The Effect of Macroeconomic Indicators on the Financial Stress Index in the Members of the Organization of the Petroleum Exporting Countries (OPEC)

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ABSTRACT
Stress in financial markets is defined as the force that influences financial agents' behavior in terms of the existence of uncertainty and the change of expectations, and its critical levels have been called "financial crisis". The increase in oil revenues may have positive impacts on total supply by increasing investment, particularly state investment, the import of capital and intermediate goods, and the introduction of new technologies. When the value of the national currency increases as a result of momentum in oil prices, the price of imported capital and intermediate goods decreases. Due to the importance of the financial stress index and its relationship with important economic variables, the current study aimed to investigate the volatility spillover of financial stress to the macroeconomic indicators in the members of the Organization of the Petroleum Exporting Countries (OPEC). The study used multivariate GARCH, BEKK, and VAR models to investigate and analyze the hypothesis. The data were investigated daily from 2010 to 2019. The findings indicated that the financial stress index causes impulses in interest rates, liquidity, and inflation in Iran, Kuwait, and Qatar.

Keywords:
Financial stress index, Macroeconomic indicators, OPEC members

1. Introduction

After the banking crisis of 2007-08, studies were conducted to construct an index that could explain the overall conditions of the financial sector, and a modern method was introduced to identify banks that were at risk. It was attempted to design an index called the “financial stress index” to investigate the health of the financial sector. Thus, this index is used to analyze different sectors such as the banking sector or stock markets by applying the indicators of performance evaluation. Then, the stress index can be used to measure stress levels in either the banking sector or stock markets. The performance indicators of both banking and stock market sectors are used to construct a financial stress index that can explain the existence of stress in either sector. Two approaches exist for measuring the financial stress index on an international scale. Based on the first approach, FSI is constructed based on market information. Thus, indicators with a high degree of volatility are used to construct FSI. Studies in this regard include the study on the hybrid stress index conducted in the EU (Hollo et al., 2012), a study on FSI in IMF (Cardarelli et al., 2009), and a study on the financial crisis in the U.S. (Nelson & Perli, 2007).

In the second approach, FSI is prepared based on banking information. Thus, the indicators of banking stability and health are applied within the framework of the CAMELS model by using the items of balance sheets and the profit/loss of banks, the changes in stock prices, and information related to interbank markets. The national banks of Switzerland (2006) and Luxemburg (2007) used all three classes of the above information to construct their banking stress index. The national bank of the Netherlands used the financial stability index within the framework of the CAMELS model and macro indicators such as the rate of currency and stock prices, as well (van den End, 2006). The national banks of Greece, Latvia, and other countries in the Baltic Sea region have also used the indicators of the CAMELS model. (Gersel & Hermanek, 2006; Sinenko, Titarenko & Arins (2013)

Concerning the studies conducted on the correlation of financial markets, it should be said that they are mostly experimental and the main foundation of the theoretical background of this field has been in isolation since the 1960s and focusing on the diversity of investment portfolios and the integration of financial markets. These experimental studies at first focused on the long-term relationship between markets or assets. However, the focus of recent experimental studies has extended to cover the analysis of short-term interactions between financial markets using daily data. Moreover, some studies have tended to focus on specific and turbulent periods. This trend has been formed by studies such as Longin and Solnik, which showed that the interactions between financial; in other words, they showed that bigger shocks in a market tend to spread rapidly.

Most of the experimental studies mentioned above are based on econometric and statistical methods that have been used to measure yields and multivariate turbulences. Techniques used in these studies include linear regressions, quantile regressions, vector auto-regression (VAR), GARCH and similar models, and co-integration methods. While some cases have focused particularly on crises, most of them have analyzed the relationships without considering the presence of any crisis.

2. Theoretical Foundations and Literature Review

FSI provides valuable information regarding future economic growth. It has been recognized that FSI has a high and dependable explanatory power for such standardized macroeconomic variables as inflation, the true growth rate in GDP, and the interest rate of monetary policy; thus, it has a quite convenient predictive potential for the real economic sector (Kremer, 2016).

According to the definition, systemic financial stress 1. Diffuses extensively in financial systems and 2. Makes negative effects on real economic sectors (Houtari, 2015). Financial stress enforces risks on the real economy such as businesses, households, and credit conditions. However, the relationship between financial stress and the real economy is in general complex and hard to understand. Hakkio & Keeton (2009) proposed 3 channels through which the increased rate of financial stress can lead to a significant reduction in economic activity. The first channel refers to increased uncertainties concerning the price of financial assets and the economic prospects in general. Financial stress is involved with 2 types of uncertainties: uncertainty concerning the fundamental value of assets and uncertainty concerning other investors’ behavior. Both types of uncertainty lead to volatility in the price of assets. Experimental studies have shown that volatilities causes companies to be more cautious and delay their important investment decisions until the reduction of the level of uncertainties. Volatility can reduce household consumptions since families become uncertain about their future wealth. The activity of the real economy gets reduced when households and businesses react in this manner.

The second path through which financial stress can influence economic activity is the increase of financing costs for businesses and households. The components “moving towards quality” and “moving towards liquidity” in addition to an increase in information asymmetry increase interest rates for businesses and consumer debts in capital markets. furthermore, financial stress can increase the financing costs of companies by way of issuing new shares. Such increases in financing costs lead to even more reductions in consumption and economic activity.

The third path of influencing financial stress is where it reduces the rate of economic activity by forcing banks to make credit standards stricter. The same factors that make investors require more yield on debt and shares during financial crises cause banks to be less inclined to lending. Banks in such situations indicate their unwillingness to offer loans in two ways. First, they increase the interest rates on new loans and reduce their attraction for the receiver of the loan. This impact of such an increase should be similar to increasing the credit costs of capital markets concerning consumption on the consumption of businesses and households. As a result, this influence can be considered a part of credit costs. Second, banks increase their minimum credit standards and make the process of receiving a loan quite difficult for applicants. Such difficulties regarding credit standards can reduce consumption even more and increase interest rates. Hence, the third path of the influence of financial stress on real economy gets formed (Morgan & Lown; 2006).

The Effects of Financial Stress on the Behavior of Economic Factors

It is assumed that financial markets are characterized by the limited enforcement of contracts. Thus, consumers who are affected by liquidity shocks face problems in getting loans. Credit institutions do not have a unique job since they can exploit limitations in loans offering by collecting investors’ assets and increasing the liquidity offered by financial markets. Moreover, limited participation in markets, limitations in the enforcement of contracts, and uncertainties regarding the price of financial assets can bring the institutions to the verge of bankruptcy. Numerous pieces of evidence indicate that the price of financial assets (e.g., shares) is determined by extreme accumulation. The fact that volatilities in the price of assets are important to consumers shows how deposit accounts increase potential costs in comparison to maintaining assets directly. Consumer satisfaction is attained when demand for deposit accounts increases, and this results in the increased price of assets (Zhang, 2017). The findings of experimental studies conducted in different countries such as the U.K., which investigated the volatility of stock markets, attitudes towards risks, and demand for money, were quite consistent (Bisandial, 2014). The empirical and theoretical model obtained from Fama-French 3-factor model as the representatives of the variables related to economic conditions indicate that the variance of these factors can be considered representative of the variables related to the future conditions of economies. Investment opportunities can arise due to reduced stock yields or increased stock instability (Campbell et al., 2017). A growing number of studies have investigated the volatility in the prices of assets in the boundary between economic and financial matters, though no complete agreement exists between stock market operators left as a puzzle for economists. Price signs have been proposed as the major causes of stock market volatilities. In a conceptual way, the value of total assets should be regarded as the market value of companies, which is equal to the total stock market value of companies and the net debt). The volatilities in the market value of companies are related to other macroeconomic components. Stock market yields, and the ratio of stock dividend price (Eerola & Santos, 2017). Volatilities observed in stock market value and the ratio of stock dividend price have been found to be 10 times higher than the rates of production and consumption and around 3 times higher than the actual investment, and this indicated an increased rate of uncertainty concerning the price of financial assets (Gomeh et al., 2011).

The development of general equilibrium models has uncovered that institutional investors tend to give more weight to assets that are closer to their criteria, and this increases the price of those assets. However, they are unaware that disagreements influence the prices of assets. Thus, a general equilibrium model was developed where disagreements and standard motivations were applied simultaneously, and it was analyzed how the influences affect the dynamicity of the price of assets. Institutional investors' preferences have been defined in this model, and it has been shown that institutional investors get more desirability from their consumed product when the standard shares are valued higher than non-standard shares. These characteristics of institutional investors' preferences show their standard motivations well. Numerous experimental studies have been conducted on these characteristics where the investors' performance has been measured in relation to a particular index (Kuku & Kaniel, 2015; Basak & Pavlova, 2013; Schindler et al., 2015) In cases of disagreements, a method has been designed that allows institutional investors to show "agreement on a disagreement" concerning basic economics. This brings about a constant disagreement between them and even lets them learn it according to the Bayesian way. (Damas et al., 2009; Bhamra & Opal, 2014)

The effects of standard motivations and disagreements regarding institutional investors' optimization plans are investigated, and disagreements cause institutional investors to get access to stock markets since they increase the risk of the prices set by institutional investors and reduce the number of pessimist investors. Particularly, optimist institutional investors always consider long periods for their shares since the difference get increases, but risks related to the changes of future markets favor pessimist investors. Investors usually receive loans in the form of other shares and securities to avoid and cover risks. At the same time, the value of any peripheral instrument used by institutional investors gets increased in line with the standard motivations and investment in shares that are more valuable and yield more profits. Consequently, standard stimulants can strengthen the impact of disagreements in any stock condition (Wang et al., 2017).

A major question concerning financial markets and every time series system, in general, is whether there is a driving force behind the yield. Can this force be defined within the context of physical concepts? All dynamic systems have some force, but identifying a driving force in a random system is usually difficult and identifies a system with average characteristics or the distribution of assets. In time series systems such as the price of assets in stock markets, such characteristics can be explained by using different theoretical methods. The standard approach within financial mathematics is the use of Geometric Brownian Motion (GBM), though the actual conditions may accompany a quite high degree of complexity. The nature of the force behind the price of assets or any other time-series system can be interpreted according to the Aristotelian principle of "potential – actual" in a way that today's actuality is the potential of tomorrow's actuality. The value of tomorrow is not limited to a potential force in this definition but is affected by a high degree of possible effects such as future expectations. The conversion of capability into actuality can be analyzed using dispersion diagrams. Since the consecutive points in a time series system are connected using arrows, the length of the arrows can be interpreted as capabilities and the actual values in the system. This makes it possible to define a force in consecutive events, determine changes that occur in the system, and consider conservative and shocking characteristics (Yalin and Gankor Gandz, 2016). Asymmetric volatilities in stock markets have been confirmed extensively in the case of financial matters, and this shows that yields and volatilities are related to each other (with a stronger relationship for negative yields). In other words, major volatilities increase, and a severe reduction is observed in markets. The instability of asymmetric stock markets has at least 3 causes. First, one of the major characteristics of the dynamicity of market volatilities is the consequences of asset prices and is considered a feature of price risk factors. Second, it plays a significant role in risk prediction and coverage and proving authority. Finally, asymmetric symmetry means the negative diagonal form of yield distribution, which means that it can help to explain some major probable losses (Abura & Wagner, 2016).

As financial institutions usually face global volatility shocks, they report financial capability that can in turn influence economic performance. Systemic risk is a well-known criterion concerning financial stability that is sensitive to stock market volatility. Such volatility is conversely related to synchronous financial stability. Implicit volatility is significantly correlated with the systematic risk of financial companies that sustain losses. Thus, a portion of volatility is related to the prices of total assets. Furthermore, the major issue is how the global volatility is related to the systematic risk of international financial institutions (Bekaert & Harova, 2014; Bankoni et al., 2014)). How is it predicted that the expected volatility of markets is related to the total prices of assets? What are the effects of asymmetric volatility when markets face severe shocks? Researchers have devised an index to predict the effect of probable risk volatility on their analyses. Two major economic hypotheses that have been applied to explain the phenomenon of asymmetric volatility include the hypothesis of the reduction of share values as a financial leverage and a higher risk and the hypothesis of the yield of the variable effects of volatilities that implies increased market risks and expected yields and reduced prices. However, it has been found that changes in volatility have indirect effects on changes in prices. It has not been determined whether such behavior can be considered a driving force during stressful periods of markets. Based on the index applied to measure the expected volatility in the future, it can be investigated whether the asymmetry of price – volatility leads to severe price shocks or suppress them. In the event of its occurrence, this phenomenon can help justify the dramatic decline in the market. (Campbell & Hentschel, 1992; Bekaert & Wu, 2000)

Yelang & Ur (2020) investigated the economic and financial characteristics of petroleum and presented a structured study of the dynamic of petroleum prices. Particularly, they provided evidence related to the major factors that determine the price of petroleum and showed the effects of shocks in petroleum markets on macroeconomics and stock exchanges. Furthermore, they investigated the impacts of petroleum financial markets on the performance and efficiency of petroleum markets. Apostolakis and Papadopoulos (2018) investigated the relationship between financial stability, monetary stability, and growth using the Panel Vector Auto-regression (PVAR) method. The findings revealed that positive shocks to financial stress have negative effects on all macroeconomic variables; first, it was shown to have a negative effect on growth and inflation. Stona et al., (2018) investigated the differences between macroeconomic dynamicity during 2000-2015 when the financial market of Brazil was unstable. Thus, FSI in Brazil was introduced as the predictor of financial stress, and its interaction with actual activities, inflation, and monetary policies was investigated using the Markov-Switching VAR model. In a study titled “Financial Stress Regimes and the Macro economy”, Galvao and Owyang (2018) stated that some cases of financial stress result in recessions in the macroeconomic. Financial stress regimes use a model that explicitly states how financial variables affect macroeconomic conditions. By examining only financial variables, it is possible to create risk taking in financial stress risks as well as economic change between financial variables and economic variables such as industrial production and inflation. Ferrer et al. (2018) investigated the interactions of financial stress and economic activities in the U.S. by the wavelet square consistency and phase difference and the wavelet measurement methods. It was found that the effect of financial stress on the real economy is significant particularly during financial crises, and the effect of financial stress on economic activities is mostly determined in the long run. دایری et al. (2017) investigated stress in the financial systems of European countries and found that financial stress recorded in terms of FSI levels both reflects uncertainty in the prices of market assets and the intense modification of market prices and being shared in terms of the grading of assets. Evgenidis and Tsagkanos (2017) investigated the asymmetric effects of the spillover of the U.S. financial stress at the international level. Using the threshold-VAR approach to harmful financial shocks in the US leads to deteriorating financial and economic conditions both domestically and in the eurozone. Furthermore, the financial facilitator mechanism intensifies the spillover of the shocks of financial stress to the Euro Zone by a significant reduction in economic activity. Moreover, the small shocks of financial stress (unlike large-scale accidental shocks) create major volatilities in the rate of inflation. Finally, the impact of harmful shocks on financial conditions will bring about more negative consequences in comparison to the positive impacts brought about by useful shocks of financial conditions. Jung Kuo et al. (2016) introduced a strong set of indicators for financial stress and stability in Taiwan. Their findings confirmed that using the Two-regime Markov-Switching method with the FSI of Taiwan and the market-based FSI can determine a turning point for major financial crises. Moreover, with the success of the Asian financial crisis, the price bubble, the cross-economic-political tensions, the global financial crisis, the European debt crisis, etc., especially to resolve the financial crisis caused by the political and economic tensions in 2004, which fully reflects a specific feature of political sensitivity in Taiwan's financial system. Paputsuneh (2016) analyzed the relationship between the variables of FSI and the monetary policy of South Africa with a focus on the effect of such variables on the credit of monetary interest rates. The findings showed that a set of FSI variables including the expansion of bonds, unlimited securities, and corporate securities, stock market yields, financial sector marketing, growth in credits, and the yield of real estate markets is estimated by the motion of interest rates and monetary policies in most regression models. In addition, a set of variables related to FSI including the yield of commodity markets, petroleum markets, the beta of financial sectors, and the fundamental banking sector implicitly coincides with the motion of the interest rate of monetary policies. Cevik et al. (2015) the financial stress and economic activities of some emerging economies in Asia and used a model of dynamic agents to develop an FSI for Indonesia, South Korea, Malaysia, the Philippines, and Thailand and investigate the relationship between financials tress and economic activity. FSI includes the risks of the banking sector, the risk of market securities, the risk of currencies, foreign debts, and the risk of governance. The findings showed that FSI is quite important from economic activities. A two-way VAR model of financial stress and industrial production showed that financial stress significantly reduces the rate of economic activities. Van Roye (2013) investigated the European financial and debt crisis and showed that financial can be considered a major risk for economic activities. It was found that the effect of financial stress on economic activities is quite evident, and it can estimate the 12-month growth rate of industrial production, inflation rate, and short-term interest rate. The advantage of the TVAR model is that it can make it possible to investigate no-linear effects. Specifically, the asymmetric behavior of particular variables against shocks and a multiple equilibrium framework can be investigated using the framework of this model. Balakrishnan et al. (2009) emphasized the effect of stock markets on periods of financial stress instead of banking, currencies, and debt-related crises.

Method

The current study was conducted to investigate the impact of macroeconomic factors of OPEC members on FSI. the study is retrospective in terms of its prospect, applied in terms of purpose, pragmatic in terms of the interpretation of results, and ex-post facto in terms of type. Moreover, the study is descriptive in terms of data collection, correlational in terms of methodology, and survey-exploratory in terms of implementation. The GARCH and VAR models were applied in the current study as instruments to model the dependency structure of peripheral indicators and measure FSI. first, the volatility and variance of each component related to the construction of FSI were measured using the univariate GARCH model. Then, the dynamicity of FSI was investigated in the current study since the factors and components of FSI differed for each country and could take any possible value. Thus, the index was found to be dynamic due to its variability among OPEC members and the presence of several variables related to the construction of FSI. The data relating to the current study were investigated in a monthly way during 2010-2019. Moreover, it should be pointed out that the study was conducted on 13 countries that are members of OPEC (Algeria, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the UAE, Ecuador, Angola, Venezuela, and Congo). Only Iran, Qatar, Saudi Arabia, the UAE, Venezuela, and Iraq had stock exchanges, and only 4 countries including Iran, Qatar, Kuwait, and Saudi Arabia had an industrial index; thus, only these 4 countries were selected for the study.

The Construction of FSI

The selected variables of different markets are divided into sub-indicators (e.g., stock market, money market, banking sector, debt securities market, and the market of foreign currencies). Each one of these sub-indicators is obtained as arithmetic means. The last stage of the construction of FSI is according to the portfolio-based approach. The methods proposed by Hollo et al. (2012) and Ychini & Nobini (2016) were used to accumulate the 5-fold indicators of the financial system to present the FSI by combing the GARCH models. Based on portfolio theory, the overall risk of the portfolio of financial stress sub-indicators depends not only on their volatility but also on their mutual dependencies.

FSI is constructed in the following manner:

$$FSI = (w \circ s_t) \times C_t \times (w \circ s_t)',$$

where w is the weight vector of the sub-indicators, s is the vector of the sub-indicators, the matrix multiplication of the sub-indicators, and the vector of the sub-indicators in time t. In addition, … is the reverse of the matrix. CT is the matrix of mutual correlation coefficients of the variable during times i and j.

$$C_t = \begin{pmatrix} 1 & \rho_{12,t} & \rho_{13,t} & \rho_{14,t} & \rho_{15,t} \\ \rho_{21,t} & 1 & \rho_{23,t} & \rho_{24,t} & \rho_{25,t} \\ \rho_{31,t} & \rho_{32,t} & 1 & \rho_{34,t} & \rho_{35,t} \\ \rho_{41,t} & \rho_{42,t} & \rho_{43,t} & 1 & \rho_{45,t} \\ \rho_{51,t} & \rho_{52,t} & \rho_{53,t} & \rho_{54,t} & 1 \end{pmatrix}$$

The variables involved in the construction of FSI are as follows:

Stock Markets: The volatility of the total stock market index of OPEC members in a monthly manner by using GARCH (p, q).

Volatility in the Price of Shares (MTSEI): This variable indicates the overall volatility of the price of shares. In the studies conducted on global financial markets, the implied volatility index of the price of shares that measures the expected volatility of share prices based on the market value has been used. Since the implied volatility index is not being used in Iran, the volatility identified in Iran was used instead. This index considers uncertainty concerning the fundamental value of assets as equal to uncertainty in financial investors' behavior and calculates it.

Money Market:

The gap between interbank rates and interest rates.

The gap between interbank interest rates and the interest rates of deposit accounts (DIID_r)

The difference between the interest rates of banks and the interest rate of transactions can be used to calculate the gap between interbank interest rates and the interest rates of deposit accounts. The weighted average of the interest rates of transactions was used for the interbank interest rates.

The Currency Rate Market:

The monthly volatility of the U.S. dollar rate (US$) using GARCH(p, q)

The Volatility of the Currency Rate (US$):

Due to the significant dependency of OPEC members on petroleum revenues and import/export, the volatility of currency rates in those countries is a quite important index for measuring the stress of their financial markets.

The Banking Industry:

The beta of the banking industry

Banking beta (β)

where rt and mt are the monthly yields of the banking industry and markets. the monthly yields are calculated as the logarithmic difference of the current and previous indicators, and the daily indicators are converted into monthly indicators.

The independent variables of the current study are as follows:

Central Bank Inflation Rate:

In the current study, inflation was obtained according to the data presented on the websites of national banks. However, a simple way to calculate the rate of inflation is as follows:

$$\frac{B-A}{A} \times 100$$

where A indicates the price at the beginning of the period and B is the price at the end. Using this formula is not limited to a particular period and can be applied for any given time basis (weekly, monthly, or yearly).

Liquidity (M2):

The liquidity was obtained using the websites of the national banks. Nevertheless, liquidity can also be obtained as follows:

In a common definition, the volume of money (1M) is equal to the sum of bills and coins among people (CU) and visible deposits (DD).

M۱ = CU + DD

M ۲= M ۱+ T

The BEKK-GARCH Model

The bivariate GARCH model used in the current study is called the diagonal BEKK model that was introduced by Baba, Engle, Kroner, and Kraft in 1991 as another version of multivariate GARCH models. The model was proposed as a continuation of the M-GARCH model, and the fact that it is public is its major characteristic. Another characteristic of the model is that the conditional covariance of this time series influences each other and a smaller number of parameters are calculated compared to other methods (Keshavarziyan, 2010). The method makes it possible to investigate the effects of shocks and volatilities – whether symmetric or asymmetric - on the volatilities of other series.

Lucis and Woldis (2013) believe that this method is more optimal when a model is small in size (N=5 in the current study). No convergence issues arise in this model, and there is no need to make limitations on parameters to make sure of the absoluteness of the conditional covariance matrix. Moreover, the selected BEKK method gives more weight to recent observation compared to the classic methods of calculating correlation. Thus, the BEKK-GARCH model makes it possible to consider sudden changes in correlations and recognize phenomena that are known to have high stress. Unlike the moving average indicators, this approach makes it possible to gradually eliminate the effects of volatility shocks and avoid the randomness of the selection of smoothing coefficient. The BEKK model used in the current study can be illustrated as follows:

$$H_{t-1} = \acute{C}C + \acute{B}H_tB + \acute{A}\varepsilon_t\acute{\varepsilon}_tA$$

In the case of the bivariate model used in the current study, C is a triangular 2×2 matrix with 3 parameters, and B is a square 2×2-parameter that relates the current levels of conditional variances to the previous conditional variances. In addition, A is a 2×2-parameter matrix that assesses how the conditional variances are related to the errors of the previous square and correlate with them. Thus, the overall number of estimated parameters was 13. The development of conditional variances for each equation in the bivariate GARCH model (1,1) is as follows:

$$\begin{aligned}h_{11,t+1} = C_{11}^2 + b_{11}^2h_{11t} + 2h_{11}b_{21}h_{12.t} + b_{21}^2h_{22.t}\\ + a_{11}^2\varepsilon_{1.t}^2 + 2a_{11}a_{21}\varepsilon_{1.t}\varepsilon_{2,t}\\ + a_{2.1}^2\varepsilon_{2.t}^2\end{aligned}$$

$$\begin{aligned}h_{22,t+1} = c_{12}^2 + c_{22}^2 + b_{12}^2h_{1t} + 2b_{12}b_{22}h_{12.t}\\ + b_{22}^2h_{22.t} + a_{12}^2\varepsilon_{1.t}^2\\ + 2a_{12}a_{22}\varepsilon_{q,t}\varepsilon_{2.t} + a_{22}^2\varepsilon_{2.t}^2\end{aligned}$$

The above equations show the spillover of shocks and volatilities over time in the form of two series. The quasi-maximum likelihood estimate with extended standard error estimated (Bollerslev & Wooldridge, 1992). The parameters of the multivariate generalized conditional model of variance heterogeneity can be estimated by applying the quasi-maximum likelihood method. The logarithm of the likelihood function can be illustrated in the following manner:

$$\begin{aligned}L(\theta) = T\log 2\pi - 0.5\sum_{t-1}^{T}\log|H_t(\theta)|\\ - 0.5\sum_{t-1}^{T}\varepsilon_t(\acute{\theta})\log H_t^{-1}\varepsilon_t(\theta)\end{aligned}$$

where T is the number of observations and Θ is the vector of parameters that have to be estimated. The estimation of parameters according to the maximum likelihood method was conducted by the application of a logarithm proposed by Brent et al. (1974). The following equations indicate the equations for the mean and conditional variance of the M-GARCH (p, q) model:

$$Y_t = \mu_t + \sigma_tZ_t \qquad Z_t \sim NID(0,1)$$
$$\mu_t = a + \sum_{i=1}^{k} b_iX_{i,t}$$
$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2 + \beta_1\sigma_{t-1}^2 + \beta_p\sigma_{t-p}^2$$
$$\varepsilon_t \sim NID(0، H)$$
$$= \alpha_0 + \textstyle\sum_{i=1}^{q}\alpha_i\,\varepsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i\,\sigma_{t-i}^2$$

The Vector Auto-regression (VAR) model

VAR is a statistical model that indicates linear dependency among several instances of time series. It is a generalization of the auto-regressive model for the modeling of dependencies among more than a single time series. In VAR, the future of a time series is estimated according to its past and other series in several delays. VAR is defined in the following manner (Souri, 2015).

$$Y_t = C + \sum_{i=1}^{p} A_i\,Y_{t-1} + \varepsilon_t$$

Yt is a vector column of observations in time t in relation to all variables of the model. In addition, C is the vertical intercept, and εt is the vector column of the values of random interference that may correlate randomly. Ai is the matrix of parameters and is non-zero. The terms related to the seasonal dummy variables and algebraic time procedures can in practice be added to the general model of VAR.

Based on the above discussions, the hypothesis of the current study are as follows:

1) The volatility spillover of the inflation index leads to impulses in the FSI of OPEC members.
2) The volatility spillover of the economic growth index leads to impulses in the FSI of OPEC members.
3) The volatility spillover of the liquidity index leads to impulses in the FSI of OPEC members.
4) The volatility spillover of the banking index leads to impulses in the FSI of OPEC members.

4. Findings

4.1. Descriptive Statistics

The descriptive statistics of the variables of the model were obtained by EViews9 (Table 1).

Based on Table 1, the highest SD among the investigated variable is related to the economic growth of Saudi Arabia, while the least SD is related to the FSI of Qatar. Moreover, in terms of the kurtosis and skewness of the research variables, the economic growth of Saudi Arabia and the banking index of Iran were found to be platykurtic. Furthermore, the economic growth of Iran and the banking index of Qatar were found to have kurtosis. The statistics obtained by the Jarque-Bera test rejected the normality of the research variables at the level of $p<0.05$. Since the p-value was below 0.05, H0 was confirmed.

Table. The descriptive statistics of the variables of the study

	Jarque-Bera probability	Jarque-Bera	Kurtosis	Skewness	SD	Min.	Max.	Median	Mean
FSI of Iran	۰,۰۰۰	44.453	2.398	-0.048	3.665	8.716	24.27	17.059	16.535
FSI of Kuwait	۰,۰۰۰	91.863	2.186	-0.162	3.455	13.259	27.128	20.641	20.688
FSI of Qatar	۰,۰۰۰	18.799	2.983	-0.198	0.576	-2.742	1.359	-۰.867	-۰.764
FSI of Saudi Arabia	۰,۰۰۰	83.87	2.611	0.371	5.984	-7.445	13.396	1.007	0.808
The inflation rate in Iran	۰,۰۰۰	181.865	2.12	-0.432	13.553	-25.958	17.258	0.223	0.442
The inflation rate in Kuwait	۰,۰۰۰	216.156	2.367	-0.593	13.233	-25.13	18.27	0.767	-۱.148
The inflation rate in Qatar	۰,۰۰۰	116.144	2.192	-0.282	10.644	-16.909	17.191	0.486	1.497
The inflation rate in Saudi Arabia	۰,۰۰۰	288.571	1.725	-0.444	12.973	-18.122	20.15	7.076	5.205
Economic growth of Iran	۰,۰۰۰	143.026	3.161	0.541	3.126	-2.05۹	9.997	2.699	2.911
Economic growth of Kuwait	۰,۰۰۰	421.146	2.975	0.938	5.937	-1.49۸	19.592	4.753	6.118
Economic growth of Qatar	۰,۰۰۰	24.22	2.832	0.209	4.408	-7.07۶	9.628	0.593	0.795
Economic growth of Saudi Arabia	۰,۰۰۰	32350.48	17.552	3.836	292334.8	6157	1836965	59802.6	136818.5
Liquidity in Iran	۰,۰۰۰	35.933	2.49	0.1	5831.708	20267.48	48835.53	29352.54	29836.72
Liquidity in Kuwait	۰,۰۰۰	230.15	1.952	-0.455	9493.709	13769.78	42734.15	30793.64	30094.28
Liquidity in Qatar	۰,۰۰۰	224.227	1.965	0.449	103246.4	409693.6	731920.2	535364.2	558627.7
Liquidity in Saudi Arabia	۰,۰۰۰	141.234	1.916	0.041	26.025	9.84	124.59	71.15	75.103
Banking index of Iran	۰,۰۰۰	32970.77	17.655	3.906	1797.594	93.9	10863.7	579.3	988.461
Banking index of Kuwait	۰,۰۰۰	77.547	2.336	0.228	159.084	454	1223	807	821.755
Banking index of Qatar	۰,۰۰۰	8660.022	9.615	2.678	2735.501	640.95	14578.67	2836.13	3386.571
Banking index of Saudi Arabia	۰,۰۰۰	200.11	2.037	-0.432	4966.931	4670.32	24211.7	15174.31	13646.41

4.2. The Dicky-Fuller Unit Root Test

A random process (and consequently a time series) is indeed durable if its shared distribution does not change over time. However, since determining the shared distribution of a random process is in practice quite difficult, the variance and covariance of random variables over time are applied. Before attending to the estimation of the model, it should be considered that time series data are static (durable). In the current study, the Dicky-Fuller unit root test was used to investigate the data being static/durable. The findings have been presented in the table below:

Table 2. The results of the Dicky-Fuller unit root test

Variables	Condition	y-intercept				
		probability	Critical values			t
			10%	5%	1%	
OPEC oil price	level	0.547	-2.567	-2.863	-3.435	١٤,٢٣٥
	1 level difference	0.000	-2.567	-2.863	-3.435	-40.684
FSI of Iran	Level	0.267	-2.567	-2.863	-3.435	-2.0447
	1 level difference	0.000	-2.567	-2.863	-3.435	-17.24١
FSI of Kuwait	Level	0.180	-2.567	-2.863	-3.435	-2.275
	1 level difference	0.000	-2.567	-2.863	-3.435	-54.036
FSI of Qatar	level	0.102	-2.567	-2.863	-3.435	-2.555658
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.96568
FSI of Saudi Arabia	Level	0.105	-2.567	-2.863	-3.435	-2.541269
	1 level difference	0.000	-2.567	-2.863	-3.435	-24.24361
Inflation rate of Iran	Level	0.626	-2.567	-2.863	-3.435	-1.254662
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.53512
Inflation rate of Kuwait	Level	0.241	-2.567	-2.863	-3.435	-2.109964
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.52691
Inflation rate of Qatar	Level	٠.1541	-2.567	-2.863	-3.435	-2.357748
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.52977
Inflation rate of Saudi Arabia	Level	0.151	-2.567	-2.863	-3.435	-2.368430
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.52826
Economic growth of Iran	Level	0.3168	-2.567	-2.863	-3.435	-1.933879
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.52753
Economic growth of Kuwait	Level	0.1460	-2.567	-2.863	-3.435	-2.385187
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.52914
Economic growth of Qatar	Level	0.661	-2.567	-2.863	-3.435	-1.23٦
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.537
Economic growth of Saudi Arabia	Level	0.251	-2.567	-2.863	-3.435	-2.082575
	1 level difference	0.0001	-2.567	-2.863	-3.435	-53.52651
Liquidity of Iran	Level	0.026	-2.567	-2.863	-3.435	-3.108413
Liquidity of Kuwait	Level	0.954	-2.567	-2.863	-3.435	-0.029
	1 level difference	0.000	-2.567	-2.863	-3.435	-20.21340
Liquidity of Qatar	Level	0.251	-2.567	-2.863	-3.435	-2.08٣
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.57121
Liquidity of Saudi Arabia	Level	0.565	-2.567	-2.863	-3.435	-1.437917
	1 level difference	0.000	-2.567	-2.863	-3.435	-53.52922
Banking index of Iran	Level	0.000	-2.567	-2.863	-3.435	-6.781729
Banking index of Kuwait	Level	0.267	-2.567	-2.863	-3.435	-2.044507
	1 level difference	0.000	-2.567	-2.863	-3.435	-42.60034
Banking index of Qatar	Level	0.0109	-2.567	-2.863	-3.435	-3.404056
Banking index of Saudi Arabia	Level	0.7024	-2.567	-2.863	-3.435	-1.138
	1 level difference	0.000	-2.567	-2.863	-3.435	-50.511

According to the augmented Dicky-Fuller test, the values obtained for the research variables (except for the liquidity of Iran, the banking index of Iran, and the banking index of Qatar) were found to be above 0.05. thus, H0 about durability is rejected. However, the p-values reach 0 with 1 level difference, and durability is attained.

4.5. Models

4.5.1. The Estimation of the Multivariate GARCH Model

In the current study, the GARCH model was applied to estimate parameters as wells as the conditional mean, variance, and covariance of the research variables including stock markets and the price of oil, currencies, and gold. The results have been presented in the tables below. Moreover, the volatility spillover among the variables was estimated by the BEKK model. The general form of the bivariate GARCH model is as follows:

$$\begin{aligned} h_{11.t+1} = C_{11}^2 + b_{11}^2 h_{11.t} + 2h_{11} b_{21} h_{12.t} + b_{21}^2 h_{22.t} \\ + a_{11}^2 \varepsilon_{1.t}^2 + 2a_{11} a_{21} \varepsilon_{1.t} \varepsilon_{2.t} \\ + a_{2.1}^2 \varepsilon_{2.t}^2 \end{aligned}$$

$$\begin{aligned} h_{22.t+1} = c_{12}^2 + c_{22}^2 + b_{12}^2 h_{11.t} + 2b_{12} b_{22} h_{12.t} \\ + b_{22}^2 h_{22.t} + a_{12}^2 \varepsilon_{1.t}^2 \\ + 2a_{12} a_{22} \varepsilon_{q.t} \varepsilon_{2.t} + a_{22}^2 \varepsilon_{2.t}^2 \end{aligned}$$

The results obtained from the bivariate BEKK model are as follows:

Testing the first hypothesis: Investigating the effect of the volatility spillover of the inflation index on the FSI of OPEC members

The first hypothesis dealt with the impact of the volatility spillover of the inflation index on the FSI of OPEC members. Investigations showed that the FSI of Iran is significant due to its significance level at -3.661 (which is not between +1.96 and -1.96) and its p-value at 0.000; thus, the rate of inflation decreases in Iran when its FSI increases. The volatility spillover of the FSI of Kuwait can have a negative correlation with the rate of inflation in this country since the obtained statistic was not between +1.96 and -1.96 and its p-value was 0.000 (and the positive coefficient with a 95-percent probability). Moreover, investigating the volatility spillover of the FSI of Qatar showed that the obtained statistic was 54.697 at p=0.000. Thus, increasing FSI in this country increases the rate of inflation, and there is a positive correlation between the two variables. Furthermore, the FSI of Saudi Arabia was found to be -0.127 at p=0.899, and this indicated that the volatility spillover of FSI cannot affect the rate of inflation in Saudi Arabia.

Table 3. The BEKK model with the effect of volatility spillover of the inflation index on the FSI of OPEC members

The FSI of Saudi Arabia on the interest rate			The FSI of Qatar on the interest rate			The FSI of Kuwait on the interest rate			The FSI of Iran on the interest rate			
Probability	z	Coefficient	Probability	z	Coefficient	Probability	z	Coefficient	Probability	z	Coefficient	
0.000	7.712	0.000	0.000	159.244	1.446	0.000	250.794	0.526	0.000	9.848	0.036	M(1,1)
0.894	-٠.134	0.000	0.000	-130.561	-٠.295	0.000	-188.194	-٠.176	0.022	2.296	0.003	M(1,2)
0.000	17.725	0.004	0.000	126.526	0.073	0.000	213.002	0.064	0.000	13.089	0.004	M(2,2)

Testing the second hypothesis: Investigating the volatility spillover of the volatility of economic growth on the FSI of OPEC members

The second hypothesis of the study focused on the effect of the volatility spillover of economic growth on the FSI of OPEC members. The investigations showed that the FSI of Iran was -0.175 (outside the range of +1.96 and -1.96) with p=0.240. Thus, it was not found to affect economic growth, and the rate of economic growth does not change as financial stress increases. The volatility spillover of the FSI of Kuwait was found to be outside the range of +1.96 and -1.96 with p=0.000 (with a positive coefficient having the probability of 95%). Thus, it can have a significant effect on the economic growth of Kuwait. Furthermore, the volatility spillover related to the FSI of Qatar was found to be -9.831 with p=0.000. Thus, increasing financial stress has a negative correlation with the rate of economic growth in this country. Moreover, the FSI of Saudi Arabia was found to be -0.205 with p = 0.838. Thus, it was found that the volatility spillover of financial stress does not affect the economic growth of this country.

Table 4. The BEKK model with the effect of the volatility spillover related to economic growth on the FSI of OPEC members

The FSI of Saudi Arabia on economic growth			The FSI of Qatar on economic growth			The FSI of Kuwait on economic growth			The FSI of Iran on economic growth			
Probability	**z**	**Coefficient**	**Probability**	**z**	**Coefficient**	**Probability**	**z**	**Coefficient**	**Probability**	**z**	**Coefficient**	
0.639	0.470	0.002	0.539	0.615	0.000	0.100	-1.645	0.000	0.000	11.448	0.084	M(1,1)
0.838	-٠205	-٠.001	0.000	-9.831	-٠.003	0.000	8.249	0.000	0.240	-1.175	-٠.002	M(1,2)
0.000	5.075	0.004	0.000	49.805	0.033	0.000	12.289	0.006	0.000	7.737	0.002	M(2,2)

Testing the third hypothesis: Investigating the effect of the volatility spillover the liquidity index on the FSI of OPEC members

Investigating the third hypothesis focused on the effect of the volatility spillover of the liquidity index on the FSI of OPEC members. The investigations showed that the FSI of Iran was 5.932 (being outside the range of +1.96 and -1.96) with p=0.000. Thus, a positive correlation was found between the two variables in which increasing financial stress in Iran increases the rate of liquidity in it. In addition, the volatility spillover of FSI in Kuwait was found to be outside the range of +1.96 and -1.96 with p=0.000 (and a positive coefficient with a 95% probability). Thus, it can have a positive effect on the liquidity of this country. Furthermore, the volatility spillover of the FSI in Qatar was found to be 52.454 with p=0.00. Thus, increasing financial stress can increase liquidity in Qatar, and a positive correlation exists between the two variables. Furthermore, the FSI of Saudi Arabia was found to be -0.787 with p=0.431. Thus, it can be observed that the volatility spillover of financial stress does not influence liquidity in Saudi Arabia.

Table 5. The BEKK model with the effect of the volatility spillover of the liquidity index on the FSI of OPEC members

Liquidity index on the FSI of Saudi Arabia			Liquidity index on the FSI of Qatar			Liquidity index on the FSI of Kuwait			Liquidity index on the FSI of Iran			
Probability	**z**	**Coefficient**	**Probability**	**z**	**Coefficient**	**Probability**	**z**	**Coefficient**	**Probability**	**z**	**Coefficient**	
0.000	19.377	2030011.000	0.000	112.580	182614.200	0.000	69.567	81035.750	0.000	6.943	9.328	M(1,1)
0.431	-٠.787	-٥.302	0.000	150.598	81.899	0.000	52.454	19.963	0.000	5.932	0.397	M(1,2)
0.000	15.523	0.004	0.000	300.959	0.043	0.000	43.531	0.012	0.000	21.761	0.066	M(2,2)

Testing the fourth hypothesis: Investigating the effect of the volatility spillover of the banking index on the FSI of OPEC members

The fourth hypothesis of the study investigated the effect of the volatility spillover of the banking index on the FSI of OPEC members. It was found that the FSI of Iran is -2.29 (being in the range of +1.96 and -1.96) with p=0.226. Thus, the variable was not found to affect the banking index. In addition, the volatility spillover of the FSI of Kuwait was found to be outside the range of +1.96 and -1.96 with p=0.000 (and a negative coefficient with a 95% probability). Thus, the variable can have a reverse correlation with the banking index of Kuwait. Moreover, the volatility spillover of the FSI of Qatar was found to be 8.848 with p=0.000. Thus, it was found that increasing financial stress increases the banking index of Qatar, and a positive correlation exists between them. Furthermore, the FSI of Saudi Arabia was found to be -6.8181 with p=0.000, which indicated that the volatility spillover of the FSI of Saudi Arabia does not influence the banking index of this country.

Table 4.6. The BEKK model with the effect of the volatility spillover of the banking index on the FSI of OPEC members

Banking index on the FSI of Saudi Arabia			Banking index on the FSI of Qatar			Banking index on the FSI of Kuwait			Banking index on the FSI of Iran			
Probability	z	Coefficient	Probability	z	Coefficient	Probability	z	Coefficient	Probability	z	Coefficient	
0.000	19.352	58371.790	0.000	23.619	876.519	0.000	24.916	77.457	0.177	1.349	0.449	M(1,1)
0.000	-16.818	-۱3.212	0.000	8.848	3.273	0.000	-5.694	-۰.114	0.226	-1.210	-۰.028	M(1,2)
0.000	15.232	0.006	0.000	22.622	0.010	0.000	16.612	0.008	0.000	12.949	0.018	M(2,2)

5. Discussion and Conclusion

The current study investigated the volatility spillover of FSI to the macroeconomic indicators of OPEC members. The first hypothesis investigated the effects of the volatility spillover of the inflation rate on the FSI of OPEC members. The FSI of Iran was found to be -3.666 (outside the range of +1.96 and -1.96) with p=0.000. Thus, it was found that increasing financial stress in Ira can reduce the rate of inflation in this country. In addition, the volatility spillover of the FSI of Kuwait can have a negative correlation with the rate of inflation in this country since the obtained statistic was not in between +1.96 and -1.96 and its p-value was 0.000 (and the positive coefficient with a 95-percent probability). Moreover, investigating the volatility spillover of the FSI of Qatar showed that the obtained statistic was 54.697 at p=0.000. Thus, increasing FSI in this country increases the rate of inflation, and there is a positive correlation between the two variables. Furthermore, the FSI of Saudi Arabia was found to be -0.127 at p=0.899, and this indicated that the volatility spillover of FSI cannot affect the rate of inflation in Saudi Arabia.

The second hypothesis of the study focused on the effect of the volatility spillover of economic growth on the FSI of OPEC members. The investigations showed that the FSI of Iran was -0.175 (outside the range of +1.96 and -1.96) with p=0.240. Thus, it was not found to affect economic growth, and the rate of economic growth does not change as financial stress increases. The volatility spillover of the FSI of Kuwait was found to be outside the range of +1.96 and -1.96 with p=0.000 (with a positive coefficient having the probability of 95%). Thus, it can have a significant effect on the economic growth of Kuwait. Furthermore, the volatility spillover related to the FSI of Qatar was found to be -9.831 with p=0.000. Thus, increasing financial stress has a negative correlation with the rate of economic growth in this country. Moreover, the FSI of Saudi Arabia was found to be -0.205 with p = 0.838. Thus, it was found that the volatility spillover of financial stress cannot affect the economic growth of this country.

The third hypothesis investigated the effect of the volatility spillover of the liquidity index on the FSI of OPEC members. The investigations showed that the FSI of Iran was 5.932 (being outside the range of +1.96 and -1.96) with p=0.000. Thus, a positive correlation was found between the two variables in which increasing financial stress in Iran increases the rate of liquidity in it. In addition, the volatility spillover of FSI in Kuwait was found to be outside the range of +1.96 and -1.96 with p=0.000 (and a positive coefficient with a 95% probability). Thus, it can have a positive effect on the liquidity of this country. Furthermore, the volatility spillover of the FSI in Qatar was found to be 52.454 with p=0.00. Thus, increasing financial stress can increase liquidity in Qatar, and a positive correlation exists between the two variables. Furthermore, the FSI of Saudi Arabia was found to be -0.787 with p=0.431. Thus, it can be observed that the volatility spillover of financial stress does not influence liquidity in Saudi Arabia.

The fourth hypothesis of the study investigated the effect of the volatility spillover of the banking index on the FSI of OPEC members. It was found that the FSI of Iran is -2.29 (being in the range of +1.96 and -1.96) with p=0.226. Thus, the variable was not found to affect the banking index. In addition, the volatility spillover of the FSI of Kuwait was found to be outside the range of +1.96 and -1.96 with p=0.000 (and a negative coefficient with a 95% probability). Thus, the variable can have a reverse correlation with the banking index of Kuwait. Moreover, the volatility spillover of the FSI of Qatar was found to be 8.848 with p=0.000. Thus, it was found that increasing financial stress increases the banking index of Qatar, and a positive correlation exists between them.

Furthermore, the FSI of Saudi Arabia was found to be -6.8181 with p=0.000, which indicated that the volatility spillover of the FSI of Saudi Arabia does not influence the banking index of this country.

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