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Financial risk contagion to real sector in Iran: A VAR-BEKK-GARCH approach

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ABSTRACT

Asset market interconnectedness can give rise to significant contagion risks during periods of financial crises that extend beyond the risks associated with changes in volatilities and correlations. These channels include the transmission of shocks operating through changes in the higher order co-movements of asset returns, including changes in co-skewness arising from changes in the interaction between volatility and average returns across asset markets. These additional contagion channels have nontrivial implications for the pricing of options through changes in the payoff probability structure and more generally, in the management of financial risks. The purpose of this study was to investigate the financial risk contagion from the financial sector to the real sector of the economy using VAR-BEKK-GARCH for the active industries in the Tehran Stock Exchange during the period of 1388-1395. The estimated coefficients for considering the period of the crisis and the recession in the stock market indicate that the coefficients are positive for the effect of the outflow in the stock market. Also, in the case study, there is a probability of financial risk fluctuation between the investigated industries. In addition, the results indicate that the risk and turmoil among the active industries in the stock market and the real sector of the Iranian economy are tangible.

***Keywords*:** Risk contagion, Volatility spillover, financial markets, VAR-BEKK-GARCH approach

JEL Classification: C32, C50, G15, G11

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1. INTRODUCTION

In many countries, the financial sector is the key source of financing for service and industrial enterprises (as the real sector of the economy). Besides, the returns and risks of the real sector's economy are affected by the vicissitude of the financial market in particular through profitability and performance. The financial crisis, through the destruction of financial servants, leads to the transmission of crisis and volatility from the capital market to the real sector of the economy. Studies by Rajan and Zingales (1998) and Baur (2011) examined the relationship between the capital market and the real sector of the economy through factors other than returns and profitability (Chien et al., 2014).

The investigation and analysis of risk contagion among markets have been applied for decades by theorists and researchers from different fields. The complexity of the financial and economic markets and the close interrelationship among these markets, as well as the vital need for predicting future financial and economic scenarios, have led the financial researchers to explore and analyze these relationships between markets as an effective step forward in achieving the goals of the financial and economic system (Fang and Egan, 2018).

Risk contagion between financial indices indicates the process of information transmission among markets. Given that financial markets are interrelated, information created in a marketplace can affect other markets. Consequently, from the point of view of financial market analysis, risk modeling in different markets and the interrelationship among them is important due to its use in forecasting. One of the effective elements in risk management is the risk transmission from the financial sector to other sectors of the economy (Gudarzi Farahani and Dastan, 2013, Forbes and Rigobon, 2000).

The Global Financial Crisis of 2007–2009 has been linked to the Great Depression of 1929 due to the joint deterioration of stock markets and macroeconomic variables such as industrial production and world trade. The global scale of the recent crisis also distinguishes it from previous financial crisis with a more regional focus such as the Asian financial crisis in 1997 or the Mexican crisis in 1994. While the simultaneous drop in stock prices and macroeconomic conditions has been described and analyzed (e.g. see Eichengreen and O'Rourke, 2009), there is no global and comprehensive study of the transmission of shocks from stocks of the financial sector to stocks representing non-financial sectors and thus ‘‘real economy’’ stocks such as Industrials, Consumer Goods, Utilities or Technology. Such a study is important as it can provide information about investor behavior in times of turmoil and thus how a crisis spreads. For example, do investors sell stocks of specific sectors and countries or do they sell stocks across all sectors and countries? The latter would lead to a reduced effectiveness of diversification while the former would maintain the benefits of diversification. An assessment of the breadth of a financial crisis can also assist governments in effectively designing stimulus packages to reduce the costs of an infection of multiple sectors in an economy.

Most of the existing literature on contagion analyzes aggregate stock market indices (e.g. see Baig and Goldfajn, 1999; Forbes and Rigobon, 2002; Bae et al., 2003; Baur and Schulze, 2005; Bekaert et al., 2005; Boyer et al., 2006; Chandar et al., 2009; Markwat et al., 2009 and Dungey et al., 2010 among others). Studies that test for contagion based on non-aggregate data are rare. Phylaktis and Xia (2004) analyze contagion of sectors within an asset pricing perspective for the period from 1990 to 2004 and find mixed evidence for contagion. They see this as evidence that diversification is beneficial despite the existence of contagion and financial crises. Horta et al. (2010) analyze the Global Financial Crisis for four European aggregate stock markets and two sectors (financial and industrial) with copulas and find contagion for all markets and sectors.

The present study was therefore conducted to investigate volatility spillover between financial markets and real sector of economy using the VAR-BEKK-GARCH for model estimation. In the following, the theoretical and literature review of the study are presented, followed by discussing the methodology, detailing the findings and concluding.

2. THEORETICAL AND LITERATURE REVIEW

Many models of financial asset pricing and risk management are based on the level of volatility of financial variables. Identifying the relationships and volatility spillover among financial markets has therefore attracted the attention of researchers (Gonzalez Rivera et al., 2004; Soriano and Climent, 2006). Two general views are held on the relationship between exchange rates and stock prices. The flow-oriented models suggest that national current account and current balance are the two main determinants of the exchange rate. Accordingly, the changes in exchange rates affect international competitiveness and trade balance, as well as actual economic variables such as real production and income and the future and current cash-flow of firms and their stock prices (Dornbusch and Fischer, 1980).

According to this model, an increase in exchange rates increases the competitiveness of domestic firms and makes their exports cheaper compared to other foreign competitors. An increase in the advantage of a domestically-produced commodity causes an increase in export and income, and increases the stock prices of firms. Exchange rate is therefore positively associated with stock price based on this model. According to the second perspective, known as stock-oriented models, capital account is a determining factor of exchange rates. These models include portfolio balance and monetary models. According to the portfolio model, exchange rate is negatively associated with stock price in a way that reductions in stock price reduces the wealth of domestic investors, lowering the interest rate and demand for money. With other factors remaining stable, reductions in the interest rate can therefore cause the capital outflow to foreign markets, the devaluation of domestic currency and an increase in exchange rates. On the other hand, according to the monetary model proposed by Gavin (1989), there are no relationships between exchange rate and stock price. Based on the discussed points, the relationship between exchange rate and stock price is unclear.

Furthermore, investment in gold is an attractive alternative as a method of saving and keeping the value of money, especially in an inflationary economy. According to the portfolio theory, gold price can affect other financial assets. Investors earn their intended profit by selecting an optimal combination of financial assets in their portfolio. Individuals keep different combinations of assets such as cash, stock, bank deposits, bonds, gold and currency, and change their portfolio combination by replacing a low-return asset with a more profitable one. Changes in these assets therefore change the demand for stocks, and cause stock price fluctuations. In addition, inflationary expectations, exchange rate fluctuations, fluctuations in stock price index and announcing international sanctions can cause some sorts of excitement for the demand in the gold market, therefore increasing gold price (Wang et al., 2011).

The following references can be cited for research on volatility spillover:

Fenghua et al. (2018) considered the effect of oil prices and the Chinese stock market. For this purpose nonlinear autoregressive distributed lags (NARDL) model and Diks and Panchenko (DP) tests were used. The empirical results showed that there were not significantly asymmetric co-integration effects between the oil prices and the Chinese stock market for the overall and sectoral levels. However, the significantly nonlinear causality between the oil prices and the Chinese stock market can be found. Specifically, the oil prices can widely affect Chinese stock indices through the nonlinear channel. The cases in the reverse also worked for overall indices, Mining, Utilities, Financial, and Real Estate sectors. Also, the potential sources of nonlinear causality linkages were examined (Fenghua et al., 2018).

Xiao et al. (2018) examined the asymmetric effects of the oil price uncertainty on Chinese stock returns under different market conditions. In this paper, the crude oil volatility index (OVX) was a direct and more accurate measure of the oil price uncertainty. The paper used the kind of implied volatility index of the oil price to investigate the impacts of the oil price uncertainty on the aggregate and sectoral stock returns in China. This issue was resolved by using quality regression, which can provide a more detailed examination under different markets conditions. Meanwhile, the asymmetric effects of uncertainty shocks were also examined by using the positive and negative changes of the OVX. The results revealed that OVX changes mainly showed significant negative effects on the aggregate and sectoral stock returns in the bearish markets. In particular, these effects depended largely on the positive shocks of the OVX rather than the negative shocks of the OVX (Xiao et al., 2018).

Hu et al. (2018) considered the asymmetric impact of the oil price shock on the stock market in China based on SVAR and NARDL models. The results showed that the demand-side shocks of the oil price had a significant impact on the Chinese stock market in both the short and long run, but the supply shock was an exception. In terms of asymmetric nature, there was no evidence of asymmetric impact when it referred to the supply shock and the oil-specific demand shock on the stock market and only the aggregate demand shock had asymmetric effect in short run (Hu et al., 2018).

Ding et al. (2017) considered the contagion effects of the international crude oil price fluctuations on Chinese the stock market investor sentiment. The structural vector autoregression(SVAR) model was used for this purpose. The results showed that the international crude oil price fluctuations significantly cause Chinese the stock market investor sentiment; in the long term, if the international crude oil price fluctuated by 1%, stock market sentiment has negatively fluctuated 3.9400%. From the view of short-term effects, if the international crude oil price fluctuated by 1%, stock market investor sentiment in the same period has negatively fluctuated 1.0223%. International crude oil prices made a greater early contribution to investor sentiment and showed a rapid growth trend, with a contribution of 2.8076% in the first period and 8.1955% in the second. The growth rate slowed and eventually stabilized at the 25% level; the average contagion delayed for international crude oil price fluctuation to affects investor sentiment was 8 months (Ding et al., 2017).

Bastanzad and Davoudi (2017) examined the evaluation of risk transmission over foreign exchange, real estate, and stock markets in Iran’s economy by using a parametric and non-parametric value at the risk approach. The results indicated that the international spillover remarkably affected the asset markets risks mainly through macroeconomic variables in Iran`s economy. The results underscore the VaR (Value at Risk) which were statistically computed by the nonparametric approaches during 1990-2015 was considered more efficient than parametric approaches due to lower standard deviation and coefficient of variation as well as a better reflection of cyclical shocks. The causality test indicated the foreign exchange VaR caused the stock price VaR while the stock price VaR simultaneously caused the mortgage price VaR. The impact of macroeconomic variables on the assets market VaRs was estimated by the causality test as the output growth adversely inspires the VaRs of mortgage price and foreign exchange rate. Meanwhile, the money base was constantly stimulated by the assets market VaRs in the short and medium term owing to the money base. As a consequence reduction, foreign exchange market risk led to a reduction in other assets market risk and eventually overall economy. Therefore, it was desirable to design complementary mechanisms to fulfill the task (Bastanzad and Davoudi, 2017).

Rezagholizade et al. (2017) examined the transmission of world oil price volatility on chemical industry stock price index (VAR-BEKK-GARCH approach). In this study, the spillover effects of world oil price volatility on the index of chemical industries were evaluated. Also, it was examined how volatility move from the global oil market to the Tehran Stock Exchange and vice versa from the Tehran Stock Exchange to the oil market. The pattern of changes in daily oil prices and value of chemical industries index was investigated in Tehran for the period of 2011-2014 by using the VAR-GARCH models within the BEKK framework. Based on results, the oil price changes had a determining effect on stock prices of chemical industries. It was not observed any reverse relationship from chemical industry stock prices on international oil prices. Also, the results showed that changes in oil prices had a positive effect on the chemical industries' stock prices (Rezagholizade et al., 2017).

Aghasi et al. (2016) investigated the relationship between financial risk tolerance and investment properties based on native Donald. Hence, financial risk tolerance was considered as a dependent variable and financial intelligence, wealth, and financial management skills as independent variables. The results showed that there was a meaningful relationship between the independent variable and the dependent variable and young people might be more willing to take financial risk than their older counterparts. The importance of the independent examined factors or variables was not the same for the respondents, and the factor of financial management skill had the highest responder (Aghasi et al., 2016).

Hosseinioun et al. (2016) studied the volatility spillover effects among stock, gold, and exchange rate markets. The VAR–MGARCH models were applied in Iranian financial markets for the period of March 21, 2011, to September 22, 2014. The used data were daily price of Bahar Azadi Coin, Tehran price stock index, and nominal exchange rate (Dollar in terms of Rial). The results indicated that there were bilateral shock transitions between gold and exchange markets and gold and stock markets and there was a unidirectional shock transition from stock market to exchange market (Hosseinioun et al., 2016).

Nikoomaram et al. (2015) investigated the spillover effect of parallel markets (currency and gold) based on import and export oriented industries. For this purpose, two methods of VAR and MGARCH were applied. The data was collected from October 2007 to August 2013 and estimated by Eviews software. The results confirmed the spillover of export-oriented industries from currency but did not confirm the spillover of export-oriented industries from the gold market. Also, the results did not confirm the spillover import oriented industries from the currency and gold market. The side result of research demonstrated a positive bilateral relation between currency and gold markets in the studied period (Nikoomaram et al., 2015).

Alotaibi and Mishra (2015) examined the effects of return spillovers from Saudi Arabia and the USA markets to stock markets of Bahrain, Oman, Kuwait, Qatar, and the United Arab Emirates. The bivariate BEKK-GARCH model was used and the data employed were weekly equity indices over the period from June 2005 to May 2013. The results indicated the return spillover effects from Saudi Arabia and the USA to markets of these countries (Alotaibi and Mishra, 2015).

Boubaker and Sghaier (2014) examined the contagion effect and change in the dependence between the oil and ten MENA (the Middle East and North Africa) stock markets. In this paper, the local change point (LCP) testing procedure was used for test the changing independence structure. The results provided strong evidence of asymmetric dependence structure between the oil price changes and stock market returns for all countries. In addition, the dependence structure was larger in oil-exporters than oil-importers. Furthermore, there was a significant change in this dependence structure. For all countries (except Kuwait and Jordan), the copula parameters and the tail dependence coefficients were greater during crisis periods than calm ones, thus indicating the presence of the contagion effect (Boubaker and Sghaier, 2014).

Ghorbel et al. (2014) studied the volatility contagion between the oil and stock markets. To this end, the data examined during the crisis 2008-2009 by using information from the US stock and oil markets. In this study, the estimation of time-varying correlation coefficients was used to predict the errors of stock and oil markets. This paper used BEKK-GARCH model to examine the volatility spillover between the oil market, the USA stock market, and stock markets for 22 oil importer and exporter countries. Also, by using the Kalman-filter and state-space models, this paper evaluated and predicted errors of time-varying parameters. The results indicated that there was a sharp increase in the time-varying correlation coefficients during the oil and financial crisis in 2008-2009, which led to the fluctuation and volatility contagion between markets (Ghorbel et al., 2014).

Mensi et al. (2014) used the VAR-BEKK-GARCH and VAR-DCC-GARCH models in order to investigate the daily prices and volatility transmission between energy markets (including WTI oil, Europe Brent oil, gasoline, and heating oil) and cereals (corn, sorghum, and wheat). The results provided evidence of significant linkages between the energy and cereal markets. Moreover, the OPEC news announcements were found to exert influence on the oil markets as well as on the oil-cereal relationships (Mensi et al., 2014).

Mensi et al. (2013) used the VAR-GARCH model to investigate the return links and the volatility transmission between the S&P and commodity price indices for energy, food, gold, and beverages over the turbulence period from 2000 to 2011. For the return and volatility spillover, the results showed significant transmission from the S&P to the gold market and WTI index. Also, there was a two-way volatility spillover between the gold market and WTI oil market (Mensi et al., 2013).

Abunoori and Abdollahi (2012) modeled the different sector volatility of Iran Stock Exchange by using a multivariate GARCH model. In this study used the multivariate GARCH model simultaneously to estimate the mean and conditional variance using daily returns among different Tehran sector indices from July 2007 to July 2012. Since the different financial assets were traded based on these sector indices, it was important for the financial market participants to understand the volatility transmission mechanism over time and across sectors in order to make optimal portfolio allocation decisions. Results showed significant transmission of shocks and volatility among different sectors. These findings supported the idea of cross-market hedging and sharing of common information by investors in these sectors (Abunoori and Abdollahi, 2012).

Zamani et al. (2011) investigated the existence of the risk contagion between companies' shares in the Tehran Stock Exchange by using a multivariate dynamic model. In this study, the return and volatility spillovers were important for portfolio selection, asset valuation, and market efficiency investigation. Therefore, the return and volatility spillover effects between three size-sorted equity indices in the Tehran Stock Exchange using the VAR-BEKK framework model. The results showed that although daily return of large stocks led to small stocks, there wasn't any the spillover effect in monthly and seasonal returns and volatilities. These results were against evidence of the volatility spillovers in many stock markets that might be due to trading limits such as price limit and the existence of base volume in TSE (Zamani et al., 2011).

3. METHODOLOGY

3. 1. Data

The present study used the daily data of oil price, Tehran Stock Exchange Index and US dollar exchange rate based on market rates in Iran. To compare volatility spillover among financial markets, the data analyzed for periods 1 March 2008 to 20 July 2018. Returns in financial markets were calculated using the following equation:

$$r_t = lnp_t - lnp_{t-1} \qquad (1)$$

where $p_t \; and \; p_{t-1}$ respectively represent the price of the three financial assets in periods t and t-1, and r_t is the return on price in period t. The data were extracted from the databases of the Central Bank of the Islamic Republic of Iran, Tehran Stock Exchange and the World Bank.

3. 2. Model specification

GARCH was proposed by Bollerslev (1986) as the most general method of modeling volatility and variability of financial time series data. This model was derived from generalizing the GARCH autoregressive conditional variance model introduced by Engle (1982) for modeling the process of conditional variance of return on assets. In the GARCH model, previous estimates of volatility may affect the estimate of future variance. GARCH models are divided into univariate and multivariate models depending on the number of variables. In univariate GARCH models, the conditional variance of each time series is assumed to be independent of other time series, and the covariance between the series, which is an important factor in assessing the volatility of variables, is ignored. These limitations in univariate GARCH models impede their applications, and make them unrecognizable in many cases (Agnolucci, 2009; Hassan and Malik, 2007; Kang et al., 2009).

The two important advantages of the VAR-MGARCH model proposed by Ling and McAleer (2003) over the multivariate GARCH model include its flexibility compared to the conditional mean effects model, which facilitates the analysis of conditional mutual effects and volatility spillover between series, and its fewer computational complexities in assessing conditional volatility spillover, which saves time (Chang et al., 2011).

The present study used the VAR-BEKK-GARCH model described in the following to investigate volatility spillover among financial markets in Iran. The conditional mean equation is as follows:

$$Y_t = \mu + \varphi Y_{t-1} + \varepsilon_t \tag{2}$$

where μ denotes the vector of fixed factors in the VAR model, and Y_t is a vector of daily variations in the rate of return on the study variables as follows:

$$Y_t = \begin{pmatrix} r_t^{ex} \\ r_t^{oil} \\ r_t^{s} \end{pmatrix}$$

where r_t^{ex} is the return on exchange rate, r_t^{oil} return on oil price and r_t^{s} return on the stock index. Y_{t-1} represents the vector of return lags, φ the matrix of coefficients and ε_t the vector of error terms in conditional mean equations as follows:

$$\varepsilon_t = \begin{pmatrix} \varepsilon_t^{ex} \\ \varepsilon_t^{oil} \\ \varepsilon_t^{s} \end{pmatrix}$$

which ε_t^{ex}, ε_t^{oil}, and ε_t^{s} respectively represent the normally-distributed error terms in conditional mean equations for returns on exchange rate, oil and stocks. Engle and Kroner (1995) proposed the method of constructing the system of variance-covariance matrix. The following equation was used to derive the conditional covariance matrix for the study variables.

$$H_t = C'C + B'H_tB + A'\varepsilon_{t-1}'\varepsilon_{t-1}A \tag{3}$$

The matrix form is also as follows:

$$\begin{pmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{pmatrix} = \begin{pmatrix} c_{11,t} & 0 & 0 \\ c_{21,t} & c_{22,t} & 0 \\ c_{31,t} & c_{32,t} & c_{33,t} \end{pmatrix}' \begin{pmatrix} c_{11,t} & 0 & 0 \\ c_{21,t} & c_{22,t} & 0 \\ c_{31,t} & c_{32,t} & c_{33,t} \end{pmatrix} +$$

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}' \begin{pmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{1,t-1}\varepsilon_{3,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 & \varepsilon_{2,t-1}\varepsilon_{3,t-1} \\ \varepsilon_{3,t-1}\varepsilon_{1,t-1} & \varepsilon_{3,t-1}\varepsilon_{2,t-1} & \varepsilon_{3,t-1}^2 \end{pmatrix} \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

$$+ \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix}' \begin{pmatrix} h_{11,t-1} & h_{12,t-1} & h_{13,t-1} \\ h_{21,t-1} & h_{22,t-1} & h_{23,t-1} \\ h_{31,t-1} & h_{32,t-1} & h_{33,t-1} \end{pmatrix} \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix} \tag{4}$$

In equation (4), volatility spillover between oil, exchange rate and stock markets over time is associated with two sources of mutual value between errors and the value between conditional volatility of previous periods. The mutual values between errors measure the directs effects of the shock transmission, and the value between conditional volatility of previous periods directly determines the transmission of risk between markets. Assuming conditional normality, the model's parameters can be calculated by maximizing the following probability function:

$$L(\theta) = -\frac{TN}{2}\ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}(\ln(|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t) \tag{5}$$

In equation (5), θ denotes the vector of all the estimated unknown parameters, N the number of variables and T the number of observations.

4. EMPERICAL RESULTS

4. 1. Unit root test

Nelson and Plosser (1982) argue that almost all macroeconomic time series typically have a unit root. Thus, by taking first differences the null hypothesis of nonstationarity is rejected for most of the variables. Unit root tests are important in examining the stationarity of a time series because nonstationary regressors invalidates many standard empirical results and thus requires special treatment. Granger and Newbold (1974) have found by simulation that the F-statistic calculated from the regression involving the nonstationary time-series data does not follow the Standard distribution. This nonstandard distribution has a substantial rightward shift under the null hypothesis of no causality.

Thus the significance of the test is overstated and a spurious result is obtained. The presence of a stochastic trend is determined by testing the presence of unit roots in time series data. Non-stationarity or the presence of a unit root can be tested using the Dickey and Fuller (1981) tests.

The test is the t statistic on φ in the following regression:

$$\Delta Y_t = \beta_0 + \beta_1 . trend + \rho Y_{t-1} + \sum_{i=0}^{\infty} \varphi_i \Delta y_{t-i} + \varepsilon_t \tag{6}$$

where *Δ* is the first-difference operator, ε_t is a stationary random error.

If a time-series is found to be non-stationary, a filtering mechanism such as the first difference of the variable can be employed to induce stationarity for univariate model estimation. Results of ADF test for stationarity are reported in Table 1. The null hypothesis of a unit root can be rejected in the level of the variables. The results in Table 1 unanimously confirm that all variables are stationary.

Table 1. The results of the unit-root test of the variables.

Variable	ADF t-statistic	Prob
Stock return	-4.30	0.000
Oil return	-5.66	0.000

Exchange return	-4.52	0.000
Critical Value (95%)	-3.45	

The ARCH test proposed by Engle was then used to investigate the presence of the ARCH effect or dependence of the conditional variance of the study variables. The serial auto-correlation of the model was also assessed using the Ljung-Box Q test. Table 2 presents the results of ARCH and Ljung-Box tests. According to the results of the ARCH effect test, the null hypothesis suggesting the absence of the ARCH effect on the study variables was rejected. Furthermore, the results of the Ljung-Box test confirmed the presence of serial auto-correlation in the study variables.

Table 2. The results of ARCH and Ljung-Box tests.

	Stock return	Oil return	Exchange return
ARCH test	227.29	82.52	74.28
Prob.	0.0000	0.0000	0.0000
Ljung-Box test	388.19	499.52	461.46
Prob.	0.0000	0.0000	0.0000

Given that the present study investigated the effects of precedence and lagging of the returns on stock, oil, and exchange rate and also the spillover of these three variables to one another, the BEKK approach, and more specifically the VAR-BEKK-GARCH model, were used to estimate the study model. Table 3 presents the results obtained from estimating the VAR-BEKK-GARCH model.

Table 3. Results of estimating the VAR-BEKK-GARCH model.

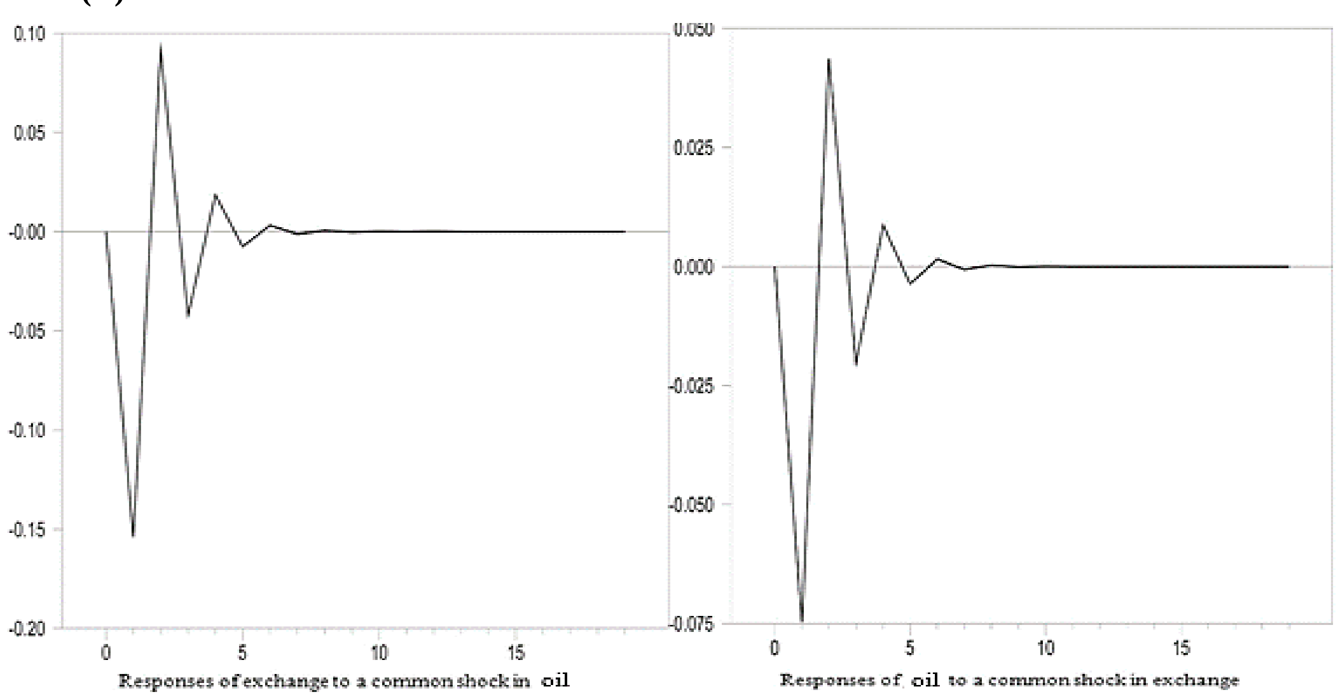
	Coefficients	T-Stat.	Prob.
b(1,1)	0.864	12.54	0.000
b(1,2)	-0.087	-4.76	0.000
b(1,3)	0.005	0.89	0.319
b(2,1)	-0.052	-3.54	0.000
b(2,2)	0.754	8.69	0.000

b(2,3)	-0.024	-4.66	0.000
b(3,1)	0.065	2.60	0.031
b(3,2)	0.214	3.42	0.000
b(3,3)	0.778	4.12	0.000

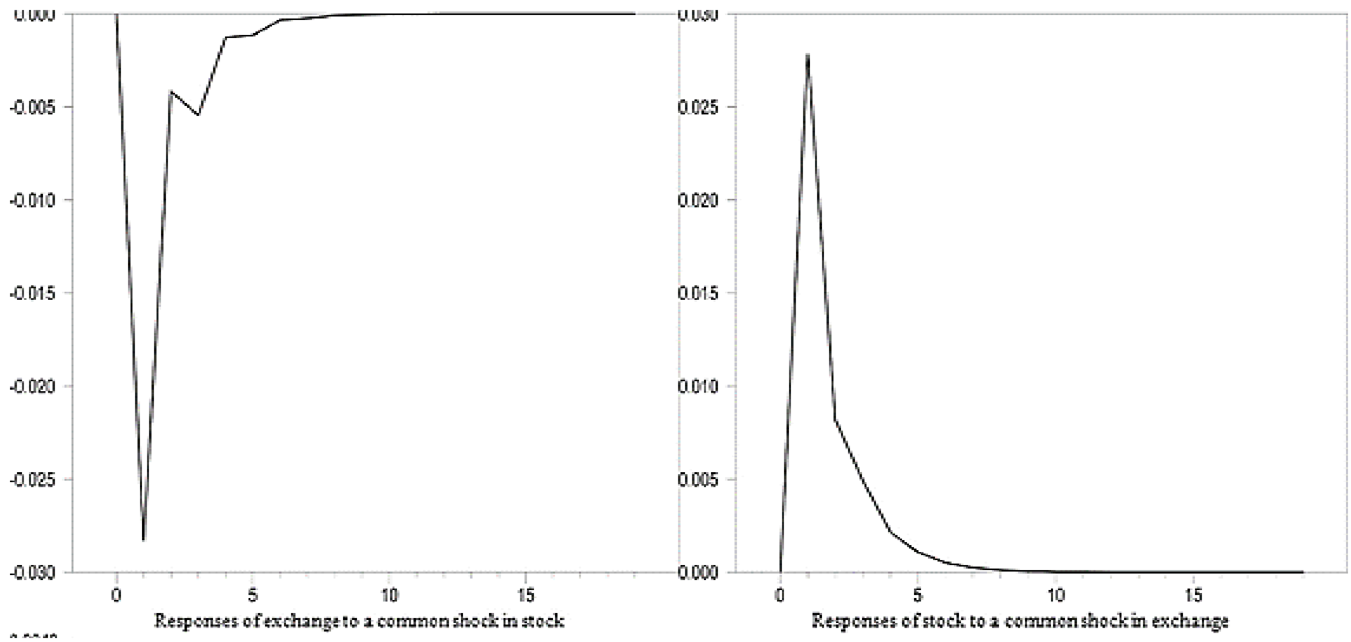
According to Table 3, the effect of fluctuations spillover of the return on currency on the fluctuations in the return on oil, i.e. b(1,2), is insignificant. This effect on the fluctuations in the return on stocks, i.e. b(1,3), is positive and significant. The effects of volatility spillover of the currency market on the stock market has been confirmed. The effects of fluctuation spillover of the return on oil on the fluctuations in the returns on exchange rate, i.e. b(2,1), and stocks, i.e. b(2,3), are negative and significant. Furthermore, the effect of the fluctuation spillover of the return on stocks is positive and significant on the fluctuations in the return on oil, i.e. b(3,2). A two-way volatility spillover between oil and stock markets and a one-way spillover from the oil to currency market and from the stock market to the currency market are confirmed.

Figure 1 show the impulse-response functions of the variables, namely stocks, oil and currency. The reaction of the series to the variables' impulse is only considered in the impulse-response functions of the conventional VAR model, and the asymmetric GARCH variance is excluded. The present modeling approach simultaneously estimated the VAR model with the MGARCH, and the associated impulse-response functions were calculated by including the asymmetric variance of the error terms in MGARCH-type equations.

(A)



(B)



(C)

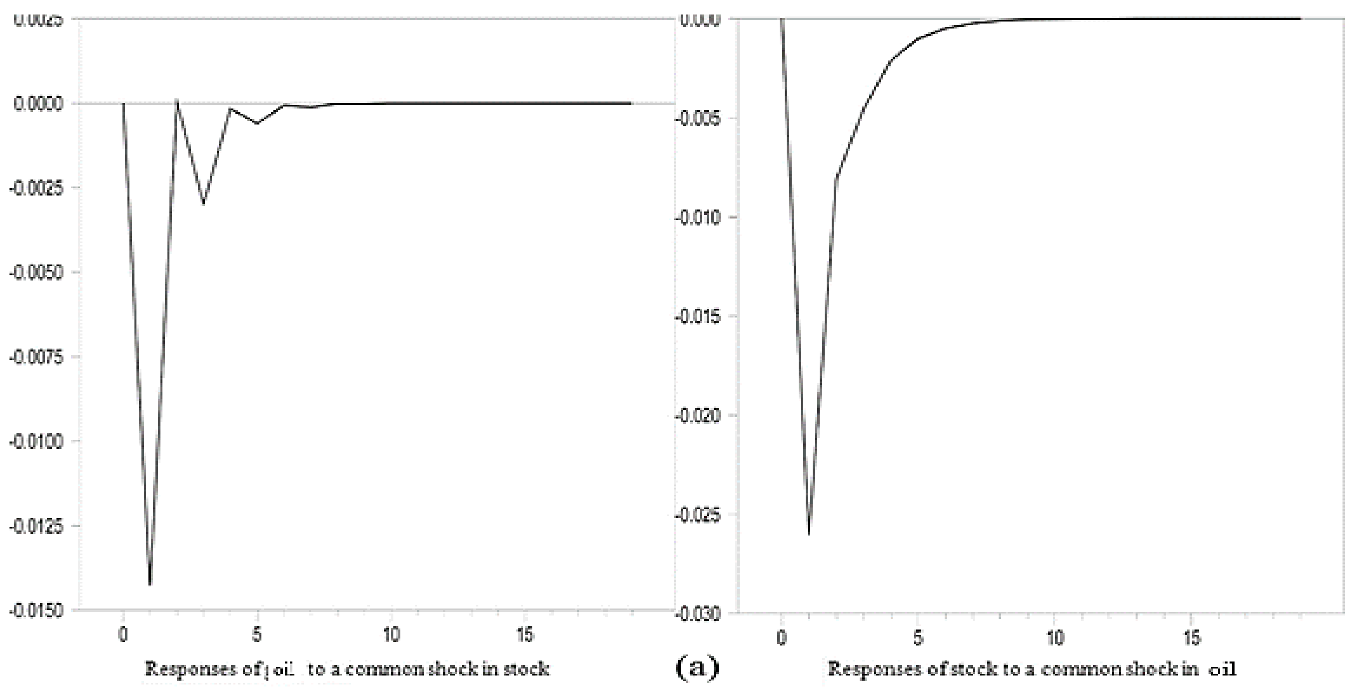


Figure 1(A-C). Impulse-response functions of Variables

Comparing the results of volatility spillover in financial markets using the VAR-BEKK-GARCH model can be summarized as follows: firstly, a two-way volatility spillover between oil and stock markets was confirmed; secondly, a two-way volatility spillover between currency and stock markets and a one-way spillover from the stock market to the currency market were confirmed; thirdly, the effect of fluctuation spillover of the stock market was negative on the currency market. Ultimately, volatility spillover among financial markets significantly decreased.

5. CONCLUDING REMARK

This paper studied the financial risk contagion to real sector in Iran. The results show that the financial volatility can be characterized by strong contagion effects among other markets such as oil and exchange. The paper contributes to the literature by modeling and estimating financial and real economy volatility contagion. The study thus provides important information about the role of the financial sector in spreading the risk to other markets and sectors and can assist policy makers and investors to reduce the costs of a financial volatility in the future. The study also uses a novel approach to identify the volatility contagion with an extensive sensitivity analysis. In addition, the disaggregated analysis of contagion increases the number of potential incidences of contagion and provides a more detailed and robust picture of contagion. Future research could investigate the impact of regulatory measures and government stimulus packages on the probability of an infection of the real economy and the severity of a crisis.

References

[1] Abunoori, E., & Abdollahi, M. R. (2012). The relationship between Iran, USA, Turkey and Malaysia Stock Markets in a multivariate GARCH model. *Quarterly Journal of Securities Exchange*, 4 (14), 61-79.

[2] Aghasi, S., Aghasi, E., Biglari, S. (2016). Examine the relationship between financial risk tolerance and investment properties (financial intelligence, skills, financial management, wealth) based on native Donald- Case Study of the Tehran Stock Exchange. *Financial Knowledge of Securities Analysis*, 9(31), 21-33.

[3] Agnolucci, P. (2009). Volatility in Crude Oil Futures: a Comparison of the Predictive Ability of GARCH and Implied Volatility Models. *Energy Economics*, 31, 316–321.

[4] Alotaibi, A. R. & Mishra, A. V. (2015), Global and Regional Volatility Spillovers to GCC Stock Markets. *Economic Modeling*, 45, 38-49.

[5] Bastanzad, H., Davoudi, P. (2017). An Evaluation of Risk Transmission over Foreign Exchange, Real Estate and Stock Markets in Iran`s Economy (An Application of Parametric and Non-Parametric Value at Risk Approach). *Asset Management and Financing*, 5(4), 33-50.

[6] Baur, D.G., (2011). Financial contagion and the real economy. *Journal of Banking & Finance* 36 (10), 2680-2692.

[7] Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*, Volume 31, Issue 3, 307-327

[8] Boubaker, H. and Sghaier, N. (2014) Instability and Dependence Structure between Oil Prices and GCC Stock Markets. *Energy Studies Review*, 20, 50-65.

[9] Chang, C. L., Khamkaew, T., Tansuchat, R. & McAleer, M. (2011). Interdependence of International Tourism Demand and Volatility in Leading ASEAN Destinations. *Tourism Economics*, 17 (3), 481-507.

[10] Chen, N. F., Roll, R. and Ross, S. A. (1986). Economic Forces and the Stock Market. *Journal of Business*, 59, 383-403.

[11] Chien-Chiang Lee, Chen, Pei-Fen, and Jhih-Hong Zeng. (2014). The relationship between spot and futures oil prices: Do structural breaks matter? *Energy Economics*, 43, 206-217.

[12] Ding, Z.H., Liu, Z.H., Zhang, Y.J., Long, R.Y., (2017). The contagion effect of international crude oil price fluctuations on Chinese stock market investor sentiment. *Applied Energy*, 187, 27-36.

[13] Dornbusch, R., Fischer, S. (1980). Exchange Rates and the Current Account. *American Economic Review*, 70(5), 960-971.

[14] Engle, R. F. (1982). Autoregressive Conditional Heteroscedadticity with Estimates of the Variance of UK Inflation. *Econometrica*, 50 (4), 987-1008.

[15] Engle, R.-F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation, *Econometrica*, 50(4), 987-1007

[16] Fang, S., & Egan, P. (2018). Measuring contagion effects between crude oil and Chinese stock market sectors. *The Quarterly Review of Economics and Finance*, 68, 31-38.

[17] Fenghua Wen, Jihong Xiao, Xiaohua Xia, Bin Chen, Zhengyan Xiao, Jinyi Li. (2019). Oil Prices and Chinese Stock Market: Nonlinear Causality and Volatility Persistence. *Emerging Markets Finance and Trade*, 55(6), 1247-1263

[18] Forbes, K. and R. Rigobon (2002), No contagion, only interdependence. *The Journal of Finance* Volume 57, Issue 5, 2223-2261

[19] Gavin, M. (1989). The Stock Market and Exchange Rate Dynamics. *Journal of International Money and Finance*, 8(2), 181-200.

[20] Ghorbel, A., Abdelhedi, M., & Boujelbene, Y. (2014). Assessing the impact of crude oil price and investor sentiment on Islamic indices: Subprime crisis. *Journal of African Business*, 15(1), 13-24.

[21] Gudarzi Farahani, Yazdan and Dastan, Masood (2013). Analysis of Islamic bank's financing and economic growth: A panel cointegration approach. *International Journal of Islamic and Middle Eastern Finance and Management*, 6, 2, 156-172.

[22] Hassan, S. A. & Malik, F. (2007). Multivariate GARCH Modeling of Sector Volatility Transmission. *The Quarterly Review of Economics and Finance*, 47, 470-480.

[23] Hosseinioun, N., Behname, M., Ebrahimi Salari, T. (2016). Volatility Transmission of the Rate of Returns in Iranian Stock, Gold and Foreign Currency Markets. *Iranian Journal of Economic research*, 21(66), 123-150.

[24] Hu, C., Liu, X., Pan, B., Chen, B., Xia, X., (2018). Asymmetric impact of oil price shock on stock market in China: a combination analysis based on SVAR model and NARDL model. *Emerging Markets Finance and Trade*, 54 (8), 1693-1705.

[25] Kang, S. H., Kang, S. M. & Yoon, S.M. (2009). Forecasting Volatility of Crude Oil Markets. *Energy Economics*, 31 (1), 119-125.

[26] Mensi, W., Beljid, M., Boubaker, A. & Managi, S. (2013). Correlations and Volatility Spillovers across Commodity and Stock Markets: Linking Energies, Food, and Gold. *Economic Modeling*, 32, 15-22.

[27] Mensi, W., Hammoudeh, S., Nguyen, D. K. & Yoon S. M. (2014). Dynamic Spillovers among Major Energy and Cereal Commodity Prices. *Energy Economics*, 43, 225-243.

[28] Nikoomaram, H., Pourzamani, Z., Dehghan, A. (2015). Spillover Effect the on Contest Import & Export oriented industries. *Financial Knowledge of Securities Analysis*, 8(25), 1-18.

[29] Rajan, R.G., Zingales, L., (1998). Financial dependence and growth. *American Economic Review*, 88 (3), 559-587.

[30] Rezagholizad, M., Aghaei, M. (2017). Transmission of World Oil Price Volatility to Chemical Industry' Stock Price Index (A VAR-BEKK-GARCH Approach). *Quarterly Energy Economics Review*, 14(54), 1-32.

[31] Soriano, Pilar and F.G. Climent (2006), Region Versus Industry Effects: Volatility Transmission, *Financial Analysts Journal*, 62(6), 52-64.

[32] Wang, K. M., Lee, Y. M. and Nguyen, T. (2011). Time and place where gold acts as an inflation hedge: An application of long-run and short-run threshold model. *Economic Modelling*, 28, 806-819.

[33] Xiao J, Zhou M, Wen F, Wen F (2018). Asymmetric impacts of oil price uncertainty on Chinese stock returns under different market conditions: Evidence from oil volatility index. *Energy Economics*, 74, 777-786.

[34] Zamani, S., Souri, D., Sanaei Alam, M. (2011). A Dynamic Investigation to Indexes Spillovers in Tehran Stock Exchange Using a Multivariate Dynamic Model. *Journal of Economic Research*, 45(4), 29-54.