developed in some studies. The most important developmental theories of trilemma focused on foreign exchange reserves (Aizenman & Sengupta, 2013) so that internal and external imbalances are moderated through open market operations (OMOs) or foreign exchange operations (FXOs) by economic policymakers. The lack of sufficient foreign exchange reserves to balance the real and the monetary sectors on the one hand and the simultaneous policing of exchange rate, interest rate and capital account variables in a small country with an open economy on the other hand is a clear reason for creating balance of payments and foreign exchange crises (Krugman, 1979). The mechanism of the transition of internal and external imbalances to the foreign exchange sector through the system of simultaneous equations is examined in the context of the extension of trilemma theory. It should be noted that in trilemma theory, the emphasis is on exchange rate stabilization (exchange rate policy), which is one of the limitations of trilemma ignored when the exchange rate floats. Since exchange rate stabilization is important in some small economies as an anchor of price, any variable influencing exchange rate stabilization is important (Maurice, 2005).

2. Literature Review

According to Bidabad (2005) the items affecting Balance of Payment (BOP), import and export prices, liquidity, interest rates, risk at both home and abroad, customs barriers and restrictions for export and import affect the exchange rate. In this study, Bidabad used the equilibrium condition of BOP and using the Fischer's quantity theory of money (QTM) (assuming the stability of velocity of money, prices and earnings) to determine exchange rate by the imbalances of money and goods markets at home and abroad under specific assumptions.

According to Mundell (1963); Fleming (1962) monetary policy in terms of floating exchange rate and full capital mobility has the most effect on national income compared to fixed exchange rate (in general equilibrium). In sterilization conditions, the volume of the reserves is not effective on the monetary basis, in other words, if the monetary policy is expanded under the fixed exchange rate regime, reducing the reserves having a negative impact on the monetary base reduces the liquidity that should be offset by the injection of new money. The policy should be short-term because, by continuously injecting liquidity in order to counteract the decline in the reserves and its monetary effect, the reserves are continually diminished, whereas in non-sterilization and fixed exchange rate regimes, the reduction of foreign exchange reserves is effective on a monetary basis and the effect of monetary policy is neutralized. Fixed exchange rate and the effects of sterilization of the reserves to keep equilibrium is one of the reasons for limiting trilemma in concurrent interest rate and capital account policy making.

Frankel (1983) view is another important monetary base theory in determination of exchange rate. In general, according to the theory, the factors influencing the exchange rate and BOP are the relative supply and demand for money. In this model, for the stability of money demand function, the QTM is used as the basic theory of money demand function (first assumption). According to this view, the economy is permanently in full employment as prices and wages adjusted rapidly (second hypothesis). Also the theory of purchasing power parity (PPP) (third assumption) is crucial to determine the exchange rate. In the monetary BOP model, the relative increase in the supply of money relative to the demand for money (the increase in the money supply compared to the trading country) is effective in raising the exchange rate. It is therefore inferred that any of the factors affecting money supply and demand (money supply sources including net domestic and foreign assets of the banking system) can lead to exchange rate volatility and force the policy maker to intervene, or without government intervention leading to turbulence, and the currency crisis in the economy as well. The current account deficit is one of the factors influencing the exchange rate in the theoretical literature of the monetary model[1].

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[1] Based on the monetary model of exchange rate, one can see how changes in the money supply stimulate the exchange rate. The demand (M^d) and supply (M^s) of money equations in terms of relative equilibrium (based on QTM) are defined as follows for the domestic and foreign country:

$M^d = kPy$

$M^{d*} = k^*P^*y$

$k, k^* > 0$

Where M^d is money demand, k is income elasticity of money demand, P is local prices index, y is real national income, M^s is money supply and e is the exchange rate (The asterisk (*) represents foreign countries variables). In equilibrium case, equality of supply and demand of domestic and foreign currency, the following equations exist:

$M^s = M^d$

$M^{s*} = M^{d*}$

In the research of Mussa (1976) four main points are made in the development of the fundamental principles of the monetary base of BOP method:

- The exchange rate is the relative value of national currencies rather than national product.
- The exchange rate is strongly influenced by the future expectations of asset owners that are affected by the exchange rate, and these expectations are influenced by monetary policy.
- Real factors, as same monetary factors as, influence the behavior of exchange rate.
- The contradiction in the nature of fixed exchange rate policy (trilemma), though reduced by the advent of managed floating exchange rates, but it has not been entirely eliminated. This paper deals with some applications of rational expectations in exchange rates.

According to Maurice (2005) studies, the choice of a fixed exchange rate regime in the periphery economies makes monetary policy serve to stabilize the exchange rate. In their work, the reasons for choosing a fixed exchange rate regime despite the monetary policy sacrifice are:

- Unpredictable exchange rate volatility is detrimental, and most economists believe that exchange rate uncertainty will reduce international trade, reduce investment and harm human capital.
- Fixed exchange rate avoids inflationary pressures on the economy, which may be due to government budget deficits, wage policy and pricing by private sector. Therefore, the fixed exchange rate prevents the incentives to follow the macroeconomic expansionary policies of the government.
- The fixed exchange rate regime is seen as the anchor of prices after a period of price volatility in some economies to determine price expectations of the goods and services for the next economic activity period.

Aizenman & Ito (2014) examined the potential effect of divergence on open door policies (capital mobility) in the context of the macroeconomic trilemma. They found that emerging countries in the past 15 years (since the date of the survey) have adopted a combination of policy indicators of trilemma with the least relative deviation of policies. They also found that countries most likely to deviate from policy indicators are likely to be in a foreign exchange or debt crisis. However, under developing and emerging countries with the most relative deviation from the policies are less likely to be disrupted in the event of a foreign exchange or banking crisis.

Maurice (2015) examines resilience of emerging market economies to financial and monetary shocks of foreign origin through the monetary policies of these countries. In other words, how the emerging countries' interest rate policy is driven by foreign financial and monetary shocks is important in this study. The trilemma first brings to mind that the countries with a floating exchange rate have a much better position than those countries that sacrifice their monetary policy, although the floating exchange rate regime by itself does not protect countries' economies from foreign and monetary shocks. The study shows that, despite the potential economic benefits of global integration, globalization weakens economic management. In other words, the trade-off efficiency of monetary policy indicators for achieving multiple domestic goals is undermined.

Ray's (2016) study also suggests that the exchange rate regime (whether fixed or floating) affects the correlation between the short-term interest rates of periphery and center countries, so that in the floating exchange rate regime, the interest rates of these countries are less correlated and in the fixed exchange rate regime, the interest rates are higher.

Magas (2018) study shows that the resilience of the economy to external shocks depends not only on the structure of trilemma but also on other macroeconomic components. In this regard, the stability of the budget and the repayment of external debt is of particular importance. The problem of reaction to external impulses is not limited to trilemma. The debt crisis of Portugal and Greece is one of the recently confirmed examples of the use of the European currency (Euro Money) as domestic currency, whereas the Czech Republic, despite being a traditional conservative non-euro European member, has relative independence in interest rate policy, and it resists foreign shocks well through its floating exchange rate and interest rate margins.

3. Methodology

In this paper, we try to analyze the effect of internal and external imbalances on exchange rate fluctuations in line with macroeconomic theories in real and monetary equilibrium conditions based on trilemma framework. Extending of the trilemma theory in determining the exchange rate, applying the economic relations governing the structure of general equilibrium in the

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$k, k^* > 0$

Given the relative supply and demand of money in terms of equilibrium (based on the above equations) and PPP, the following equation can be obtained:

$e = P/P^*$

$M^s/M^{s*} = k.P.y / k^*.P^*.y^*$

The above equation can be rewritten as the following equation by PPP equation and replacing it with the equilibrium equations of money supply and demand and solving its reduced form of exchange rate as follows:

$M^s/M^{s*} = k.y.e / k^*.y^*$

$e = (M^s/M^{s*})/(k.y/k^*.y^*)$

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markets for goods and services and money and how they relate to each other and having a purely theoretical framework based on the applicable principles of the National Accounts System (2008) and practical and applied monetary economic theories is achieved. Assuming that the real sector markets are not cleared under this model so that it affects the net changes in the assets (domestic and foreign assets) of the banking system multiplies velocity of money, and it effects on the exchange rate as well, the main question in this paper is, what is the role of policy variables in imbalances so as to stabilize the exchange rate? The exchange rate fluctuations resulting from the model presented in this paper separates the role of the trilemma factors into two parts of internal and external imbalances affecting the exchange rate. Internal imbalances, including the private sector and the public sector deficits increase unofficial exchange rate and external imbalances (balance of payments surplus) reduce it. In other words, this paper attempts to apply policy variables such as government expenditures, interest rates on domestic deposits, interest rates on domestic loans, export, import, capital inflows and outflows effective exchange rate, and analyzes opposite effects through trading off internal and external imbalances in the model.

3. Exchange Rate Determination
3.1 Real Economy Sector Equilibrium
The equilibrium condition in the real sector of the economy is obtained by the following equation in the macro-economic:

$$I - S + G - T + EX - IM - R_f = 0 \tag{1}$$

I: private sector investment costs, S: private savings, G: government expenditures (both investment and consumption), T: net indirect taxes, EX: export, IM: import and R_f: net foreign transfer payments.
The equation shows that the balance of aggregate supply and aggregate demand, which means that the sum of the following items at macroeconomic level must be equal to zero:
- Net (deficit or surplus) private sector savings or borrowings (I-S)
- Government financial budget (deficit or surplus) (G - T)
- Net (deficit or surplus BOP) external sector (EX - IM - R_f)

3.2 Monetary Sector Equilibrium
The equilibrium condition in the monetary sector of the economy is obtained by the following equation:

$$NFA + NCG + NCP + NK = M_2 = TD + DD + CU \tag{2}$$

On the left side of the above equation, Liquidity Uses (M2) include Net Foreign Assets (NFA), Net Domestic Assets (NDA) (including Net Claims on Government (NCG), Net Claims on Private sector (NCP) and net capital account of the banking system (NK) (in the form of non-returnable assets). Liquidity items to the right of the equation include Time Deposits (TDs), Demand Deposits (DDs) and money (banknotes and coins) in circulation (CU). For convenience, the value of NK in the NCP can be considered and the following equation can be used to define liquidity:

$$M_2 = NCP + NCG + NFA \tag{3}$$

3.3 The Relationship between the Real and the Monetary Sector
According to Fisher definition, the QTM is defined as the following equation (Mankio, 107: 2016):

$$M.V = P.t = T \tag{4}$$

Here, M: supply (or demand for money), V: velocity of money, P: price level, t: quantity of goods or services traded, T: value of goods and services traded in the economy. In other words, Persons (2012) in his book, Purchasing Power of Money, describes the relationship between money and transactions in the economy, while other economists in QTM explain the relationship between income and money. In other words, the following can be said:

$$M.V = P.t = T = P.as = P.ad = AS = AD \tag{5}$$

ad: aggregate demand in economy at constant price, as: aggregate supply in economy at constant price, AS: aggregate supply in nominal price, and AD: aggregate demand in economy in nominal price.
According to the above equations, multiplying the amount of money by the velocity of money is equal to the value of transactions in the economy. Substituting Equation (3) into Equation (4) or (5) can be written as follows:

$$M.V = V[NCP + NCG + NFA] = P.t = P.as = AS \tag{6}$$

In order to connect a relationship between the real economy sector (goods and services) and the monetary sector in the economy, the above equation is differentiated. Assuming V remains unchanged, the following equation can be obtained:

$$V.\Delta M = V.\Delta NCP + V.\Delta NCG + V.\Delta NFA \tag{7}$$

The right side of the Equation (7) can be divided into two groups of banking system assets: NDA and NFA. In other words, Equation (7) can be rewritten as Equation (8):

$$V.\Delta M = V.\Delta NDA + V.\Delta NFA \tag{8}$$

On the left side of the Equation (8), the changes in the supply or demand of money multiply by the velocity of money, can be divided into two parts the sum of the changes of the domestic (ΔM^s) and foreign (ΔM^{s*}) money supply (in the domestic money) multiply by the velocity of money (V). In other words, the left of Equation (8) can be written as:

$$V \ .\Delta M = V(\Delta M^s + \Delta M^{s*}) \tag{9}$$

Since the result of changes in domestic money supply multiply by the domestic velocity of money comes from the changes in net domestic assets of the banking system multiply by the velocity of money (V.ΔNDA), and the result of changes in the foreign money supply multiply by the foreign velocity of money caused by the changes in the net foreign assets of the banking system multiply by the velocity of money (in domestic money), so by using the Equation (8) and (9), we can write the following equations:

$$V. \Delta M^s = V.\Delta NDA \tag{10}$$
$$V.e.\Delta M^{s*} = V.\Delta NFA \tag{11}$$

Assuming, the foreign prices stability, only one foreign currency in outside the world that can be converted into domestic currency by the exchange rate (e), given the stability of the domestic-to-foreign money demand ratio (k.y/ k*.y* = 1), purchasing power parity (PPP= P/P*) validity, so in accordance with the monetary model exchange rates, the following equations can be defined for the exchange rate.

$$e = M^s / M^{s*} / k. \ y / k^*. \ y^* = NDA/NFA \tag{12}$$
$$V.\Delta e = V.\Delta NDA / \ V.\Delta NFA \tag{13}$$

By simplifying algebraic Equation (12) and taking the logarithm and the derivative from the both sides, the following equation is obtained:

$$\overset{\square}{e} = \overset{\square}{NDA} - \overset{\square}{NFA} \tag{14}$$

The equation shows that the percentage of exchange rate changes, in case ceteris paribus mentioned in this study, is directly related to the percentage of NDA and inversely related to the percentage NFA of the banking system.

It is now possible to examine each of the components of the liquidity utilization arises from what part of the real economy changes in equilibrium. By comparing the components of changes in the monetary sector to the imbalances in the real sector, one can infer the concept of the reasons for the imbalances in the money sector resulting from the imbalances in the real sector of the economy as follows:

$$(I - S) \ \equiv V.\Delta NCP$$
$$(G - T) \equiv V.\Delta NCG \tag{15}$$
$$(EX - IM - R_f) \equiv V.\Delta NFA$$

The above accounting equations mean that:

- Private sector deficit (deficit or surplus), (I-S) by using the banking system resources, causes changes in NCP of banking system to the same extent.
- Government budget surplus (or deficit), (G-T), causes changes in NCG of banking system to the same extent.
- Surplus (or deficit) foreign sector, (EX-IM-Rf) in foreign currency, causes changes in NFA of the banking system to the same extent.

Here, inserting the accounting Equation (15) into Equation (13) then we can arrive at Equation (16):

$$V.\Delta e = (I\text{-}S) + (G\text{-}T) \ / \ (EX\text{-}IM\text{-}R_f) \tag{16}$$

The right-hand side of Equation (16) suggests the relationship between exchange rate, income, and BOP through absorption method (Pilbim, 1998). In other words, although internal and external imbalances in the case of non-trade-off the NDA and the NFA affect the liquidity, under these circumstances, it can have an opposite effect on the exchange rate. The Equation (16) highlights an important issue in determining of the exchange rate, so that the greater the foreign exchange reserves due to the BOP surplus (external imbalances) than the private and public sector imbalances (internal imbalances), the unofficial exchange rate expectations decrease, and conversely, the greater the internal imbalance than the external imbalance, the unofficial exchange rate market expectations increase as well. The above equation somehow illustrates the extension of the trilemma theory (Allahyarifard et al., 2019), the effect of internal (I-S) + (G-T) and external (EX-IM-Rf) imbalances on the effect of money changes multiplied by velocity of money[2].

Equation (17) shows the variables that influence the behavior of the principal components of Equation (16):

$$V.\Delta e = (I\,(i^L,\ IROLPV) - S\,(i^D,\ Y)) + (G - T(Y))/(\$.\ ((ee_x.EX\$((ee_x.P^*/P),\ IRXOILD,\ y) - ee_m.IM\$((ee_m.P^*/P),\ (EX\$ + TX\$\ -TM\$)) + ee_{xf}.TX\$((i^D\text{-}\ ee_{xf}\ .i^{D^*}),\ P) - ee_{mf}.TM\$(i^D\text{-}\ ee_{mf}.\ i^{D^*}))) \tag{17}$$

Equation (17) shows the reduced form of the equilibrium exchange rate in terms of both the monetary and real sector economy equilibrium. In Equation (17) i^L: interest rates on domestic loans, IROLPV: obligated loan, i^D: interest rates on domestic deposits, Y national income or GDP at nominal prices, y: national income or GDP at constant prices (as a production capacity), ee_x: effective exchange rate of export, IRXOILD: oil export, ee_m: effective exchange rate of import, ee_{xf}: effective exchange rate of production factor export, ee_{mf}: effective exchange rate of production factor import, P: domestic prices index, P*: foreign prices index and i^{D^*}: interest rate on foreign deposits. The $ suffix is to express variables in foreign currency.

3.4 Exchange Rate Dynamics

Based on Krugman's (1991) target zone regime, the exchange rate is determined by the following equation.

$$E_K = m\ + v + \Upsilon E\big[ds\big]/dt \tag{18}$$

Where E_k is the (log of the) spot price of foreign exchange, m the domestic money supply, v a shift term representing velocity shocks, and the last term is the expected rate of depreciation.

Since, Krugman (1991) considers the Equation (18) for the mathematical modeling of exchange rate under a target zone regime such that m changes caused by OMO and FXO are assigned to keep the minimum and maximum targeting intervals $[\underline{e},\overline{e}]$. In the model, there are two fundamental factors that affect the exchange rate, money supply (m) to stabilize the exchange rate in the minimum and maximum intervals and velocity shift term (v). If the exchange rate is within the minimum and maximum range, the value of m is constant and exchange rate expectations are E [ds]/ dt =0. Under these conditions, the exchange rate fluctuations between the minimum and maximum depend on the transfer rate (v) and m, which is similar to (12) and (14).

4. Empirical Application

To study the effect of internal and external imbalances on the exchange rate and policy influencing variables on the behavior of model endogenous variables in different scenarios and how they trade-off with one another in the Iran economy, it is necessary to use a system of simultaneous equations. The time series data of Iran's macroeconomic variables[3] in the current study are from 1959 to 2016 AD (according to 1338-1396 Hijri Shamsi). The equations have been tested several times, and the best ones have

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[2] The extension of the trilemma (Allahyarifard et al., 2019) is deduced as follows:

$V .\Delta M = (I - S) + (G - T) + (EX - IM - R_f)$

[3] The data in this study are derived from the Bank of Iran time series macroeconomic variables database.

been estimated. It should be borne in mind that endogenous and exogenous variables (policy variables) are divided into two parts: flow and inventory, so the balance between the left and right variables of the structural equations is considered in this study.

4.1 System of Simultaneous Equations

Since the exchange rate equation (Equation 17) is a function of the components of internal and external imbalances derived from the extension of the trilemma theory. Thus, it can be shown in the context of a system of equations that the internal imbalances include the imbalance of the private sector investment-national savings, government deficit and the external sector imbalances, including BOP, affecting the unofficial exchange rate.

4.1.1 System of Equations

The Equation (19) to (26) is the structural equation of the Equation (17).

$$
\begin{aligned}
&IREM = C(1) + C(2)*IREM(-1) + C(3)*D(IRIPV - IRSV + IRGV - IRGRTV) + \\
&C(4)*D(IRXV / IREEX - IRMV / IREEM + IRXFYV / IREEXFY - IRMFYV / IREEMFY) \\
&IV: C, \; IREM(-2), \; (IRIPV - IRSV + IRGV - IRGRTV), \\
&\quad (IRXV / IREEX - IRMV / IREEM + IRXFYV / IREEXFY - IRMFYV / IREEMFY), \\
&\quad IRIRD, \; IRIRL
\end{aligned}
\tag{19}
$$

The above equation confirms the effect of internal and external imbalances on the exchange rate.

$$
\begin{aligned}
&IRIPV = C(10) + C(11)*IRIPV(-1) + C(12)*IROLPV \\
&+ C(13)*(IRIRL - IRIRL(-1)) + C(14)*D92 \\
&IV: C, \; IRIPV(-2), \; IROLPV(-1), \; (IRIRL - IRIRL(-1)), \; D92
\end{aligned}
\tag{20}
$$

Investment equation (Equation (20)) as a result of economics theory, the inverse function of the interest rate.

$$
\begin{aligned}
&IRSV = C(20) + C(21)*IRIRD + C(22)*IRGDPMV(-1) \\
&IV: C, \; IRIRD(-1), \; IRGDPMV
\end{aligned}
\tag{21}
$$

According to the Keynesian model, the savings equation is considered as a function of national income.

$$
\begin{aligned}
&IRGRTV = C(30) + C(31)*IRGRTV(-1) + C(32)*D(IRGDPMV) \\
&+ C(33)*D89 + C(34)*D91 \\
&IV: C, \; IRGRTV(-2), \; (IRGDPMV - IRGDPMV(-1)), \; D89, \; D91
\end{aligned}
\tag{22}
$$

The equation of government tax revenue is considered as a function of national income according to economic theories.

$$
\begin{aligned}
&IRXDFCPI = (C(40) + C(41)*IRXDFCPI(-1) \\
&+ C(42)*(IRXOILD / FCPI - IRXOILD(-1) / FCPI(-1)) + \\
&C(43)*IREEX*FCPI / IRPGDPM + C(44)*D(IRGDPM) \\
&IV: C, \; IRXDFCPI(-2), \; IRXOILD / FCPI, \\
&\quad IREEX*FCPI(-1) / IRPGDPM(-1), \; IRGDPM / IRGDPM(-1), \\
&\quad IREEXFY, \; IREEMFY
\end{aligned}
\tag{23}
$$

In the above equation, the export at constant prices (in foreign currency) is shown as a function of the effective export exchange rate and the GDP at constant prices as a production capacity

$$
\begin{aligned}
&IRMDCIFP = (C(50) + C(51)*IRMDCIFP(-1) \\
&+ C(52)*(IREEM*FCPI / IRPGDPM) + C(53)*D(IRXD + IRXFYV / IREEXFY \\
&- IRMFYV / IREEMFY) \\
&IV: C, \; IREEM(-1), \; FCPI(-1), \; IRPGDPM(-1), \\
&\quad (IRXD + IRXFYV / IREEXFY - IRMFYV / IREEMFV)
\end{aligned}
\tag{24}
$$

$$
\begin{aligned}
&IRXFYV = C(60) + C(61)*IRXFYV(-1) + C(62)*(IRIRD - FIR*IREEXFY) \\
&+ C(63)*D91 + C(64)*D88 + C(65)*D93 + C(66)*D92 \\
&IV: IRIRD(-1), \; FIR(-1), \; IREEXFY(-1), \; D91, \; D88, \; D93, \; D92
\end{aligned}
\tag{25}
$$

Foreign currency imports at constant prices are considered as a function of the effective exchange rate of import and export earnings.

Export and import of factor income from abroad (equations 25 and 26) according to Frankel (1983) are considered as a function of the difference between domestic interest rates.

$$\begin{aligned}
& IRMFYV = (C(70) + C(71) * IRMFYV(-1) + \\
& C(72) * (IRIRD - FIR * IREEMFY) + C(73) * D(IRGDPMV) \\
& IV : C, \ IRMFYV(-2), \\
& (IRIRD(-1) - FIR(-1) * IREEMFY(-1)), \ IRGDPMV
\end{aligned} \tag{26}$$

Model accounting equations to tight the closure includes:

$$IRXD \equiv IRXDFCPI*FCPI \tag{27}$$

The above accounting equation shows the relationship between nominal exports (million Dollars) and real exports (million Dollars).

$$IRXV \equiv (IREEX* IRXD)/1000 \tag{28}$$

The above equation indicates the relationship between the nominal exports (billion Rials) and the nominal exports (million Dollars).

$$IRMD \equiv IRMDCIFP*IRCIFP \tag{29}$$

The above equation indicates that the relationship between nominal imports (million Dollars) and real imports (million Dollars).

$$IRMV \equiv (IREEM* IRMD)/1000 \tag{30}$$

The above equation indicates the relationship between nominal imports (billion Rials) and nominal imports (million Dollars).

$$IRGDPMV \equiv IRCV+ IRIV+ IRGV+ IRXV- IRMV+ IRDISV+ IRNITV \tag{31}$$

The above equation illustrates the relationship between nominal GDP and its accounting components (billion Rials).

$$IRPGDPM \equiv IRGDPMV/IRGDPM \tag{32}$$

The above equation indicates the relationship between real GDP and nominal GDP, agregate price deflator.

$$IRGDPM \equiv (IRCV+ IRIV+IRGV+ IRXV- IRMV+ IRDISV+ IRNITV)/IRPGDPM \tag{33}$$

The above equation illustrates the relationship between real GDP and its accounting components (billion Rials).

Endogenous variables

1	IREM	Market exchange rate, Rials/Dollar
2	IRGRTV	Government tax revenue, billion Rials
3	IRIPV	Private investment at current prices, billion Rials
4	IRMD	Import at current prices, million Dollar
5	IRMV	Import at current prices, billion Rials
6	IRSV	Private Saving at current prices, billion Rials
7	IRMDCIFP	Real import, million Dollars
8	IRMFYV	Nominal import of factor income from abroad, billion Rials

9	IRPGDPM	Gross domestic product price deflator
10	IRXFYV	Nominal export of factor income from abroad, billion Rials
11	IRXD	Export, million Dollars
12	IRXDFCPI	Real export, million Dollars
13	IRXV	Nominal export, billion Rials
14	IRGDPM	Real gross domestic product at market prices, billion Rials
15	IRGDPMV	Nominal gross domestic products at market price, billion Rials

Exogenous variables

1	FCPI	Average OECD consumer price index
2	FIR	Average OECD Interest rate (banking system)
3	IRCV	Nominal private consumption, billion Rials
4	IRCPI	Consumer price index
5	IRCIFP	Import CIF price index
6	IRDISV	Nominal discrepancies, billion Rials
7	IREEM	Effective exchange rate for Import
8	IREEMFY	Effective exchange rate for Import of factor income from abroad
9	IREEX	Effective exchange rate for Export
10	IREEXFY	Effective exchange rate for Export of factor income from abroad
11	IRGV	Nominal government consumption, billion Rials
12	IRNITV	Nominal net indirect taxes, billion Rials
13	IROLPV	Government budget obligatory loans granted to private sector
14	IRIRD	Saving deposits weighted average interest rate (banking system)
15	IRIRL	Loans weighted average interest rate (banking system)
16	IRXOILD	Export of oil, million Dollars
17	D88	Dummy variable for the 1388
18	D89	Dummy variable for the 1389
19	D91	Dummy variable for the 1391
20	D92	Dummy variable for the 1392
21	D93	Dummy variable for the 1393

4.1.2 Structural Equations Identification

In general, before estimating the parameters of the model equations, it is necessary to identify the order (necessary condition) and the rank condition (necessary and sufficient condition) for consistent estimation[4]. As can be seen in Equations (19) to (33) there is a stochastic equation or an accounting equation for each endogenous variable in Equation (19). The absence of linear combination in the vectors of the instrumental variables and other independent variables determines the rank condition. In other

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[4] If the structural equation has an endogenous variable (y_1) on the left, an endogenous variable (g_1) and an independent variable (k_1) on the right, so that the endogenous variable to the right of the equation is correlated with the error term, then the estimation of the model equation coefficients is inconsistent under the OLS method. If there is a structural equation for each right endogenous variable to describe its behavior then it is called a complete system of equations. Assuming that K independent variables exist in the system of equations, then the minimum number of independent variables necessary for consistent estimation in the structural equations is obtained through the order condition for identification. The order condition is obtained from $k_2 \geq g_1$ provided $k_2 = K - k_1$; k_2 is the number of the independent variables outside the equation examined for identification in the equation system that affect the behavior of the endogenous variables to the right of the equation. It should keep in mind that the order condition is necessary to identify and the rank condition is sufficient as well. Also, without using the matrices used to obtain the rank order, the two-stage least squares (2SLS) method can have a consistent estimate for the parameters, so that in the first step, the endogenous variables of the equation are obtained using the other independent variables affecting the behavior of the endogenous variable are estimated by the OLS method and secondly, by estimating the variables in the first step, the endogenous variable to the left of the equation is estimated. Therefore, the order condition identification requirement in the 2SLS method is sufficient for consistent estimation of model equations (Baltagi, 2008: pp.256: 277). In the model examined in this paper, Equation (19) has 7 endogenous variables on the right and 9 structural equations that each equation is estimated from at least one independent variable outside of Equation (19). Therefore, the order condition is over-identified which can be estimated by using the 2SLS method. The recent issue is also mentioned in Chapter15 of the book Econometrics Analyzes (Green, 2002: 393) that "It is unusual for a model to pass the order but not the rank condition".

words, if the model of the M equations and the M endogenous variables can only have at least one non-zero determinant of the matrix (M-1) * (M-I) related to the coefficients of the endogenous and predetermined variables outside the examined equation but included in other model equations is identified (Gujarati, 2004).

The model has 8 random equations, 7 accounting equations, 15 endogenous variables (M = 15) and 28 pre-determined explanatory variables (K = 33)[5]. So the model equations (equation19 to 26) are over-identified.

4.1.3 Stationary of the Variables Consideration

As can be seen in the table (1), some variables are at least first-order integrated I(1), and the first differences are used in the regression equations for being stationary. Therefore, in order to avoid spurious regressions in the system of equations, first-order difference is used. According to table (2), all the parameters of lagged variables of the structural equations are approximately equal to one, and mathematically if the lagged variable is moved to the left of the equation then the endogenous variable difference is obtained[6]. In other hand, after numerous and repeated reviews this solution can be solved first, I(1) and random walk by first order difference through insertion of first order lagged dependent variable to the right, then by using the residual inverse through Weighted Least Squares method (WLSs) eliminate variance heterogeneity of the residuals that have more than first-order integrated I (1)[7].

Table 1. Generalized Dickey-Fuller unit root test on the level of the model variables

Variable	Augmented Dickey-Fuller test statistic	Prob.*	t-Statistic
IREM	1.579045	0.9707	-1.946764
IRIPV	-4.655605	0.0000	-1.947975
IRSV	0.317437	0.7732	-1.947975
IRGV	6.668408	1.0000	-1.947520
IRXV	2.965434	0.9990	-1.947975
IRMV	-.225549	0.5997	-1.947975
IRXFYV	3.373523	0.9997	-1.947975
IRMFYV	-4.31828	0.0001	-1.947975
IROLPV	-2.309784	0.0214	-1.946654
IRIRL	0.665009	0.8568	-1.946654
IRIRD	1.518375	0.9668	-1.946764
IRGDPMV	1.390017	0.9569	-1.947975
IRXDFCPI	-0.930043	0.3095	-1.946654
IRXOILD	-0.760627	0.3824	-1.946654
FCPI	-1.157899	0.2222	-1.946996
IREEX	5.273733	1.0000	-1.946654
IRPGDPM	2.875961	0.9987	-1.947975
IRMDCIFP	-1.575963	0.1074	-1.946764
IREEM	2.595083	0.9972	-1.947975
IRXD	.177568	0.7341	-1.946654
IREEXFY	1.270808	0.9467	-1.946654

---

[5] Number of independent variables in the model (26) + Number of lagged endogenous variables (7) = Number of explanatory and predetermined variables (K = 33). The 26 independent variables included: 5 dummy variables + 5 weighted variables (residuals of the model equations) to eliminate heteroskedasticity + 16 policy variables.

[6] The stability of the endogenous variables of the structural equations of this model, without considering the lagged endogenous variable on the right of the equations, can be examined by Engle-Granger method. The stability results are discussed in table (3).

[7] Economic theories refer to possible equilibrium relationships between variables, but do not explain the relevant adjustment processes at work. If there is an equilibrium relationship, then the variables specified in the relationship should be cointegrated. Testing for cointegration is, in fact, the test of equilibrium relation, and hence of whether the model is well defined. When the variables are cointegrated, the estimates of the long-run equilibrium parameters are consistent and highly efficient. Indeed these estimates are "super consistent", converging even more quickly in probability to the true parameter values than the least-squares estimator in the standard case. This consistency property does not require the absence of correlation between the right-hand-side variables and the error term, unlike consistency results in the usual classical regression-model context (Perman, 1991).

IREEMFY	7.721210	0.9999	-1.947248
FIR	-0.574141	0.4643	-1.946654

Source: Obtained from results of the research

Some economic events and structural failures in some variables were corrected through dummy variables. The statistics of F and its probability are highly acceptable such that the standard deviation error statistics, t, and significant probability close to zero confirm the parameters (see Table 2).

4.2 Estimation of the System of Equations by OLS, 2SLS and 3SLS Methods

Since the explanatory variables in the simultaneous equations are correlated with the error term, so the OLS parameter estimation is not consistent with classical econometric issues[8], so it is necessary to use the 2SLS or 3SLS (IV) variables to estimate the regression equations parameters. Three-Stage Least Squares method (3SLS) is a version of Two-Stage Least Squares (2SLS) in the Seemingly Unrelated Regression equations (SUR). On the other hand, if the structural equation error term has heteroskedasticity and the correlation between error terms with each other structural equation is recognized, then 3SLS is more efficient (less variance) than 2SLS[9]. If there is no correlation between the error terms of the simultaneous equations, then the results of the estimators in the 2SLS and 3SLS methods are the same. Another point is that since 2SLS is a single-equation estimation method it is not possible to examine the covariance between the residuals of the equations.

Table 2. Results of Estimates and Statistics by OLS, 2SLS and 3SLS Methods

Variable	Type of estimates	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	OLS	261.45	28.39	9.21	0.0000
	2SLS	306.40	66.93	4.59	0.0000
	3SLS	264.95	78.77	3.36	0.0008

---

[8] The estimators are consistent when the assumption that X_t is non-random, or no correlation between the explanatory variables and the disturbance component is proved. That is, despite the autocorrelation with increasing sample size, the variance of the estimating parameters tends to zero, ie:

$$plim(\hat{\beta}) = \beta$$

9 2SLS is a single equation estimator that does not take into account the covariances between the residuals of simultaneous equations, so this method is generally not efficient. In contrast, 3SLS is a systematic method for simultaneous estimation of all coefficients of the model, after simultaneous estimation of all coefficients, the weights are formed, and the model is again estimated using the estimated weight matrix. System estimators such as 3SLS consider zero constraints of each structural equation as the variance-covariance matrix of the whole system of equations residuals. The first two stages of 3SLS are similar to 2SLS, and the third stage uses Feasible Generalized Least Squares (FGLS) in the same way as SUR. 3SLS uses the 2SLS residuals for consistent estimation of the structural equation (Σ) covariance matrices. In 3SLS, structural equations overlap like SUR, in mathematical terms. So consider:

$$y = Z\delta + u$$

$$y = \begin{bmatrix} y_1 \\ y_2 \\ . \\ . \\ y_G \end{bmatrix} ; Z = \begin{bmatrix} Z_1 & 0 & 0 & 0 \\ 0 & Z_2 & 0 & 0 \\ . & . & . & . \\ 0 & 0 & 0 & Z_G \end{bmatrix} ; \delta = \begin{bmatrix} \delta_1 \\ \delta_2 \\ . \\ \delta_G \end{bmatrix} ; u = \begin{bmatrix} u_1 \\ u_2 \\ . \\ u_G \end{bmatrix}$$

where in:

u with 0 mean and $\sum \otimes I_T$ variance-covariance indicating the correlation between the residuals of the structural equations. $\sum = \begin{bmatrix} \sigma_{ij} \end{bmatrix}, E(u_i u'_j) = \sigma_{ij} I_T$, and the marker $\otimes$ represents the Kronecker variance - residual covariance. If there is no correlation between the residuals of the structural equations with each other then $\sum \delta_{ij} = 0$, as a diagonal matrix, therefore the estimators of the least squares and ordinary least squares are similar (Baltagi, 2008: pp.256: 277).

IREM(-1)	OLS	1.014	0.002	484.84	0.00000
	2SLS	1.011	0.003	296.53	0.0000
	3SLS	1.016	0.007	144.93	0.0000
D(IRIPV- IRSV+ IRGV-IRGRTV)	OLS	0.001	0.00008	13.11	0.0000
	2SLS	0.001	0.0001	9.42	0.0000
	3SLS	0.0009	0.00002	4.01	0.0000
D(IRXV/IREEX) - (IRMV/IREEM) + (IRXFYV/IREEXFY)-(IRMFYV/IREEMFY)	OLS	-13.79	2.39	-5.77	0.0000
	2SLS	-17.55	5.64	-3.11	0.0030
	3SLS	-14.42	6.62	-2.18	0.0299
Intercept	OLS	7067.74	7243.03	0.98	0.3337
	2SLS	6309.48	7795.32	0.81	0.4220
	3SLS	6284.52	7423.56	0.85	0.3984
IRIPV(-1)	OLS	1.08	0.01	104.60	0.0000
	2SLS	1.07	0.02	63.97	0.0000
	3SLS	1.07	0.02	2567	0.0000
IROLPV	OLS	0.56	0.06	9.12	0.0000
	2SLS	0.69	0.14	5.13	0.0000
	3SLS	0.69	0.13	5.38	0.0000
(IRIRL-IRIRL(-1))	OLS	-12039.17	5279.18	-2.28	0.0267
	2SLS	-16725.79	6975.73	-2.40	0.0202
	3SLS	-16710.36	6655.21	-2.51	0.124
D92	OLS	-467599.5	58073.07	-8.05	0.0000
	2SLS	-518314.8	77059.63	-6.73	0.0000
	3SLS	-518246.5	72536.69	-7.05	0.0000
Intercept	OLS	-250670.9	17986.51	-13.94	0.0000
	2SLS	-312893	33811.88	-9.25	0.0000
	3SLS	-244555.1	35909.34	-6.81	0.0000
IRIRD	OLS	38276.33	2628.25	14.56	0.0000
	2SLS	47386.45	4947.54	9.58	0.0000
	3SLS	37959.78	5217.06	7.28	0.0000
IRGDPMV(-1)	OLS	0.39	0.008	49.15	0.0000
	2SLS	0.37	0.015	25.02	0.0000
	3SLS	0.39	0.01	25.58	0.0000
Intercept	OLS	-892.62	2313.75	-0.39	0.7012
	2SLS	-962.83	2363.62	-0.41	0.6855
	3SLS	-893.82	2254.57	-0.40	0.6920
IRGRTV(-1)	OLS	1.16	0.02	53.55	0.0000
	2SLS	1.16	0.02	52.34	0.0000
	3SLS	1.16	0.02	54.88	0.0000
D(IRGDPMV)	OLS	0.04	0.007	5.27	0.0000
	2SLS	0.04	0.007	4.99	0.0000
	3SLS	0.04	0.007	5.24	0.0000
D89	OLS	-94729.88	16077.64	-5.89	0.0000
	2SLS	-94958.33	16242.40	-5.85	0.0000
	3SLS	-95007.14	15496.55	-6.13	0.0000
D91	OLS	-53079.03	16217.26	-3.27	0.0019
	2SLS	-53565.12	16387.80	-3.27	0.0019
	3SLS	-53941.74	15634.96	-3.45	0.0006
Intercept	OLS	-1520.59	160.35	-9.48	0.0000
	2SLS	-1395.74	154.00	-9.06	0.0000
	3SLS	-1763.34	452.68	-3.89	0.0001

IRXDFCPI(-1)	OLS	1/00	0.003	334.40	0.0000
	2SLS	1/00	0.002	450.74	0.0000
	3SLS	1/00	0.009	115.07	0.0000
IRXOILD/FCPI-IRXOILD(-1)/FCPI(-1)	OLS	0.83	0.1	57.13	0.0000
	2SLS	0.83	0.01	71.37	0.0000
	3SLS	0.84	0.03	25.25	0.0000
IREEX*FCPI/IRPGDPM	OLS	0.17	0.03	5.69	0.0000
	2SLS	0.14	0.03	4.52	0.0000
	3SLS	0.22	0.09	2.36	0.0188
D(IRGDPM)	OLS	0.03	0.003	13.46	0.0000
	2SLS	0.003	0.001	23.32	0.0000
	3SLS	0.03	0.007	4.46	0.0000
Intercept	OLS	112846.9	5624.06	20.06	0.0000
	2SLS	119149.1	6066.96	19.64	0.0000
	3SLS	83608.23	20792.606	4.02	0.0001
IRMDCIFP(-1)	OLS	0.91	0.02	47.64	0.0000
	2SLS	0.90	0.02	43.47	0.0000
	3SLS	0.97	0.06	15.83	0.0000
(IREEM*FCPI/IRPGDPM)	OLS	-14.16	0.65	-21.86	0.0000
	2SLS	-14.90	0.69	-21.39	0.0000
	3SLS	-10.62	2.44	-4.35	0.0000
D(IRXD+IRXFYV/IREEXFY-IRMFYV/IREEMFY)	OLS	1.43	0.08	19.18	0.0000
	2SLS	1.52	0.08	19.00	0.0000
	3SLS	1.12	0.26	4.34	0.0000
Intercept	OLS	-369.85	212.73	-1.74	0.0883
	2SLS	-298.12	255.62	-1.17	0.2491
	3SLS	-311.13	239.03	-1.30	0.1937
IRXFYV (-1)	OLS	0.96	0.02	50.32	0.0000
	2SLS	0.95	0.03	31.04	0.0000
	3SLS	0.95	0.03	33.17	0.0000
IRIRD-FIR*IREEXFY	OLS	-0.25	0.03	-7.85	0.0000
	2SLS	-0.24	0.06	-4.13	0.0001
	3SLS	-0.24	0.05	-4.50	0.0000
D91	OLS	28230.86	1302.04	21.68	0.0000
	2SLS	28438.76	1337.61	21.26	0.0000
	3SLS	28446.82	1251.62	22.73	0.0000
D88	OLS	-15367.00	1305.66	-11.77	0.0000
	2SLS	-15224.69	1327.01	-11.47	0.0000
	3SLS	-15251.71	-1241.11	-12.29	0.0000
D93	OLS	-22578.59	1645.75	-13.72	0.0000
	2SLS	-22255/00	1868.64	-11.91	0.0000
	3SLS	-22285.11	1748.68	-12.74	0.0000
D92	OLS	17001.52	1449.77	11.73	0.0000
	2SLS	17405.01	1464.6	11.88	0.0000
	3SLS	17316.56	1367.71	12.66	0.0000
Intercept	OLS	5.96	0.15	38.51	0.0000
	2SLS	5.62	0.18	30.84	0.0000
	3SLS	4.93	1.32	3.73	0.0002
IRMFYV(-1)	OLS	1.04	0.005	210.96	0.0000
	2SLS	1.05	0.006	184.17	0.0000
	3SLS	1.06	0.04	25.76	0.0000
) IRIRD - FIR*IREEMFY (	OLS	0.008	0.001	40.61	0.0000

	2SLS	0.007	0.0002	31.35	0.0000
	3SLS	0.006	0.001	5.56	0.0000
D(IRGDPM)	OLS	0.001	0.00006	25.98	0.0000
	2SLS	0.001	0.000006	202.62	0.0000
	3SLS	0.001	0.00005	2.35	0.0191

Source: Obtained from results of the research

According to the table (2), R-squared and Adjusted R-squared show very good explanatory power of the equations. The use of lagged first order endogenous variables on the right of the equations increases R-squared (R^2). Dorbin-Watson's statistics show good quality model equations specifications and no serial correlation in the residuals. It should be noted that in cases of the high R-squared, it is not necessary to consider the Dorbin-Watson's statistic on the problem of the serial correlation of the residuals, this is not. However, acceptable either weak serial correlation or when the statistic falls within the uncertain limits of serial correlation in the Dorbin-Watson's table. Note that the Dorbin-Watson's statistic is not usable for the expression of the residuals due to the existence of an endogenous lagged variable on the right of the equation. It should keep in mind that if R^2 is high, the estimates of the equations in the two methods OLS and 2SLS are very close to each other (Gujarati, 2004, p. 879).

In order to examine the residual stability, prior to simulating the actual data, it is necessary to examine the Dickey-Fuller unit root test according to the table (3).

Table 3. Group unit root test: Summary

Series: RESID04, RESID06, RESID08, RESID09, RESID10, RESID11, RESID12, RESID13				
Date: 05/27/19 Time: 02:37				
Sample: 1338 1395				
Exogenous variables: None				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 8				
Newey-West automatic bandwidth selection and Bartlett kernel				
			Cross-	
Method	Statistic	Prob.**	sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-18.0355	0.0000	8	432
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	407.884	0.0000	8	432
PP - Fisher Chi-square	933.188	0.0000	8	443
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Obtained from results of the research

According to the statistics of the table (3) based on the Engle-Granger method, the residuals of the regression equations of the model were evaluated for stability, the results show both common or individual do not have any unit root.

4.3 Simulation
After estimating the parameters, the model was solved statically for the Ex-post simulation by using the Broyden method. The time searies of the main equation of the proposed model for real (squared) and simulated (starred) information is shown in Figure (1).
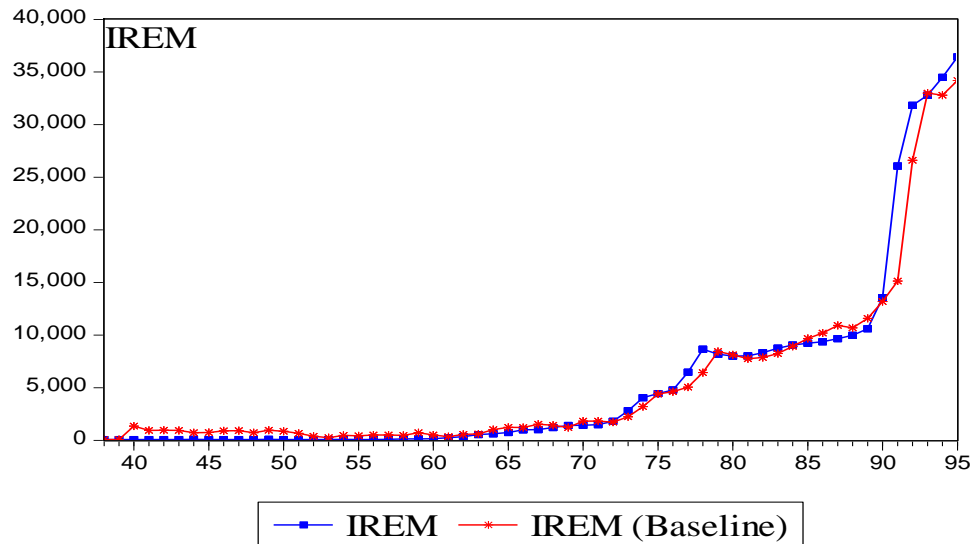
Figure (1): An informal exchange rate trend chart based on real and simulated information
Source: Obtained from results of the research

4.4 Model Evaluation

To evaluate the model, the root mean square error (Rmsp (e)) method, which represents the percentage error of the simulated variable in the model, was used as follows:

$$Rmsp(e) = 100. \sqrt{\frac{\sum_{i=1}^{M}(\frac{e_t}{Y_t})^2}{M}} \tag{34}$$

$e_t = Y_t - \hat{Y}$: Simulated variable error
Y_t: The actual variable
$\hat{Y}$: Simulated variable

Table 4. Root Mean Square Error of Simulated Error (Rmsp (e)) 1998-2016

Type of estimation	IREM	IRIPV	IRSV	IRGRTV	IRXV	IRMV	IRXFYV	IRMFYV
OLS	13.58	10.79	40.28	17.88	15.64	48.64	41.25	34.09
2SLS	14.02	10.64	46.86	17.87	15.73	50.61	41.25	34.27
3SLS	13.28	10.64	40.39	16.99	13.03	43.50	43.00	35.47
	IRGDPMV	IRXD	IRMD	IRXDFCPI	IRMDCIFP		IRPGDPM	
OLS	12.59	15.64	48.64	15.64	48.64		0.000001	
2SLS	12.97	158.73	50.61	15.73	50.61		0.0001	
3SLS	10.98	13.02	43.50	13.02	43.50		0.0001	

Source: Obtained from results of the research

Table (4) shows the root mean square error of the endogenous variables for the 18-year period ending in 2016, which illustrates the appropriate model explanation.

4.5 Impulse Analysis

After simulation of endogenous variables through comparative static solution of the model and examining the validity of the model, by generating impulse in each of the exogenous variables, several scenarios can be defined with respect to impulse and response of the endogenous variables. The analysis shows that despite the imbalances in the real sectors of the economy, the

unofficial market exchange rate does not fluctuate if internal and external imbalances are cleared through the trade-off private, government and BOP imbalances. The response of the impulses considered varies according to the type of relationship of the exogenous variables. Various scenarios with the assumption that other conditions are stable (ceteris paribus) over the 18-year period ending in 2016 are shown in table (5).

Table 5. Exchange of imbalances in real sector due to shocks (OLS / 2SLS / 3SLS

	Type of estimation	10% impulse on government spending	1% impulse domestic deposit interest rate	1% Impulse domestic loan interest rate	10% Impulse effective exchange rare	10% impulse foreign prices	1% impulse foreign deposit interest rate
IRIPV	OLS	-	-	-1.07	-	-	-
	2SLS	-	-	-1.48	-	-	-
	3SLS	-	-	-1.48	-	-	-
IRSV	OLS	-	2.70	-	-	-	-
	2SLS	-	3.37	-	-	-	-
	3SLS	-	2.78	-	-	-	-
IRGRTV	OLS	0.60	-	-	2.11	0.62	-
	2SLS	0.57	-	-	2.11	0.54	-
	3SLS	0.63	-	-	1.72	0.72	-
IRXV	OLS	0.83	-	-	13.53	11.11	-
	2SLS	0.80	-	-	13.53	10.97	-
	3SLS	0.80	-	-	12.71	11.18	-
IRMV	OLS	1.74	-	-	-0.12	3.25	-
	2SLS	1.77	-	-	-0.47	3.29	-
	3SLS	1.32	-	-	-5.63	384	-
IRXFYV	OLS	-	-	-	1.87	-	5.36
	2SLS	-	-	-	1.79	-	5.14
	3SLS	-	-	-	1.83	-	5.24
IRMFYV	OLS	0.36	-	-	1.16	017	-0.11
	2SLS	0.33	-	-	1.10	0.11	-0.10
	3SLS	0.30	-	-	0.73	0.21	-0.09
IREM	OLS	0.13	-	-	-1.30	-0.26	-0.03
	2SLS	0.16	-	-	-1.68	-0.28	-0.03
	3SLS	0.09	-	-	-1.10	-0.35	-0.03

Source: Obtained from results of the research

According to table (5), a 10% increase in government expenditures, after trading off internal and external imbalances, has an effect on the unofficial exchange rate about 0.09% to 0.16% (in case ceteris paribus). In other words, under general equilibrium as long as the government expenditures shocks are offset through external sector imbalances, it will not have an involuntary effect on the unofficial exchange rate. The impact of other policy variable shocks on unofficial exchange rates such as interest rates on domestic deposits, interest rates on domestic loans, effective exchange rates on exported-imported goods and services, expored-imported factor income from abroad, foreign prices, and foreign interest rates can be similarly analyzed .

5. Concluding Remarks

The main purpose of this paper is to provide a theoretical framework for examination of the relationship between internal and external imbalances and the unofficial exchange rate. Based on the extension of the trilemma theory in general equilibrium framework, the trade-off between the real sector imbalances of the economy reduces the impact of internal and external imbalances on the unofficial exchange rate. In other words, this paper shows that the policy variables affecting the real economy components so that internal and external imbalances have moderated each other, it is then possible to avoid high volatility of the

exchange rate as one of the key elements of the trilemma theory. Trading off financial imbalances in the private, public and foreign sectors of the economy enables the equilibrium of the real sector to be maintained without involuntary shock (with other factors remaining constant), and the unofficial exchange rate is less volatile. Failure to clear internal and external imbalances in the real sector of the economy, the imbalances in the form of changes in the net domestic and foreign assets of the banking system is transferred to the unofficial exchange rate. The use of simultaneous equations for time series data of macroeconomic variables of Iran proves the above theory so that any impulse in the policy variables confirms the effect on the exchange rate. In other words, a 10 percent increase in government expenditures, will increase the unofficial exchange rate fluctuation by 0.9-0.16 percent. Any impulse is driven by other policy variables, such as rising domestic interest rates (which lead to increased national savings or reduced demand for real balances) or increasing tax revenues or affecting the external sector, then the imbalances in the real sector of the economy can be moderated by the increase in government expenditures. The issue of trade-off between the imbalances can be analyzed in the form of different impulses in policy variables and the response of real-sector endogenous variables in different scenarios. Simply put, the purpose of this article is to illustrate the important point that, as long as macroeconomic policy-making has a neutral effect on the financial markets of the private sector, the government sector and the external sector, it does not cause real and currency fluctuations. From a theoretical point of view, this can be seen as a new approach to the development of the trilemma theory that has a realistic and practical view of equilibrium in the real, monetary and foreign exchange rate sectors. The econometric study of the empirical application in this paper suggests a strong confirmation of the recent expression.

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Appendices

OLS-Simulation
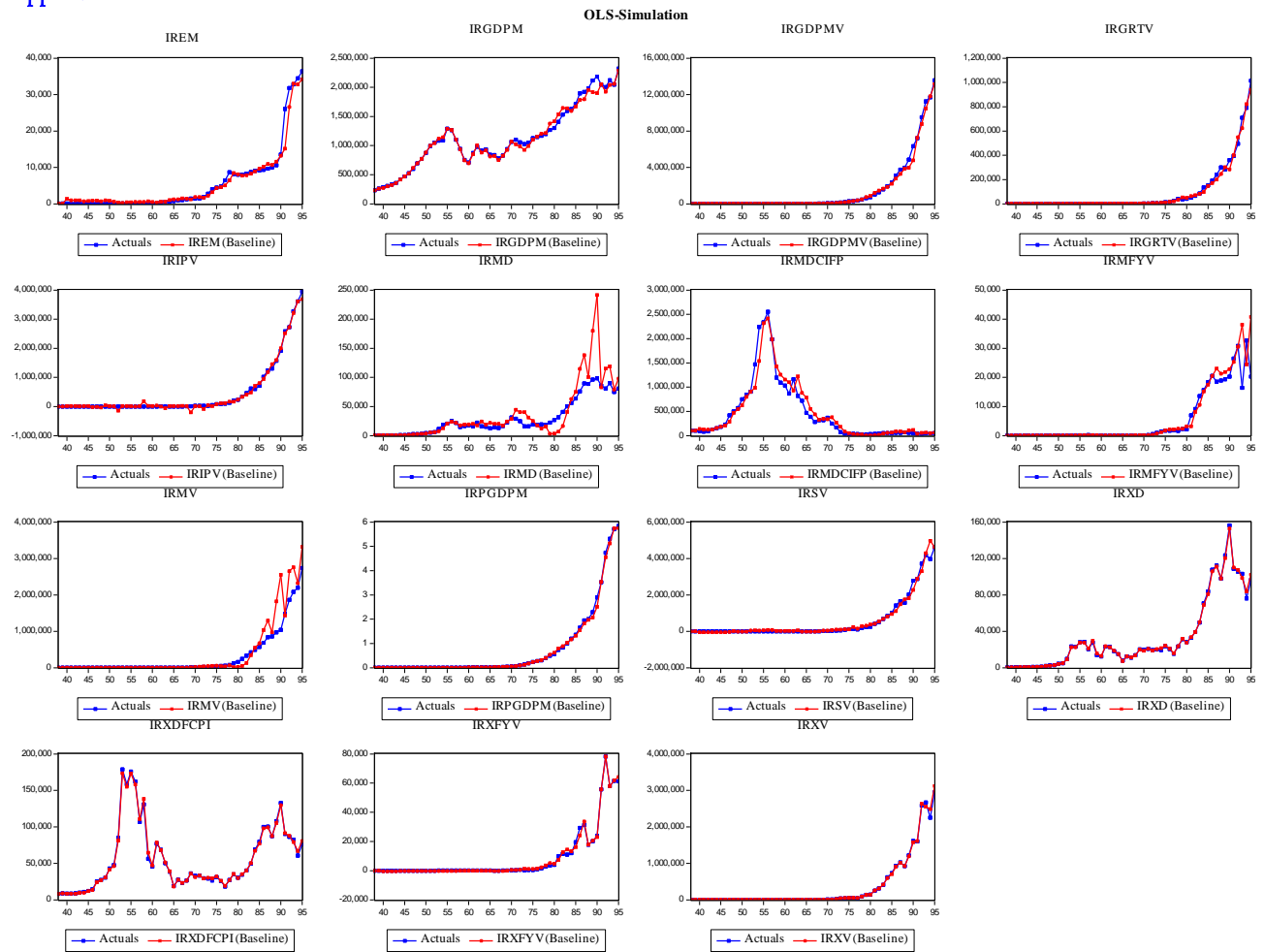
System: SYS3SLSH
Estimation Method: Three-Stage Least Squares
Date: 05/26/19   Time: 14:35
Sample: 1339 1395
Included observations: 57
Total system (unbalanced) observations 451
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	257.4782	78.53644	3.278456	0.0011
C(2)	1.016612	0.006980	145.6551	0.0000
C(3)	0.000946	0.000237	4.000208	0.0001
C(4)	-13.79725	6.597782	-2.091194	0.0371
C(10)	6502.746	7431.449	0.875031	0.3821
C(11)	1.073701	0.015968	67.24165	0.0000

C(12)	0.693183	0.129148	5.367339	0.0000
C(13)	-16667.99	6654.533	-2.504757	0.0126
C(14)	-518010.6	73536.49	-7.044265	0.0000
C(20)	-247194.3	35944.07	-6.877193	0.0000
C(21)	38446.01	5208.951	7.380759	0.0000
C(22)	0.382802	0.014729	25.98960	0.0000
C(30)	-893.5623	2254.571	-0.396334	0.6921
C(31)	1.159795	0.021133	54.88123	0.0000
C(32)	0.036973	0.007056	5.239906	0.0000
C(33)	-95011.44	15496.55	-6.131134	0.0000
C(34)	-53945.09	15634.96	-3.450286	0.0006
C(40)	-1752.126	454.1764	-3.857810	0.0001
C(41)	1.008546	0.008766	115.0503	0.0000
C(42)	0.840617	0.033307	25.23851	0.0000
C(43)	0.218115	0.093692	2.327999	0.0204
C(44)	0.030519	0.006828	4.469704	0.0000
C(50)	84002.14	20788.60	4.040778	0.0001
C(51)	0.967116	0.061199	15.80282	0.0000
C(52)	-10.65886	2.439674	-4.368968	0.0000
C(53)	1.121065	0.257734	4.349702	0.0000
C(60)	-287.3049	238.2357	-1.205969	0.2285
C(61)	0.949651	0.028643	33.15526	0.0000
C(62)	-0.243415	0.053905	-4.515581	0.0000
C(63)	28374.06	1249.203	22.71372	0.0000
C(64)	-15191.66	1239.338	-12.25789	0.0000
C(65)	-22132.75	1743.549	-12.69408	0.0000
C(66)	17320.84	1366.833	12.67224	0.0000
C(70)	4.929394	1.323247	3.725226	0.0002
C(71)	1.067234	0.041424	25.76360	0.0000
C(72)	0.006378	0.001278	4.990199	0.0000
C(73)	0.001141	0.000485	2.352898	0.0191

Determinant residual covariance	1.45E-06

Equation: (IREM)/RESIDIREM^2= (C(1)+C(2)*IREM(-1)+ C(3)*D(IRIPV-IRSV

+IRGV-IRGRTV)+ C(4)*D(IRXV/IREEX-IRMV/IREEM+ IRXFYV/IREEXFY

-IRMFYV/IREEMFY))/RESIDIREM^2

Instruments: C IREM(-2) (IRIPV-IRSV+IRGV-IRGRTV) (IRXV/IREEX-IRMV

/IREEM+ IRXFYV/IREEXFY-IRMFYV/IREEMFY) IRIRD IRIRL

Observations: 56

R-squared	0.999889	Mean dependent var	0.060141
Adjusted R-squared	0.999882	S.D. dependent var	0.183909
S.E. of regression	0.001996	Sum squared resid	0.000207
Durbin-Watson stat	1.950318		

Equation: IRIPV = C(10) + C(11)*IRIPV(-1) + C(12)*IROLPV+ C(13)* (IRIRL

-IRIRL(-1)) + C(14)*D92

Instruments: C IRIPV(-2) IROLPV(-1) (IRIRL-IRIRL(-1)) D92

Observations: 56

R-squared	0.997424	Mean dependent var	481023.0
Adjusted R-squared	0.997222	S.D. dependent var	977225.2
S.E. of regression	51503.05	Sum squared resid	1.35E+11
Durbin-Watson stat	2.124041		

Equation: $IRSV/RESIDIRSV^2 = (C(20) + C(21)*IRIRD + C(22)*IRGDPMV(-1))/RESIDIRSV^2$

Instruments: C IRIRD(-1) (IRGDPMV)

Observations: 57

R-squared	0.998510	Mean dependent var	0.000158
Adjusted R-squared	0.998455	S.D. dependent var	0.000581
S.E. of regression	2.28E-05	Sum squared resid	2.82E-08
Durbin-Watson stat	1.560718		

Equation: $(IRGRTV) = (C(30) + C(31)*IRGRTV(-1) + C(32)*D(IRGDPMV)) + C(33)*D89 + C(34)*D91$

Instruments: C IRGRTV(-2) (IRGDPMV-IRGDPMV(-1)) D89 D91

Observations: 56

R-squared	0.994865	Mean dependent var	97808.20
Adjusted R-squared	0.994462	S.D. dependent var	212364.7
S.E. of regression	15803.64	Sum squared resid	1.27E+10
Durbin-Watson stat	3.253614		

Equation: $(IRXDFCPI)/(RESIDIRXDFCPIF^2) = (C(40) + C(41)*IRXDFCPI(-1) + C(42)*(IRXOILD/FCPI-IRXOILD(-1)/FCPI(-1)) + C(43)*IREEX*FCPI/IRPGDPM + C(44)*D(IRGDPM))/(RESIDIRXDFCPIF^2)$

Instruments: C IRXDFCPI(-2) IRXOILD/FCPI IREEX(-1)*FCPI(-1)/IRPGDPM(-1) (IRGDPM)/IRGDPM(-1) IREEXFY IREEMFY

Observations: 56

R-squared	1.000000	Mean dependent var	1.273640
Adjusted R-squared	1.000000	S.D. dependent var	8.750115
S.E. of regression	0.001857	Sum squared resid	0.000176
Durbin-Watson stat	1.871593		

Equation: $(IRMDCIFP)/(RESIDIRMDCIFPF^2) = (C(50) + C(51)*IRMDCIFP(-1) + C(52)*(IREEM*FCPI/IRPGDPM) + C(53)*D(IRXD + IRXFYV/IREEXFY - IRMFYV/IREEMFY))/(RESIDIRMDCIFPF^2)$

Instruments: C IREEM(-1) FCPI(-1) IRPGDPM(-1) (IRXD+IRXFYV/IREEXFY -IRMFYV/IREEMFY)

Observations: 57

R-squared	0.998256	Mean dependent var	0.000613
Adjusted R-squared	0.998158	S.D. dependent var	0.001492
S.E. of regression	6.41E-05	Sum squared resid	2.17E-07
Durbin-Watson stat	2.095896		

Equation: $IRXFYV = C(60) + C(61)*IRXFYV(-1) + C(62)*(IRIRD-FIR*IREEXFY)$

+ C(63)*D91+C(64)*D88 + C(65)*D93 + C(66)*D92			
Instruments: IRIRD(-1) FIR(-1) IREEXFY(-1) D91 D88 D93 D92 C			
Observations: 57			
R-squared	0.995999	Mean dependent var	9075.868
Adjusted R-squared	0.995519	S.D. dependent var	18647.67
S.E. of regression	1248.256	Sum squared resid	77907200
Durbin-Watson stat	1.553226		

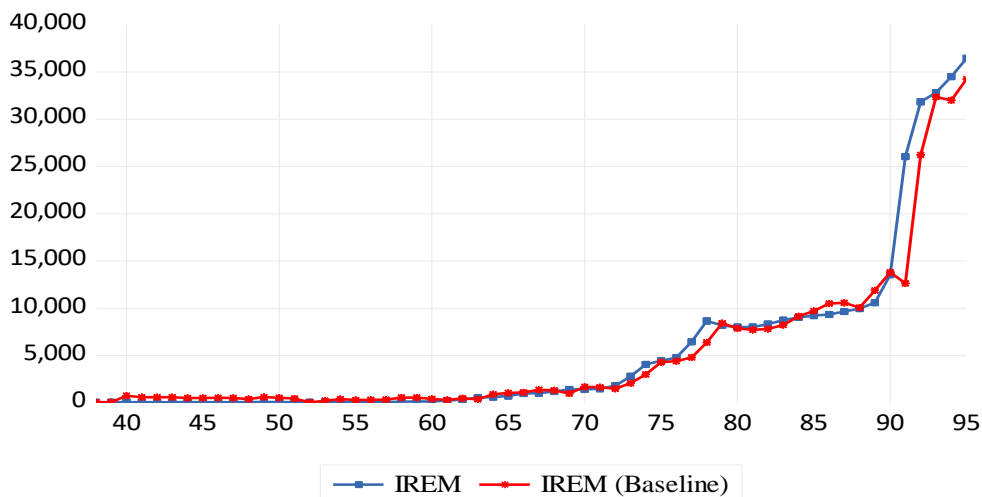| Equation: (IRMFYV)/RESID07^2= (C(70) + C(71)*IRMFYV(-1) + C(72) *(IRIRD - FIR*IREEMFY)+ C(73)*D(IRGDPMV))/RESID07^2			
Instruments: C IRMFYV(-2)/RESID07^2 (IRIRD(-1) - FIR(-1)*IREEMFY(-1)) /RESID07^2 (IRGDPMV)/RESID07^2			
Observations: 56			
R-squared	0.999999	Mean dependent var	72.69083
Adjusted R-squared	0.999999	S.D. dependent var	389.7440
S.E. of regression	0.431112	Sum squared resid	9.664583
Durbin-Watson stat	1.749032		

3SLS
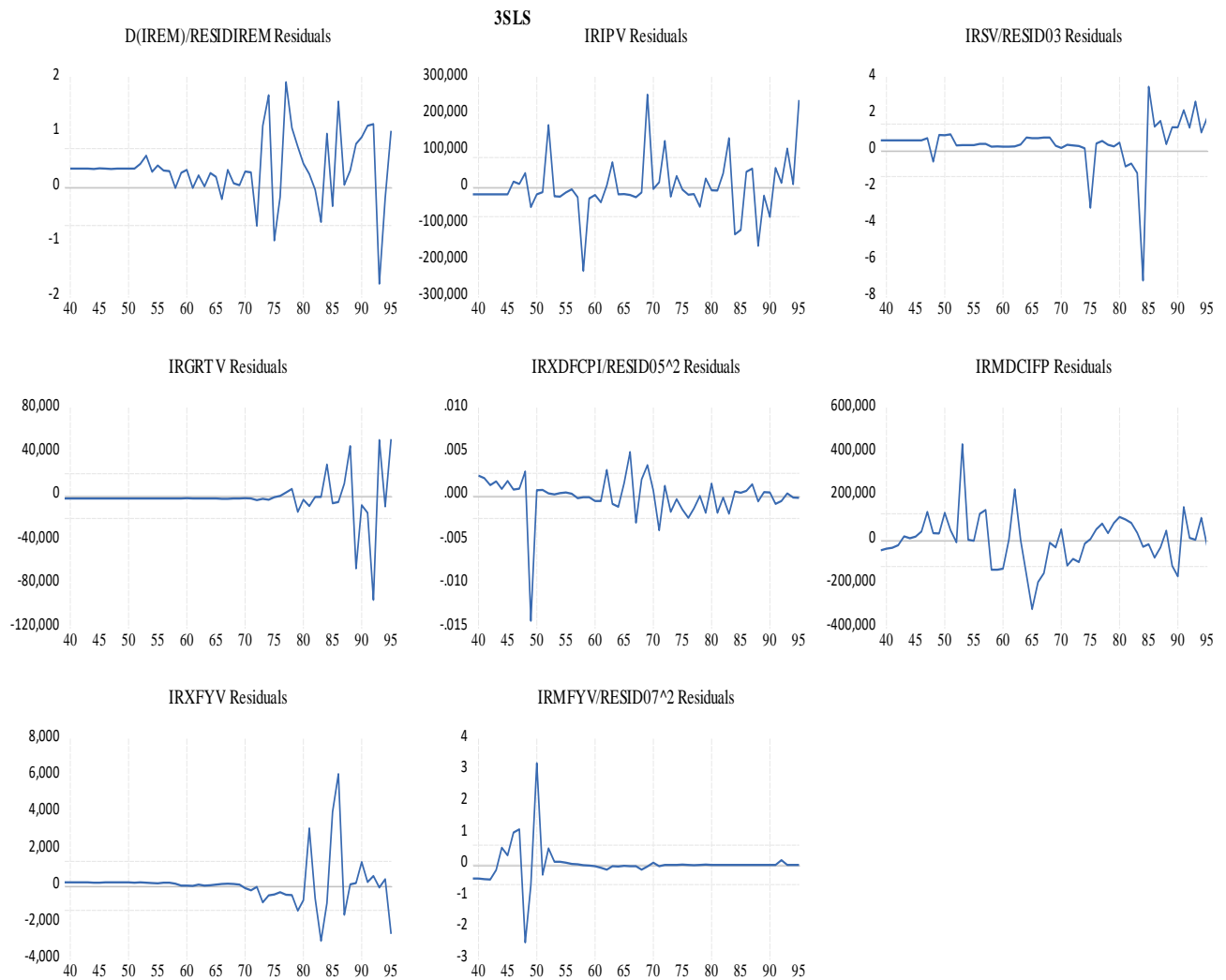
Structural Equation residual correlation table

	RESID04	RESID06	RESID08	RESID09	RESID10	RESID11	RESID12	RESID13
RESID04	1.00	0.00	-0.17	0.05	-0.18	-0.03	-0.16	-0.01
RESID06	0.00	1.00	-0.28	-0.37	0.05	-0.18	0.07	0.04
RESID08	-0.17	-0.28	1.00	0.07	0.25	-0.03	0.09	-0.11
RESID09	0.05	-0.37	0.07	1.00	0.08	-0.06	-0.24	0.00
RESID10	-0.18	0.05	0.25	0.08	1.00	-0.05	0.29	0.17
RESID11	-0.03	-0.18	-0.03	-0.06	-0.05	1.00	-0.01	0.02
RESID12	-0.16	0.07	0.09	-0.24	0.29	-0.01	1.00	-0.01
RESID13	-0.01	0.04	-0.11	0.00	0.17	0.02	-0.01	1.00

IREM 3SLS

3SLS Simulation