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RESEARCH PAPER

Comparing the Volatility Spillovers among Financial Markets in Iran pre and post JCPOA: A VAR-BEKK-GARCH Approach

Vahid Dehbashi[a], Teymour Mohammadi[b,*], Javid Bahrami[c], Abbas Shakeri[d]

a. Department of Economics, Allameh Tabataba'i University, Tehran, Iran; Department of Economics, Zabol University, Zabol, Iran
b, c, d. Department of Economics, Allameh Tabataba'i University, Tehran, Iran

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Abstract
Volatility spillovers among financial markets suggest some sort of information transmission between these markets. The present article uses VAR-BEKK-GARCH approach to investigate volatility spillovers among financial markets in Iran, including stock, foreign exchange and gold markets pre and post JCPOA. To compare volatility spillover among financial markets, the data analyzed were associated with two periods, one pre-JCPOA, i.e. 25 March 2009 to 13 July 2015, and the other post-JCPOA, i.e. 15 July 2015 to 18 July 2018. Moreover, the impulse-response functions were calculated by including the asymmetric volatility spillover of error terms in MGARCH-type equations. Comparing the results obtained from estimating the model confirmed two-way volatility spillover between gold and stock markets in both of the periods, two-way volatility spillover between foreign exchange and stock markets, one-way volatility spillover from gold to foreign exchange markets in the per-JCPOA period, two-way spillover between foreign exchange and gold markets and one-way spillover from stock to foreign exchange markets in the post-JCPOA period. In addition, the effect of volatility spillover from stock to foreign exchange markets was negative in the per-JCPOA period and positive in the post-JCPOA period, and volatility spillovers between financial markets significantly decreased in post JCPOA period. The results of impulse-response functions also confirmed a reduction in the transmission of uncertainty among financial markets in Iran in the post-JCPOA period.
Keywords: Volatility Spillover, Financial Markets, VAR-BEKK-GARCH Approach, JCPOA.
JEL Classification: C32, C50, G15, G11.

Introduction

At some points, financial asset markets may face volatilities caused by domestic or global political and socioeconomic events. The volatility in financial markets are a concern for many investors and financial analysts which have made them seek tools for reducing the risk and evaluating upcoming prospects (Mensi et al., 2013). Evidences suggests that financial markets are interrelated, and volatility can spread from one market to another and cause investors to change their asset portfolio, which can further exacerbate the turbulence (Khalifa et al., 2014). Analyzing a financial asset market would therefore be incomplete if the conditions of other markets are neglected, and thus the analyses should be performed based on the relationships among different financial asset markets.

Recent investigations of the development process of financial markets in Iran, including stock, gold and foreign exchange markets, obviously suggest that the prices of these assets have been dramatically affected by sanctions, the so-called targeted subsidy plan, growing

*. Corresponding author email: mohammadi@atu.ac.ir

liquidity and JCPOA. Tightening the sanctions imposed on Iran by the US and EU in the early 2012 reduced oil revenues and consequently suddenly increased exchange rates, the cost of international transactions and investment risk in Iran. Implementing JCPOA is therefore said to have exerted significant effects on Iran's financial markets and economic activities. JCPOA can positively affect financial markets in four main ways, including 1) reducing the cost of international transactions for many industries, which is particularly important for many domestic firms importing raw materials and intermediate commodities. Car manufacturers, pharmaceutical companies, banks and financial institutions are the main industries benefiting from the reduced cost of international transactions, 2) facilitating the partnership and collaboration with credible international firms, which can cause significantly positive effects on firms importing intermediate commodities, including car manufacturers and pharmaceutical companies, 3) enhancing investment security in Iran, which increases domestic and foreign investment and boosts economic activities and therefore increases companies' profitability and 4) causing a general economic improvement. Given that instability and the severe atmosphere of uncertainty are the most destructive effects of sanctions on country's economy, the question posed is whether or not JCPOA has been able to help stabilize the markets and reduce the volatility of financial markets. The present study investigates and compares volatility spillovers in financial markets pre and post JCPOA using the VAR-BEKK-GARCH[1] model. The most important innovation of this study is to examine the effect of associated political measures on financial markets, which compares the volatility spillovers among financial markets pre and post JCPOA. Also, extracting the impulse-response functions by including variance of error terms in MGARCH-type equations is a new approach that has rarely been addressed. In the following, the theoretical principles and background of the study are presented, followed by discussing the methodology, detailing the findings and conclusion.

Theoretical Foundations

Many models of financial asset pricing and risk management are based on volatility of financial variables. Identifying the relationships and volatility spillovers 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 rate and stock price. 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 one of the determinants of the exchange rate. 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 constant, reductions in the interest rate can therefore

1. Vector AutoRegressive-Baba, Engle, Kraft and Kroner-Generalized Auto Regression Conditional Hetroskedostisity

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 is no relationship 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 foreign exchange, 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). As regards to the volatility spillovers, the following research references can be cited: Bouri (2017) investigated the relationships among gold price, oil price and Indian stock market using the ARDL model, and showed that gold and oil price fluctuations were positively and non-linearly associated with the fluctuations in the stock price index. Jain and Biswal (2016) included the variable of exchange rate and used the DCC-GARCH model and lag linkages and non-linear symmetric and asymmetric tests, and found that the decline in gold and crude oil prices reduce the value of Indian Rupees and the stock index. Sujit and Kumar (2011) used a vector autoregressive co-integration method, and showed that exchange rates are mainly affected by changes in variables other than stock market, which plays an insignificant role in these changes. Alotaibi and Mirshra (2015) investigated and confirmed the spillover of the US and Saudi stock markets to the stock markets of Bahrain, Oman, Kuwait, Qatar and UAE using the bivariate BEKK-GARCH model. Beirne et al. (2010) also investigated the global and regional spillovers across the emerging local stock markets of Asia, Europe, Latin America and the Middle East. Their results confirmed the presence of volatility spillovers from regional and global markets in most of the emerging markets.

Arouri et al. (2015) investigated the transmission of return and volatility between the global gold price and China stock market from 22 March 2004 to 31 March 2011 using the CCC-GARCH, DCC-GARCH, BEKK-GARCH and VAR-GARCH models. The results confirmed a two-way volatility spillover between the gold and stock markets. Comparing these models showed that VAR-GARCH had performed the best. Kumar (2014) also observed a one-way volatility spillover from gold to stock in India in 2000-2011.

Aboura and Chevallierm (2014) used the asymmetric DCC-MGARCH model to investigate the stock market index, bonds, exchange rate and commodity prices in 1983-2013. Their results confirmed the effect of spillover on the indices of these four markets caused by volatility shocks. Mensi et al. (2014) studied return and volatility spillover between energy and grains markets, and confirmed the shock and volatility spillover between oil and wheat markets according to VAR-BEKK-GARCH and VAR-DCC-GARCH models. Moreover, volatility spillover between European oil and stock markets was confirmed by Arouri et al. (2012) using the VAR-MGARCH model. Mensi et al. (2013) also investigated volatility spillover between the S&P stock market index and commodity price index using the VAR-GARCH model. Their results confirmed a one-way shock and volatility spillover from the S&P stock market index to WTI gold and oil markets, and two-way volatility spillover between WTI gold and oil markets.

Badshah et al. (2013) investigated the spillover effects among the implied volatility indices for stocks, gold and the exchange rate between 3 June 2008 and 30 December 2011 using the SVAR-MGARCH model, and the findings confirmed a one-way volatility spillover from the stock market to gold market and exchange rate, and a two-way spillover from gold to exchange rate.

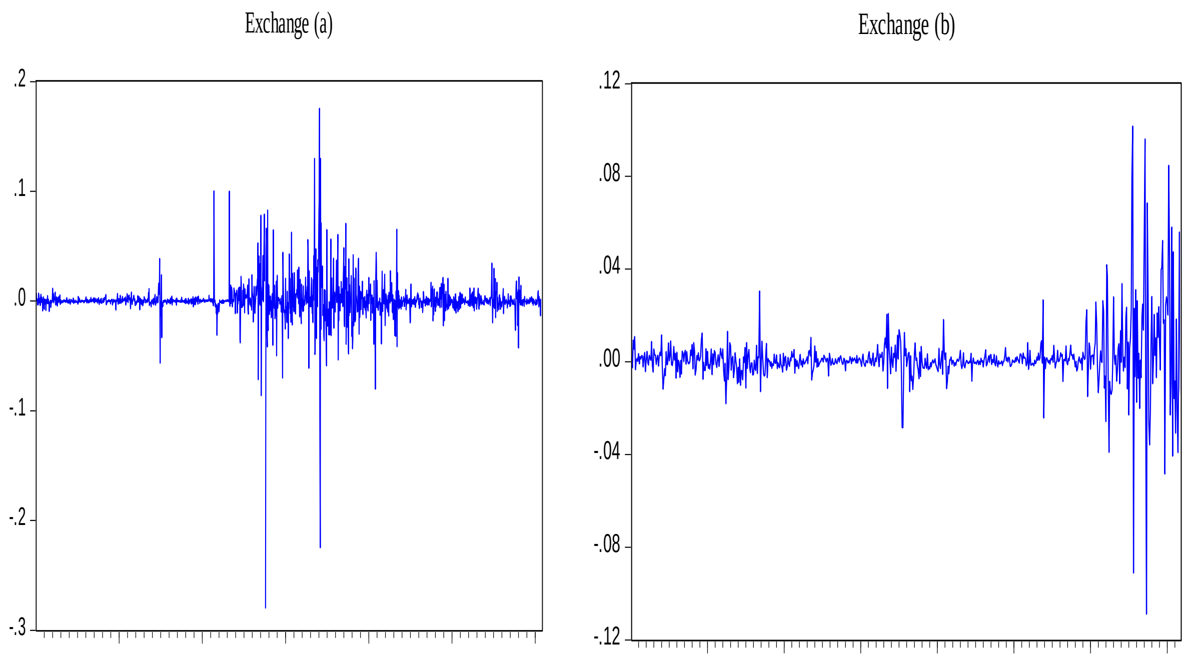
Methods

Data

The present study used the daily data of global gold price, Tehran Stock Exchange Index and exchange rate in the form of Rials per US dollar in Iran. To compare volatility spillover among financial markets, the data analyzed were associated with two periods, one pre JCPOA, i.e. 25 March 2009 to 13 July 2015, and post JCPOA, i.e. 15 July 2015 to 18 July 2018. Returns in financial markets were calculated using the following equation:

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

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. The diagram in figure 1 shows the time series trend of the variables, namely returns on gold, stocks and exchange rate pre and post JCPOA.



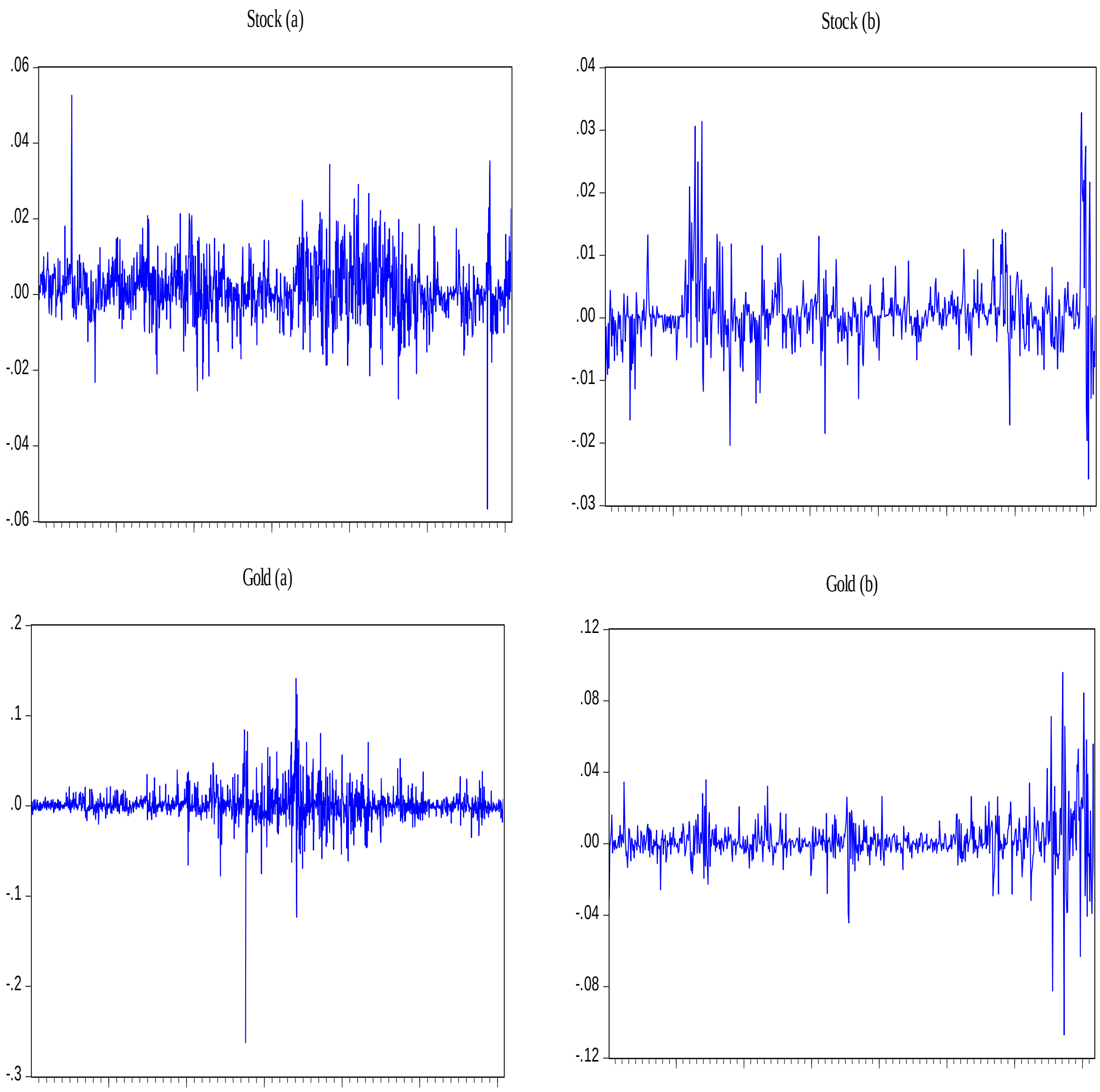


Figure 1. The trend of time series of returns on exchange rate, gold and stocks over two periods; a) pre-JCPOA and b) post-JCPOA
Source: Research finding.

The associated return diagrams of the series shows that the underlying variables have clustered volatility and those large and small variances appear as clusters, suggesting that price variations in the next period are associated with price variations in the current period. Cluster volatility is a feature of the financial assets, and shows autocorrelations in returns volatility on financial assets (Martin et al., 2012). Volatility in financial markets is also observed to be different for pre-JCPOA and post-JCPOA periods. Statistical characteristics of the series are shown in table 1.

Table 1. Statistical Characteristics of the Variables

	Pre-JCPOA			Post-JCPOA		
	Stock return	**Gold return**	**Exchange return**	**Stock return**	**Gold return**	**Exchange return**
Mean	0.0014	0.0009	0.0007	0.0006	0.0015	0.0015
Std. Error	0.0076	0.0807	0.0820	0.0055	0.0138	0.0132
Skewness	0.1635	4.0185	3.5133	1.2639	0.2647	1.0612
Kurtosis	7.4829	694.4988	693.4338	11.4549	17.9375	26.5314
Jarque-Bera	128.398	30308156	30213921	2329.823	6683.713	16700.46
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Research finding.

According to table 1, the mean value being below the variance is a sign of the high volatility of the variables. The variance of exchange rate is higher than that of the gold and stock rate of returns, which suggests a higher risk in this market. In fact, reductions are observed in the variance of the variables in post-JCPOA period, suggesting a reduction in the risk of financial markets in the period. Given the positive skewness of all the three variables, the distribution of the variables is quite asymmetric, and given the probability value of the Jarque-Bera statistic the rate of returns on gold, foreign exchange and stock do not follow a normal distribution. The estimation is therefore performed using a wider range of distributions in comparison to a specific distribution such as normal.

Model specification

GARCH model was proposed by Bollerslev (1986) as the most general method of modeling volatility of financial time series data. This model was derived from generalizing GARCH autoregressive conditional variance model introduced by Engle (1982) for modeling the process of conditional variance of return on assets. In 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 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 inapplicable 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 among series, and its fewer computational complexities in assessing conditional volatility spillover, which saves effort and cost (Chang et al., 2011).

The present study uses 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:

$$Y_t = \mu + \varphi Y_{t-1} + \varepsilon_t \qquad (2)$$

where μ denotes the vector of constants in the VAR model, and Y_t is a vector of daily variations in the rate of return of the series:

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

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

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

in which ε_t^{ex}, ε_t^g, and ε_t^s respectively represent the normally-distributed error terms in conditional mean equations for returns on exchange rate, gold and stocks. The following equation was used to derive the conditional covariance matrix for the variables.

$$H_t = C'C + B'H_tB + A'\varepsilon'_{t-1}\varepsilon_{t-1}A \qquad (3)$$

where C is a (3×3) lower triangular matrix of constants with elements c_{ij}; A is a (3×3) matrix of coefficients a_{ij} that capture the effects of own shocks and cross-market shock interactions; and B is a (3×3) matrix of coefficients b_{ij} that capture the own volatility persistence and the volatility interactions between markets i and j.

The matrix form of (3) equation is also as follows:

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

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

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

In equation (4), volatility spillovers among gold, exchange rate and stock markets over time are associated with two sources of mutual value between errors and the value between conditional volatility of previous periods. The cross-products of the error terms measure direct effects of the shock transmission, and the lagged terms of covariance directly determines the transmission of risk among markets. The model's parameters can be estimated by maximizing the following likelihood function:

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

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

Findings

Estimation results

Before estimation, the stationarity of the variables is tested using the augmented Dicky Fuller and KPSS[1] tests. Table 2 presents the results of these tests. According to these tests, all the variables are found to be stationary.

Table 2. The Results of the Unit-root Tests of the Variables

	Pre-JCPOA			Post-JCPOA		
Variables	**ADF Stat.**	**KPSS Stat.**	**Result**	**ADF Stat.**	**KPSS Stat.**	**Result**
Stock return	-17.19	0.16	I(0)	-11.03	0.15	I(0)
Gold return	-24.23	0.18	I(0)	-22.07	0.17	I(0)
Exchange return	-25.66	0.22	I(0)	-9.79	0.33	I(0)

Note: Critical values for ADF and KPSS tests are -2.86 and 0.14 respectively at 5% level.
Source: Research finding.

In order to ensure evidence of no structural breaks in the series, the breakpoint unit root tests are implemented. The results are presented in Table 3, indicating that all the variables are stationary.

Table 3. The Results of the Breakpoint Unit-root Tests

	Total period		Pre-JCPOA		Post-JCPOA		Result
Variables	**TBs**	**t-stat**	**TBs**	**t-stat**	**TBs**	**t-stat**	
Exchange return	01/28/2012	-66.51	01/28/2012	-56.20	13/05/2018	-21.62	I(0)
Gold return	01/28/2012	-66.51	01/28/2012	-56.39	05/05/2018	-23.67	I(0)
Stock return	08/26/2009	-21.17	05/25/2014	-26.69	24/06/2018	-11.70	I(0)

Note: Critical value is -4.44 at 5% level.
Source: Research finding.

The ARCH test proposed by Engle was then used to investigate the presence of the ARCH effect. The serial auto-correlation of the series was also assessed using the Ljung-Box Q test. Table 4 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 in variables was rejected. Furthermore, the results of the Ljung-Box test confirmed the presence of serial auto-correlation in the variables.

Table 4. The Results of ARCH and Ljung-Box Tests

	Pre- JCPOA			Post-JCPOA		
	Stock return	**Gold return**	**Exchange return**	**Stock return**	**Gold return**	**Exchange return**
ARCH test	227.29	82.52	74.28	641.19	729.08	789.62
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ljung-Box test	388.19	499.52	461.46	222.87	82.06	110.69
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Research finding.

Given that the present study investigates the dynamics of the returns on stock, gold, and exchange rate and also the spillover of these three variables to one another, the BEKK approach; more specifically the VAR-BEKK-GARCH model, is used to estimate the model.

1. Kwiatkowski, Phillips, Schmidt and Shin

Due to the non-normal distribution of the variables as indicated in Table 1, Generalized Error Distribution (GED) is used in estimation of the VAR-BEKK-GARCH model including the families of exponential distribution ranging from leptokurtic to platykurtic distributions (depending on the shape parameter). The estimated parameter values in table 5 confirm the non-normality of the distribution of the series. Therefore, final estimation of the model is performed without limitation of a specific distribution imposed on the data that is an appropriate strategy for the financial markets.

Table 5. Estimation the Shape Parameter

	Pre-JCPOA			**Post-JCPOA**		
	Coefficients	**T-Stat.**	**Prob.**	**Coefficients**	**T-Stat.**	**Prob.**
Shape parameter	0.746***	70.990	0.000	0.487***	32.243	0.000

Source: Research finding.

Table 6 presents the results obtained from estimating the VAR-BEKK-GARCH model pre- and post-JCPOA.

Table 6. Comparing the Results of Estimating the VAR-BEKK-GARCH Model Pre and Post JCPOA

	Pre-JCPOA			**Post-JCPOA**		
	Coefficients	**T-Stat.**	**Prob.**	**Coefficients**	**T-Stat.**	**Prob.**
b(1,1)	0.665***	35.604	0.000	0.859***	50.161	0.000
b(1,2)	-0.016	-0.308	0.757	-0.094***	-4.912	0.000
b(1,3)	0.120***	6.799	0.000	0.008	0.996	0.319
b(2,1)	-0.164***	-10.785	0.000	-0.060***	-6.096	0.000
b(2,2)	0.524***	9.037	0.000	0.892***	54.289	0.000
b(2,3)	-0.125***	-6.945	0.000	-0.039***	-4.221	0.000
b(3,1)	-0.080***	-2.997	0.002	0.072**	2.151	0.031
b(3,2)	0.348***	4.384	0.000	0.207***	3.659	0.000
b(3,3)	0.919***	45.530	0.000	0.856***	20.514	0.000

Note: ** and *** indicate the rejection of the t-test at a 5% and 1% significance level respectively.
Source: Research finding.

According to table 6, the effect of volatility spillover of the exchange rate of return on the return on gold, i.e. b(1,2), is insignificant in the pre-JCPOA period and negative and significant in the post-JCPOA period. This effect on the volatility of the return of stocks, i.e. b(1,3), is negative and significant in the pre-JCPOA period and insignificant in the post-JCPOA period. The effects of volatility spillover of the foreign exchange market on the stock market pre-JCPOA and those of the foreign exchange market on the gold market post-JCPOA are therefore confirmed. In both pre- and post-JCPOA periods, the effects of volatility spillover of the return on gold on the volatilities in the returns on both exchange rate, i.e. b(2,1), and stocks, i.e. b(2,3), are negative and significant, although these effects are more significant in the pre-JCPOA period. Furthermore, the effect of the volatility spillover of the return on stocks on the volatilities in the return on gold, i.e. b(3,2) is positive and significant in both pre- and post-JCPOA periods, whereas this effect is negative on the volatilities in the return on exchange rate, i.e. b(3,1), in the pre-JCPOA period, and positive in the post-JCPOA period. Two-Way volatility spillover between gold and stock markets and one-way spillover from the gold to foreign exchange market and from the stock market to the foreign exchange market are therefore confirmed both pre- and post-JCPOA periods, although the degree of volatility spillover has been reduced in the post-JCPOA period.

Figures 2 to 4 show the impulse-response functions of the variables, namely stocks, gold and foreign exchange. The present modeling approach simultaneously estimated the VAR model with the MGARCH, and the associated impulse-response functions were calculated by including variance of the error terms in MGARCH-type equations. Comparing the impulse-response functions of stocks, gold and foreign exchange clearly shows that the effect of impulses in a financial market more rapidly dies in the post-JCPOA period compared to pre-JCPOA period, suggesting a lower transmission rate of volatility among stock, gold and foreign exchange markets in the post-JCPOA period.

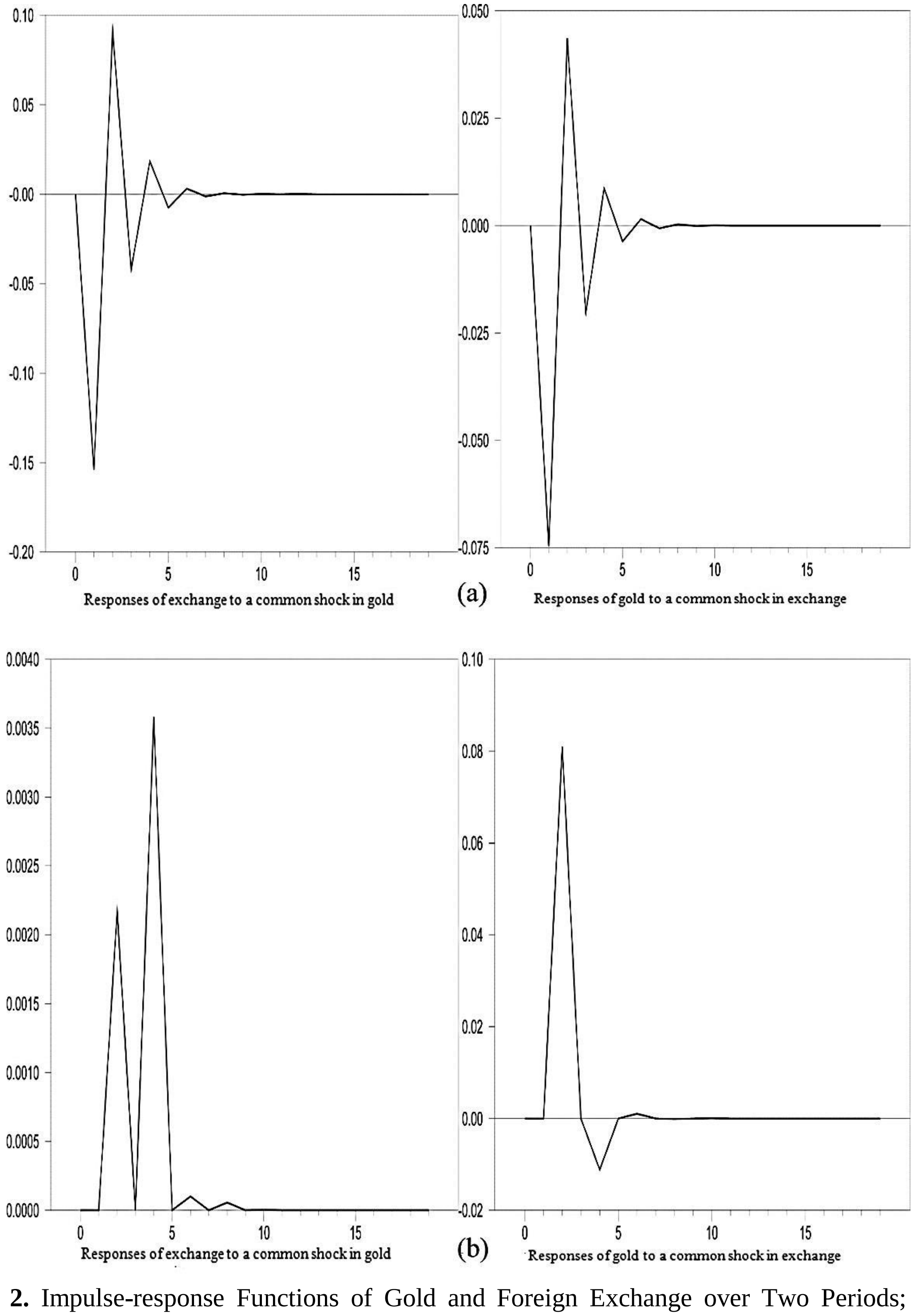


Figure 2. Impulse-response Functions of Gold and Foreign Exchange over Two Periods; a) Pre-JCPOA and b) Post-JCPOA
Source: Research finding.

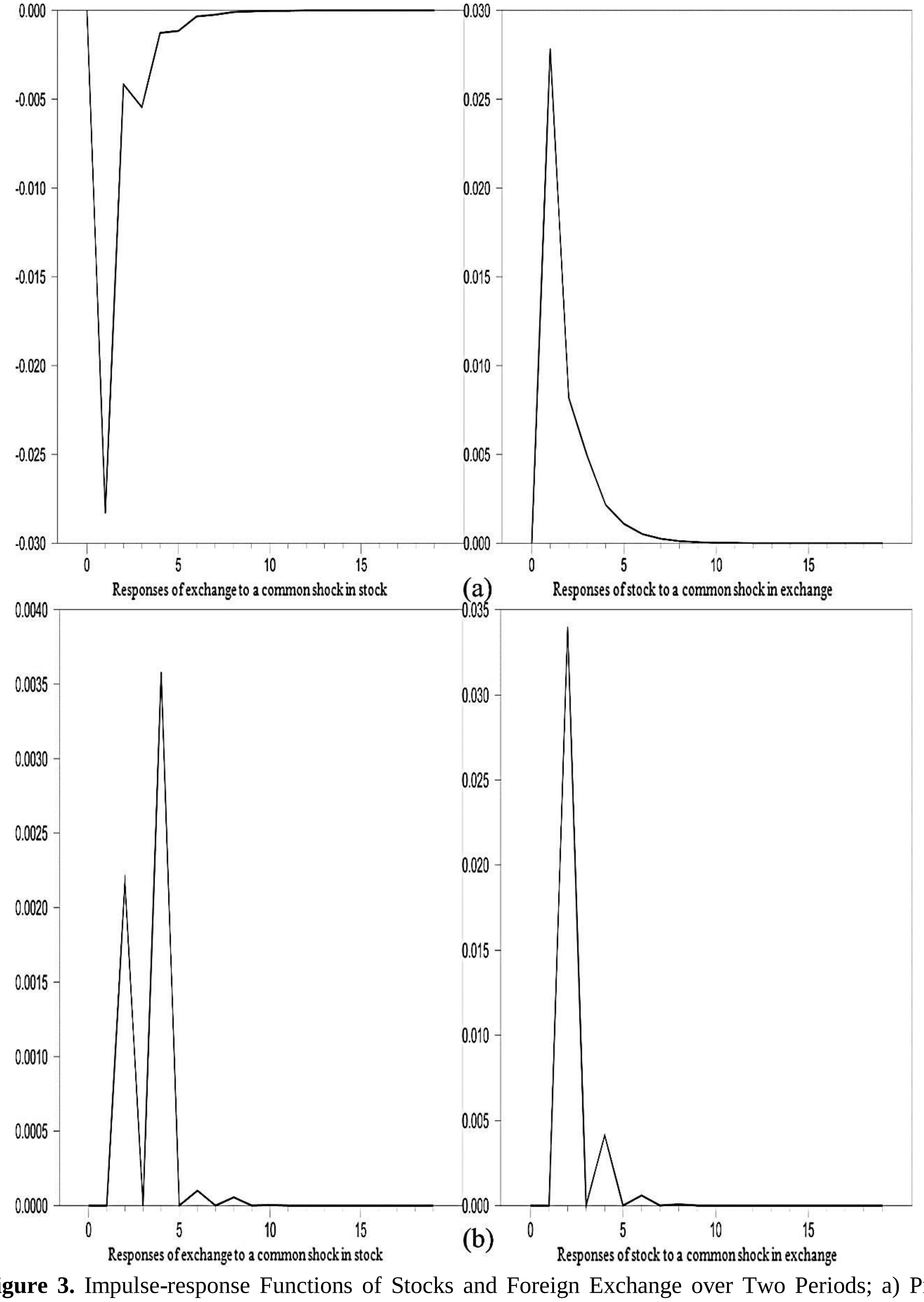


Figure 3. Impulse-response Functions of Stocks and Foreign Exchange over Two Periods; a) Pre-JCPOA and b) Post- JCPOA

Source: Research finding.

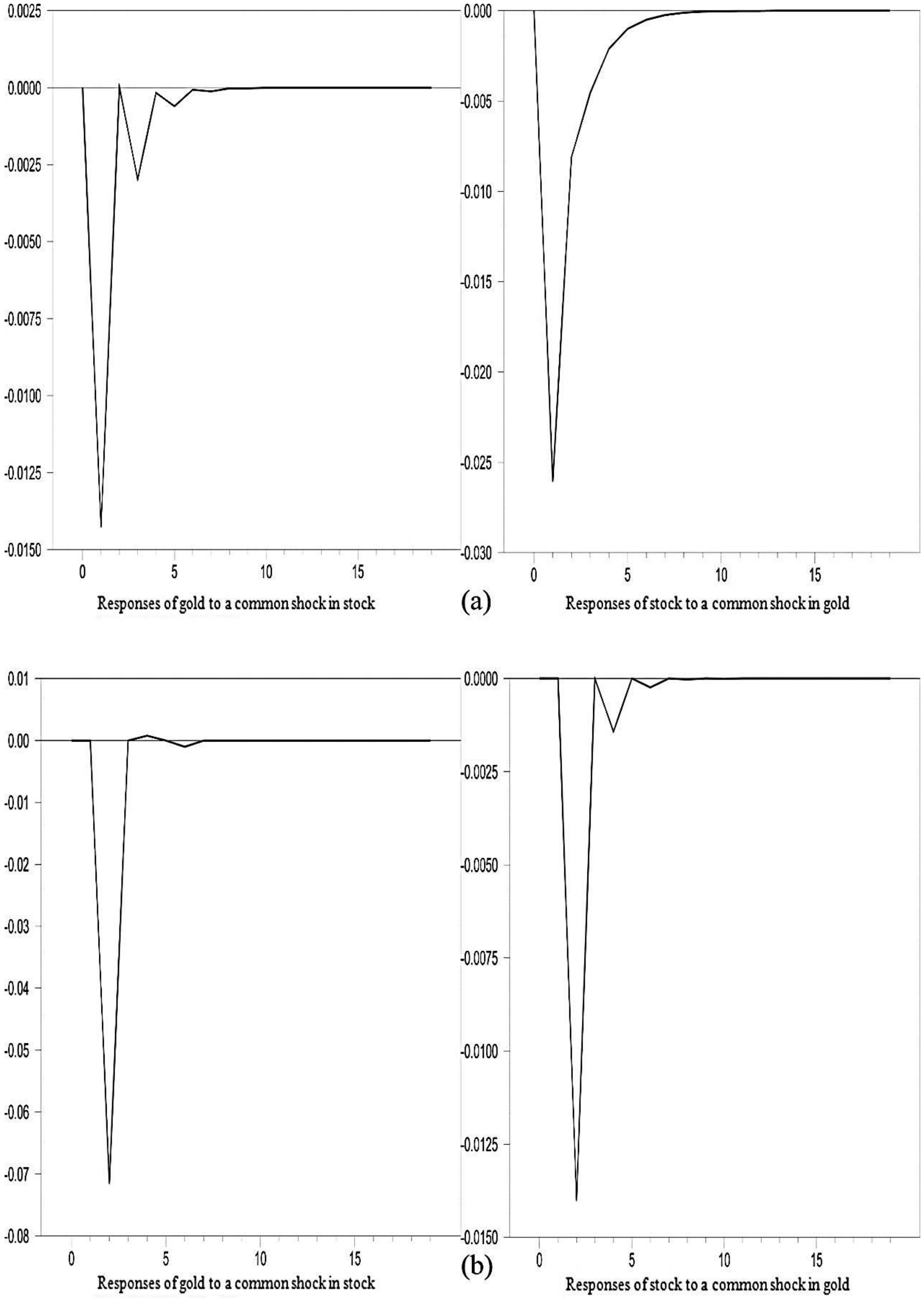


Figure 4. Impulse-response Functions of Stocks and Gold over Two Periods; a) Pre-JCPOA and b) Post- JCPOA
Source: Research finding.

Conclusion

The present article investigates and compares volatility spillovers among financial markets in Iran pre-and post-JCPOA using the daily data of the stock price index of Tehran Stock

Exchange, exchange rate and gold price. Returns of the variables were therefore calculated using the data associated with pre-JCPOA, i.e. 25 March 2009 to 13 July 2015, and post-JCPOA, i.e. 15 July 2015 to 18 July 2018. The results of volatility spillover in financial markets using the VAR-BEKK-GARCH model can be summarized as follows: firstly, two-way volatility spillover between gold and stock markets is confirmed in both periods; secondly, two-way volatility spillover between foreign exchange and stock markets pre-JCPOA and one-way spillover from the stock market to the foreign exchange market post-JCPOA are confirmed; thirdly, two-way volatility spillover between foreign exchange and gold markets post-JCPOA, and a one-way spillover from the gold to foreign exchange market pre-JCPOA are accepted; fourthly, the effect of volatility spillover of the stock market is negative on the foreign exchange market pre-JCPOA, an positive post-JCPOA. Ultimately, volatility spillover among financial markets significantly decreased in the post- compared to pre-JCPOA period.

According to the results, comparing volatility spillover among financial markets in Iran pre and post JCPOA shows that JCPOA was able to reduce volatility spillover among these markets. In other words, JCPOA caused relative stability in most markets and reduced volatility in financial markets by easing the US and EU sanctions against Iran, increasing oil revenues and reducing the cost of international transactions and investment risks in Iran. According to the results, confirming the effect of economic and political conditions on the relationships among financial markets in Iran can be interesting for policy-makers at the macro level. The findings in terms of the direction and magnitude of the effects of spillover among financial markets also have major implications for risk and portfolio management, and investigating the status of the stock market and the effect of other financial markets on this market constitutes a major component in investment management analyses.

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