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Proposed Framework for Predicting Stock Return Volatility Using Neural Network: An Applied Study on the Egyptian Stock Exchange

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Abstract

Purpose: the primary purpose of the study is to determine the effect of both internal and external factors on stock returns volatility using different statistical methods, applied on Egyptian stock exchange.

Methodology: the researchers have compared the accuracy of (GLS Model, GARCH Model, and Neural Network) in predicting the stock return volatility to choose the most accurate one. Data was collected from the Egyptian Stock Exchange (EGYX 30) for the period (2014 to 2017) on a monthly basis.

Findings: The results of the study revealed that the Neural Network Model has proven to outperform the traditional models in the prediction of stock return volatility.

Originality: the study contributes to literature as it used Artificial Neural Network in two functions (Prediction of stock return volatility) and (Classification of the volatility to –high volatility and Low volatility)**.** Also few studies concerned with stock return volatility in developing countries, especially Egypt.

Keywords: Stock return volatility, Artificial neural network, GARCH model, GLS model, Egyptian stock exchange

1. Introduction

Increased globalization of the financial market has made stock return volatility a vital research topic and challenge for both: practitioners, researchers, and policymakers. The most recent liberalization of economic policies and exchange rate regimes in many developing countries including Egypt have caused a realignment of competitive structures of many emerging stock markets and their relative attractiveness to both local and global markets alike. This task will be achieved through the comparison between the degree of accuracy of the proposed Artificial Neural Network Model (ANN) against the accuracy of the alternative model - GARCH model which has dominated the research area for many years (Monfared and Enke, 2015). Moreover, the results of this study will provide a set of recommendations that are expected to be helpful to both individual and institutional investors in the Egyptian Stock Market in rationalizing their investment decisions on one hand and to the Egyptian policymakers in their efforts to improve market surveillance and efficiency on the other side.

(Qiu and Song 2016) have indicated that it has always been a difficult task to predict the exact daily return of the stock market index; hence, there is a great deal of research being conducted regarding the prediction of the direction of stock return index movement. Many factors such as political events, general economic conditions, and traders, expectations may influence the stock market index.

There are several definitions of stock return volatility. According to one of the leading definitions in this area, volatility is defined as a statistical measurement of the changes in returns or market index (Monfared and Enke, 2015) Volatility can be measured using either the standard deviation or variance between returns from the market index. Typically, a higher degree of volatility is considered more dangerous for stability in the field of finance. Other scholars in the area define volatility is the degree of variation in a series of trading return over a specified period (Chaudhuri and Indranil, 2016). Volatility is commonly measured by the standard deviation of returns where the symbol "σ" is used as the measure of volatility which should not be confused with the variance of the same name, which instead σ2.

2. Literature Review

The study focused on the factors that affect the stock return volatility either company specific or macroeconomic variables, and many researchers have examined these factors in many points of view. According to the literature review, numerous studies have attempted to

explain the effect of company-specific factors on stock return volatility. Research conducted by Hartono (2005) examines the impact of a sequence of positive and negative dividend and earning information on stock returns. Results show that the positive recent gaining information has significant relation with stock returns when it follows negative dividend information, and the negative current earning information has a significant relationship with stock returns when it follows positive dividend information.

Several studies thus far have linked Company-specific factors with stock return volatility, Hashemijoo et al. (2012) study has shown a significant negative relationship between share return volatility with two primary measurements of dividend policy which are dividend yield and dividend payout. Moreover, a significant negative correlation between share return volatility and size is found. Sewelen, J (2018) studied the effect of Payout ratio; Earnings volatility, Size, and Leverage on the volatility of the stock return. Results showed that All variables but Earnings Volatility were statistically significant.

Many authors have reported a significant effect of macroeconomic variables on stock return volatility. Kasman et al. (2011) conducted a study on the effects of interest rate and foreign exchange rate changes on Turkish banks' stock market returns using the GARCH model. The sample consists of thirteen Turkish commercial bank stocks listed on the Istanbul Stock Exchange. They used daily closing individual Bank stock returns, the closing return of the bank index, exchange rates, and interest rates. The period begins on 27 July 1999 and ends on 9 April 2009. The results have indicated that there's a negative and significant effect of interest rate and exchange rate changes on the conditional bank stock return.

Ayopo, et al. (2016), have also studied the effect of macroeconomic factors on stock return volatility in Nigeria. Result shows that Exchange rate is the most important factor affecting stock return volatility .Also, Vikalp et al. (2018) conducted a detailed analysis of the different relations between the prediction and individual stock returns of financial sector companies in National Stock Exchange and a set of macroeconomic variables as independent variables. The result has shown that macroeconomic variables and physical factors will affect the share returns of the different stock returns because of the strong relationship between the macroeconomic variables and different stock values it plays a vital role.

Erdem et al. (2005) also have studied the effect of macroeconomic variables on the Turkish stock exchange returns. The list of the independent variables used in the study included: exchange rate, interest rate, inflation, industrial production, and money supply. A GARCH model was used in the study to test the effect of macroeconomic variables on stock returns volatility. Results reveal the strong unidirectional impact of inflation, the interest rate on all stock return indexes. There is a strong effect of money supply on the financial index, and from exchange rate to both IMKB 100 and industrial indexes. There is no effect of industrial production on any index. Nguyen and walther (2017) have investigated the effect of long term economic and financial variables on stock return volatility and results have revealed that general economic activities, changes in customer preferences, economic policy and industrial production are the most common factors affecting stock return volatility.

On the other hand, many studies also have examined the use of ANN in the prediction of

stock return volatility,

Chaudhuri and Ghosh (2016) conducted a comprehensive survey of the use of Neural Network Models in the prediction of stock return volatility in the Indian stock market. In this study, the researchers used a back propagation algorithms type of neural network to predict the stock market volatility more accurate. The study model was based on the Indian VIX, CBOE VIX indices, and the volatility of crude oil returns (CRUDESDR), volatility of DJIA returns (DJIASDR), volatility of DAX returns (DAXSDR), volatility of Hang Seng Index returns (HANGSDR)and volatility of Nikkei returns (NIKKEISDR) as predictor variables. The study shows that only one hidden layer was used while the number of hidden neurons has been varied at three levels (20, 30 & 50 respectively). Hence the total number of trials was fifty-four (2*9*3). The time frame for this study has tested three different periods. The framework of study could satisfactorily forecast volatility for 2015 using training data for 2013-15.

Arneric, J. et al. (2014) also made a comparative study between ANN and GARCH model in the accuracy of prediction using both models, results indicated that the ANN model has superior performances compared to the standard GARCH model.

Agrawal and Murarka (2015) study examined the Stock Return Trend Prediction using Artificial Neural Network and Derived Parameters. The researchers indicated that the use of neural networks in the field of finance has significantly increased over the last two decades. Furthermore, different types of Neural Network Models have been used in predicting stock returns and return fluctuations. On the other hand, Johnson, (2018) has also studied the prediction of stock return index using artificial neural network but results show that there's no evidence that ANN accuracy outperform traditional models (GARCH, E-GARCH, T-GARCH). The success of those models has the potential to bring numerous rewards – both academic and financial analysts. There are multiple reasons why neural networks offer an advantage in the quest to predict stock return fluctuations. There is only one widely accepted theory on stock returns and markets, called the Efficient Markets Hypothesis (EMH), which ultimately concludes that such return changes may never be predicted (Ilaboya & Aggreh, 2013).

3. Methodology

3.1 The Data Sample

The largest, most actively trading companies representing the most famous Egyptian Stock Exchange indices – EGEX 30 – were included in the final sample of this study. The combined market value of these companies is more than 50% of the total Value of all listed companies.

3.2 The Data Collection

1. The entire data set related to the internal variables used in the study was obtained from the Department of Economic Research of the Egyptian Stock Exchange. The Quarterly and Annual Financial reports for all listed companies - for the 2014-2017 periods - were extracted from the data set. Those companies include: the 30companies of the Egyptian Stock Exchange Index (EGEX 30) in addition to 10 other actively traded companies. After a

detailed examination of the data set, the Quarterly and Annual Financial reports for forty companies were selected for inclusion in the study sample. The final selection was made from data availability and consistency for the whole study period.

2. The values of the Company - Specific Variables (Log T.A, EPS, Price to Book Value and the average monthly Return used in the study were calculated.

3. Nine companies were excluded from the final sample due to the presence of some irregularities in the financial reports of those companies and the incompleteness of required data.

4. Data for the Macro Variables (Exchange rate, interest rate, Inflation Rate, and GDP) were gathered from the monthly Economic Bulletins published by the Egyptian Central Bank over the study period.

5. Data were reviewed and compiled using Excel Sheets in which the study data set was arranged as Columns Containing: Company name along with computed values of the study variables. Only two variables- Total assets and Gross National Product were transformed to the Log form due to their unique nature - values made of several digits – to make them consistent with the values of other variables used in the study.

6. As a regular practice in this type of studies, the data were preprocessed where extreme (outliers) were eliminated.

3.3 The Framework for Data Analysis

As this study involves the use of three different Models: GLS (Generalized Least Squares) model, GARCH (Generalized Auto Regressive Conditional Heteroscedasticity model and ANN (Artificial Neural Network) model, the standard descriptive analysis is used to describe the main characteristics of data used - including mean, median, range, variance, and standard deviations. Besides Correlation Matrices measuring the relationships among the study, variables were also computed.

3.4 The Study Time - Frames

Two-time frames were used in the study: Yearly Analysis and Full Period Analysis. Since the study period (2014-2017) has witnessed various types of economic and political changes including the implementation of the economic recovery program, the liberalization of the exchange rate regime and the unprecedented increase in interest rates in 2016, the First type of analysis (Yearly Analysis) was designed to gain more insights into the phenomenon under investigation- Stock Return Volatility on a year -by- year basis before conducting the Full Period Analysis.

3.5 Statistical Analysis Techniques and Tests

In this research, three techniques were used to determine the effect of (size of the company which represented in total assets, EPS and market to book value, Interest rate, Exchange rate, Inflation Rate, and GDP) on stock return volatility:

1) GLS using E-views 10

2) GARCH using E-views 10

3) Logit Regression Model using SPSS Version 22

4) ANN using Mat lab statistical program.

Statistical Analysis Tests:

1) Normality test: Fixed vs. Random

2) Different correlation coefficients (Spearman test)

3) Dickey-Fuller Test to test the stationary or non-stationary of data.

4) Root Square Error.

5) Mean Square Error

3.6 The Study Hypotheses

1. "There's a statistical significant relationship between the stock return volatility (as dependent variable) and both internal and external variables (as independent variables) using 3 statistical models:

a) GLS Model

b) GARCH Model

c) Artificial Neural Network

2. "ANN can achieve better predictive accuracy than the LOGIT Method in the classification of the stocks traded in the Egyptian Exchange into "High Volatility and Low Volatility".

3. "There is no significant difference between the predictive accuracy of Neural Network Model and the competing statistical models – GLS and GARCH models"

4. Empirical Results and Testing Hypothesis

Hypothesis One: There's a statistical significant relationship between the stock return volatility (as dependent variable) and both internal and external variables (as independent variables) using 3 statistical models:

A) GLS Model

B) GARCH Model

C) Artificial Neural Network

Table 1. GLS regression between the internal and the external factors

			log-TA EPS	P-BV	Mean	Int-rate	Exche Rate	Inf rate	log-GDP	STD
Spearman's rho	log-TA	Correlation Coefficient	1.000							

		log-TA	EPS	P-BV	Mean	Int-rate	Exche Rate	Inf rate	log-GDP	STD
	Sig. (2-tailed)	.								
	N	1390								
EPS	Correlation Coefficient	.247**	1.000							
	Sig. (2-tailed)	.000	.							
	N	1390	1390							
P-BV	Correlation Coefficient	-.105**	.045	1.000						
	Sig. (2-tailed)	.000	.092	.						
	N	1390	1390	1390						
Mean	Correlation Coefficient	.034	.049	.104**	1.000					
	Sig. (2-tailed)	.209	.067	.000	.					
	N	1390	1390	1390	1390					
Int-rate	Correlation Coefficient	-.002	-.042	-.173**	-.012	1.000				
	Sig. (2-tailed)	.953	.121	.000	.660	.				
	N	1390	1390	1390	1390	1390				
Exchange Rate	Correlation Coefficient	-.037	-.088**	-.117**	-.044	.738**	1.000			
	Sig. (2-tailed)	.167	.001	.000	.098	.000	.			
	N	1390	1390	1390	1390	1390	1390			
Inflation rate	Correlation Coefficient	-.003	-.070**	-.066*	-.101**	.238**	.363**	1.000		
	Sig. (2-tailed)	.899	.009	.013	.000	.000	.000	.		
	N	1390	1390	1390	1390	1390	1390	1390		

			log-TA	EPS	P-BV	Mean	Int-rate	Exche Rate	Inf rate	log-GDP	STD
	log-GDP	Correlation Coefficient	-.011	.034	-.021	-.009	-.011	-.008	.003	1.000	
		Sig. (2-tailed)	.681	.205	.428	.750	.669	.765	.911	.	
		N	1390	1390	1390	1390	1390	1390	1390	1390	
	STD	Correlation Coefficient	-.195**	-.067*	.057*	.084**	.086**	.118**	.171**	.041	1.000
		Sig. (2-tailed)	.000	.012	.034	.002	.001	.000	.000	.127	.
		N	1390	1390	1390	1390	1390	1390	1390	1390	1390

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Results have shown that the relationship between P-BV, Mean Stock Return, Int. -Rate, Exchange Rate, Inflation Rate, and Standard Deviation is significant with a positive sign as the corresponding P-values are less than 0.05 and correlation coefficients are 0.057, 0.084, 0.086, 0.118 and 0.171 respectively. The reported results also show that there is a significant negative relation between Log-TA, EPS and Standard Deviation with corresponding P-values less than 0.05 and correlation coefficients of -0.195 and -0.067. Log of GDP is insignificant.

There's a statistically significant relationship between the selected set of independent variables both internal (size of the company - represented by total assets, EPS and market to book value) and external (Interest rate. Exchange rate, Inflation Rate, GDP and stock return volatility using GARCH Model as shown in Table 2.

Table 2. The GARCH model for the internal and the external factors

Dependent Variable: STD				
Method: ML - GARCH (Marquardt) - Normal distribution				
Sample: 1 1390				
Included observations: 1390				
Convergence achieved after 468 iterations				
Presample variance: backcast (parameter = 0.7)				
GARCH = C(11) + C(12)*RESID(-1)^2 + C(13)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
EPS	0.000140	0.000197	0.714601	0.4749

EXCHANGE_RATE	1.09E-05	0.000123	0.088767	0.9293
INFLATION_RATE	0.001170	0.000251	4.655937	0.0000
INT_RATE	0.112219	0.034410	3.261235	0.0011
LOG_GDP	0.008515	0.002851	2.986832	0.0028
LOG_TA	-0.001251	0.000306	-4.082456	0.0000
MEAN	0.024512	0.032034	0.765168	0.4442
P_BV	0.002680	0.000198	13.52461	0.0000
PRICE	0.000126	4.63E-05	2.722805	0.0065
C	-0.005691	0.008553	-0.665456	0.5058
	Variance Equation			
C	5.22E-05	2.81E-06	18.56515	0.0000
RESID(-1)^2	0.645145	0.077737	8.299047	0.0000
GARCH(-1)	0.110321	0.030889	3.571484	0.0004
R-squared	-1.336088	Mean dependent var		0.022558
Adjusted R-squared	-1.351323	S.D. dependent var		0.010633
S.E. of regression	0.016304	Akaike info criterion		-6.321236
Sum squared resid	0.366840	Schwarz criterion		-6.272256
Log-likelihood	4406.259	Hannan-Quinn criter.		-6.302920
Durbin-Watson stat	0.975247			

Results have shown that the relationship between P-BV, Int. -Rate, Inflation Rate, and Log GDP and Standard Deviation is significant with a positive sign as the corresponding P-values are less than 0.05 and correlation coefficients are 0.00, 0.0011, 0.000, and 0.0028 respectively. The reported results also show that there is a significant negative relation between Log-TA and Standard Deviation with corresponding P-values less than 0.05 and correlation coefficients of -0.0125. Mean, EPS, and Exchange rate insignificant.

There's a statistically significant relationship between the selected set of independent variables both internal (size of the company - represented by total assets, EPS and market to book value) and external (Interest rate. Exchange rate, Inflation Rate, GDP and stock return volatility using ANN Model.

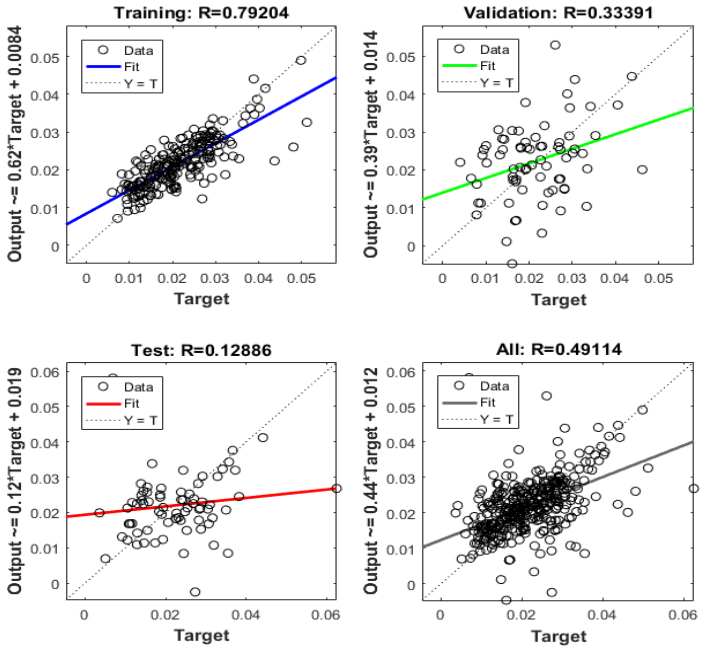

Figure 1. The artificial neural network model

The fitted line produced by the neural network model - as shown in Figure 5-18 - measures the joint effects of the independent variables (Input Variables) on the dependent variable (the output variable) and as such it resembles the coefficient of determination produced by the standard statistical models. The overall performance is equal to 49, 11% which will be evaluated against the other traditional models (GLS and GARCH).

Hypothesis Two: ANN can achieve better predictive accuracy than the LOGIT Method in the classification of the level of volatility (high) and (Low) for the Egyptian stocks.

The percentage of correct classification for the neural network model is 72% while the percentage of correct classification for the Logit model is 70% which illustrated in the two following matrix:

Table 3. The matrix for neural network

Predicted Actual	High	Low	Total
High	314 (51%)	303 (49%)	617 (100%)
Low	113 (13%)	750 (87%)	863 (100%)
Total	427	1053	1480

Table 4. The matrix for logit model

Predicted Actual	High	Low	Total
High	346 (56%)	271 (44%)	617 (100%)
Low	146 (19%)	699 (81%)	863 (100%)
Total	510	970	1480

Hypothesis Three: There is no significant difference between the predictive accuracy of The Neural Network Model and the competing statistical models – GLS and GARCH models.

Table 5. Comparative analysis of the three used models

Model Name	Value of MSE
GLS	0,011
GARCH	0,008
ANN	0,002

5. Conclusion

Regarding the Size Factor as represented by the Log of total assets, several previous studies have examined the effect of company size on the stock return volatility. Cheung and Lillian 1992 have studied stock price dynamics and firm size, and results indicated that there was a negative relationship between company size and stock return volatility. In other words, the stocks of large companies tend to have much lower volatility than their smaller counterparts. Investors tend to retain stocks of large companies for the more extended period as compared to their holdings of shares of smaller companies. This tendency contributes to the decrease in the volatility of stock returns of large companies. The findings of the current study confirm the existence of a significant negative impact on the company size on the stock return volatility.

On the other hand, Bayo et al. (2016) study revealed that the company size – total assets- has no significant impact on stock return volatility.

Regarding the Earning –Per-Share (EPS) variable, several studies have indicated that there is a significant positive effect for EPS on stock return volatility. Those studies include Hartono (2005), Velankar, et al. (2017), which reveals the existence of a significant positive relation between EPS and stock price volatility. Those findings are in line with the results of the current study.

As for Price to Book Value variable (P/BV), few studies have examined its effect on stock return volatility. Among those studies the study of Osundina et al., (2016) which has investigated the impact of accounting information - including P/BV -on stock price volatility. The reported results are in line with findings of the current study as both studies confirm the existence of a significant positive relation between Price-to-Book Value and stock return volatility.

Concerning the Mean Stock Return (Mean) some previous studies examined its impact on stock return volatility. Leading research by Haugen, R (1991) has examined the effect of the

level of stock return on the on the level of volatility of share prices. The reported results showed a negative relationship between the level of stock return and the level of volatility of share prices. This finding is incompatible with the findings of the current study which indicated the Mean Stock Return has a significant positive impact on the volatility of stock returns.

As for Inflation Rate variable, several previous studies have examined its impact on stock return volatility. Those studies include Erdem et al. (2005). The results of those studies show that there is a strong adverse effect of inflation rate on stock return volatility. The results of the current study confirm the findings of previous studies in the area. Those studies concluded that it is helpful for investors to have a better understanding of the impact of inflation on market risk - as measured by return volatility when selecting the appropriate investment strategy.

Regarding the Exchange Rate and Interest rate variables, many previous studies have investigated their relative impact on the stock return volatility. Those studies include Kasman et al. (2011), khaled (2017), Nesrin, et al. (2018). Those studies have reported a significant negative impact on the stock return volatility. These results are in line with findings of the current study.

For the GDP variable: many studies have studied the effect of GDP on stock return volatility and reveal a positive relation, but in our study, with given data, there's an insignificant effect of GDP on stock return volatility.

6. Recommendation and Further Research

6.1 Recommendation

1. Policymakers can use the findings of this study in the formulation of regulatory frameworks and market surveillance procedures designed to improve the functioning of the Egyptian stock market.

2. Policymakers should take into consideration the potential impacts of economic actions of the foreign countries on the level of volatility in the Egyptian stock markets and design appropriate policies to protect Egyptian stock market from the potential impact of those actions.

3. Investors may use the findings of this study in their portfolio selection decisions since the two main criteria considered in the portfolio selection are: risk (measured by volatility) and return.

4. Managers of investment Funds and other Institutional Investors can use the findings of this study in the selection of appropriate securities to be included in their funds. Since most funds have risk tolerance objectives which are strongly related to the level of stock return volatility.

6.2 Further Work

1. Further studies could advance our knowledge about other regions like a MENA region

and other emerging markets such as Turkey, South Africa, and India.

2. The comparative study should be conducted between developing and developed countries which will allow researchers to identify factors affect stock return volatility in developed versus developing countries.

3. Further studies show they include the investigation of stock return volatility in periods of boom and recession to investigate the impact of the business cycle on the stock return volatility in various economic conditions.

4. Future studies on stock return volatility should be expanded to study the impact of Economic Reform programs on stock return volatility by comparing the level of volatility before and after the implementation of those reforms.

5. Further studies should include the impact of the level of foreign investors holding of Egyptian shares and their actions (massive sales and massive purchases) on stock return volatility.

6. Future researches should be expanded to include the potential impact of tax reforms including the capital gain tax on stock trading on the level of stock return volatility in the Egyptian stock market

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