Studying Volatility Risk Transmission in Automatable Supply Chain Companies in the Tehran Stock Exchange

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ABSTRACT

Supply chain companies are one of the most important elements of the economy of each country. These companies play an important role in the expansion and activities of other companies through the provision of capital, customers, credit and even raw materials and technology. Therefore, the main goal of this research was to examine the impact of contagion of return and volatility in the return of the automobile companies supply chain listed in Tehran Stock Exchange.

For doing so, Iran Khodro and SAIPA automobile supply chain companies were investigated separately. In addition to the main companies (Iran Khodro and SAIPA), three other supply chain companies were selected for research. The results of the multivariate GARCH model applied for daily data in time interval of 2013/3/21 to 2017/3/21 showed that both the return and the volatility of stock returns of SAIPA and Iran Khodro supply chain companies affected the return and volatility of these two companies stock return. This finding confirms the research hypothesis providing that the return and volatility of Iran Khodro and SAIPA companies are affected by these companies supply chain. In this research the risk contagion resulting from fluctuations in return has also been examined. It can be interpreted that the risk is contagious as the same as the different shares return.

Keywords:

Supply chain companies, volatility Risk , Spillover Effects and Multivariate GARCH Models.

1. Introduction

In recent decades, formation of new financial markets, intensification of competition between companies as well as rapid economic, social and technological changes have increased the uncertainty and instability in financial environments and consequently, the complexity of the financial decision-making process has also enhanced. In particular, with expansion of information systems and the ever-increasing communications rise in financial markets, it has been proven that volatility in prices and return on assets are contagious across financial markets. This has made the prediction of the return and the prices of assets and goods more difficult and as a result it has complicated the financial decision-making process. In fact, financial markets convergence increase has created a strong tendency toward understanding the effect of external fluctuations from one market to other market. These external effects of fluctuations are attributed to the inter-market coverage and change in shared information and expectations of the markets may be converted simultaneously. In other studies the external effects of fluctuations and influence of financial contagion have been discussed. Financial contagion is defined as a shock in the assets market of a country that is affected by the market of assets of other countries. Kodres and Pritsker (2002) developed a multiplier rational prediction model to explain financial contagion. They showed that the extent of financial contagion depends on the market sensitivities to macroeconomic risk factors and the degree of information asymmetry among markets.

The main goal of the present study was to assess the effects of contagion of the return and volatility of the automobile supply chain companies in Tehran Stock Exchange. Supply chain companies are one of the key elements of the stock structure. These companies play an important role in the expansion and activities of other companies through the provision of capital, customers, credit and even raw materials and technology. Therefore, the main goal of this research was to examine the effects of contagion of return and volatility in the return of the automobile companies supply chain in Tehran Stock Exchange.

In cross-sectional econometric models, the constant of the variance of the disturbance sentences is always considered as one of the classic assumptions. Engel (2012) proposed a new model called ARCH to eliminate this limiting assumption. In this model, it is assumed that the disturbance sentences are independent of each other with the mean of zero, but their variance is formed assuming the existence of the past information. One of the reasons for using the ARCH models is existence of small and large prediction errors in the economic clusters (such as exchange rate, inflation, and stocks), so that each mentioned series may display different behaviors over years. In other words, in some years, it had low fluctuations and in some other years, it showed more fluctuations. In such a condition, it is expected that the variance is not constant during the mentioned series random trend and it is a function of the behavior of the disturbance sentences. Indeed, the conditional variance can be explained via the GARCH models with respect to previous data. In this article, multivariate ARCH model was used to model fluctuations due to the existence of heterogeneity of variance.

2. Literature Review

Ewing (2012) analyzed the bilateral relationship among five important sectors (capital, financial, industrial, transport, and electrical items) in the US stock market using the Variance Analysis of Extended Prediction Error with a Vector Autoregressive Framework (VAR). Using monthly S&P stock index data from January 1988 to July 1997, he found that news or unexpected shocks in one sector had a significant effect on the return of other sectors. Ewing, Forbes and Payne (2014) studied the effects of macroeconomic shocks on the indices of the five main S&P sectors during critical period before 1987. Using the generalized abrupt response analysis, they showed that the assets prices were affected more than unpredictable macroeconomic events compared to predictable events. Worthington and Higgs (2004) evaluated the mechanism of transfer of the fluctuations and return between stock markets of East Asian countries using the GARCH model. Their results were based on weekly data from three advanced markets (Hong Kong, Japan, Singapore) and six emerging markets (Korea, Indonesia, Malaysia, Philippines, Taiwan and Thailand) and showed the high convergence among these markets as well as the differentiated impact of emerging markets compared to the advanced markets. Lafuenthe and Roez (2004) examined the relationship between the return and volatility of the Spanish stock market indices and the technology sector index. Results of the positive effects of fluctuations from the technology sector to other sectors using the heterogeneous conditional variance method (GARCH) showed that the financial sector was affected significantly. Wang et al. (2005) examined the dynamics of the relationship between the shares of the Chinese stock market in Shanghai and Shenzhen in 2001. Their results showed a high degree of dependency between sectors in the Chinese stock market. Hassan and Malik (2016) investigated the transfer of shock and fluctuations among six financial, technology, consumer and services, health, industry and energy sectors using a multivariate GARCH model and found significant transfer of shocks and fluctuations among these sectors. Lee (2007) examined the relationship among Chinese, Hong Kong and US stock markets using a BEKK multivariate GARCH model. He did not find any direct relationship between the Chinese and American stock markets. However, unilateral effect of the Hong Kong Stock Exchange on Shanghai and Shenzhen stock exchanges was seen.

In the internal studies, Keshavarz Hadad and Esmailzadeh (2009) modeled a time series model to predict volatility in Tehran Cement Company stock returns using a multivariate GARCH model. Their results depicted that good and bad news had symmetrical effects on cement stock prices. Abunori and Abdollahi (2012) investigated the transmission of volatility among different parts of Iran stock market using a multivariate GARCH model. They suggested that since financial assets are traded on the basis of these sectorial indices, the mechanism for the fluctuations transmission over time and among sectors is important in order to decide on the optimal allocation of the resources. Their results indicated a significant shift in shocks and fluctuations among different sectors.

3. Methodology

3.1. Model

This research has investigated the transmission of volatility and dependence among automobile supply chain companies using the Multivariate GARCH model. For doing so, a brief description of the various models of Multivariate GARCH is presented.

3.1.1.Multivariate GARCH models

Nowadays multivariate models have been broadly developed for dynamical modeling of return. The use of multivariate time series models has two important advantages. First, it is very effective in identifying the relationship among the series, and secondly, it increases the accuracy of predictions. For example, if the past values of a series affects the other series, it is better to use multivariate models. However, the use of systemic or multivariate models instead of univariate models will have two important constraints. First, the more parameters that are estimated, the accuracy of the results will be reduced and more data will be needed for the reliability of the results. Secondly, in many cases, the results are not highly explanatory. Thus, we usually look for simple structures (Tessai, 2002).

Univariate ARCH and GARCH models have expanded to multivariate GARCH models. In the multivariate GARCH models, the covariance variance matrix of the sentences of the series disturbance is estimated, while in the univariate models, only the variance of the series disturbance sentences is calculated. Hence, the multivariate GARCH model has been used to analyze the coexistence of volatility and leverage effects among different markets and recognition of the evidence of the existence of fluctuations in various markets. In recent years, multivariate GARCH models have developed broadly.

In multivariate GARCH models, the number of parameters increases with increasing dimensionality of the model and on the other hand, it is essential that the variance matrix to be positive. Setting these features by the estimated parameters is not so easy (Bauwens L, Laurent S, Rombouts, 2006).

Linear combinations of univariate GARCH models, as their name implies are linear combinations of several univariate models which each of them is not necessarily a standard GARCH model. However, nonlinear combinations of univariate GARCH models allow the researcher to determine each of the conditional variances separately on one hand and specify the conditional correlation matrix on the other hand. However, among multivariate GARCH models, the VEC-GARCH models, Baba-Engle-Kraft-Kroner (BEKK) as well as the Factor-GARCH (F-GARCH) are used more in modeling of financial time series (Bauwens L, Laurent S, Rombouts, 2006). In the following a general structure of some of the above models is presented:

Suppose the vector r_t is a vector of N return on financial assets in the t[th] period and I_{t-1} collected of data over time $t-1$. So, it can write:

$$r_t = \mu_t(I_{t-1}) + \varepsilon_t \quad (1)$$

Where μ_t is the expected return vector of the t[th] period according to the past information and it can be considered as a VAR model as following:

$$\mu_t = A_0 + \sum_{i=1}^{p} A_i r_{t-i} \quad (2)$$

The vector ε_t also indicates the remainders in the t[th] period, which can be defined as follows:

$$\varepsilon_t = H_t^{\frac{1}{2}}(I_{t-1})z_t \quad (3)$$

Where $H_t^{\frac{1}{2}}(I_{t-1})$ is a positive matrix $N \times N$ and z_t is randomized vector as $N \times 1$ with the following first and second moments:

$$E(z_t) = 0$$
$$Var(z_t) = I_N \quad (4)$$

Where I_N is the first matrix with N dimension and it can be easily shown that the conditional variance matrix r_t is equal H_t

3.1.2. Vector GARCH model

Bollerslev in 1988 proposed a general equation for H_t that is the simple model of VEC (1.1) defined as follows:

$$h_t = c + A\eta_{t-1} + Gh_{t-1} \quad (5)$$

Where

$$h_t = vech(H_t)$$
$$\eta_t = vech(\varepsilon_t \varepsilon_t') \quad (6)$$

The operant $vech$ is defined on a square matrix and provides the main diameter and the under-diameter values as a vector. Also, the number of parameters of this model is equal to $N(N+1)(N(N+1)+1)/2$. For example, for each $N=3$, 78 parameters should be estimated. Therefore, this model is used in two-variant cases. To solve this problem, limitations are usually applied to model parameters. Bollerslev (1988) proposed a VEC diametric model in which the matrices A and G are assumed diametric and the elements h_{ijt} are merely dependent on their interruptions and values of a previous period $\varepsilon_{it}\varepsilon_{jt}$. This limitation reduces the number of parameters to $N(N+5)/2$, however, in models with a high dimension, it will be difficult to estimate the model.

3.1.3. BEKK model

According to this fact that in a VEC model assurance of being positive definite H_t without imposing strong limits is difficult, Engle and Kroner (1995) proposed the BEKK model. A BEKK (1, 1, K) model is defined as follows:

$$H_t = C^{*'}C^* + \sum_{k=1}^{K} A_k^{*'} \varepsilon_{t-1}' \varepsilon_{t-1} A_k^* + \sum_{k=1}^{K} G_k^{*'} H_{t-1} G_k^* \quad (7)$$

In a simpler form, a BEKK (1, 1) model is defined as follows:

$$H_t = C^{*'}C^* + A^{*'}\varepsilon_{t-1}'\varepsilon_{t-1}A^* + G^{*'}H_{t-1}G^* \quad (8)$$

Where A^*, G^*, C^* and matrices $N \times N$ and C^* are triangular matrix.

It should be noted that BEKK models are a special form of VEC models, however the parameters of the BEKK model, unlike the VEC model do not directly show the effect of interruptions on the elements H_t. Despite imposing various restrictions to BEKK models, the high number of the parameters is still a fundamental problem. Therefore, these models are not used in the cases with dimension more than 3 and 4 variables (series).

4. Results

In this research, Iran Khodro and SAIPA automatable supply chain companies were investigated separately. For this purpose, except for the main companies (Iran Khodro and SAIPA), three other companies of the supply chain of these companies have been selected for research. For the Iran Khodro supply chain, the Iran Khodro, Automobiles Parts, Mehvarsazan and Khavar Fanarsazi with the symbols of automobile, Khatoga, Khosaz and Khafner in the Tehran Stock Exchange have been chosen. Also, for SAIPA supply chain companies, SAIPA, Plasokar SAIPA, SAIPA Azin and SAIPA Shisheh with symbols of Khaspa, Plasq, Khazin and Kaspa were selected.

Table 1 shows the descriptive statistics of Iran Khodro and SAIPA supply chain companies. As it is shown, the average daily returns of all the companies was positive. However, in the Iran Khodro supply chain, the symbol of Khafner had the highest average and the Khosaz symbol had the lowest average. Also, in the SAIPA supply chain, the Khazin symbol had the highest average return and the Plasq symbol showed the lowest average return during the study period. The standard deviation (std. dev) in the table shows that the fluctuations of the companies with the highest returns were higher than other firms. Also, the results of the Jarque-Bera statistic indicate rejection of the zero assumption of the normality of the distribution for all return series.

Also, the results of the single root tests for Iran Khodro and SAIPA supply chain companies show that the price return of all companies is at stable at 1% level.

The results of the Ljung box test to examine the null hypothesis of the research providing lack of self-correlation for the model remainders indicate that the null hypothesis was not rejected and in other words, it shows the lack of self-correlation for remainders in all models. The statistical tables of this test are presented for all models in section (c).

Table 1: Descriptive statistics of Iran Khodro and SAIPA supply chain companies

SAIPA				Iran Khodro				
Kasapa	**Plasq**	**Khasap**	**Khazin**	**Khosaz**	**Khodro**	**Khafnar**	**Khatoga**	**Explanation**
0.0014	0.0008	0.0033	0.00553	0.0013	0.0019	0.0025	0.0015	Mean
0.00153	0.00003	0.00073	0.002	0.0000	-0.0003	0.0000	-0.0001	Median
0.0195	0.0361	0.040	0.0629	0.0442	0.0372	0.0552	0.0363	SD
-0.2659	1.3720	2.0423	9.2573	-6.3654	1.58983	12.2533	0.8593	Skewness
6.0582	9.6208	24.443	161.71	112.80	24.563	243.28	12.544	Elongation
217	1160	10760	576613	3400	1322	1623	2617	Jarque-bera
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Probability

Table 2: Stability test results for Iran Khodro and SAIPA supply chain companies

SAIPA				Iran Khodro				Explanation
Explanation	**Khatoga**	**Khafnar**	**Khodro**	**Khosaz**	**Khazin**	**Khasap**	**Plasq**	**Kasapa**
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Prob
-22.54	-26.11	-28.31	-24.89	-24.43	-22.54	-24.43	-23.8	PP
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Prob

4.1. Being influenced of return and volatility of automobile supply chain companies

4.1.1.Being influenced of return and volatility of SAIPA supply chain companies

In this section, the transmission of volatility and dependence among four supply chain companies of SAIPA has been investigated using the multivariate GARCH model. SIC statistics were used to select the optimal interrupt interval. The results of estimating the

VAR (1) -BEKK (1.1) model are presented in Table 3 with the T-Student distribution.

The values in the parentheses depict P_Value.

As it is shown in section A of Table 3, the results of VAR model estimation reveal that the returns with interruption of the symbols Khazin and Kasapa have been effective on the SAIPA return. However, the inverse relationship does not exist. This suggests the impact of the automobile supply chain companies on SAIPA return. This issue shows the impact of the return of SAIPA supply chain companies on the return of SAIPA. In this way, intelligibility of return from supply chain companies to the mother company (holding) can be certified.

Also, section B of table 3 shows the results of the BEKK model. The results of this section reveal that most of the coefficients of matrices A and G were meaningful. It means that there was a significant association in the returns of these companies with each other. Investigating the coefficients of these two matrices shows that there was a bilateral relationship between the volatility of the SAIPA Company and its supply chain companies except for Plasq. Therefore, it can be justified that contagion of volatility risk amongst the supply chain companies is a two-way process. In other words, risk transmits from the mother companies to their subsidiary and dependent companies. In the other way around, the risks transmit from dependent and subsidiary companies to the mother company. In this way, if the stock price of a supply chain drops this drop can transmit to other companies. In section C of Table 3, the results of the Ljung box test are presented. These results indicate rejection of null hypothesis and lack of serial correlation between model remainders and the square of model remainders. Lack of serial self-correlation in the fitted model signifies the efficiency of the model. If there is serial self-correlation amongst the constituents, OLS estimators will no longer be efficient amongst all other biased estimators, meaning that they would not have the minimum variance, meaning that statistical inferences would not be reliable.

a. Results of estimation of VAR model (1)

$$\begin{bmatrix} Kesapa_t \\ Khazin_t \\ Khsapa_t \\ Plask_t \end{bmatrix} = \begin{bmatrix} \mathbf{0.003} \\ (0.01) \\ \mathbf{0.002} \\ (0.02) \\ \mathbf{0.002} \\ (0.00) \\ \mathbf{0.006} \\ (0.02) \end{bmatrix} + \begin{bmatrix} \mathbf{-0.15} & \mathbf{0.02} & \mathbf{-0.03} & \mathbf{0.03} \\ (0.02) & (0.22) & (0.28) & (0.16) \\ \mathbf{0.31} & \mathbf{0.09} & \mathbf{-0.10} & \mathbf{0.03} \\ (0.00) & (0.04) & (0.12) & (0.48) \\ \mathbf{0.24} & \mathbf{0.11} & \mathbf{-0.20} & \mathbf{0.03} \\ (0.00) & (0.00) & (0.00) & (0.60) \\ \mathbf{0.035} & \mathbf{0.02} & \mathbf{-0.01} & \mathbf{0.02} \\ (0.70) & (0.56) & (0.06) & (0.70) \end{bmatrix} \times \begin{bmatrix} Kesapa_{t-1} \\ Khazin_{t-1} \\ Khsapa_{t-1} \\ Plask_{t-1} \end{bmatrix}$$

b. Results of estimation of BEKK(1,1) model

$$H_t = C^{'}C^{'} + A^{'}\varepsilon'_{t-1}\varepsilon_{t-1}A^{'} + G^{'}H_{t-1}G^{'}$$

$$\boldsymbol{A} = \begin{bmatrix} \mathbf{0.50} & \mathbf{-0.31} & \mathbf{0.17} & \mathbf{0.37} \\ (0.00) & (0.00) & (0.00) & (0.00) \\ \mathbf{0.05} & \mathbf{0.23} & \mathbf{-0.35} & \mathbf{-0.30} \\ (0.05) & (0.00) & (0.00) & (0.00) \\ \mathbf{0.06} & \mathbf{0.41} & \mathbf{1.21} & \mathbf{0.11} \\ (0.00) & (0.00) & (0.01) & (0.92) \\ \mathbf{-0.14} & \mathbf{-0.29} & \mathbf{0.18} & \mathbf{0.18} \\ (0.00) & (0.00) & (0.09) & (0.18) \end{bmatrix} \quad \boldsymbol{G}$$

$$= \begin{bmatrix} \mathbf{0.89} & \mathbf{-0.22} & \mathbf{0.11} & \mathbf{0.15} \\ (0.00) & (0.00) & (0.304) & (0.00) \\ \mathbf{-0.29} & \mathbf{-0.73} & \mathbf{-0.16} & \mathbf{0.02} \\ (0.05) & (0.00) & (0.440) & (0.188) \\ \mathbf{0.04} & \mathbf{0.40} & \mathbf{0.36} & \mathbf{-0.42} \\ (0.00) & (0.00) & (0.01) & (0.89) \\ \mathbf{-0.12} & \mathbf{-0.45} & \mathbf{-078} & \mathbf{-0.61} \\ (0.00) & (0.00) & (0.09) & (0.00) \end{bmatrix}$$

c. Tests results

Plasq	Khasapa	Khazin	Kasapa	results Ljung-Box
2.63 (0.62)	4.15 (0.38)	4.28 (0.36)	3.36 (0.49)	Q(4)
7.70 (0.10)	1.50 (0.82)	5.09 (0.27)	9.59 (0.05)	$Q^2(4)$
Student t distribution estimated degree of freedom (۰,۰۰) :3.12				

4.1.2. Being influenced of return and volatility of Iran Khodro supply chain companies

In this section, the transmission of volatility and dependence among four supply chain companies of Iran Khodro has been investigated using the multivariate GARCH model. SIC statistics were used to select the optimal interrupt interval. The results of estimating the VAR (1) -BEKK (1.1) model are presented in Table 4 with the T-Student distribution.

Table 4: Estimation results of VAR (1) -BEKK (1.1) model with T-Student distribution for Iran Khodro supply chain

The values in the parentheses depict P_Value.

As it is shown in section A of Table 4, the results of VAR model estimation reveal that the impact of return with interruption of Iran Khodro on other three companies' return was meaningful at 5% level of meaningfulness. In addition, the return of the car manufacturing company had a meaningful effect on Iran Khodro return, while the return of other companies with one pause did not have a meaningful effect on Iran Khodro return. In this way, it can be inferred that contagion of return was present in Iran Khodro supply chain group, too, and vice versa (IK return affected return of supply chain companies). Nonetheless, return contagion of subsidiary companies on mother company is not always present.

Also, section B of table 4 shows the results of the BEKK model. The results of this section reveal that most of the coefficients of matrices A and G were meaningful. It means that there was a significant association in the returns of these companies with each other. Investigating the coefficients of these two matrices shows that there was a bilateral relationship between the volatility of the Iran Khodro Company and its supply chain companies. It can be inferred that the volatility risk contagion amongst supply chain companies is a two-way process, i.e., risk moves from mother company to subsidiary and dependent companies and from these companies to the mother company. In other words, if there is a stock price drop shock for any of the supply chain companies, this effect can be transmitted to other companies of the group.

In section C of Table 4, the results of the Ljung box test are presented. These results indicate rejection of null hypothesis and lack of serial correlation between model remainders and the square of fitted model shows the efficiency of this model as if there is serial correlation amongst the constituent of disturbance, other OLS estimators will be inefficient among all other non-biased estimators. In this way, statistical inference will not be reliable.

a. Results of estimation of VAR model (1)

$$\begin{bmatrix} Khtogha_t \\ Khfanar_t \\ Khosaz_t \\ Khodro_t \end{bmatrix} = \begin{bmatrix} \mathbf{0.006} \\ (0.65) \\ \mathbf{0.002} \\ (0.08) \\ \mathbf{0.003} \\ (0.02) \\ \mathbf{0.004} \\ (0.72) \end{bmatrix} + \begin{bmatrix} \mathbf{-0.04} & \mathbf{0.04} & \mathbf{0.07} & \mathbf{0.09} \\ (0.45) & (0.18) & (0.09) & (0.08) \\ \mathbf{0.12} & \mathbf{-0.01} & \mathbf{0.07} & \mathbf{0.16} \\ (0.03) & (0.74) & (0.85) & (0.01) \\ \mathbf{0.08} & \mathbf{0.01} & \mathbf{0.10} & \mathbf{0.20} \\ (0.87) & (0.77) & (0.03) & (0.00) \\ \mathbf{0.13} & \mathbf{0.07} & \mathbf{0.06} & \mathbf{0.22} \\ (0.76) & (0.81) & (0.04) & (0.01) \end{bmatrix} \times \begin{bmatrix} Khtogha_{t-1} \\ Khfanar_{t-1} \\ Khosaz_{t-1} \\ Khodro_{t-1} \end{bmatrix}$$

b. Results of estimation of BEKK (1, 1) model

$$H_t = C^{*'} C^* + A^{*'} \varepsilon'_{t-1} \varepsilon_{t-1} A^* + G^{*'} H_{t-1} G^*$$

$$= \begin{bmatrix} \mathbf{-0.36} & \mathbf{-0.25} & \mathbf{-0.33} & \mathbf{-0.14} \\ (0.00) & (0.00) & (0.00) & (0.00) \\ \mathbf{0.05} & \mathbf{0.42} & \mathbf{0.27} & \mathbf{0.30} \\ (0.44) & (0.00) & (0.00) & (0.00) \\ \mathbf{0.23} & \mathbf{0.21} & \mathbf{0.32} & \mathbf{0.06} \\ (0.00) & (0.00) & (0.00) & (0.19) \\ \mathbf{-0.10} & \mathbf{-0.36} & \mathbf{-0.42} & \mathbf{0.04} \\ (0.00) & (0.29) & (0.00) & (0.61) \end{bmatrix} \quad \boldsymbol{G}$$

$$= \begin{bmatrix} \mathbf{-0.59} & \mathbf{0.06} & \mathbf{0.58} & \mathbf{-0.09} \\ (0.00) & (0.07) & (0.00) & (0.00) \\ \mathbf{0.41} & \mathbf{0.01} & \mathbf{0.11} & \mathbf{-0.13} \\ (0.00) & (0.09) & (0.04) & (0.25) \\ \mathbf{-0.56} & \mathbf{0.19} & \mathbf{0.92} & \mathbf{-0.72} \\ (0.31) & (0.00) & (0.01) & (0.21) \\ \mathbf{0.27} & \mathbf{-0.05} & \mathbf{0.27} & \mathbf{1.02} \\ (0.00) & (0.26) & (0.00) & (0.00) \end{bmatrix}$$

d. Tests results

Khosaz	Khodro	Khafnar	Khatoga	Test result Ljung-Box
4.63 (0.30)	4.15 (0.38)	3.34 (0.48)	4.28 (0.36)	Q(4)
2.18 (0.62)	1.83 (0.75)	5.29 (0.31)	8.52 (0.06)	$Q^2(4)$
(0.000)5.59 Student t distribution estimated degree of freedom				

5. Discussion and Conclusions

Supply chain companies are one of the key elements of the stock exchange structure. These companies play an important role in the expansion and activities of other companies through the provision of capital, customers, credit and even raw materials and technology. Therefore, the main goal of this research was to examine the impact of contagion of return and volatility in the return of the automobile companies supply chain listed in Tehran Stock Exchange.

For doing so, Iran Khodro and SAIPA automobile supply chain companies were investigated separately. In addition to the main companies (Iran Khodro and SAIPA), three other supply chain companies were selected for research. In Iran Khodro supply chain, Iran Khodro, Original equipment manufacturer, Mehvarsazan, and Fanarsazi Khavar Companies and for SAIPA supply chain companies, SAIPA, Plaskokar-e- SAIPA, SAIPA Azin and SAIPA Shisheh companies were selected.

The results of the multivariate GARCH model applied for daily data in time interval of 2013/3/21 to 2017/3/21 showed that both the return and the volatility of stock returns of SAIPA and Iran Khodro supply chain companies affected the return and volatility of these two companies stock return. This finding confirms the research hypothesis providing that the return and volatility of Iran Khodro and SAIPA companies are affected by these companies supply chain. In this research the risk contagion resulting from fluctuations in return has also been examined. It can be interpreted that the risk is contagious as the same as the different shares return. Confirmation of contagion of volatility risk amongst car manufacturing supply chain companies signifies the domino effect of shock contagion of stock price drop amongst car manufacturing company. Investors need to take in into consideration when developing their stock portfolio. They need to consider systemic risk in their stock investment portfolio as a major risk in the today's market.

According to the results of the research on the contagion of the return and volatility of automobile supply chain companies, it is recommended that the Securities and Exchange Organization (OTC) as a regulatory element of the capital market examines the fluctuations of these shares in detail and conduct an efficient management to control the eventual shock on the capital market. Also, the results of this research can be useful for investors and portfolio managers.
Considering the applicability of the subject of the present research as well as the broad scope of research, it is recommended the future researchers to consider followings:

- It is suggested to measure the effect of contagious return and volatility in supply chain companies in other industries such as heavy metals, financial intermediaries, etc. using GARCH model. Since the current proposed research depicts the rate and transmission of volatility and returns according to these industries and offers the researchers the ability to predict the effectiveness time interruptions.
- It is suggested that to compare the present research with other validation models by the aim of matching the results in order to measure the effectiveness of these models.

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