Mathematical Analysis of Impact of Oil, Gold and Currency on Tehran Stock Exchange

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Abstract:- *The use of economic factors has led to a lot of research on the behavior of stock markets. These economic factors can be evaluated simultaneously using statistical tools called joint. The present paper examines the impact of global oil, Currency (Dollar) and gold prices on the Tehran Stock Exchange, using conditional heteroscedastic Models. indeed, we used autoregressive conditional heteroscedastic (ARCH), the generalized ARCH (GARCH) to capture behavior of the volatility. Actual data of years obtained from the Iran Market is used to t the models.*

Key Words: TSE, Volatility models, Time series, Autoregressive conditional heteroscedastic, Generalized autoregressive conditional heteroscedastic

1. INTRODUCTION

Tehran Stock Exchange (TSE) opened in February 1967. During its first year of activity, only six companies were listed in TSE. Then Government bonds and certain State-baked certificate were traded in the market. The Tehran Stock Exchange has come a long way. Today TSE has evolved into an exciting and growing marketplace where individual and institutional investor trade securities of over 420 companies [1-3].

In this paper, we try to study the impact of the oil price (OPEC), gold price and currency (Dollar) on Tehran stock exchange index (TSE-index) [4-6]. Daily Data including Total 1349 observations form 3/24/2012 to 10/22/2017 is base of our study. Since, we prefer to work with nonstationary data it is a essential to concert data from price to return form. In fact, obtaining return will help us to capture better models than price [7-9].

One of the features of smart grid is the need to move away from the traditional form of balancing supply and demand to considering an active role for exile and controllable net-load energy resources like plug-in electric vehicles [10-13] omit the role of mean with converting data from price to return form, it can be seen these time series are stationary in mean and non-stationary in variance both through illustration (figure 1 and 2), as well as performing Dickey Fuller test. Based on correlation matrix, the response variable has the most positive correlation with Oil and the most negative correlation with Dollar. In fact, this observation perfectly matches to what is happening in the market as well [14-18].

To see the linear relation between the time series as response and independent variables Vector autoregressions (VARs)is used. The Akaike information criterion (AIC) and Schwarz criterion (SC) tell us that one lag is a good choice for the performing the VAR model [1, 19-21]. The following VAR model is obtained:

$$TRI_{Ret} = 0.3 * TRI_{Ret}(-1) + 0.027 * D_{Ret}(-1) + 0.004 * G_R(-1) + 0.002 * O_{Ret}(-1) + 0.01$$

As it can be found from VAR model Change of TR index in the previous work day has a significant impact on index. Besides, Dollar, oil and gold have their own small impact [22-25]. Looking at the behavior of Tehran index with carefully, (figure 3), it can be seen that the TR_Ret series has some serial correlations at lags 1 and 2, but the key feature is that the PACF of T RRet2 shows strong linear dependence for this square variable. One can find that a linear model is not a good choice to capture the complexity of the model. Therefore, Conditional Heteroscedastic Models could be a good choice to assess this impact [26]. In this project, we implement GARCH (1,1) to study the complexity of the model. performing GARCH (1,1) model for TSE index the following model can be found:

$$\text{Variance} = 0.00000231 + 0.251 \times Residual(-1)^2 + 0.735 \times \text{Variance(-1)}$$

Indeed, it seems Tehran Index is more vulnerable to earliest behavior of the Tehran exchange market than the market shocks or market news. The whole analysis is performed with R and reader can find the sample code of the paper in appendix.

2. Requirements

In econometrics, the model with autoregressive conditional heteroscedasticity is said to be a model that assumes that the variance of error terms or innovations is a function of the size of the error terms of earlier periods: usually variance is associated with the square of previous innovations. Such a model is usually called ARCH (Engle, 1982) [27-33], but abbreviations are also used for models on this basis. ARCH models are usually used for fnancial time series, which show time-dependent oscillation-oscillating oscillation periods. These are methods and econometric models available in the literature for modeling the volatility of an asset return. Volatility is an important factor in options trading [34-36]. Volatility means the conditional standard deviation of the underlying asset return. Indeed, this factor has many other financial applications, calculating value at risk, asset allocation under the mean-variance framework Can improve the efficiency in parameter estimation and the accuracy in interval forecast The volatility index of a market has recently become a financial instrument The univariate volatility models include the autoregressive conditional heteroscedastic (ARCH) , the generalized ARCH (GARCH) , the exponential GARCH (EGARCH) , the threshold GARCH

(TGARCH) , the conditional heteroscedastic autoregressive moving-average (CHARMA) [37-41].

3. Volatility Model

Serially uncorrelated but green dependent Consider the conditional mean and variance of r_t given F_t; that is,

$$\mu_t = E(r_t|F_{t-1}), \qquad \sigma_t{}^2 = Var(r_t|F_{t-1}) = E[(r_t-\mu_t)^2|F_{t-1}]$$

Where F_t denotes the information set available at time t − 1 Serial dependence of rt is weak if it exists at all. Therefore, the equation for μt should be simple (ARMA) We entertain the model:

$$r_t = \mu_t + a_t, \qquad \mu_t = \sum_{i=1}^{p}\varphi_i y_{t-i} - \sum_{i=1}^{p}\theta_i a_{t-i}, \quad y_t = r_t - \varphi_0 - \sum_{i=1}^{k}\beta_i x_{it} \tag{2}$$

Combining Equations 1 and 2 , we have:

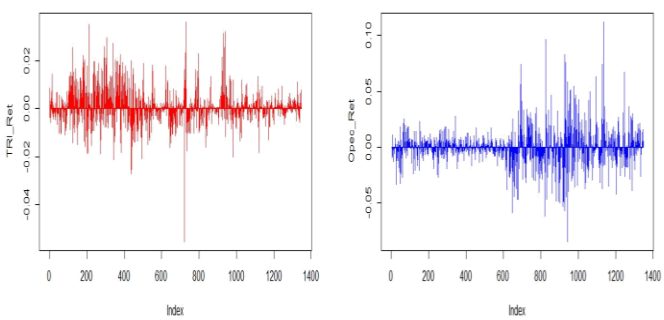
$$\sigma_t{}^2 = Var(r_t|F_{t-1}) = Var[a_t|F_{t-1}] \tag{3}$$

The conditional heteroscedastic models are concerned with the evolution of σ_t^2The manner under which f σ_t^2 evolves over time distinguishes one volatility model from another [42].

4. The GARCH Model

let $a_t = r_t - \mu_t$be the innovation at time t. at follows a GARCH (m,s) model if :

$$a_t = \sigma_t\varepsilon_t, \qquad \sigma_t{}^2 = \sum_{i=1}^{m}\alpha_i a_{t-i}{}^2 + \sum_{i=1}^{s}\beta_i\sigma_{t-j}{}^2 \tag{4}$$



(a) TRI-Return (b) Oil Return

Figure 1: Scatter Plot

where again ε_t is a sequence of iid random variables $\mu = 0$ and $\sigma = 1$ Specifying the order of a GARCH model is not easy. In fact, only lower order GARCH models, such as GARCH(1,1), GARCH(2,1), and GARCH(1,2) is used to capture the behaviour of volatility. GARCH (1,1) is as following GARCH(1,1):

$$\sigma_t{}^2 = \alpha_0 + \alpha_1 a_{t-1}{}^2 + \beta_1\sigma_{t-1}{}^2 \tag{5}$$

a large a_{t-1}^2 or σ_{t-1}^2 gives rise to a large σ_t^2.

5. The Analysis

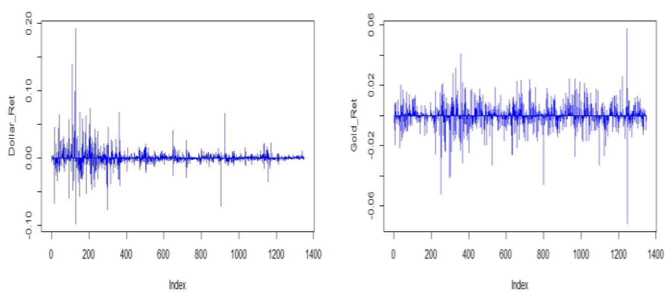
In this report we try to assess the impact of the oil price(opec), gold price and currency (Dollar) on Tehran stock exchange index (TSE-index). Data is a four time series form Daily data form 3/24/2012 to 10/22/2017 and including Total 1349 observations. In the beginning it is a good idea to mention that in order to analysis data it is a essential to concert data from price to return form. in the following one can find the summary of time series:

TRI_Ret	Dollar_Ret	Gold_Ret	Opec_Ret
Min. :-0.0551251	Min. :-9.713e-02	Min. :-7.162e-02	Min. :-0.0847158
1st Qu.:-0.0022710	1st Qu.:-2.860e-03	1st Qu.:-3.326e-03	1st Qu.:-0.0062034
Median : 0.0002983	Median : 5.281e-05	Median :-5.116e-05	Median :-0.0004486
Mean : 0.0009096	Mean : 6.517e-04	Mean :-1.880e-04	Mean :-0.0004562
3rd Qu.: 0.0033951	3rd Qu.: 3.146e-03	3rd Qu.: 3.169e-03	3rd Qu.: 0.0049563
Max. : 0.0358957	Max. : 1.919e-01	Max. : 5.746e-02	Max. : 0.1121495

The illustration of these data set through time can be seen in the following figures (1 and 2)

As it can be seen these time series are stationary in mean and non-stationary in variance. Performing the return policy for the time series, it is logically true as well. in deed we omit the role of mean with converting data from price to return form. for further investigation, one can use Dickey Fuller test for testing stationary properties of time series. Since we are trying to see the impact of covariate on response variable, taking look at correlation matrix could be the fist step.

	TRI_Ret	Dollar_Ret	Gold_Ret	Opec_Ret
TRI_Ret	1.00000000	-0.03956711	0.024655683	0.024222618
Dollar_Ret	-0.03956711	1.00000000	0.026914261	0.030330199
Gold_Ret	0.02465568	0.02691426	1.000000000	0.008735216
Opec_Ret	0.02422262	0.03033020	0.008735216	1.000000000



(a) Dollar Return (b) Gold Return

Figure 2: Scatter Plot

As it can be seen, the response variable has the most positive correlation with Oil and the most negative correlation with Dollar. In fact, this observation fairly has a meaningful interpretation in market as well. To see the linear relation between the time series as response and independent variables Vector autoregressions (VARs)is used. Vector autoregressions (VARs) were introduced into empirical economics by C.Sims (1980) [43-46], who demonstrated that VARs provide a flexible and tractable framework for analyzing economic time series [47-52]. Identification issue: since these models do not dichotomize variables into endogenous and exogenous, the exclusion restrictions used to identify traditional simultaneous equations models make little sense. A Vector Autoregression model (VAR) of order p is written as:

$$\begin{aligned} & y_t = c + \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + \varepsilon_t \\ & y_t : (N \times 1), \Phi_i = (N \times N) \forall i, \varepsilon_t : (N \times 1) \\ & E(\varepsilon_t) = 0, E(\varepsilon_t \varepsilon_\tau) = \begin{cases} \Omega & t = \tau \\ 0 & t \neq \tau \end{cases} \end{aligned} \quad (6)$$

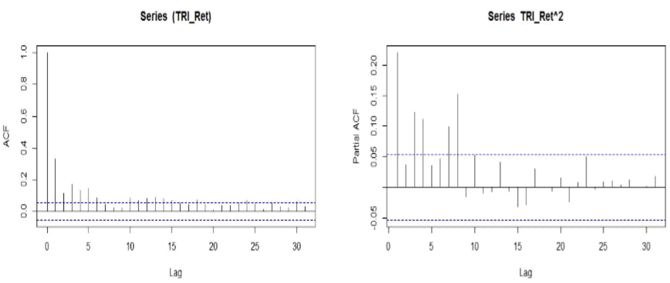
Where Ω positive definite matrix. Performing AIC and SC test, one can find the perfect lag for modeling VAR modes:

```
$selection
AIC(n)  HQ(n)  SC(n) FPE(n)
     5      1      1      5

$criteria
                  1             2             3             4             5             6
AIC(n) -3.655902e+01 -3.657896e+01 -3.657938e+01 -3.657941e+01 -3.658464e+01 -3.657106e+01
HQ(n)  -3.652990e+01 -3.652655e+01 -3.650367e+01 -3.648041e+01 -3.646235e+01 -3.642548e+01
SC(n)  -3.648130e+01 -3.643908e+01 -3.637732e+01 -3.631519e+01 -3.625825e+01 -3.618250e+01
FPE(n)  1.326237e-16  1.300046e-16  1.299512e-16  1.299474e-16  1.292700e-16  1.310386e-16
                  7             8             9            10
AIC(n) -3.655870e+01 -3.654508e+01 -3.653315e+01 -3.652007e+01
HQ(n)  -3.638982e+01 -3.635291e+01 -3.631769e+01 -3.628132e+01
SC(n)  -3.610797e+01 -3.603218e+01 -3.595808e+01 -3.588283e+01
FPE(n)  1.326695e-16  1.344902e-16  1.361066e-16  1.379015e-16
```

using these two criteria, one can find the perfect lag with corresponding minimum negative number, that is, the best lag is one lag. Performing VAR mode, one can find the following model with detail:

```
TRI_Ret = TRI_Ret.l1 + Dollar_Ret.l1 + Gold_Ret.l1 + Opec_Ret.l1 + const + trend
```



(a)Length (b)Wide

Figure 3: Uncorrelated but dependent data

```
               Estimate Std. Error t value Pr(>|t|)
TRI_Ret.l1     3.273e-01  2.578e-02  12.698  < 2e-16 ***
Dollar_Ret.l1  2.755e-02  1.293e-02   2.131 0.033246 *
Gold_Ret.l1    4.198e-03  2.252e-02   0.186 0.852169
Opec_Ret.l1    2.014e-02  1.218e-02   1.654 0.098288 .
const          1.312e-03  3.735e-04   3.512 0.000459 ***
trend         -1.057e-06  4.758e-07  -2.222 0.026456 *
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 0.006747 on 1341 degrees of freedom
Multiple R-Squared: 0.1181,Adjusted R-squared: 0.1148
F-statistic: 35.93 on 5 and 1341 DF,  p-value: < 2.2e-16
```

So, the VAR model for these time series is as follow:

$$TRI\_Ret = .3 * TRI\_Ret(-1) + 0.027 * D_R(-1) + .004 * G_R(-1) + .002 * O_R(-1) + 0.01$$

As it can be found from VAR model Change of TR index in the previous work day has a significant impact on index. Besides, Dollar, oil and gold have their own small impact.

Now, if we look at the behavior of Tehran index with carefully, (figure 3), it can be seen that the TR_{Ret}series has some serial correlations at lags 1 and 2, but the key feature is that the PACF of TR_{Ret} shows strong linear dependence Indeed, we can nd that a linear model is not a good choice to capture the complexity of the model. Therefore, Conditional Heteroscedastic Models could be a good choice to assess this impact. The conditional heteroscedastic models are concerned with the evolution of σ_t^2. The manner under which σ_t^2 evolves over time distinguishes one volatility model from another.

The univariate volatility models include the autoregressive conditional heteroscedastic (ARCH) , the generalized ARCH (GARCH) , the exponential GARCH (EGARCH) , the threshold GARCH (TGARCH) , the conditional heteroscedastic autoregressive moving-average (CHARMA). Now, our next step is using GARCH model for capture the impact of residuals.

Let $a_t = r_t - \mu_t$ be the innovation at time t. a_t follows a GARCH(m,s) model if:

$$a_t = \sigma_t \varepsilon_t, \qquad {\sigma_t}^2 = \sum_{i=1}^{m} \alpha_i {a_{t-i}}^2 + \sum_{i=1}^{s} \beta_i {\sigma_{t-j}}^2$$

where again t is a sequence of iid random variables(= 0 and = 1 It is worth noticing that specifying the order of a GARCH model is not easy and only lower order GARCH models, say, GARCH(1,1), GARCH(2,1), and GARCH(1,2) is used for academic and research purposes. here we use GARCH(1,1) model:

$$\sigma_t{}^2 = \alpha_0 + \alpha_1 a_{t-1}{}^2 + \beta_1 \sigma_{t-1}{}^2$$

performing GARCH(1,1) model for TSE index the following model can be found:

$$\sigma_t{}^2 = 0.00000231 + 0.251 a_{t-1}{}^2 + .735 \sigma_{t-1}{}^2$$

Or

$$\text{Variance} = 0.00000231 + 0.251 \times Residual(-1)^2 + 0.735 \times \text{Variance}(-1)$$

```
Error Analysis:
        Estimate  Std. Error  t value Pr(>|t|)
omega   2.312e-06   4.473e-07    5.169 2.35e-07 ***
alpha1  2.510e-01   3.874e-02    6.479 9.21e-11 ***
beta1   7.355e-01   3.178e-02   23.141  < 2e-16 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

one can interpreted that Tehran Index is more vulnerable to earliest behavior of the Tehran exchange market than the market shocks or market news.

6. Conclusion

In this paper, we study the behavior of the index of Tehran Stock Exchange based on three parameters of global oil, Currency (Dollar) and gold prices. Indeed, we investigate these connections based on the return form of our data. Using Vector autoregressions (VARs), we realized that the one lag is the perfect to demonstrate the correlation of the data where we specially observe that the behavior of market in one day before has more impact on index rather than other factors. So, we went through the Conditional Heteroscedastic Models to capture the complexity of this dependency. At the end, we used state of art models such as ARCH and GARCH to see the behavior of the residuals. From our finding of fitting models, we realize that Tehran Index is more vulnerable to earliest behavior of the Tehran exchange market than the market shocks or market news.

Appendix

```
cat('\014')
attach(Daily90)
hist(TRI)
TRI_Ret = diff(TRI)/TRI[-length(TRI)]
Dollar_Ret = diff(Dollar)/Dollar[-length(Dollar)]
Gold_Ret = diff(Gold)/Gold[-length(Gold)]
Opec_Ret = diff(Opec)/Opec[-length(Opec)]
hist(TRI_Ret)
hist(Dollar_Ret)
hist(Gold_Ret)
hist(Opec_Ret)
shapiro.test(TRI_Ret)
shapiro.test(Dollar_Ret)
shapiro.test(Gold_Ret)
shapiro.test(Opec_Ret)
plot(TRI_Ret)
plot(Dollar_Ret)
plot(Gold_Ret)
plot(Opec_Ret)
Return_matrix = cbind(TRI_Ret,Dollar_Ret,Gold_Ret,Opec_Ret)
cor(Return_matrix)
install.packages("vars") #If not already installed
install.packages("astsa") #If not already installed
library(vars)
library(astsa)

plot.ts(Return_matrix , main = "", xlab = "")
fitvar1=VAR(Return_matrix, p=1, type="both")
summary(fitvar1)
acf(TRI_Ret)
pacf(TRI_Ret)


acf(TRI_Ret^2)
pacf(TRI_Ret^2)
##################################################
install.packages("fGarch") #If not already installed
library(fGarch)
y = TRI_Ret - mean(TRI_Ret) # T _ VAR(T,P=1)?????????????
x.g = garchFit(~garch(1,1), y, include.mean=F)
summary(x.g)
```

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