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Effect of Nominal Exchange Rate Volatility on Output in Iran's Economy

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Volatility of exchange rate while changes from time to time, is expected to affect firm level operations as well as aggregate level outcomes i.e. macroeconomic performance. This paper, investigates the effects of exchange rate volatility on aggregate production in Iran using a Structural Vector Auto Regressive model with Exogenous Variables (SVARX). The model is estimated based on macroeconomic data during 1990q2-2015q1. Impulse response functions show that realization of a positive shock to the exchange rate volatility-measured by quarterly coefficient of variation derived from daily exchange rate data set rather than common GARCH-based measures- is associated with a significant production drop. These results are robust in reference to changing output measures. We also provide some necessary sensitivity analysis to check robustness of the results with respect to recursive restrictions which are imposed to identify the structural model. After all this robustness checks the model confirmed negative effect of exchange rate volatility on output in Iran's economy. Furthermore, the results show that CPI and exchange rate will significantly increase when exchange rate volatility rises while import declines.

Keywords: Exchange Rate, Volatility, Production
JEL Classification: E23, F31, F32, F41

1 Introduction

Volatile financial markets which are mainly originated from prevailing uncertainty can cripple performance of economy and even make some nonlinearities in economic behavior. Among the financial markets, foreign exchange market has a great importance in determining merits of economic functioning, especially in developing countries. Since the collapse of post-war Bretton Woods system of fixed exchange rates in 1973, policy-oriented and

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academic investigations questioning the optimal degree of exchange rate volatility and superior exchange rate regime have gained ground. As long as it is expected that exchange rate volatility would alter not only most of the firms' economic positions, but also their aggregated performance at the macroeconomic level, these investigations are well reasoned.

Although one may expect that changes in volatility of foreign exchange market notably influence the performance of other segments of economy essentially real sector, surprisingly early researches failed to provide evidences supporting negative effect of exchange rate volatility on production or even on international trade and investment. Presuming that the answer to the questions about the effect of exchange rate volatility on economic performance, especially on production indexes, might be country-specific, more recent researches have adopted two strategies to overcome this issue; first to investigate the effect of exchange rate volatility between different countries by controlling on different factors such as level of financial development[1], and second to put in the test the effect of exchange rate volatility in a country-specific model.

In this paper we investigate the effects of nominal exchange rate volatility -rather than real exchange rate volatility which is mostly addressed by related literature in Iran- on aggregate production measures in Iran. We draw on a Structural Vector Auto Regressive model with Exogenous Variables (SVARX) estimated based on Iran's macroeconomic data during 1990q2-2015q1. While in previous works, exchange rate volatility is mostly taken into account indirectly by using measures of conditional volatility which are computed based on GARCH models, in this paper we use a daily exchange rate dataset and assign coefficient of variation for each quarter to represent measure of exchange rate volatility in our model. The Impulse response functions show that realization of a positive shock to the exchange rate volatility is associated with a significant production drop. We also present some extensive sensitivity analysis with respect to output measures, modeling of oil sector and recursive identification order which confirm our results. Given that some studies show that exchange rate volatility is an indicator of the overall uncertainty of economy[2], this study is of great importance for Iran's economy.

The rest of the paper is organized as follows: next section reviews related literature. Section (3) introduces our economic and empirical model, Section

[1] See for example Aghion, Bacchetta and Ranci (2009).
[2] See Krol (2014).

(4) presents impulse response functions and finally section (5) briefly summarizes the results.

2 Literature Review

2.1 Theoretical and Empirical Studies

Exchange rate volatility, its causes and its economic effects has been critical questions in the literature since fall of Bretton Woods. Following seminal work of Dornbusch (1976), Mussa (1982) presents a model in which price of foreign currency which is modeled as an asset, depends on expectation of real and nominal shocks and he argues that sluggish price adjustment plays a critical role in determining exchange rate volatility. But Stockman (1987) and Meese and Rogoff (1988) believe that emperical evidences does not support the idea that sticky prices in intraction to monetary disturbances can explain exchange rate dynamics. Gali and Tommaso (2005) lay out in a small open economy model with calvo sticky price adjustment, that monetary policy rule is the main factor which detemines relative exchange rate volatility. Hodrick (1989) shows that variances of exogenous processes, such as future government spending and future rates of income growth can have a significant effect on volatility of foreign exchange market. There are also some researhes which argue that exchange rate volatilty is mostly driven by micro structure of foreign exchange markets (see Melvin and Yin (2000) and Goodhart and O'Hara (1997)).

Parallel to researches that suggest theoratical sources of exchange rate voltility, there are other theoratical researches trying to investigate effect of exchange rate volatility on various economic performance measures. Obstfeld and Rogoff (1998) propose a two country DSGE model which put aside the certainty-equivalence assumption for price setting behavior and show exchange rate volatility requires a substantial welfare cost. Devereux and Engel (2003) argue that in the presence of local-currency pricing exchange rate volatility is unwelcoming and traditional desirability of expenditure-switching role that flexible exchange rate is expected to play is overestimated. Ghosh, Ostry and Chamon (2016) also show that welfare cost of exchange rate volatility is dependent on various criteria such as monetary regime, monetary instrument (policy interest rate or sterilized foreign exchange market intervention), degree of imperfect capital mobility/asset substitutability, and severity of time inconsistency problems.

While some researchers show that exchange rate volatility increase uncertainty and costs for firms and as a result it can impair international trade and economic performance of firms (see for example Baron (1976) and Clark (1973)), there are some researches which discuss positive effect of exchange rate volatility. Franke (1991) by supposing entry and exit cost in export market, shows that in this setting exporting is an option that its value is related to exchange rate volatility and exporters exercise this option when it is profitable. Sercu and Vanhulle (1992) develop a theory that incorporates linear demand and cost structures in which exchange rate volatility will increase exporters value.

Aligned with theoretical works, many researches empirically try to put to the test various effects of exchange rate volatility. Ghosh, Gulde-Wolf and Wolf (2003) show that in a large sample of countries there are weak evidences for positive or negetive effect of exchange rate stability on economic growth. Eichengreen and Leblang, (2003) report a negetive effect of exchange rate stability on economic growth. Edwards and Levy-Yeyati (2005) report that countries with more flexible exchange rate grow faster. Eichengreen (2007), after an extensive literature review, concludes that the effect of exchange rate volatility on investment and growth is likely to be contingent on circumstances. Folowing this conclusion, Aghion, Bacchetta and Ranci (2009) show that the effect of exchange rate volatility on economic growth depends critically on the level of financial development of the country.

There are strands of economic researches which try to explain the impacts of exchange-rate volatility on trade. Bleaney and Greenaway (2001) investigate the effects of terms of trade and real exchange rate volatility on investment and growth. They use a dataset which includes 14 sub-Saharan African countries that are the exporters of primary commodities and report a significant negative effect of real exchange rate volatility on investment, as well as negative effect of terms of trade volatility on growth. Bredin, Fountas and Eithne (2003) using an error correction model show that the exchange rate volatility has no effect on the Irish trade volume in the short-run but a significant positive effect in the long run. Bahmani-Oskooee and Hegerty (2007) review this literature and show that there are some theoretical background supporting both negative and positive effects of exchange-rate volatility on trade. They moreover surveyed empirical studies and concluded that empirical literature supports both negative and positive effects as well as theories.

As literature study shows, the question of exchange rate volatility impact on economic performance, especially on production indexes, may have country-specific answers.

2.2 Exchange Rate Regime and Exchange Rate Volatility

Aghion, Bacchetta and Ranci (2009) discuss exchange rate regime literature as an autonomous strand of researches explaining economic effects of exchange rate volatility. Exchange rate regime literature shaped around traditional question of the optimal exchange rate regime. These researches provide insightful theories, although they deliver no one-size-fit-all suggestion about the optimal degree of exchange rate flexibility. Optimum Currency Area (OCA) theory was maturated in three seminal papers of Mundell (1961), McKinnon (1963), and Kenen (1969). On the one hand some researchers argue that fix exchange rate regimes will cut down uncertainty and transaction costs. As a consequence, if fix exchange rate regime is associated with some desired state of affairs such as flexibility of prices (including wages) as well as mobility of production factors, it will improve trade and welfare gains in small open economies specially ones their international trade is concentrated toward one trade partner (for a review of literature see Kunroo (2015)). On the other hand Friedman (1953) rejects the paradigm of fixed exchange rates regime due to crucial role that exchange rate flexibility plays to facilitate economic adjustments in the face of real shocks with inter-border nominal rigidities.

In parallel to OCA theory, some researchers argue in favor of financial considerations that should be taken into account when the economic effects of exchange rate volatility is the research agenda. If firms, banks and households have accumulated liabilities denominated in a foreign currency while they have not enough such foreign currency earnings or assets to serve their liabilities, exchange rate volatility is unfortunate. Existence of currency mismatch in balance-sheets even can be more disastrous when financial markets are not deep enough to provide risk hedging opportunities for firms, banks and households. In such circumstances, a sudden devaluation is likely to trigger a default domino in the economy and deteriorate balance-sheets of economic agents which slows down recovery of economy. Yeyati (2006) reports that "financially dollarized economies display a more unstable demand for money, a greater propensity to suffer banking crises after a depreciation of the local currency, and slower and more volatile output growth, without significant gains in terms of domestic financial depth". Calvo and Reinhart (2002) report "Fear of Floating" and Yeyati, Sturzenegger and Reggio (2010) state that "financially dollarized countries may find it more convenient to fix rather than float merely for prudential reasons".

Empirical literature alongside the theoretical researches tries to shed light on pros and cons of exchange rate regimes. There are many researches which make an effort to identify the impacts of exchange rate regimes on economic performance (see for example Ghosh, Gulde-Wolf and Wolf (2002), Klein and Shambaugh (2012), Levy-Yeyati and Sturzenegger (2003) and Bailliu, Lafrance and Perrault (2003)), however empirical results are not robust due to lack of choices for indisputable criteria for classification of exchange regimes (see Tavlas, Dellas and Stockman (2008)). Calvo and Reinhart (2002) also underscore problems that a researcher may face trying to identify exchange rate regime of a country. Furthermore Calvo and Mishkin (2003) and Rogoff, et al. (2004) conclude that economic performance is more tied up to institutional framework rather than exchange rate regime which is missed consideration in some analysis.

There is no shared consensus about the effects of exchange rate regimes therefore the economic outcomes of exchange rate regimes should be considered in interaction with each country's structural and institutional fundamentals. This conclusion is well articulated by Rose (2011) when states that " While a fixed exchange rate with capital mobility is a well-defined monetary regime, floating is not; thus, it is unclear whether it is theoretically sensible to compare countries across exchange rate regimes. This comparison is quite difficult to make empirically. It is often hard to figure out what the exchange rate regime of a country is in practice, since there are multiple conflicting regime classifications. More importantly, similar countries choose radically different exchange rate regimes without substantive consequences for macroeconomic outcomes like output growth and inflation."

2.3 Exchange Rate Volatility and Iran's Economy

There are some studies focused on analysis of reciprocal relation between exchange rate and macroeconomic variables in Iran, however they are mainly concentrated on effect of some measures of exchange rate (i.e. nominal exchange rate, real exchange rate, real effective exchange rate, etc.) rather than exchange rate volatility on other macro-economic variables (for example See Bahmani-Oskooee and Kandil (2007) and Fegheh Majidi and Alimoradi Afshar (2015), Mojab and Barackchian (2011), Elahi, et al. (2016)).

Bahmani-Oskooee's research (2002) is among other strand of empirical research which focused specifically on the effects of real exchange rate volatility measured by standard deviation of quarterly real exchange rate and reports negative effect of real exchange rate volatility in the black markets on trade in Iran. Asgari (2008) using moving average standard deviation on monthly exchange rate data as measure of real exchange rate volatility, shows that selected industries in Iran will suffer from exchange rate volatility.

Kochakzadeh and Jalaiee Esfandabadi (2013) using conditional volatility of exchange rate (GARCH) report similar result on non-oil export. Mohseni Zonouzi, Feizi and Mosavi (2017) run an ARDL model which incorporates conditional volatility of exchange rate and report negative effect of exchange rate volatility on consumption in Iran. Mirani, Baradaran khanian and Salmani (2015) using identical measure for exchange rate volatility show that real exchange rate volatlity negetively affect domestic production.

3 Model

Considering that exchange rate is a price which is determined in a macroeconomic framework and simultaneously it is affected by international trade development, a convenient model to investigate the effect of exchange rate volatility on Iran's production is in a following form:

$$f(y, m, i, o, p_d, p_f, e, v) = 0$$

Where:
y=Real GDP;
m=Nominal Money Balance;
i=Real Import;
o=Oil Revenue in US Dollar;
p_d=Domestic Price Index;
p_f= Foreign Price Index;
e=Nominal Exchange Rate;
v=Volatility of Nominal Exchange Rate.
We use a SVARX as an empirical model in the following form

$$A_0^* y_t = A_1^* y_{t-1} + \cdots + A_p^* y_{t-p} + B_0^* x_t + \cdots + B_q^* x_{t-q} + C^* D_t + \varepsilon_t \quad (1)$$

Where y_t is a vector of endogenous variables observed at time t, x_t is a vector of exogenous variables observed at time t, D_t contains all deterministic and/or exogenous variables which may consist of a constant, seasonal dummy variables as well as user specified other dummy variables, and u_t is an unobservable zero mean white noise process with positive definite covariance matrix. A_0^* stands for matrix of contemporaneous relation and the A_i^*, B_j^* and C^* are parameter matrices. Accordingly equation (1) can be interpreted as structural form of a reduced form equation such that $A_i = {A_0^*}^{-1} A_i^*$, $B_j = {A_0^*}^{-1} B_j^*$, $C = {A_0^*}^{-1} C^*$ are parameter matrices of reduced form equation and $u_t = {A_0^*}^{-1} \varepsilon_t$ is comparable white noise error term.

While the coefficients in A_0^*, A_i^*, B_j^* and C^* are the parameters of interest, the main matter of contention in the estimation of structural models is that one cannot directly estimate equation (1) and derive the 'true' values of the coefficients due to identification problem. Imposing some restriction on the coefficients provides convenient solution to overcome identification problem.

There are different identification methods. Following Sims' (1980) seminal paper, dynamic analysis of VAR models is mostly based on the orthogonalized impulse responses, where the underlying shocks to the VAR model are orthogonalized using the Cholesky decomposition (Pesaran and Shin (1998)). Cholesky decomposition encompasses a set of well-known identification restriction usually developed by incorporating a priori non-statistical information originated from economic theory which is identical to impose some ordering or "recursive restrictions" on A_0^* to be a triangular matrix. In distinction to identification method based on recursive restrictions, some researchers use "sign restrictions" or "long-run restrictions" to single out structural parameters (for example see Clarida and Gali (1994), Ulhig (1999), and Bernanke and Mihov 1998).

Our empirical model has two sets of variables, endogenous and exogenous. Endogenous variables are consist of Iran's (sectoral and aggregated) real GDP, nominal exchange rate, broad money (M2), consumer price index (CPI) and index of exchange rate volatility. Endogenous variables excluding index of exchange rate volatility are employed in log-transformed value.

Exchange rate volatility is taken into account using quarterly coefficient of variation (CV) calculated based on daily nominal exchange rate. Considering that Iran's economy has been faced double digit inflation for more than four decades which has been associated with comparable Rial's nominal depreciations, some measures such as quarterly standard deviation or variance of daily nominal exchange rate can be misleading. As a consequence, the coefficient of variation calculated based on normalized volatility measures of nominal exchange rate is a more convenient alternative.

In this model there are some exogenous variables including seasonal dummies, oil export revenue as well as import price index. Oil export revenue generally is dependent to oil export and global oil prices. Oil export is mainly driven by export contracts agreed in international negotiations. Similar to oil export, global oil prices are determined internationally. Thus oil export revenue is fundamentally exogenous to Iran's economy and therefore oil export revenue is an exogenous variable.

Although one can offer some import price index in reference to Iran's trade statistics, unfortunately these measures cannot be computed for a sufficient time span or in advantageous frequency which are necessary for obtaining desirable degree of freedom. In this model Germany's CPI is used as a proxy for Iran's import price index. This decision can be justified when one notes that traditionally European countries are Iran's important trade partners, and Germany is one of the leading economies, even the most important one, in European countries to the extent that since 1979 until when Euro was adopted by some member states of the European Union in 1999, Deutsche Mark functioned as a de facto anchor for the European Currency Unit (ECU), a weighted average of European Monetary System (EMS) currencies, which was used to keep participating currencies within a narrow band under an exchange rate mechanism (ERM).

To evaluate the impact of exchange rate volatility on real economic production, we estimate the SVARX explained above on quarterly data from 1990q2 to 2015q1. Table 1 presents the result of Augmented Dickey-Fuller test for model variables. As test results suggest all variables except Exchange Rate CV should be considered as I(1) process.

Table 1
Augmented Dickey-Fuller

Variable	Exchange Rate CV	Exchang e Rate	M2	CPI	Impo rt	Nonoil GDP	Germany's CPI	Oil Revenue
Test Statistic (Lag=1)	-3.54***	3.77	18.11	11.97	-0.06	0.88	9.63	0.21
Test Statistic (Lag=2)	-2.69***	2.65	5.02	2.81	-0.17	2.02	3.37	0.04
Test Statistic (Lag=3)	-2.21**	2.40	5.59	1.83	-0.32	9.59	2.77	0.05

Null Hypothesis: Random Walk without Drift. *Source*: Research Findings
Critical Values for Augmented Dickey-Fuller Test: 1% (-2.6), 5%(-1.95), 10%(-1.61).
***: Null hypothesis is rejected based on 99% confidence level.
**: Null hypothesis is rejected based on 95% confidence level.

It is important to mention that we do not use the variables in their stationary form because this most probably makes us lose some original information due to differencing or de-trending dataset using well-known filters. On this ground our model is estimated using variables at their levels while they are non-stationary. Considering some theories such as quantity theory of money or purchasing power parity that suggesting the existence of some co-integrating vector between these variables, the estimation results based on variables at their levels could not be discredited in reference to spurious regression problem. Furthermore, Table 2 provides results of Johansen tests for cointegration wich shows that there are 3 cointergerating vectors between variables. However, since specification of co-integrating vector between variables does not help us to answer our main question, we choose SAVRX rather than structural Vector Error Correction Model (VECM) with exogenous variables.

Table 2

Johansen Tests for Cointegration

rank	eigenvalue	statistic	5% critical value
0		286.19	94.15
1	0.84	108.71	68.52
2	0.46	48.57	47.21
3	0.25	20.68*	29.68
4	0.14	5.59	15.41
5	0.06	0.00	3.76
6	0.00		

Number of Observation =98. *Source*: Research Findings

3.1 Identification

Using short-run restrictions to identify structural shocks, is the approach to identify a simple SVARX model.

$$u_t = {A_0^*}^{-1} \varepsilon_t \tag{2}$$

$$\begin{bmatrix} u_t^y \\ u_t^m \\ u_t^i \\ u_t^{pd} \\ u_t^e \\ u_t^v \end{bmatrix} = \begin{bmatrix} a_{1,1} & \cdots & a_{1,6} \\ \vdots & \ddots & \vdots \\ a_{6,1} & \cdots & a_{6,6} \end{bmatrix} . \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^m \\ \varepsilon_t^i \\ \varepsilon_t^{pd} \\ \varepsilon_t^e \\ \varepsilon_t^v \end{bmatrix}$$

Equation (2) shows general format which specify relation between vector of reduced-form shocks, (containing u_t^js, j is correspondent variable symbol) and vector of unobservable structural shocks (containing ε_t^js) which its elements expected to be independent of each other, i.e. $E(\varepsilon_t \varepsilon_t') = \sum_\varepsilon$ is a diagonal matrix. Considering symmetry of each variance-covariance matrix, we have only 21 independent equations for determining each element of ${A_0^*}^{-1}$(i.e. $a_{n,p}$) derived from corresponding relation between variance-covariance matrix of reduced-form shocks and variance-covariance matrix of structural shocks which shown in following equations.

$E(u_t u_t') = ({A_0^*}^{-1}) E(\varepsilon_t \varepsilon_t') ({A_0^*}^{-1})'$
$\sum_u = ({A_0^*}^{-1}) \sum_\varepsilon ({A_0^*}^{-1})'$
$E(u_t u_t') = \sum_u$
$E(\varepsilon_t \varepsilon_t') = \sum_\varepsilon$

Imposing restrictions on diagonal elements of ${A_0^*}^{-1}$ to be one (i.e. $a_{n,n} = 1$), we need at least 15 additional independent equations to identify ${A_0^*}^{-1}$ uniquely. We present this additional equations using economic theories and structural characteristics of Iran's economy.

First we begin with Iran's foreign exchange market to determine relation between structural shocks and reduced-form shocks of exchange rate equations, u_t^e. Given that oil export has a considerable share in Iran's export value, it can be said that foreign exchange market of Iran is roughly determined by its monopole (or at least main player) which is the government. Knowing that we have oil revenue in our model which can capture changes of Iran's oil revenue stemming from either variations of global oil price or fluctuations of Iran's oil export (including changes due to imposition of sanctions targeting Iran's oil export), we can expect that u_t^e should sum up the shocks of government policy actions including trade and exchange rate policies. Also ε_t^e should be interpreted as the structural shocks related to government policy. There are also some well-grounded arguments to assume that some other structural shocks such as ε_t^y, ε_t^m, ε_t^i and ε_t^{pd} should be included in structural equation of exchange rate reduced-form shock, u_t^e since they can increase demand for exchange rate (including real, precautionary and speculative demand as well as public demand for exchange rate to save their purchasing power) in the same quarter that these structural shocks come into existence.

Iran's foreign exchange market structure is another major factor that should be considered as a structural element i.e. shocks which can constrain government to take and announce credible policies. Considering that oil export revenue makes the government as price maker in foreign exchange market, it is fair to say that government policy actions are credible unless the economy confronts undesirable international environment whether economic or political. Since in these situations, foreign exchange market experience more volatility, ε_t^v is a convenient indicator for the structural shock.

We also assume that ε_t^v is the only structural shock which should be included in equation of u_t^v since controlling for development of oil export revenues, government is recognized as price maker in foreign exchange market and do not have a preference for market volatility unless it cannot implement any effective policies when the economy faces undesirable international environment. As noted earlier, such a period will be associated with increase in exchange rate volatility.

We also know that Central Bank of Iran employs money aggregates as monetary policy instrument. Furthermore, control of money growth is frequently highlighted by CBI's top rank officials as the main target to stabilize inflation. Therefore, money assumed as a variable which is mainly controlled by CBI. Additionally, we know that preparation of production and import data is a time consuming process, and CBI does not observe current state of realized shocks regarding these variables when it tries to determine appropriate monetary policy. Thus conforming to literature on information delay (for example Inoue, Kilian and Kiraz (2009)), we exclude ε_t^y and ε_t^i from structural equation of u_t^m.

There are still some physical and time constraints in the economy which suggest some more restriction to be imposed in our model. For example processes which an importer should take such as import registration, obtaining necessary permissions, finding and negotiating with exporters, producing and shipment of the goods are some time consuming steps that justify to impose restriction on the structural shocks other than import structural shock to have no simultaneous effect on import. Under the same rationale, it can be argued that structural equation of u_t^y does not include ε_t^{pd} ,ε_t^m and ε_t^i since production is a time consuming process (for example Kydland and Prescott (1982) and Kalouptsidi (2014)). Finally, in reference to nominal frictions and information lags we assume that reduced-form shock of CPI, u_t^{pd} does not have any correlation with ε_t^e, ε_t^m, ε_t^y and ε_t^i.

The following formulation rewrites equation (2) after imposition of restrictions discussed above.

$$\begin{bmatrix} u_t^y \\ u_t^m \\ u_t^i \\ u_t^{pd} \\ u_t^e \\ u_t^v \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & a_{1,5} & a_{1,6} \\ 0 & 1 & 0 & a_{2,4} & a_{2,5} & a_{2,6} \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & a_{4,6} \\ a_{5,1} & a_{5,2} & a_{5,3} & a_{5,4} & 1 & a_{5,6} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^m \\ \varepsilon_t^i \\ \varepsilon_t^{pd} \\ \varepsilon_t^e \\ \varepsilon_t^v \end{bmatrix}$$

4 Empirical Results

This section presents results of the model. Table 3 provides lag selection criteria for the model. Based on results of Table 3 we take lag length 2 for our model by Schwarz's Bayesian Information Criterion (SBIC).

Table 3

Lag Selection Criteria

lag	AIC	HQIC	SBIC
1	-19.1	-18.5	-17.6
2	-20.9	-20.0	-18.5*
3	-21.5	-20.1	-18.1
4	-22.0*	-20.3*	-17.7

Source: Research Findings

3.1 Base Model

Figure 1 shows impulse response functions obtained once model estimated. As Figure 1 shows, realization of one standard error shock to exchange rate volatility measured by quarterly CV of daily exchange rate, fades away after about 6 quarters. It is however preceded by a significant fall in output, measured by Non-oil GDP.

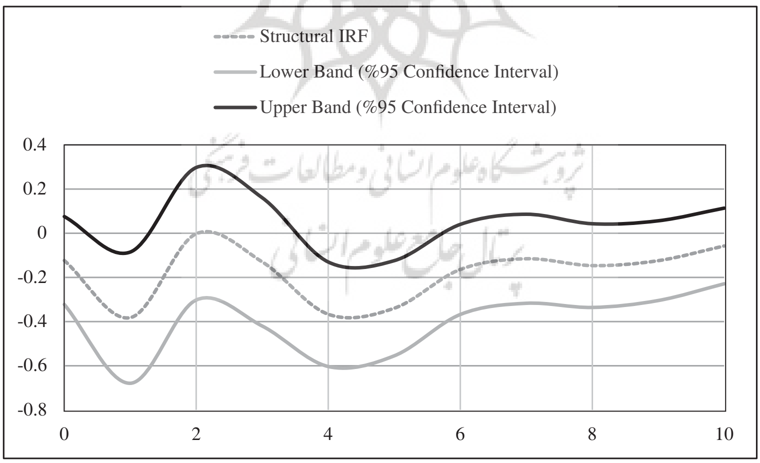

Figure 1. Response of Non-Oil GDP to Exchange Rate Volatility Shock. *Source*: Research Findings.

3.2 Empirical Results with Alternative Output Measure

This section provides the results of impulse response functions based on changing incorporated output measures. One can question convenience of Non-oil GDP to draw convincing conclusion or the effect of exchange rate volatility on other output measures.

Figure 2, Figure 3, and Figure 4 provide results of impulse response functions over different output measures in Iran. Figure 2 and Figure 4 provide sufficient statistical evidences that when Iran's economy faces a positive shock due to exchange rate volatility, value added of industry and service as well as value added of financial sector significantly decline. Figure 3 also show that increase of exchange rate volatility has negative effect on value added of industry in the quarter when exchange rate volatility shock is realized. However this effect is statistically significant for more periods when 90 percent confidence level is chosen. The different level of significance is due to inclusion of different industrial firms in the measure of output which are output-exporters or input-importers. Overall, these functions findings support the idea that increased exchange rate volatility have had a negative impact on Iran's output.

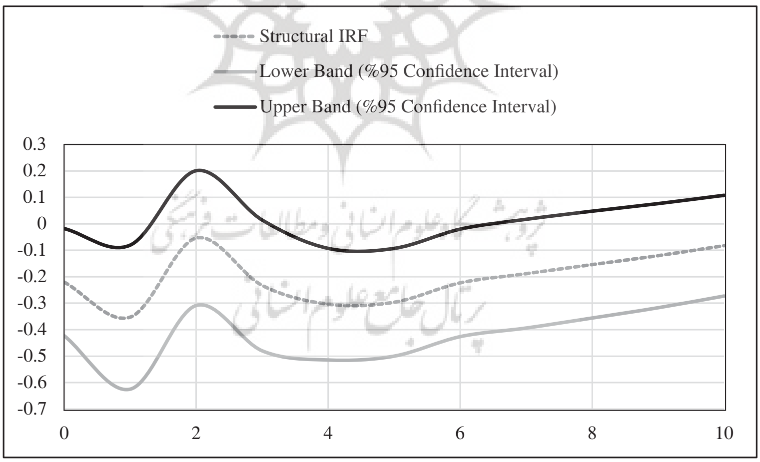

Figure 2. Response of Value Added of Industry and Service to Exchange Rate Volatility Shock. *Source*: Research Findings

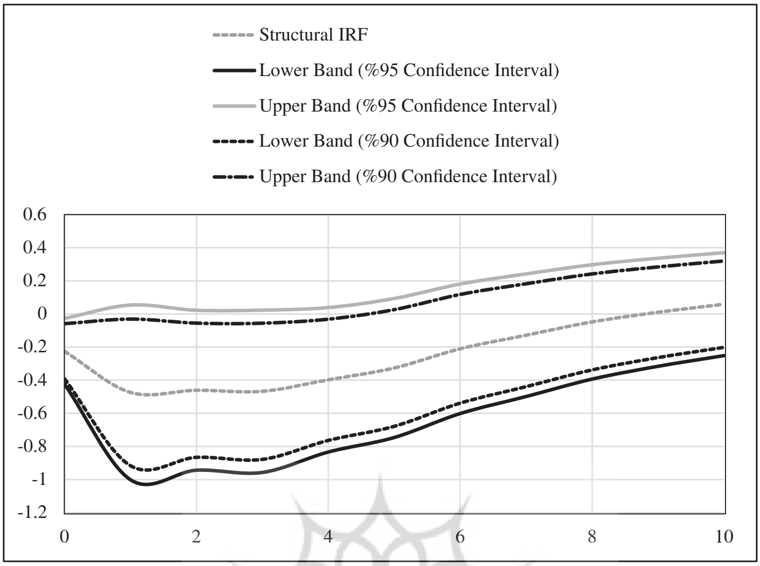

Figure 3. Response of Value Added of Industry to Exchange Rate Volatility Shock. *Source*: Research Findings

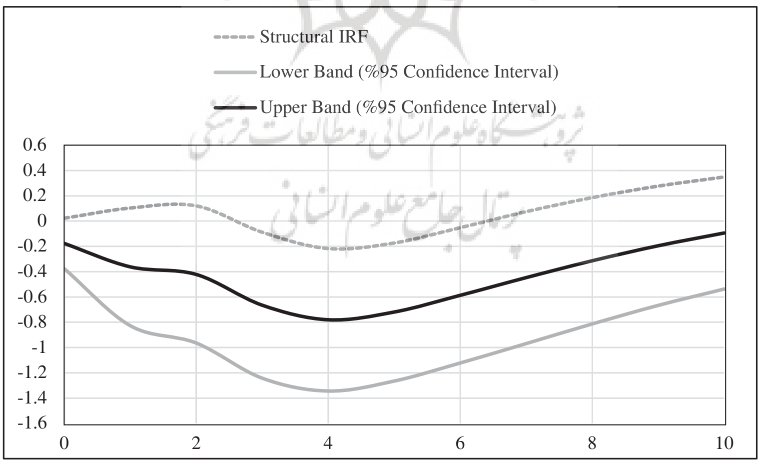

Figure 4. Response of Financial Sector Value Added to Exchange Rate Volatility Shock. *Source*: Research Findings

Presented results also offer some insights about “time to full recovery” and “depth of contractionary effect”, among other output measures. Interestingly, the value added of the financial sector falls more relative to other output measures. It is also evident that effect of exchange rate volatility shock on output measures other than value added of industry becomes insignificant after about 7 quarters while recovery of industrial sector (considering its significance level) is faster.

3.3 Sensitivity Analyses

As mentioned earlier identification of structural shocks is the important part in designing SVAR-family models. For the identification credentials presented in this article, we decide to prove our results using a different framework (a less restrictive one).

Bernanke and Blinder (1992) show that for obtaining dynamic effect of some interest shocks, nothing is required but a semi-structural or partially identified VAR models. In other words based on Bernanke and Blinder, it is not necessary to present a fully identified model to obtain a dynamic effect of some interest shocks.

In this section, to meet requirement to have a just identified model, we assume that structural shocks in our model can be ordered using a Cholesky decomposition. However, following Bernanke and Blinder indication, we do not impose any restriction on their ordering with just two exceptions i.e. output and exchange rate volatility. We assume that there is sufficient reason to explain that exchange rate volatility will simultaneously respond to other macroeconomic developments. This assumption is in contradiction with identification we have presented earlier in which exchange rate volatility do not respond to domestic development at the same time. We also assume that output will simultaneously be affected by other macroeconomic shocks excluding exchange rate volatility. As a result, output and exchange rate volatility, respectively, should be ordered as the most endogenous variables in proposed Cholsecky decomposition. It is fair to say that the proposed ordering can be one of the conservative ordering that one can expect.

Figure 5 shows robustness check for response of non-oil GDP to exchange rate volatility shock. Similar to results presented in previous sections, this simulation also suggests that increase in exchange rate volatility is associated with significant drop in output[1].

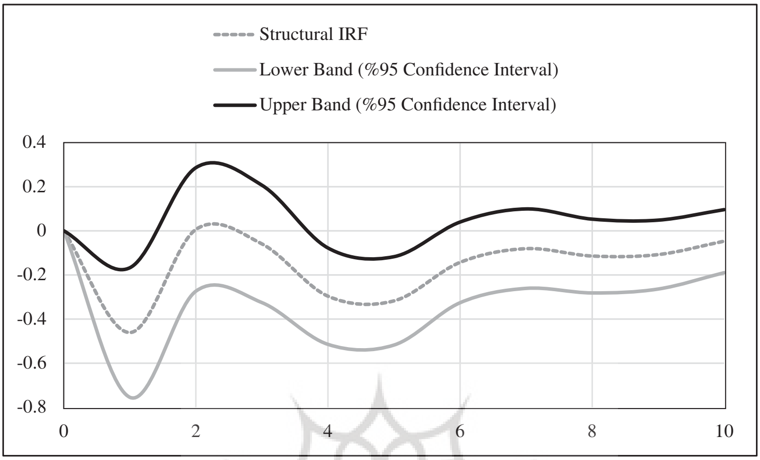

Figure 5. Response of Non-Oil GDP to Exchange Rate Volatility Shock (Robustness check Based on Bernanke and Blinder (1992)). *Source*: Research Findings

In addition to robustness of our results with respect to change in recursive restrictions, we have done other series of sensitivity analysis such as replacing oil revenue by oil sector value added, taking oil revenue / oil sector value added as an endogenous variable, taking out oil revenue / oil sector value added and import from our model, etc[2]. All of these sensitivity analysis repeatedly confirmed our conclusion[3].

[1] This ordering can be criticized as an extreme (conservative) case and one may want to see robustness of our results when this assumption is put aside but keeping partially identified VAR framework. Our simulations show that other different orderings for output and exchange rate volatility relative to other variables, confirm our conclusion as well, which affirms significant negative effect of exchange rate volatility shock on output measure.

[2] We checked also whether putting base model with stationary variables in use will change the results. Even this model confirmed significant negative effect of exchange rate volatility increment on output, however as it was expected quantitative and some secondary results changed. For example, increase of exchange rate and CPI due to realization of exchange rate volatility shock became insignificant after fewer periods and we also obtained negative response of import to exchange rate volatility shocks but it was insignificant.

[3] Our sensitivity analysis results can be provided upon request.

3.3 Some More Empirical Tests

Our model can be used to examine effects of exchange rate volatility on other macroeconomic variables. Figure 6 to Figure 9 provide respective results. Based on what Figure 6 presents, exchange rate volatility is associated with a temporary significant exchange rate depreciation which can be the result of increased speculative demand in foreign exchange market. CPI also experiences temporary upsurge in the periods in which exchange rate volatility increases which is depicted in Figure 7. This result is in harmony with conventional belief that when uncertainty increases, firms and households try to hedge their own purchasing power. Figure 8 suggests that realization of a positive shock due to exchange rate volatility is accompanied with a significant drop in import which can be a natural effect of increase in uncertainty and exchange rate devaluation. Finally in spite of above-mentioned significant effects, the impulse response functions show that money aggregates, surprisingly, do not respond significantly to exchange rate volatility.

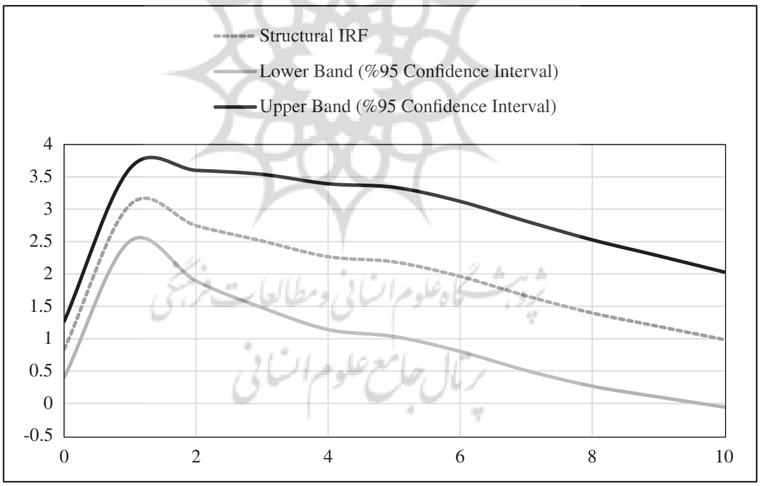

Figure 6. Response of Exchange Rate to Exchange Rate Volatility Shock. *Source*: Research Findings

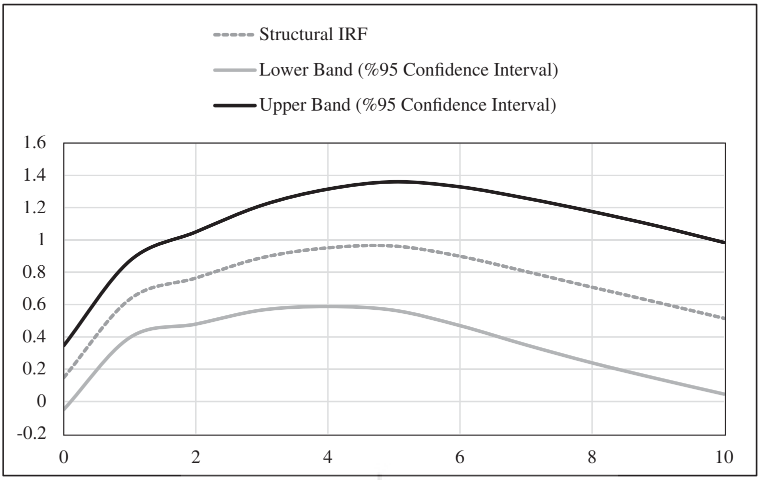

Figure 7. Response of Consumer Price Index to Exchange Rate Volatility Shock. *Source*: Research Findings

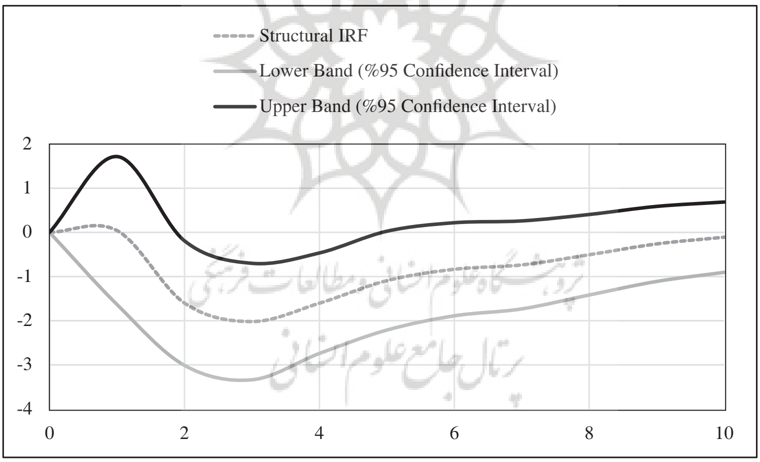

Figure 8. Response of Import to Exchange Rate Volatility Shock. *Source*: Research Findings

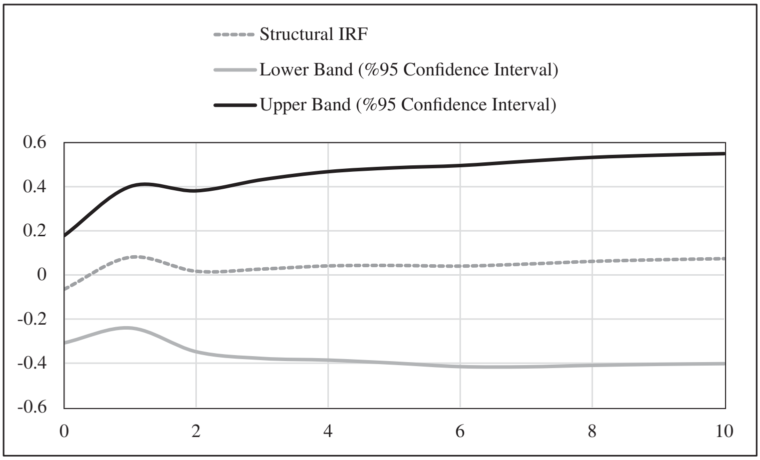

Figure 9. Response of M2 to Exchange Rate Volatility Shock. *Source*: Research Findings

There is also another explanation which is in harmony with presented results. Major rises in volatility of Iran's exchange rate market are coincided with imposition of economic sanctions and fall of oil price which are barriers to providing the necessary support for Iran's trade, which is usually granted by international and domestic banks. We have included oil export revenue in our model, however it is rather impractical to capture all effects of economic sanctions other than their effects on oil export revenue. This impracticality is specially due to their complexities including vast varieties of sanctions with reference to legal and international dimensions; time difference between their declaration, adoption and execution; and their interaction with different political development. As a result, it is expected that inclusion of exchange rate volatility in our model reflect some effects of these uncertainties.

These uncertainties generally interfere with provision of necessary support for Iran's trade usually granted by international and domestic banks, and weaken the economy through the lack of necessary and unrestricted imports. Given the fact that realization of the increase in exchange rate volatility is accompanied with a fall in import and value added of financial sector, our results are in line with the idea that banking services may play an important role in deepening the major fluctuations of Iran’s economy. However, it should be noted that provision of conclusive empirical supports for this explanation calls for further research, mainly based on micro level data.

5 Conclusion

This paper is focused on investigating the effects of exchange rate volatility on aggregate production in Iran based on an SVARX model. Our modeling results show that increase in volatility of foreign exchange market -measured by coefficient of variation- exerts a significant negative effect on production and import level. We have provided necessary sensitivity analysis to check validity of our conclusions with respect to alternative recursive restrictions which are imposed to identify the structural model and replace other production measure in the base model. After all robustness checks our model confirm negative effect of exchange rate volatility on output in Iran's economy. Our results also show that CPI and exchange rate significantly increase in periods in which exchange rate volatility rises while the economy experiences a fall in import.

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