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The Effect of Monetary Policy on Business Cycles in Iran Economy

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Abstract

Nowadays one of the most important issues in our economy, both from economic and political view is the link between monetary policy and the business cycle fluctuations. Amongst the shocks related to supply side, the shock of oil price is the important factor that has affected the world economy since 1970s. This paper examines the effects of monetary policy and oil price shocks on the business cycle fluctuations by applying the factor augmented vector autoregressive approach, Bernanke (2005) … to compare the results with VAR models by using Iran quarterly data for the period 1988:Q2 to 2011:Q3, the FAVAR models explain the effects of monetary policy which are consistent with theory better than VAR models. The results demonstrate a small but significant impact of monetary policy on business cycle fluctuations.

Keywords: Iranian Economy, Monetary Policy, Business Cycles, Factor Augmented VAR (FAVAR), Oil Price.

1- Introduction

Oil revenues are in fact the major cause of the development of business cycles. Oil is the most important export good in Iran and the major part of foreign exchange earnings and a major part of the country's budget is provided by revenues from oil export. Therefore, oil revenues practically influence monetary policies and along with it monetary policies are also influenced. Therefore, in this study it is hypothesized that business cycles in Iran are influenced by monetary policies and oil price.

The main objectives of macroeconomic policies, in general, and monetary policies, in particular, are price stability, economic growth and a

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favorable employment level. Since it is hard for policy makers to achieve the ultimate goal directly, therefore, determining intermediate objectives and introducing appropriate instruments are deemed necessary. In case of monetary policy, the issue of setting an intermediate objective is often reflected in controlling rate of return and money supply. With the monetary policy aimed at controlling monetary aggregates, attempts are made to prevent monetary expansion, incompatible with M2 and inflation targets set in the development plans, and to finance productive and investment sectors. So apparently, there have always been the questions of "Does monetary policy affect the real economy? And, what is the transmission mechanism by which these effects occur?" among the most important and controversial in macroeconomics (Bernanke and Blinder, 1992). Empirical estimation of the effects of monetary policy is another area of controversy among economists. Though now a consensus exists among economists that the long-run effects of monetary policy fall almost entirely only on prices however the impact of monetary policy impulses on real variables in the short-run is still open to debate (Walsh, 2010).

In terms of monetary policy analysis, the vector auto-regression (VAR) approach as a standard tool to analyze the effects of monetary policy shocks, was first proposed by Sims (1980) and has been further developed among others by Bernanke and Blinder (1992), Sims (1992), Christiano and Eichenbaum (1992), Gordon and Leeper (1994), Strongin (1995), Lastrapes and Selgin (1995) and Gerlach and Smets (1995), Leeper, Sims and Zha (1998), Bernanke and Mihov (1998), Christiano, Eichenbaum and Evans (1999), Angeloni, Kashyap, Mojon and Terlizzese (2003), Peersman and Smets (2001), and Mojon and Peersman (2001). The key insight of this approach is that identification of the effects of monetary policy shocks requires only a plausible identification of those shocks and does not require identification of the remainder of the macroeconomic model. These methods generally deliver empirically plausible assessments of the dynamic responses of key macroeconomic variables to monetary policy innovations, and they have been widely used both in assessing the empirical fit of structural models and in policy applications. The VAR approach to measuring the effects of monetary policy shocks appears to deliver a great deal of useful structural information, especially for such a simple method. Naturally, the approach does not lack for criticism. For example, researchers have disagreed about the appropriate strategy for identifying policy shocks. Alternative identifications of monetary policy innovations can, of course, lead to different inferences about the shape and timing of the responses of economic variables. Another issue is that the standard VAR approach addresses only the effects of unanticipated changes in monetary policy, not the arguably more important effects of the systematic portion of monetary policy or the choice of monetary policy rule (Bernanke, 2004).

In this context, two main issues have surrounded the analysis of the effects of monetary policy shocks using VAR models including the difficulty in identifying the most appropriate indicator of monetary policy stance and thus identifying monetary policy shocks, and the correct specification of the empirical model, which is restricted by the limited number of variables that can be included in a standard VAR. One way to deal with these problems is combining the standard VAR analysis with "factor analysis", which results in the so-called FAVAR model.

The aim is to propose an extension of the FAVAR model proposed by Bernanke, et al. (2005) by using data for Iran. The results show that the FAVAR's impulse response functions (IRFs) provide a more coherent picture of the effects of monetary policy shocks compared to the IRFs of alternative VAR models. In the following section we present the empirical literature. Then, we summarize the monetary policy in Iran. Next section provides the FAVAR model, motivates it within the context of a simple macroeconomic model, and lays out our estimation approach. We consider a two step estimation method, in which the factors are estimated by principal components prior to the estimation of the FAVAR. In the next section, we present and analyze the main results obtained from these two approaches, and compare the results of VAR and FAVAR estimation. Finally, we summarize our main conclusions in the last section.

2- Empirical Literature

Since the pioneered work of Sims (1980, 1992) and Bernanke and Blinder (1992), the VAR models has become the standard methodology used in the analysis of monetary policy shocks and in measuring their effects upon macroeconomic variables. Sims (1992) measures the effects of monetary policy in France, Germany, Japan, UK and the US by using VAR models, and finds that a contractionary monetary policy leads to lower output and money, while consumer price index (CPI) increases and called it as "price puzzle".[1] Bernanke and Blinder (1992) measure the impact of monetary policy on real variables in the US by using VAR model, and find that monetary policy is best measured by innovation in the federal funds rate, and concluded that firstly, the funds rate is a good indicator of monetary policy, secondly, nominal interest rates are good forecast of real variables and lastly, monetary policy works in part by affecting the composition of bank assets.

Peersman and Smets (2001) measure the macroeconomic effects of an unanticipated change in monetary policy in Euro area by using VAR model and concluded that a rise in the short term nominal interest rate leads to a real appreciation of the exchange rate with a fall in output, while prices shows sluggish behavior and fall significantly after several quarters. Miyao (2002) examine the effects of monetary policy on macroeconomic variables over the last two decades in Japan by using VAR model, and found that monetary policy shocks which are identified as call rate disturbances, have persistent effect on real output, especially in the rise and fall of Japan's bubble economy of the late 1980s.

Bernanke et al. (2005) point out three main problems that could arise using the standard VAR approach that considers only a small number of variables. First, it is possible that policy shocks are measured with error, mainly because the limited number of variables specified in a VAR may not reflect the full spectrum of information used by Central banks. Second, in VAR models, one has to take a stand on specific observable measures to represent some theoretical constructs. Third, in the standard VAR model, the impulse response functions can be observed only for those variables which are included in the model. One way to deal with these problems is combining the standard VAR analysis with "factor analysis", which results in the so-called FAVAR model (Bernanke et al. [2005])[2]. They used 120

1. Sims argues that this puzzling response of prices could be due to the fact that the Central bankers have larger information sets than captured by limit variables VAR model. He finds that the magnitude of prize puzzle decline with the inclusion of two more variables in the VAR models.

2. Factor analysis allows us to summarize a large amount of information in a small number of factors. Thus, including these "few" factors in standard VAR methodology makes feasible the

monthly macroeconomic time series data from 1959 to 2003 and employed VAR and FAVAR models. Bernanke et al. (2005) extract few common factors from the data and then use it with federal fund rate as policy variable in the FAVAR model and employed two methodologies to estimate the FAVAR.[1] They compare the results of VAR and FAVAR models first and conclude that in FAVAR model there is no price puzzle and the response of output is according to the theory with an increase in federal funds rate, while VAR model shows strong price puzzle. They find that a contractionary monetary policy, measured by positive increase in the federal funds rate leads to a decline in industrial production, 3-month treasury bills, 5 year treasury bonds, monetary base (MB), M2, commodity price index, capacity utilization rate, personal consumption, durable consumption, non-durable consumption, employment, housing starts, new orders, consumption of durable goods and consumer expectation, while prices initially rises and then decline.

Lagana and Mountford (2005) study the impact of monetary policy on a number of macroeconomic variables in the UK by using VAR and FAVAR models. Their main findings are that a contractionary monetary policy is associated with a rise in housing prices and stock market prices, while it leads to a depreciation of UK pound to US dollar. They conclude that the addition of factors to VAR model produces more superior results as compared to benchmark VAR, and it brings to light other identification issues such as house price and stock market puzzles. Shibamoto (2007) analyzes the monetary policy shocks on macroeconomic variables in Japan by using FAVAR model. There are three main findings. First, the time lags with which the monetary policy shocks are transmitted vary among various macroeconomic series. Second, a coherent picture of the effects of monetary policy on the economy is obtained, and lastly, monetary policy shocks have strong impact on real variables than industrial production.

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inclusion of the whole range of economic information used by Central banks into VAR analysis (Stock and Watson [2002], and Bernanke and Boivin [2003]).

1- Two step principal component approach and Bayesian method based on Gibbs sampling.

Carvalho and Junior (2009) analyze the effects of monetary policy in Brazilian economy by using FAVAR model. They find that with a contractionary monetary policy the variables used to measure economic activity responds negatively and their impact became null after few months which is consistent with long term neutrality of money and there is neither price puzzle nor M2 puzzle existed in Brazil. They concluded that the results of VAR and FAVAR models have no change in the response of principal variables and the marginal contribution of information from factors is low in case of Brazil. Soares (2011) measures the effects of monetary policy in the Euro area in the period of single monetary policy and used FAVAR model. He finds that a contractionary monetary policy leads to a hump shaped pattern of GDP which is consistent with theory and the IRF obtained from FAVAR model are in line with the literature and make sense from an economic point of view, while comparing the results of FAVAR with VAR models, finds that the inclusion of the information captured by the factors mitigates the price puzzle.

Kabundi and Ngwenya (2011) examine the effects of monetary policy on real, nominal and financial variables in South Africa by using FAVAR model. They find that with an increase in short-term interest rate is associated negatively with production, utilization of productive capacity, disposable income, fixed investment, consumption expenditure and employment, the response of credit and M3 is also negative but start recovering after 24 months, while South African All Share Index (ALSI) respond negatively and quickly to monetary policy and recovers quickly too. They concluded that the effects of monetary policy on key macroeconomic variables are significant with expected signs as suggested by theory.

The use of FAVAR in the literature on the impacts of the monetary policy shocks represents a major advance over the use of the VAR as traditionally applied. One primary advantage of FAVAR, highlighted in Bernanke et al. (2005), is that it is possible to obtain impulse responses for all variables used, and not just those directly included in the VAR. Another advantage is that it is not necessary to specify a series as a proxy for a theoretical concept. Bernanke et al. (2005) highlight an example of this advantage by showing that the concept of "economic activity" does not need to be represented by the industrial production series or real GDP. The use of the series is not exclusive, and other ones such as employment and sales can also be included. It is therefore not necessary to rely on arbitrary choices.

3- Monetary Policy in Iran (A Challenge to Decrease Inflation)

The conduct of monetary policy in an oil economy with a managed floating exchange rate regime can be challenging in an environment of fiscal dominance and incomplete transition to a market economy. The development plans provide a natural benchmark against which to assess monetary policy performance. Price stability has proved elusive, with M2 growth targets constantly exceeded by a large margin. Although fiscal dominance remains the main obstacle to disinflation, reforms to strengthen the anti-inflationary mandate and the operational independence of the Central bank, and more effective monetary instruments are also needed.

As it is illustrated by figure 1, Iran has had high inflation and also high M2 growth for more than 30 years, and need to reduce it to a single digit level because of following reasons: world-wide inflation decline, conflict with economic integration, a serious impediment to competitiveness, and long-term growth. This leads us to discuss the effectiveness of monetary policy in controlling M2 growth and inflation as well as the consistency of fiscal and exchange rate policies with the need to reduce inflation. Effectiveness of monetary policy depends on a number of factors (e.g. lack of fiscal dominance, clear and limited objectives, and effective instruments).

In recent years, important reforms have changed substantially the setting in which monetary policy operates. The most important change was the unification of the exchange rates in March 2002. Until then, the exchange rate system had been heavily controlled and multiple exchange rate practices and exchange restrictions prevailed. With the unification of the exchange rate system, the authorities adopted a market-based managed floating system, and eliminated most multiple exchange rate practices and exchange restrictions. Under this system, the authorities chose to target M2 growth to achieve their inflation objective and anchor inflationary expectations. This task has turned out to be quite challenging as sizable increases in government oil revenue have fueled government spending and put upward pressure on M2 growth, thereby making it more difficult for the Central bank to control M2 growth. With these changes and the gradual transition to a more market-oriented economy, the following challenges for monetary policy have increased:

The authorities' preference for using fiscal policy to stimulate growth and improve employment opportunities seems to have taken precedence over reducing inflation. This, together with the availability of abundant oil revenue, has strengthened fiscal dominance in Iran fueling M2 growth.

- Despite the sizable increase in oil export revenue and private capital inflows, the exchange rate has exhibited a downward drift imparted by policy out of concerns for competitiveness, and has made it more difficult to contain inflationary pressure.
- Monetary policy has few effective instruments at its disposal to control M2 growth.
- The Central bank's mandate to achieve price stability is less prominent than in other countries at comparable level of development, and the current institutional setting provides only a limited scope for timely arbitrage between conflicting objectives.

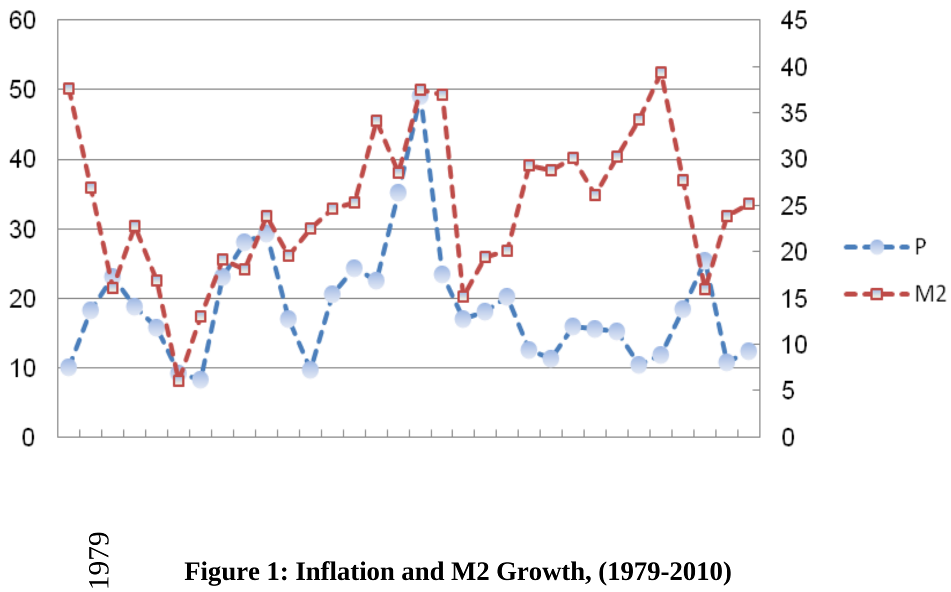

Figure 1: Inflation and M2 Growth, (1979-2010)

3-1- Fiscal Policy

Fiscal dominance, the subordination of monetary policy to fiscal financing requirements, is arguably the single most important reason for the difficulties faced by the Central bank in controlling the money supply. The non-oil fiscal deficit is by far the largest source of base money creation. Although Central bank net financing of government deficits is limited, the government budget relies to a large extent on dollar-denominated oil revenues, with very little domestic and foreign bond financing. Therefore, spending out of oil revenues, results in large injections of high-powered money that the Central bank is unable to offset owing to their sheer size. Although these injections have been very large over the last two decades, the recent increase in oil prices and the ensuing growth in government spending have exacerbated this problem. The ability of the Central bank to sterilize these injections, either through a tightening of credit to banks or through the issue of Central bank participation papers (CBPPs) has been very limited.

3-2- Exchange Rate Management

The managed float regime has worked well in providing stability to the foreign exchange rate. However, exchange rate policy does not seem consistent with the objective of reducing inflation. A constantly depreciating exchange rate may only contribute to fuel inflation, particularly if high oil prices persist and fiscal policy continues to be expansionary. This eventually frustrates the authorities' attempt to maintain the competitiveness of non-oil exports. More generally, it prevents the flexible exchange rate from playing its useful role of shock absorber, which requires the exchange rate to appreciate when positive shocks to the terms of trade, such as the recent oil price increase, occur.

It should be pointed out that numerous factors determine exchange rates, and must consider in the exchange rate management. Note that the following factors are in no particular order; like many aspects of economics, the relative importance of these factors is subject to much debate.

- **Differentials in Inflation;** As a general rule, a country with a consistently lower inflation exhibits a rising currency value, as its purchasing power increases relative to other currencies. Those countries with higher inflation typically see depreciation in their currency in relation to the currencies of their trading partners. This is also usually accompanied by higher interest rates.
- **Differentials in Interest Rates;** Interest rates, inflation and exchange rates are all highly correlated. By manipulating interest

rates, Central banks exert influence over both inflation and exchange rates, and changing interest rates impact inflation and currency values. Higher interest rates offer lenders in an economy a higher return relative to other countries. Therefore, higher interest rates attract foreign capital and cause the exchange rate to rise. The impact of higher interest rates is mitigated, however, if inflation in the country is much higher than in others, or if additional factors serve to drive the currency down.

- **Current-Account Deficits;** A deficit in the current account shows the country is spending more on foreign trade than it is earning, and that it is borrowing capital from foreign sources to make up the deficit. In other words, the country requires more foreign currency than it receives through sales of exports, and it supplies more of its own currency than foreigners demand for its products. The excess demand for foreign currency lowers the country's exchange rate until domestic goods and services are cheap enough for foreigners, and foreign assets are too expensive to generate sales for domestic interests.
- **Public Debt;** Countries will engage in large-scale deficit financing to pay for public sector projects and governmental funding. While such activity stimulates the domestic economy, nations with large public deficits and debts are less attractive to foreign investors. A large debt encourages inflation, and if inflation is high, the debt will be serviced and ultimately paid off with cheaper real dollars in the future. In the worst case scenario, a government may print money to pay part of a large debt, but increasing the money supply inevitably causes inflation. Moreover, if a government is not able to service its deficit through selling domestic bonds, increasing the money supply, then it must increase the supply of securities for sale to foreigners, thereby lowering their prices. Finally, a large debt may prove worrisome to foreigners if they believe the country risks defaulting on its obligations. Foreigners will be less willing to own securities denominated in that currency if the risk of default is great. For this reason, the country's debt rating is a crucial determinant of its exchange rate.
- **Terms of Trade;** A ratio comparing export prices to import prices, the terms of trade is related to current accounts and the balance of payments. If the price of a country's exports rises by a greater rate than that of its imports, its terms of trade have favorably improved. Increasing terms of trade shows

greater demand for the country's exports. This, in turn, results in rising revenues from exports, which provides increased demand for the country's currency. If the price of exports rises by a smaller rate than that of its imports, the currency's value will decrease in relation to its trading partners.

- **Political Stability and Economic Performance;** Foreign investors inevitably seek out stable countries with strong economic performance in which to invest their capital. A country with such positive attributes will draw investment funds away from other countries perceived to have more political and economic risk. Political turmoil can cause a loss of confidence in a currency and a movement of capital to the currencies of more stable countries.

3-3- Weak Monetary Instruments

The array of instruments available to the monetary authorities has evolved over time, but is still inadequate. Direct administrative controls on credit allocation and rates of return on lending are still pervasive. Although the share of banking sector credit subject to sectorial allocation limits has been gradually reduced, state-owned banks are bound to apply rates of return on lending set by the Monetary and Credit Council (MCC). These rates are changed infrequently and their setting is often inconsistent with monetary policy objectives, as indicated by the recent decisions to reduce rates of return despite excessive money growth. A step toward the adoption of indirect monetary instruments was taken with the introduction of CBPPs in 2001. Despite some limitations in their design, it was hoped that a secondary market for these instruments would develop and provide a market-determined benchmark for setting the rates of return in Iran. In fact, their main function consisted of providing an instrument to mop up excess M2, and help to reconcile the gradual exchange rate depreciation pursued by the authorities with increasing injection of government oil revenue in the system. Nevertheless, the cost of sterilizing the supply of foreign exchange connected with oil revenues and foreign direct investment has turned out to be too high and the issues of new CBPPs have remained well below what would have been necessary to mop up the excess M2.

3-4- Institutional Setting

The objectives of Central bank are to maintain the value of the currency and equilibrium in the balance of payments, to facilitate trade transactions, and to assist the economic growth of the country. This formulation is far too general and assigns too many objectives. What should the monetary authorities do when some of these objectives are conflicting? Take the objective of "to assist the economic growth", which calls for accommodating fiscal stimulus and rapid credit growth, which can come into conflict with the need to control M2 growth and inflation. Also, a policy to preserve competitiveness leads the authorities to buy large quantities of foreign exchange in the market to allow for a gradual depreciation of the nominal exchange rate. The liquidity so created cannot be possibly sterilized at a manageable cost with the available monetary instruments. Therefore, stimulating growth through fiscal policy and protecting competitiveness through the exchange rate are objectives that conflict with monetary control and, ultimately, with the price stability or low inflation objective. The Monetary and Banking Law does not provide a clear priority structure that could guide the Central bank in pursuing conflicting objectives.

4- Econometric Model

The main feature of the FAVAR approach is that it allows the inclusion of a huge number of variables in the VAR framework, through the use of "factor analysis". In the next subsection we present briefly the general framework, the estimation and identification of a FAVAR model.

4-1- The Factor Augmented VAR Approach

The FAVAR used by Bernanke et al. (2005) considers that there is an $M \times 1$ vector of observable economic variables (Y_t) that drive the dynamics of the economy. The dynamics of the economy can be analyzed using a VAR model of the form:

$$Y_t = \Phi(L) Y_{t-1} + v_t \qquad (1)$$

Where $\Phi(L)$ is a conformable lag polynomial of finite order *d*. however, in many applications, additional economic information not included in Y_t

may be relevant to modeling the dynamics of these series. Let us suppose that this additional information obtained from observed economic variables is included in a $N \times 1$ vector X_t , where N is large and will be assumed to be much greater than the number of factors and observed variables in the FAVAR system (Where $K+M<<N$). We assume that the informational time series X_t are related to the unobservable factors F_t and the observed variables Y_t by an observation equation of the form:

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t, \qquad t = 1,...,T \tag{2}$$

Where F_t is $K \times 1$ vector containing the K unobservable factors, Λ^f is an $N \times K$ matrix of factor loadings, Λ^y is an $N \times$M, and the $N \times 1$ vector of error terms e_t are mean zero and either weakly correlated or uncorrelated. Equation (2) captures the idea that both Y_t and F_t represent common forces that drive the dynamics of X_t, thus, conditional on Y_t, the X_t are noisy measures of the underlying unobserved factors F_t. Stock and Watson (1998) refer to equation (2) without observable factors as a dynamic factor model. Finally, it is assumed that the joint dynamics of (F_t, Y_t) can be represented by the following transition equation:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + u_t \tag{3}$$

The error term u_t is mean zero with covariance matrix Q. Bernanke et. al. (2005) called equation (3) a FAVAR model. They interpret the unobserved factors as "diffuse concepts" such as "economic activity" which usually are represented by a large number of economic series X_t and not only by one or two economic variables. As it can be noticed, equation (3) is just a VAR in *(F_t, Y_t)* which nests the standard VAR represented by equation (1). This is very important because if the true system that describes then dynamics of the economy is a FAVAR, estimation of (3) as a standard VAR system in Y_t will involve an omitted variable bias problem because of the omission of the "factors". As a consequence, the estimated VAR coefficients and everything that depends on them such as IRFs and variance decompositions will be biased. For simplicity suppose that the dynamics of the economy can be represented by real output y_t, inflation π_t, nominal exchange rate s_t, and a nominal interest rate R_t. In general, we can say that $[F_t' \;\; Y_t']' = [y_t \;\; y_t^P \;\; \pi_t \;\; s_t \;\; R_t]'$. In particular, if we assume that all those variables have an extract empirical measure, then $Y_t' = [y_t \;\; y_t^P \;\; \pi_t \;\; s_t \;\; R_t]'$ and F_t is a null vector. In this case, the dynamics of the economy can be analyzed using a standard VAR model. As another example, if potential output is unobservable, then we have $Y_t' = [y_t \;\; \pi_t \;\; s_t \;\; R_t]'$, and $F_t' = [\; y_t^P \;]'$. In this second case, the dynamics of the economy can be estimated as a FAVAR, and it would be necessary to use the information in X_t exploiting the relationship between factors and observables given by equation (2).

4-2- Estimation

The choice of the series was based on Bernanke et al. (2005), adjusting for the availability of these series for Iran. Quarterly series were used for the period between 1988:Q2 and 2011:Q3. Another point worth mentioning is that a number of series are non-existent at the national level with quarterly periodicity. Thus, it was not possible to include series that specifically capture these aspects of the economy. The estimation via two-stage principal component analysis similar to Bernanke et al. (2005) is performed as follows. In the first stage, the factors are estimated by using principal components analysis. In this way, the space generated by the components, $C_t = (F_t', Y_t')$ is obtained. However, the element of interest is $\hat{F}_t$, the portion of the space generated by $\hat{C}_t$ that is not generated by Y_t. The second stage consists in estimating the VAR via using $\hat{F}_t$ instead of F_t. It is then possible to obtain $\hat{\Phi}_t$. Once the VAR is estimated, it is possible to obtain the impulse response functions for both the factors and the original series. To perform the factor estimation, it is necessary to develop an identification scheme. Since in the principal component estimation the factors are derived entirely from the observation equation (2), it is sufficient to directly restrict the factors such that $F^{i\prime} F^{i} / T = I$, so that it becomes possible to identify the factors in a unique way. A second point concerns the identification scheme adopted to determine the VAR innovation; in the case of the model adopted in this study, this refers to the innovation in monetary policy. As with Bernanke et al. (2005), a recursive hypothesis is adopted in which the policy instrument is ordered last in the VAR estimation. However, it should be noted that this imposes the restriction that the factors cannot contemporaneously respond to a monetary policy innovation. As such, it is important to use $\hat{F}_t$ and not $\hat{C}_t$. To obtain the free factors from the policy instrument effect, the Bernanke et al. (2005) procedure is followed, discriminating between "fast-moving" and "slow-moving" variables. The "fast-moving" series (e.g. interest rate, exchange rate, and financial markets) are characterized as very sensitive to economic shocks and contemporary news. The "slow-moving" series (e.g. production and price) are basically predetermined in the current period. Subsequently, K factors are also estimated via principal component analysis using only the "slow-moving" variable group. The next step is to estimate the regression:

$$\hat{C}_t = b_{F^s}\hat{F}_t^S + b_Y Y_t + e_t \tag{4}$$

Finally, $\hat{F}_t = \hat{C}_t - \hat{b}_Y Y_t$ is constructed, and the VAR is estimated using $\hat{F}_t$ and Y_t. It should be noted that because the factors are estimated using principal components, they are orthogonal. Thus, the way in which the factors are ordered in the VAR is not relevant to the process of obtaining the impulse responses.

4-3- Number of factors and Lag Selections

The literature on multivariate analysis proposes several criteria for determining the appropriate number of factors for a series set. Many empirical studies adopt the method proposed in Bai and Ng (2002). However, none of the criteria considers that the factors will be included in the VAR and that therefore, there are restrictions imposed due to the loss of degrees of freedom. Initially, the choice was to follow Bernanke et al. (2005) and estimate the FAVAR using two factors. However, the two factors with the largest eigenvalues explained only 41.2% of the variability of set X_t.

For the lag selections of VAR model we use Schwarz information criterion (SC). Since error terms are weakly correlated in equation (2), therefore the autocorrelation is not eliminated even with the inclusion of lags. As we are using quarterly data so to include 2 lags is appropriate to encounter autocorrelation, because if at 2 lags autocorrelation does not eliminate, it minimize the problem of autocorrelation.

4-4- Impulse Response Function (IRF)

The response function of the driving factors for the monetary policy instrument was obtained using the Cholesky decomposition method. The standard error of the estimates was calculated using the Monte Carlo method with 100 repetitions and not in an analytical form based on asymptotic results. This choice was made because of the reduced number of observations in the series. Based on the impulse response functions of the factors, it was possible to obtain the impulse response function for all of the series included in X_t. It should be noted that because $K<N$ factors were used and because the impulse response functions of the factors are orthogonalized with respect to the monetary policy instrument, it was not possible to retrieve a variable X_{it} as a function of the factors through the matrix of factor loadings obtained via principal component estimation. To obtain the impulse response, the variable of interest, X_{it} was written as a linear combination of the VAR variables:

$$X_{it} = \alpha_1 \hat{F}_{1t} + \alpha_2 \hat{F}_{2t} + ... + \alpha_K \hat{F}_{Kt} + u_t \tag{5}$$

Subsequently, the IRF for each variable was obtained as the linear combination of those factors. Since the factors are themselves orthogonal, in order to construct the confidence interval a weighted sum of the response factors' variance was calculated using the weights α_j^2. the variable of interest was projected in the space generated by the factors so as to obtain the estimates of the weights α_j.

4-5- Results

It is broadly known in economics that many macroeconomic time series are integrated of order one or two. It means that they are trend stationary after differencing once or twice. In order to avoid spurious regressions and to investigate possible co-integrating relationships, it is important to first verify the degree of integration of all time series. If a time series has to be differenced P times before it becomes stationary, it is integrated of order P, denoted by *I(P)*. However, we might lose valuable long-run information when first or higher order differenced time series are used.

It is widely known that different non-stationary variables might be used at levels in one model if they are co-integrated. This means that the regression on the levels of these variables is not spurious. Different methods have been developed to examine whether a vector of time series are co-integrated. The concept of co-integration is a useful tool to model variables that are linked by economic forces. In this study, the variables are co-integrated according to Johnson's method. It means there is a long-run equilibrium relationship between them. Hence, the regression on the levels of these variables is not spurious.

The main results are shown in appendix. Each figure shows the IRFS of a selection of macroeconomic variables (e.g. GDP, Investment [I], Private consumption [PC], Government consumption [GC], Capacity utilization [CU]) to a shock of one standard deviation in the CPI, M2, MB, and exchange rate (IER), as monetary policy instruments and oil price (OILP) in log forms. One observes that the VAR estimated without any factors yields impulse responses for inflation and GDP very similar to those obtained in the FAVARs in terms of signal. However, although the result was similar for GDP in terms of duration, the impact of the contractionary shock was more persistent in the VAR.

The response of the exchange rate also showed the expected format. In response to a contractionary monetary shock, the exchange rate increased. This was followed by slight depreciation until the impact returned to zero. This behavior reveals the existence of overshooting, which is a fairly common phenomenon in the empirical literature on exchange rates. It was not possible to compare the exchange rate response obtained using VAR and FAVAR because the exchange rate projection coefficient in the space generated by the factors were all insignificant and it was therefore considered inappropriate to use the exchange rate impulse response obtained using the FAVAR.

The inclusion of factors only slightly increased the magnitude and duration of the impact of monetary contraction on the inflation. The absence of alterations in the results based on the inclusion of these factors may be related to their low explanatory power. It is interesting to note that even the responses indicated by the VAR without factors were not significant. This, in turn, corroborates the explanation that the reduced number of observations contributed to the imprecision of the results.

The MB suffers a contraction after the shock. This result is quite reasonable and evidences the absence of a M2 puzzle, which often appears in empirical studies using VAR. It should be noted that the MB response was more erratic than the other ones. In observing figures, we can also note that the contractionary shock causes a reduction in CU. All these results are consistent with the expectations based on the monetary contraction impact theory. The results for the principal variables were generally consistent with the theory in terms of signal and duration. After a contractionary monetary policy shock, there is a drop in GDP, which reaches a minimum three quarters after the monetary contraction. The effect becomes null after more quarters, which is consistent with the long-term neutrality of money.

It is clear that the paths for the CPI response, MB, and CU in the long-term are less erratic over time in the FAVAR estimation with two factors. Despite the reasonability of the results obtained, it is important to discuss the inaccuracy of the estimates. The results for the two-factor FAVAR were even more imprecise; the MB figures were also not significant. Additionally, the other variables showed significant responses only for the initial three quarters.

One way to evaluate the informational contribution of the factors is to compare the results obtained using FAVAR with those obtained using small-scale VAR. However, to accurately measure that marginal contribution, the estimation process proposed by Bernanke et al. (2005) should be followed. It is important to recognize that FAVAR is not a purely factorial model: it also includes a vector of observable variables. Thus, the observable series generally included in the VAR can be included in Y_t. These are a GDP time series as a measure of real activity, prices series and exchange rate series. The exchange rate series was included because of its importance in the analysis conducted by the monetary authority, especially in the context of inflation targeting. Taylor (2000) argues that the impact of the exchange rate on inflation positively depends on the persistence of inflation. Conversely, Calvo and Reinhart (2000), using VAR, show that the pass-through is greater for emerging countries. Thus, the monetary authority should make an effort to respond to fluctuations in the exchange rates so as to contain the pass-through.

We impose an increase in M2 as monetary policy to investigate the responses among variables in the VAR model. Firstly, the oil price decreased after a period slight growth and in short term, the effect of the MB change on the oil price was negligible. Secondly, real GDP in Iran showed a prolonged negative impact in response to the increase in the MB. There is a drop in the in inflation as a result of the shock to the exchange rate. The negative effect reaches its peak at four quarter, and at the end of the ten quarter, the response returns to zero. As a result, we can conclude that two factors are able to capture sufficient information to indicate that the price behavior follows that predicted by the theory.

Figure 9 and Figure 10 illustrate the impulse responses of different macroeconomic variables to an oil price change by using VAR and FAVAR models. The estimated response of macroeconomic variables suggests that a positive oil price shock was expected to boost the real GDP instantaneously. In contrast, the response of CU was not significant in early quarters. The graph also illustrate that the impact of the oil price shock on the exchange rate was significant.

5- Conclusions

The main purpose of the present paper was to contribute to the discussion about the analysis of the effects of monetary policy shocks, incorporating two main issues that have hampered the analysis of the effects of monetary policy shocks using VAR models: a: the difficulty in identifying the most appropriate indicator of monetary policy stance and thus identifying monetary policy shocks, b: the correct specification of the empirical model, which is restricted by the limited number of variables that can be included in a standard VAR. This paper used the FAVAR approach proposed in Bernanke et al. (2005) to study the effects of a monetary policy shock on the Iranian economy since 1988:Q2. The purpose of using this method was to match the information set included in the empirical analysis as well as possible to that available to the monetary authorities. In addition, FAVAR eliminates the need to rely on arbitrary choices regarding which series to include. The factor estimation was performed using principal component analysis, due to its good performance in other empirical studies and its computational simplicity.

The results obtained were consistent with the existing theory regarding the impact of contractionary monetary shocks. When comparing the FAVAR method with the traditional VAR method, we observe that there was no change in the response of the principal variables. Thus, we conclude that the marginal contribution of the information regarding the factors was low. However, although it captured little information, the FAVAR was still able to at least reproduce the results obtained through the small-scale VAR estimation in terms of signal, magnitude, and duration. In this paper, we examined the IRFs of various economic indicators to monetary instruments and oil price shocks using VAR and FAVAR models.

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41- Appendix

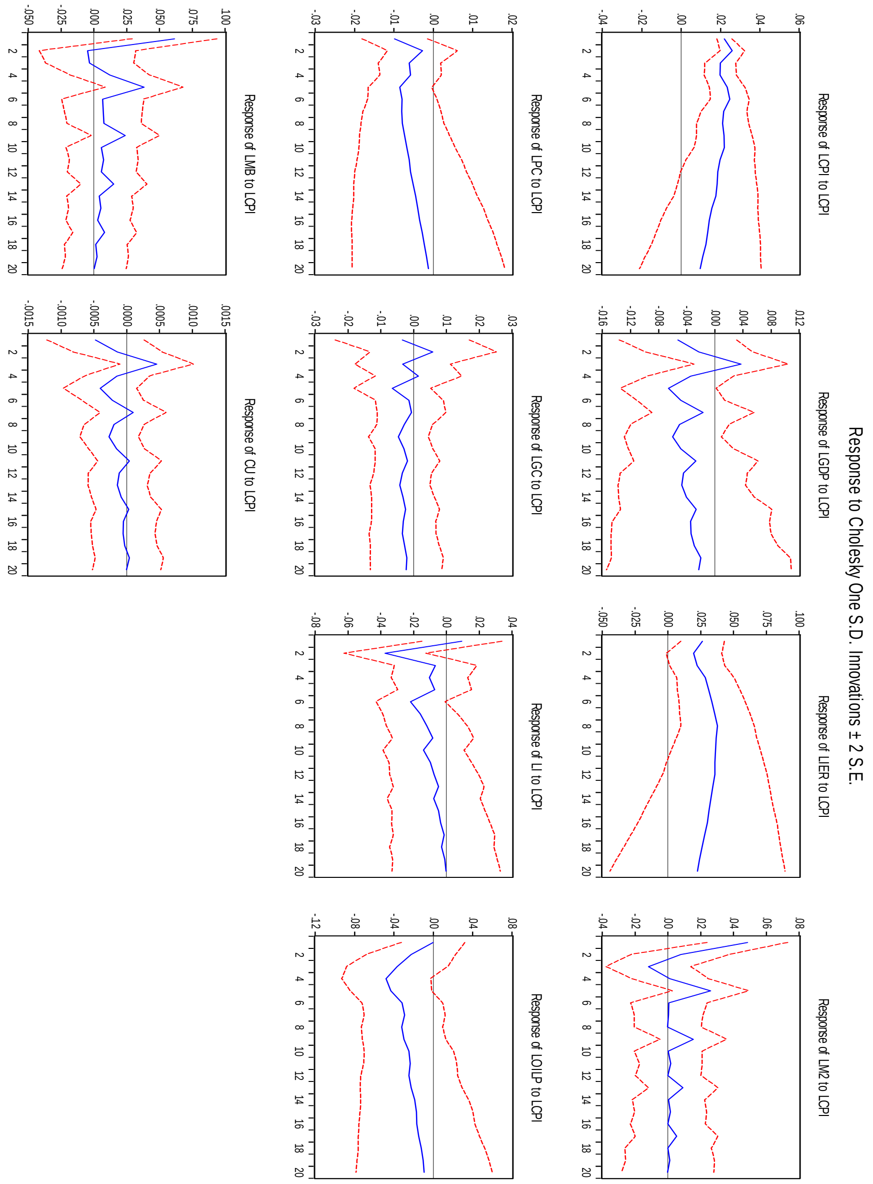

Figure 1: Impulse Responses of Different Variables to LCPI Changes in VAR

Figure 2: Impulse Responses of Different Variables to LCPI Changes in FAVAR

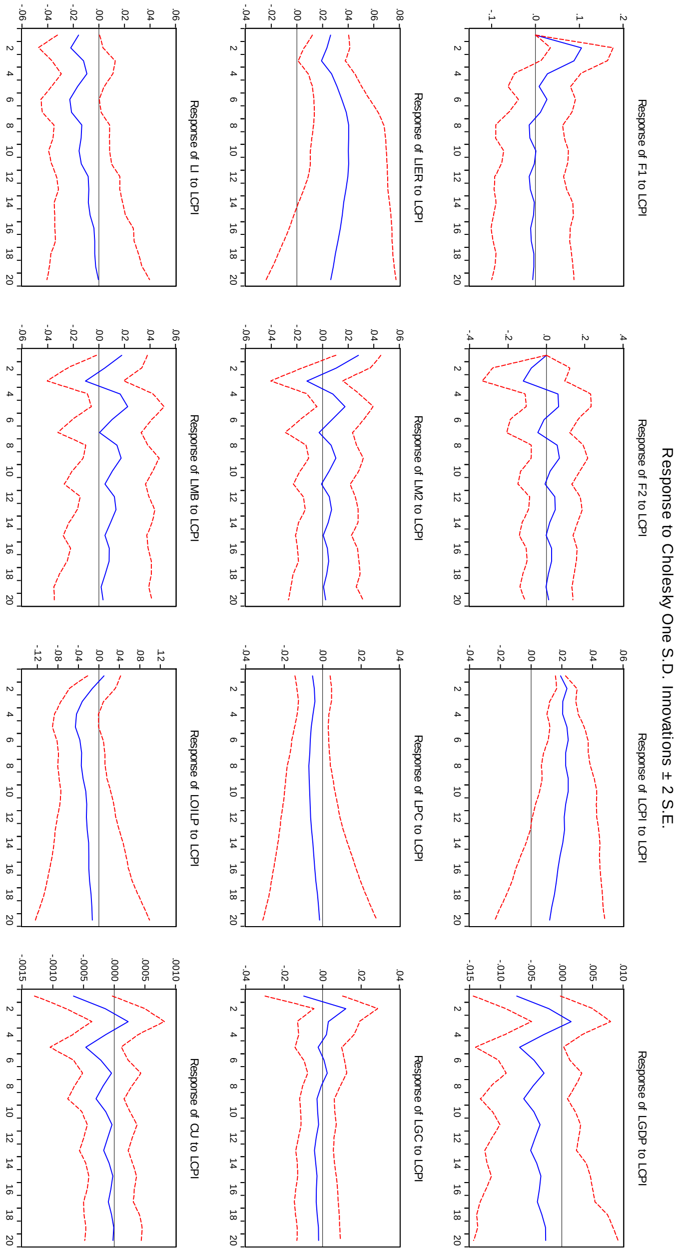

Figure 3: Impulse Responses of Different Variables to LM2 Changes in VAR

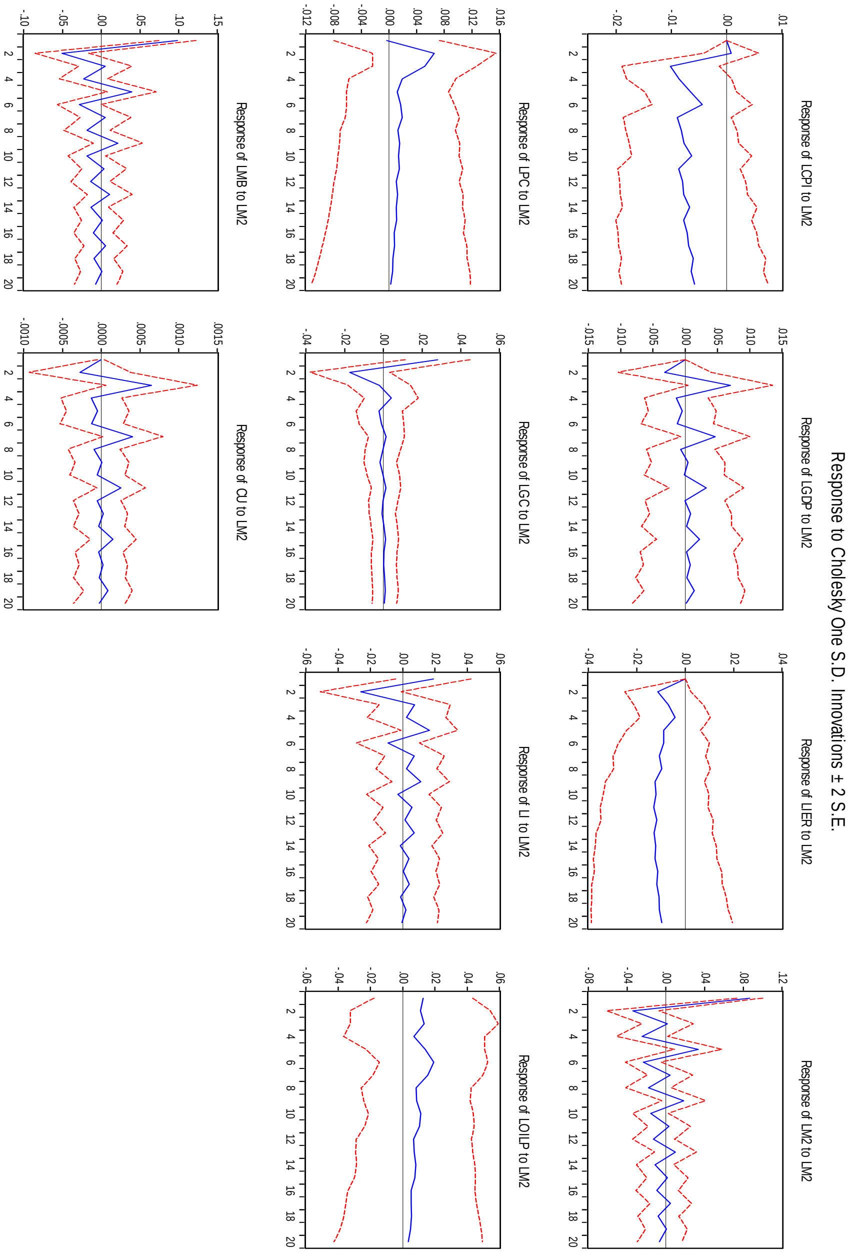

Figure 4: Impulse Responses of Different Variables to LM2 Changes in FAVAR

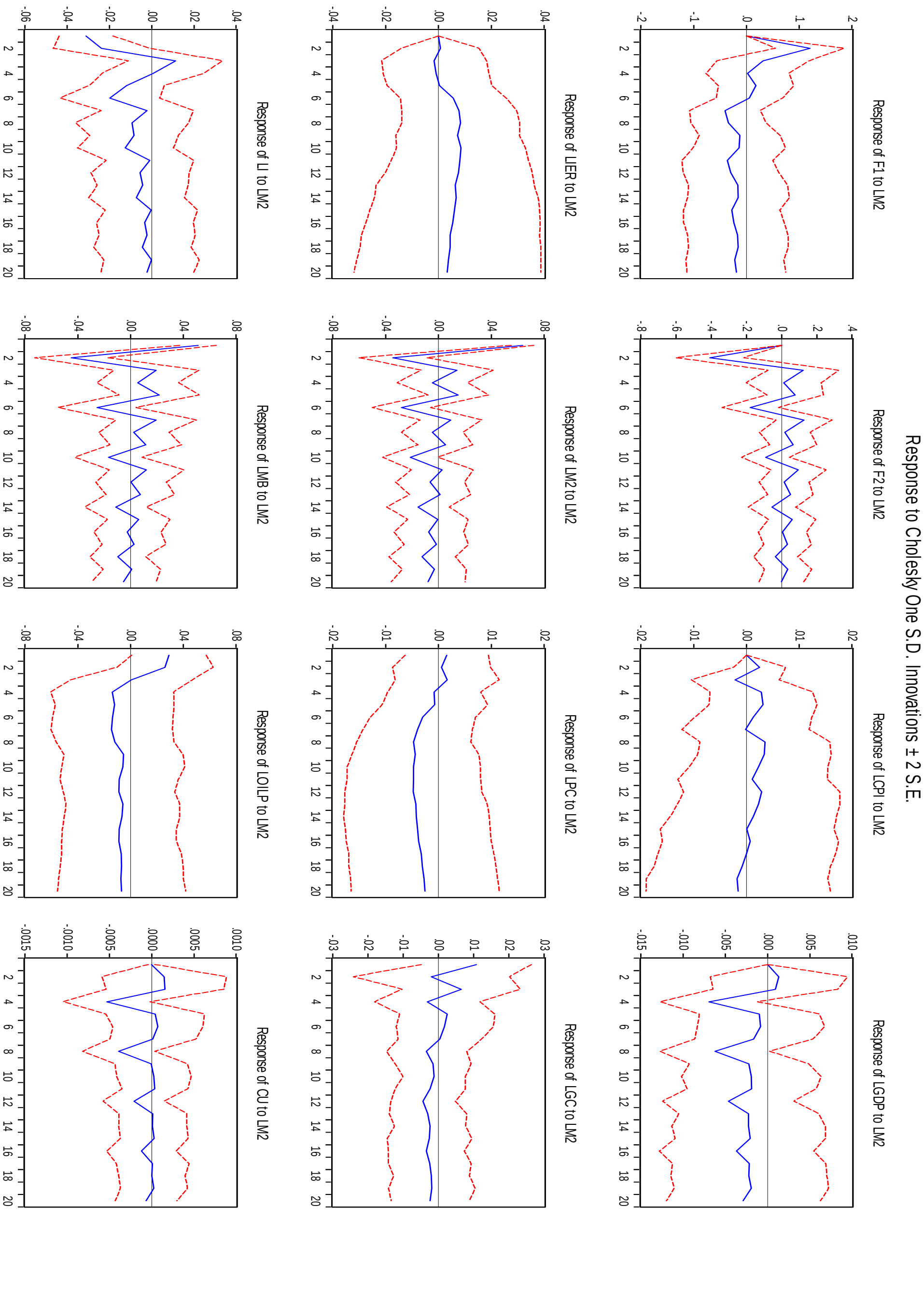

Figure 5: Impulse Responses of Different Variables to LMB Changes in VAR

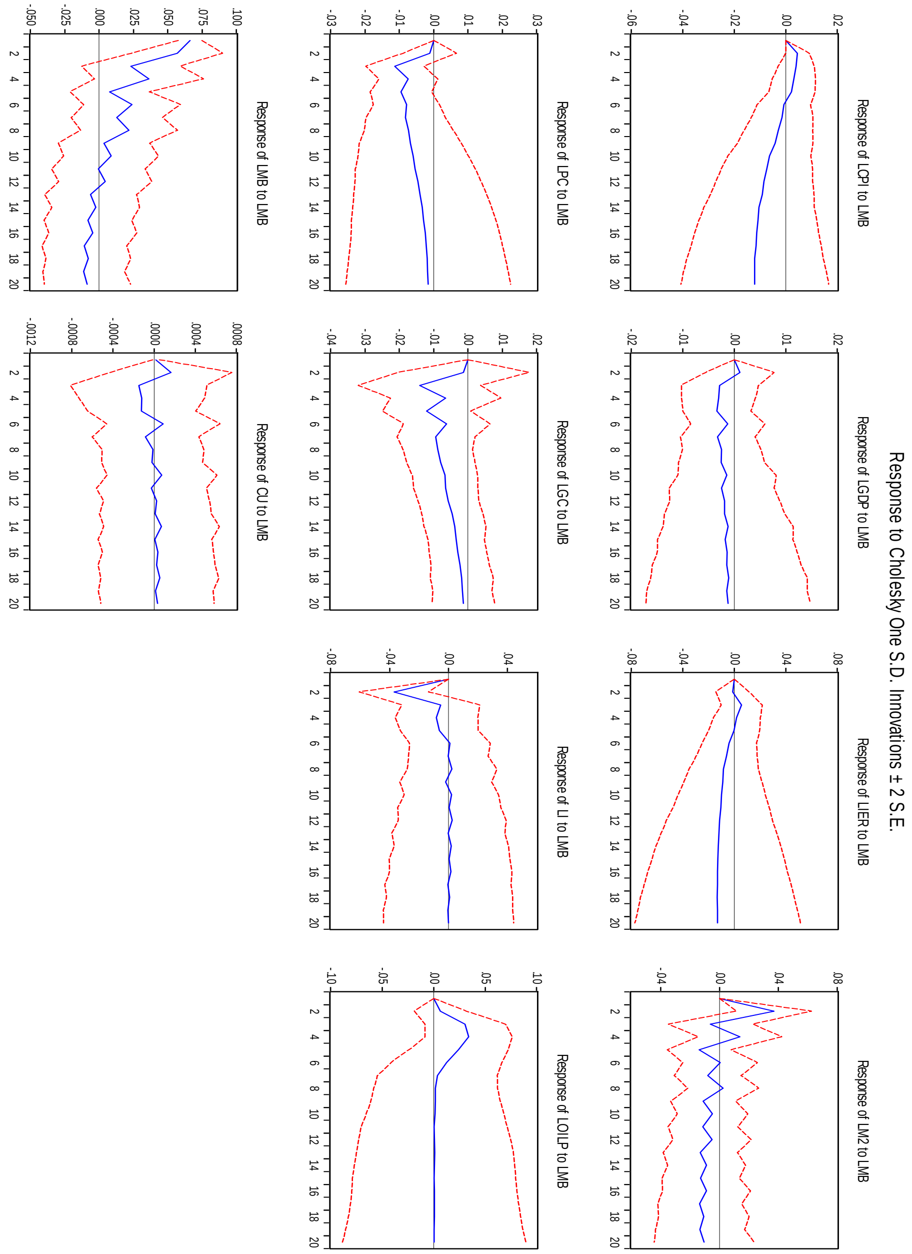

Figure 6: Impulse Responses of Different Variables to LMB Changes in FAVAR

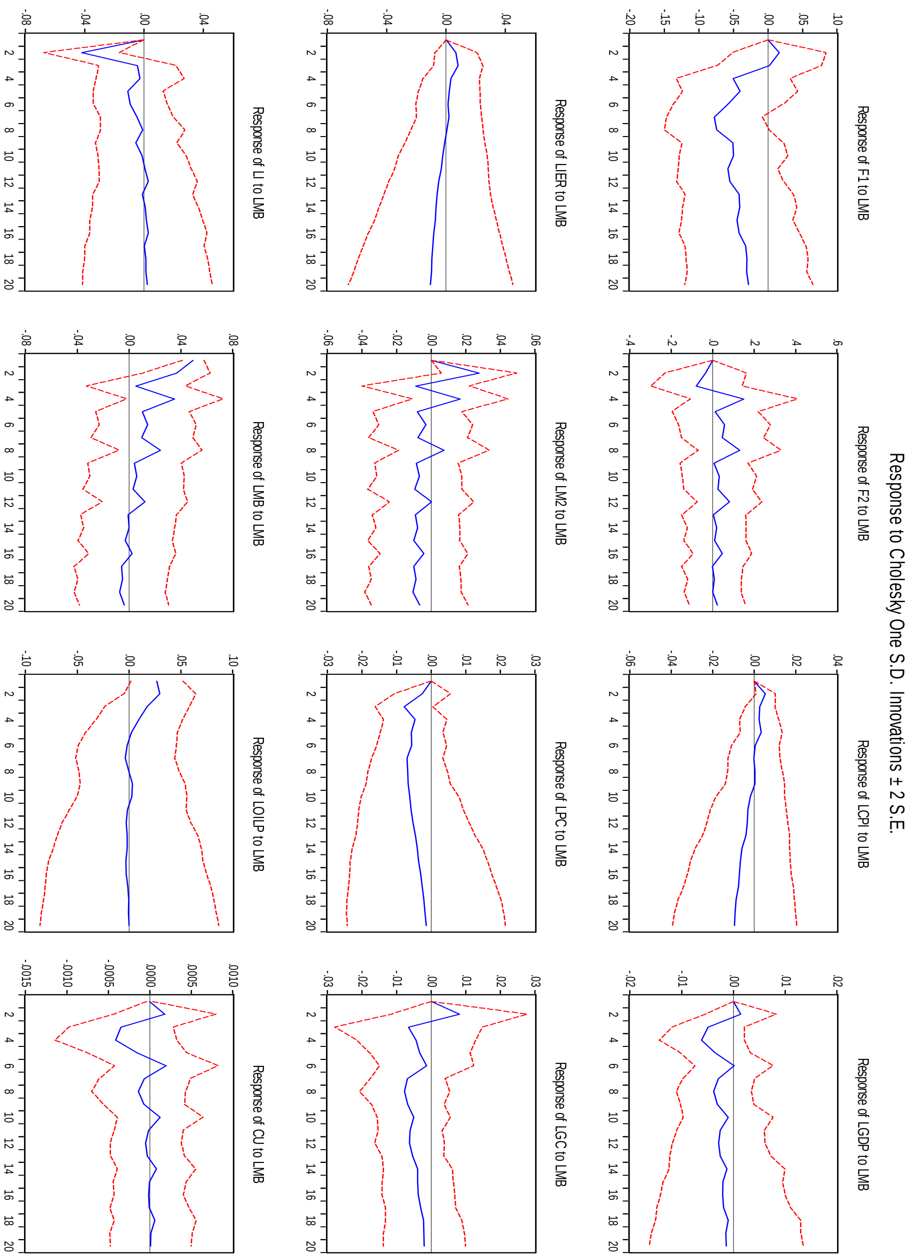

Figure 7: Impulse Responses of Different Variables to LIER Changes in VAR

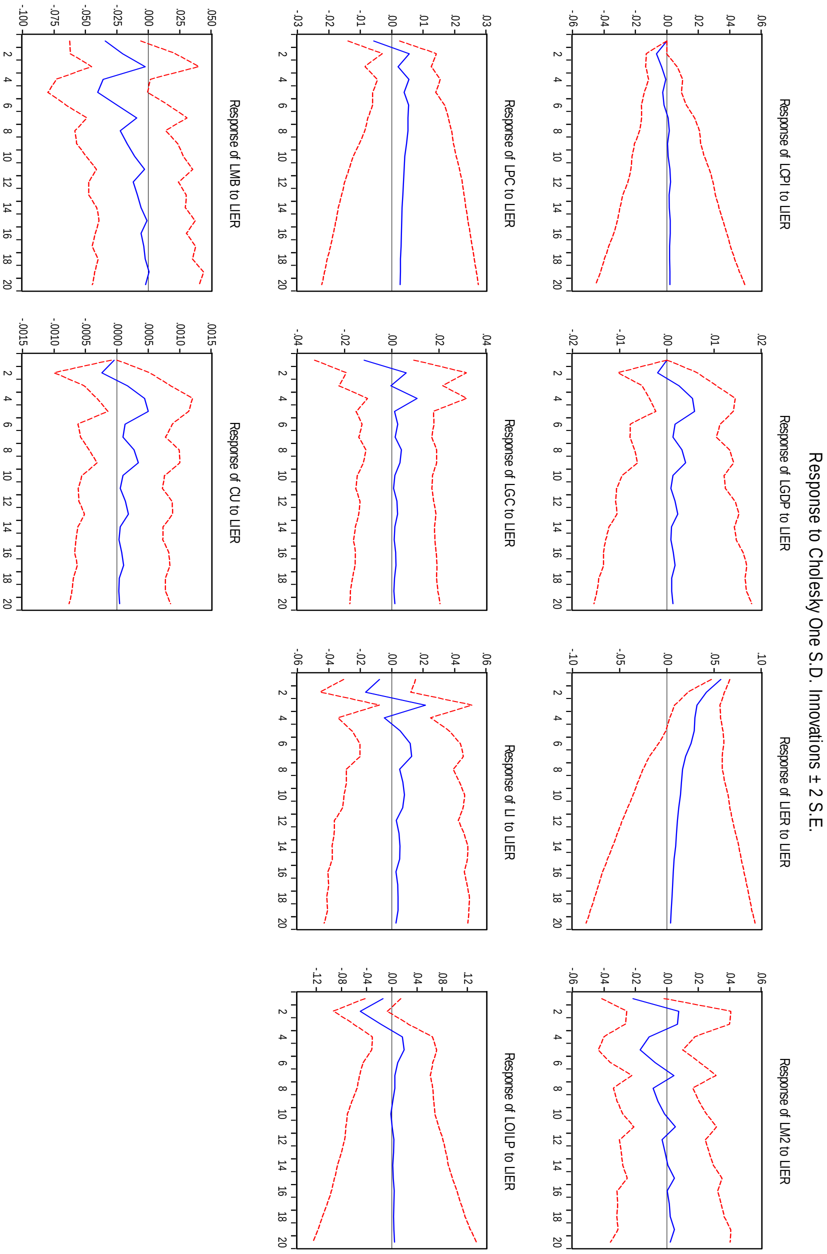

Figure 8: Impulse Responses of Different Variables to LIER Changes in FAVAR

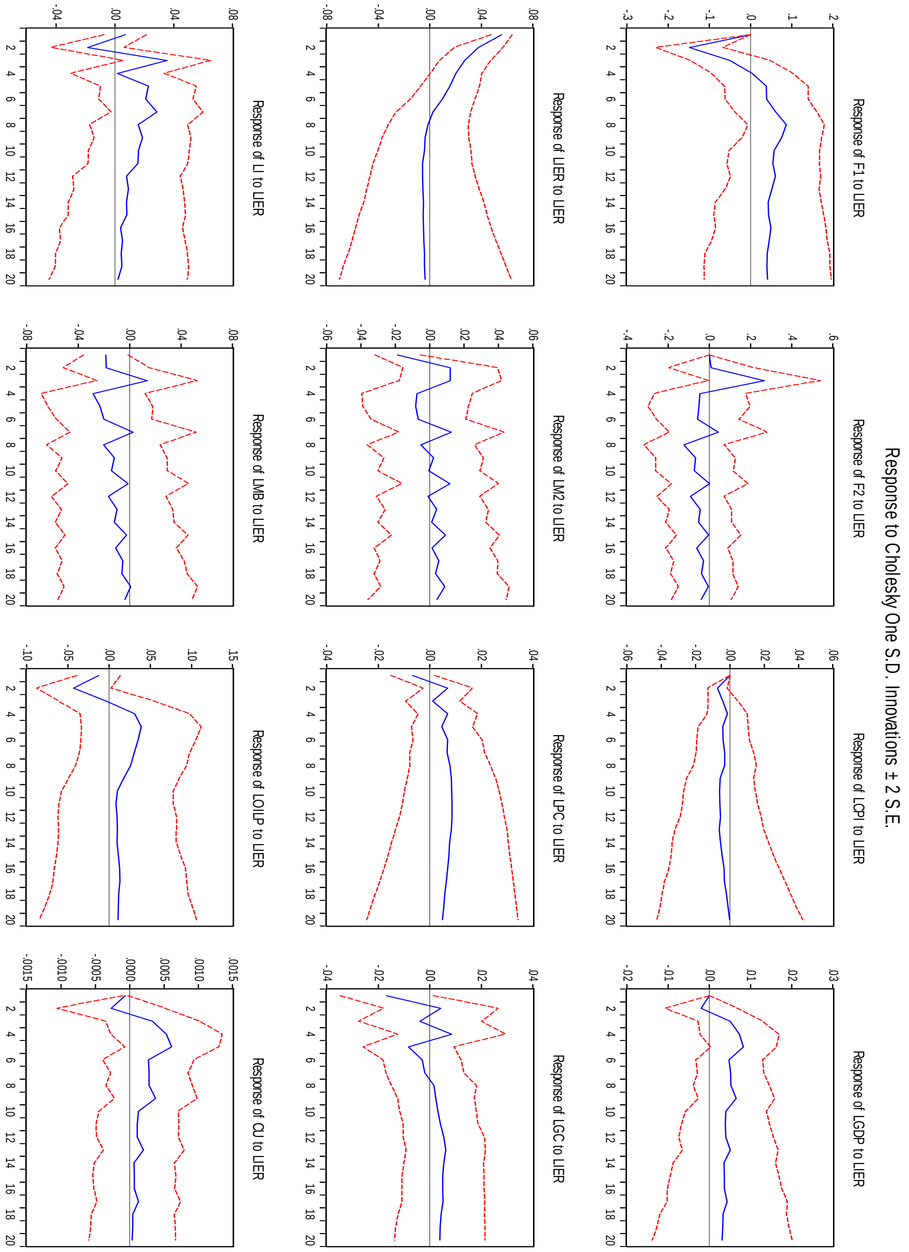

Figure 9: Impulse Responses of Different Variables to LOILP Changes in VAR

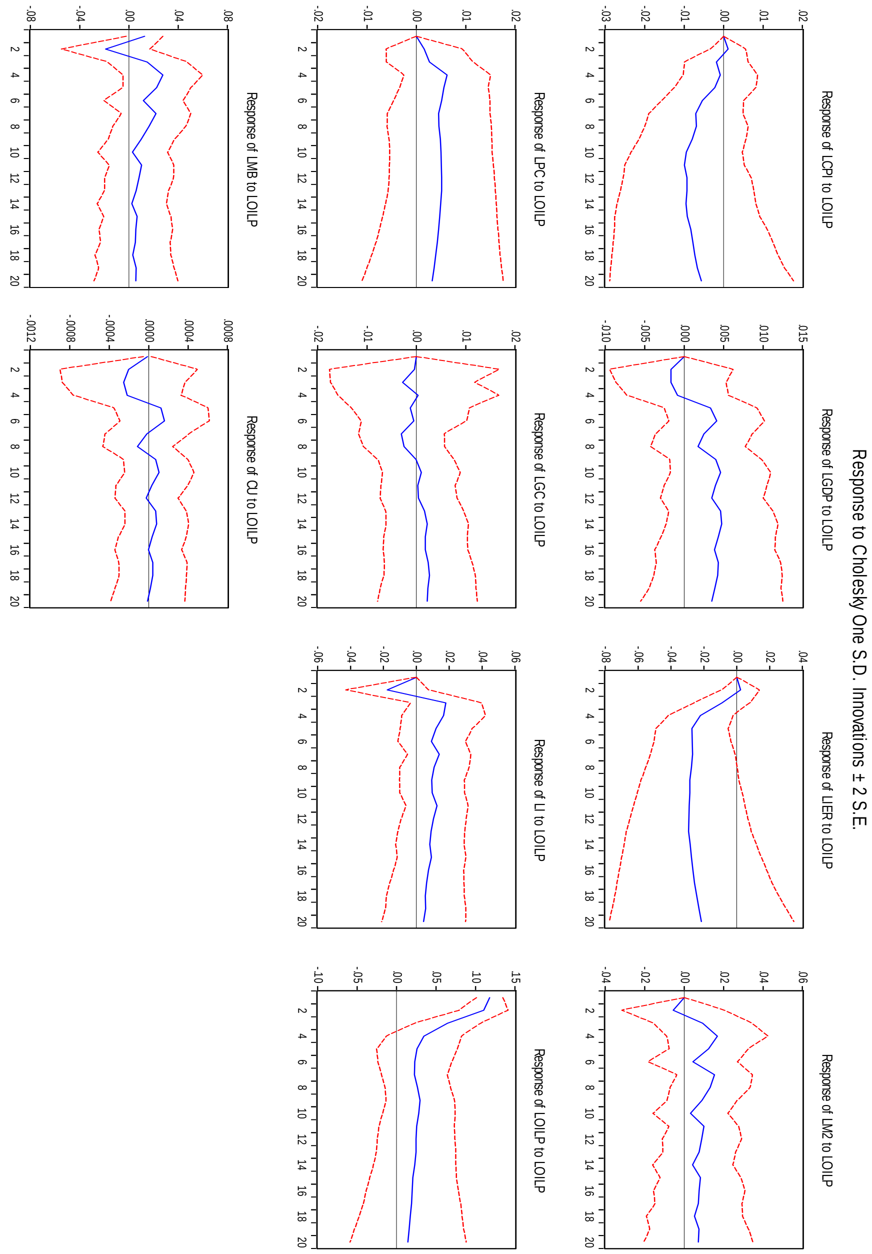

Figure 10: Impulse Responses of Different Variables to LOILP Changes in FAVAR