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Examining the Relationship between Oil Price Fluctuations and Volatility of Stocks in Different Industries (Case Study: Study of Companies Listed on Tehran Stock Exchange Using ARCH and GARCH Models)

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ABSTRACT

The aim of this study is to examine and identify the effect of oil prices on the rate of return of Tehran Stock Exchange. We analyzed five companies from each group in the theory making 20 companies from March 21, 2011 to March 19, 2016. Research method is descriptive-analytic. We collected data and using appropriate econometric time-series techniques estimated and simulated the models of research. Finally, using statistical analysis, we reviewed the hypotheses. The results showed that ARCH is a proper model to model the behavior of industrial price index at Tehran Stock Exchange, and the prices of oil are on their own, and its coefficients are statistically significant at 5% level. The correlation between the indices of groups of machinery and equipment-vehicles, parts, and chemical and pharmaceutical products with the price of oil is, respectively, 0.53, 0.57, 0.72, and 0.56.

Keywords: *Arch model, volatility of stock indices, oil price fluctuations*

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INTRODUCTION

The importance of studying the effect of the shocks of oil prices on Iran economy, as the second largest producer in Organization of Petroleum Exporting Countries (OPEC, 2009), is due to great volume of income from exports and the dependence of annual budget of the state on oil export. Thus, the shock of the global oil markets can have a huge impact on the entire economic structure of Iran (Shakibayi et al., 2008).

The requirement for a stride towards sustainable economic development is to obtain the necessary resources for a set of economic activities by equipping savings resources in the national economy. Investment decisions are made based on Tobin criteria in stock markets, so that the fluctuations in this market have a great role in resource allocation and income distribution (ShakeriAbbasi, macroeconomics, Volume 2). Thus, financial markets, and specifically stock exchange, have profound effects on the development and growth of developed and developing countries (Shahabi and Hosseini, 2008).

Stock exchange is an official market of buying and selling shares of companies based on specific criteria and rules. Many factors are involved in formation of information and the views of the parties of the market and company's stock prices. Some of these factors are internal and some parts are due to the condition of variables outside the scope of the domestic economy. Meanwhile, as an exogenous and powerful variable, world oil prices affect many macroeconomic variables, such as stock prices.

Therefore, by investigating the relationship between fluctuations in oil prices and stock indices of various industries on the stock exchange- as an institution of the capital market of the country and some macroeconomic variables- this study tries to assess the status of the capital markets of the country. Moreover, the study wants to show the share of oil price fluctuations in changes of stock indices and stock returns (Shahverdiani, 2015; 11).

Review of literature

The effect of oil price fluctuations on stock price

In their study, Abrishami et al. (2013) have examined the asymmetric effects of oil price fluctuations of OECD countries exporting net oil on economic growth. The results of this study indicate that the shock of falling oil prices has no significant effect on production, but positive oil price shock significantly affects production. Another finding of this study is that oil and monetary shocks are the main source of instability of production growth.

- Decline in oil prices makes firms' investment plans subject to uncertainty, and since the profitability of the firms is affected by oil income, stock prices can reduce (Eslamloueyan and Zare, 2006).

- Although rise in oil prices increases GDP (including oil revenues) for oil-exporting countries, it must be borne in mind that the end consumers of oil products and derivatives are mainly developing countries.

As usually oil-exporting countries are importers of oil products and derivatives due to their inability and lacking the necessary technology for processing crude oil, rising oil prices increases the cost of products manufactured by the industrial countries, which leads to an increase in the monetary value of imports of developing countries, including Iran. Thus, we expect that the relationship between the increase in oil revenue and the increase in stock market indices to be negative (Sajjadi et al., 2013).

- Iran's dependence on oil revenues due to increase in global oil price is very high, and increase in oil revenues is associated with increase in GDP, which is due to increase in all components of GDP. Moreover, the increase in oil prices will increase total employment, boom, and level of activity, profitability, and consequently stock returns. In other words, in this case, changes in oil prices has a positive effect on return on stock (Sajjadi et al., 2010).

According to the model by William Sharpe, factors affecting index of stock price can be classified in two types:

1) Internal factors

These items include those factors that are associated with the operations of the company and decisions made in the company (Sadorsky, Hog, and Basher, 2011)

2) External factors (macro)

These include the effective factors outside the authority of the management of the company and affect the company's activities.

These factors can be studied in terms of economic and political factors. Economic factors can be studied in two groups of real and monetary variables.

Capital market theory searches the equilibrium relationship between expected return and risk of efficient portfolios. Arbitrage pricing theory is normally considered as a superior alternative to other asset pricing models. The fundamental assumption of this model is the possibility of identifying variables and designing a multivariate model to determine stock returns, so that the identified variables and designing multivariate model to determine stock returns are linked.

Arbitrage does not identify the type of economic variables; however, it brings about the possibility to identify more than one factor to explain the systematic risk. In arbitrage theory, the investors get an opportunity to increase their portfolio return (without its risk). In this model, we assume that investors prefer more wealth, are risk-averse, have similar expectations, and operate in the market with total capital. The main effort in this study is to investigate the relationship between oil price fluctuations and stock index. Since stock index could be considered as discounted future cash flow, it is clear that each economic variable that affects expected cash flows or the discount rate will also affect the stock price. It is believed that stock prices are determined by some macroeconomic variables such as interest rates, currency, and inflation. Many studies have examined the effect of macroeconomic variables on the price, index, and their returns in various countries that will be described in detail. The claim that economic variables such as inflation, liquidity, exchange rates, and so on affect and drive stock price changes has been accepted as a theory. However, in the past decade, attempts have been made to assess the impact of economic forces theoretically and its effects of experimentally evaluation. Dynamic relationship between macroeconomic variables and stock returns has widely been studied. The mentioned studies are based on the theory that stock prices reflect the present value of future cash flows of that stock (present value model). For this reason, it needs both future cash flows and the expected rate of return (discount rate). Therefore, economic factors affect future cash flows and the rate of expected returns. Therefore, they could affect stock prices (Sadorsky, Hog and Bashir, 2011)

In a study entitled “Examining the effect of oil price fluctuations on the stock price in Iran” along a brief review of empirical research, RahimpourEsfanjan (2010) examined the relationship between rising oil prices and the growth of stock price index at Tehran Stock Exchange during the period from October 1997 to September 2009. His examination was on a monthly basis and by using a structural vector auto regression (SVAR) model. Analysis of dynamic interaction takes place by means of Impulse Response Functions and structure analysis.

Using Impulse Response Function, one can show the Dynamic Response of each of the endogenous variables of the system over time against a standard deviation of disruption caused by other system variables. In the analysis of variance, the contribution of each of the shocks on different variables of the model in the error of variance, and error of prediction of a variable in the short and long term are marked. The results show that increase in oil price increases stock price index, increase of stocks price index, and the shock of the oil market is of the main variables explaining fluctuations in growth of stock price index.

Hypothesis

The main hypothesis

1. There is a significant relationship between volatility of oil prices and volatility of stock index of different industries in Tehran Stock Exchange.

Secondary research hypotheses:

1. There is a significant relationship between the volatility of oil prices and the volatility of stock index in the automotive and part construction.
2. There is a significant relationship between the volatility of oil prices and the volatility of stock index products in the chemical industry.
3. There is a significant relationship between the volatility of oil prices and the volatility of stock index in machinery and equipment industry.
4. There is a significant relationship between the volatility of oil prices and the volatility of the stock index in the pharmaceutical industry.

RESEARCH METHODOLOGY

In this study, we want to examine the effect of oil price changes on industry price index at Tehran Stock Exchange. Since the stock index is a weighted average of the stock prices of different industries, one can consider it as a symbol of industry price changes. Data of the study is daily data of the last five years from March 21, 2011 to March 19, 2016. Data volume is 1278.

For a closer look, we examine the behavior of some sub-indices of industry separately. These indices include indices for groups of machinery and equipment, vehicles and parts, chemical products, and pharmaceuticals.

The daily data of these four groups starts from March 21, 2011 and continues until March 19, 2016. The number of data in each group is 963. Given that fluctuations of oil prices and stock index depend on time, we used model ARCH to measure conditional second moment of crude oil prices and stock index.

Data analysis

1. **Model NARCH (1,1): nonlinear ARCH model**

Dependent variable: oil price

Independent variable: oil prices

Table 1: Non-linear ARCH and GARCH model

Variable	Coefficient	SD	P-value	The lower limit of the confidence interval 95%	The higher limit of the confidence interval 95%
Constant value	57.87	0.1	0.000	75.66	76.08
NARCH L1	0.93	0.15	0.000	0.64	1.23
GARCH L1			0.022		
Constant value GARCH	0.83	0.19	0.000	0.45	1.21

In this section, we use the nonlinear model ARCH and GARCH. According to table, ARCH model is a good illustrator but not GARCH model. Self-explanatory equation of oil is as follows:

$$\text{oil(t)}=57.87 + 0.93\text{oil(t-1)} + \varepsilon$$

2. **Model NARCH (1,1): nonlinear ARCH model**

Dependent variable: industry price index at Tehran Stock Exchange

Independent variable: industry price index at Tehran Stock Exchange

Table 2: nonlinear ARCH model for equation of behavior of industry price index

Variable	Coefficient	SD	P-value	The lower limit of the confidence interval 95%	The higher limit of the confidence interval 95%
NARCH L1	0.98	0.19	0.000	0.63	1.4
Constant value NARCH	2139	520	0.000	1119	3160

According to the table in nonlinear ARCH model, equation of index of industry price is as follows:

$$\text{St(t)}=2139 + 0.98\ \text{st(t-1)} + \varepsilon$$

The model models the behavior of price index based on the prior period. Significance of coefficients at 5% level show accuracy of the model.

3. **ARCH model for to other indices**

In this section, we examine the effect of oil price changes on some specified indices of sub-set of industry. These indices include indices for groups of machinery and equipment, vehicles and parts, chemical products, and pharmaceuticals. By applying models ARCH and GARCH on data of these groups, we found that similar to industry price index, GARCH model is not a suitable illustrator and coefficient estimated for it at all regressions is insignificant, so results of GARCH are not reported in this section.

First, we look at the data of indices of machinery and equipment, automotive parts and chemical products. Data of the study is daily data of the last five years from March 21, 2011 to March 19, 2016. The data in this group is 963.

Table 3: Data of indices of machinery and equipment, automotive parts and chemical products

Variable	Frequency	Mean	SD	Minimum	Maximum
Machinery	963	2491	336	1957	3217
Automotive	963	4789	2102	2583	9699
Chemical products	963	621	282	251	1274
Pharmaceuticals	963	4690	2150	2580	9545

The result of regression of data of any group on data of oil prices can be seen in the table below. As you can see, oil prices increases the price of index of the industry.

Table 4: Regression result of data of any on oil prices

Dependent variable	Independent variable	Coefficient of dependent variable (SD)	p-value of dependent variable	Constant value (SD)	p-value constant value	R^2
Machinery	Oil	7.27 (0.37)	0.000	1863 (33)	0.000	0.28
Automotive	Oil	8.3 (0.25)	0.000	-93 (23)	0.000	0.51
Chemical products	Oil	49 (2.2)	0.000	555 (202)	0.000	0.32
Pharmaceuticals	Oil	4.702 (0.24)	0.000	-91 -21	0.000	0.49

Now we examine the behavior of data of these three groups in the form of ARCH and GARCH models. Before applying ARCH and GARCH model on three groups, we have to ensure lack of unit root and thus stability of them. For this purpose, we apply augmented Dicky Fuller and Phillip Perron tests on them:

Table 5: Behavior of data of these three groups in the form of ARCH and GARCH models

Test	Variable		Statistic	Critical value 1%	Critical value 5%	Critical value 10%	MacKinnon p-value
ADF	Machinery	(t)Z	-6.1	-3.4	-2.8	2.5	0
ADF	Chemical products	(t)Z	3.1	-3.4	-2.8	2.5	0.02
ADF	Automotive and parts	(t)Z	3.3.	-3.4	-2.8	2.5	0.01
PP	Machinery	(t)Z	-4.1	-3.4	-2.8	2.5	0
PP	Machinery	(rho)Z	32	20	14	11	
PP	Chemical products	(Z)t	-2.7	-3.4	-2.8	2.5	0.06
PP	Chemical products	(Z)rho	16	20	14	11	
PP	Automotive and parts	(Z)t	3.3.	-3.4	-2.8	2.5	0.02
PP	Automotive and parts	(Z(rho	-18.8	-20.7	14	11	
PP	Pharmaceuticals	(Z(t	2.5	3.1	2.1	-2.2	0.05
PP	Pharmaceuticals	(Z(rho	16	18	12	10	

ADF: Augmented Dickey-Fuller test for unit root

PP: Phillips-Perron test for unit root

As can be seen, data are static, so ARCH model can be applied on them.

The results of applying ARCH model on data of index on machinery and equipment are as follows:

Table 6: Applying ARCH model on the data of index of machinery and equipment

Variable Machinery	Coefficient	SD	P-value	The lower limit of the confidence interval 95%	The higher limit of the confidence interval 95%
ARCH L1	0.92	0.35	0.005	0.3	1.69
ARCH constant value	395	79	0.000	240	550

As a result, the equation of explaining the behavior of machinery and equipment index is as follows:

$$X(t)= 395 + 0.92\, X(t-1) + \varepsilon$$

The results of applying ARCH model on chemical products group index data is as follows:

Table 7: Results of applying model (1) ARCH on chemical products group index data

Variable Chemical products	Coefficient	SD	P-value	The lower limit of the confidence interval 95%	The higher limit of the confidence interval 95%
ARCH L1	0.97	0.22	0.000	0.58	1.45
ARCH constant value	4.3	1.6	0.000	1.2	7.5

As a result, the equation of explaining the behavior automotive and manufacturing parts index is as follows:

$$X(t)= 4.3 + 0.97\, X(t-1) + \varepsilon$$

The results of applying ARCH model on automotive and manufacturing parts index data is as follows:

Table 8: Results of applying model ARCH on automotive and manufacturing parts group index data

Variable automotive	Coefficient	SD	P-value	The lower limit of the confidence interval 95%	The higher limit of the confidence interval 95%
ARCH L1	0.94	0.15	0.000	0.74	1.33
ARCH constant value	8.6	2.1	0.000	4.4	13

As a result, the equation of explaining the behavior of automotive and manufacturing parts index is as follows:

$$X(t)= 8.6 + 0.94\, X(t-1) + \varepsilon$$

CONCLUSION

Results based on industry price index at Tehran Stock Exchange and the price of oil

First, we examine the results of the relationship between industry price index at Tehran Stock Exchange and the price of oil. The important results of the study are as follows:

1. In simple regression, industry price index at Tehran Stock Exchange on oil prices index as the independent variable oil prices is significant at 5% level, and this means that the behavior of industry price index at Tehran Stock Exchange is easily predictable from the behavior of oil prices.

2. In ARCH model, where the behavior of industry price index at Tehran Stock Exchange is modeled on the price of oil as the independent variable, the coefficient of price of oil is significant at the level of 5%. Moreover, industry price index at Tehran Stock Exchange a day before has a significant effect on the price index at 5% today.

3. In GARCH model, variance of error of industry price index at Tehran Stock Exchange on the day before has a little but positive impact on prices today.

4. In general, ARCH model is suitable to model the behavior of industry price index at Tehran Stock Exchange and the price of oil is on its own, and its coefficients are statistically significant at the 5% level. The model shows that by increasing the price of oil, industry price index at Tehran Stock Exchange increased.

5. In ARCH model, at Tehran Stock Exchange, both industry price index and oil prices of the previous day have a significant correlation with the price.

6. In general, GARCH model is not suitable to model the behavior of industry price index at Tehran Stock Exchange, and the price of oil is not on its own and its coefficients are meaningless.

7. In nonlinear ARCH model, price of previous day significantly affects prices today and this effect is positive.

8. In nonlinear GARCH model, variance of the error of the previous day has no impact on prices today. Thus, nonlinear GARCH is not an appropriate model to explain the behavior of industry price index at Tehran Stock Exchange and oil prices.

Results based on machinery and equipment, automotive and parts, chemical products, and pharmaceuticals and oil price:

1. Degree of correlation between groups of machinery and equipment, automotive and parts, chemical products, and pharmaceuticals and oil price is, respectively, 0.53, 0.57, 0.72, and 0.56.

2. In simple regression, each of these indices is meaningful on oil prices coefficient at 5% level, so oil price is the main factor determining the price index of these groups. The value of R^2 of machinery and equipment, automotive and parts, chemical products, and pharmaceuticals and oil price is, respectively, 0.28, 0.32, 0.51, and 0.49.

3. ARCH model explain the behavior of index of these four groups well, and in all them, coefficient of price index is significant at 5% the day before.

4. Coefficient of ARCH model in all four groups is above 0.9 and in chemical products; this coefficient is more as it depends on oil more and directly.

5. GARCH model dos not explain the behavior of the indicators of the four groups well.

In general, and to put it in simple words, the results show that the rise in oil prices increases the industry price index at Tehran Stock Exchange as well as machinery and equipment, automotive and parts, and chemical products. The most important characteristic of oil price is being seasonal. With the advent of cold season in Europe and America, its price increases, so we can expect that in cold seasons, industry price index at Tehran Stock Exchange increases as well. However, it should be noted that oil prices are affected by the global economic situation, Iran's political relations with other countries, as well as the political situation in the Middle East. As with any conflict, whether political debate or series of wars that occur in the region, oil price increases, it can be expected that in the case of these events, industry price index at Tehran Stock Exchange also increase. However, this is only the effect of rising oil prices on the industry price index at Tehran Stock Exchange, and certainly there are other factors that affect stock prices in the industry, and their impact should not be ignored.

Suggestions

1. The first suggestion to macroeconomic policymakers is that by transparency of exchange and its mechanism pave the way for attracting wandering investment. In addition to strengthening exchange and thus production in the country, it creates jobs, which has always been one of the most important problems of our country. Moreover, it prevents the flow of terrible liquidity to the markets, such as currency and gold, which leads to disruption in production.

2. In order to clarify the behavior of stock variables, the results of research such as the current study should be given to investors in stock to invest optimally. This would reduce investment risk and increase the amount of investment.

3. The investors are suggested investing on industry set and its sub-groups, especially chemical products with increase in oil prices at the beginning of the cold season.

4. In case of political conflicts in the Middle East, investors should invest on exchange industry and its sub-groups, especially chemical products.

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