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ԱՐԺԵԹՂԹԵՐԻ ՇՈՒԿԱ

ANDRANIK MANUKYAN
PhD Student at the Chair of International Economic Relations at ASUE

STOCK PRICE PREDICTIONS IN INTERNATIONAL FINANCIAL MARKETS (Case Study of Royal Dutch Shell)

Contemporary time series models constitute a rich research toolbox that has been put to extensive use in various disciplines including financial econometrics and analysis. Arguing for the effectiveness of technical analysis, many financial specialists resort to using conventional time series models as a medium to predict the future movements of the prices of stocks and other financial derivatives. This paper examines the suitability of ARMA and ARCH/GARCH models for this purpose using the monthly price data of the stocks of Royal Dutch Shell Company. The paper further employs in-sample simulations as a way to measure the goodness of fit of the specified models. The research shows that for the case of Royal Dutch Shell the GARCH (1,1) model possesses considerable forecasting capacity yielding correct predictions for the 73,33% of values under consideration. The results substantiate the argument that predictions via time series models can provide valuable insights for the agents in international financial markets to develop more informed and reasonable line of actions.

Key words: *financial predictions, ARIMA and ARCH/GARCH models, in-sample predictions*

JEL C53, G17

Introduction: Today methods of time series analysis are extensively used by researchers in both social and natural sciences. In financial econometrics, tools of time series analysis are being widely employed to discover historical patterns of various financial variables which later on are exploited for forecasting purposes. In the scope of this paper, we will examine the applicability of basic time series models for analyzing the behavior of stock prices, which will be followed by in-sample predictions as a way of evaluating their goodness of fit.

Conventional time series models like ARMA, ARCH and GARCH allow to analyze the stock price behavior based on the historical data of stock's past values without incorporating other independent variables. However, building on the ARMA specifications, the author also extends the model to incorporate additional independent variables that can be significant in determining the price movements of the stock under consideration. For the purposes of the analysis, the author has chosen to use the monthly data of the adjusted closing prices of Royal Dutch Shell Company, which is a British–Dutch multinational oil and gas27company headquartered in the Netherlands and incorporated in the United Kingdom.

Literature Review: There is a huge stock of literature discussing the usage of time series models for analyzing stock price movements and making financial predictions. With the continuous development of financial markets and institutions as well as financial instruments, we witness increasing number of research papers that apply time series techniques for financial market analysis.

According to Gili Yen and Cheng-Few Lee (Review of Pacific Basin Financial Markets and Policies, vol 11, issue 2, 2008), two main schools of thought for analyzing the behavior of financial instruments exist - technical analysis and fundamental analysis. Fundamental analysis attempts to determine a stock's value by focusing on underlying factors that affect a company's actual business and its future prospects, while technical analysis looks at the price movement of a stock and uses this data to predict its future price movements.[1]

Time series were mainly studied under a deterministic prism, until Yule introduced the notion of stochasticity in 1927. According to him, every time-series approach can be regarded as the realization of a stochastic process. This simple idea launched a number of time-series methods, varying in parameter estimation, identification, model checking and forecasting[2]. The notion was followed by the "Time Series Analysis: Forecasting and Control" by G.E.P. Box, G.M. Jenkins, that integrated the existing knowledge and laid the foundation for many contemporary methods of times series analysis, including the different extensions of ARMA model. These Box-Jenkins approaches present a coherent and versatile instrument for time series identification, estimation and diagnostic checking.

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1 **Yen G., Lee Ch.,** Efficient Market Hypothesis (EMH): Past, Present and Future, Review of Pacific Basin Financial Markets and Policies, Vol. 11, issue 2, 2008, pp. 305-329.

2 **Christodoulos C., Michalakelis C., Varoutas D.,** Forecasting with Limited Data: Combining ARIMA and Diffusion Models, Journal of Technological Forecasting & Social Change, Vol. 77, 2010, pp. 558–565.

According to the Efficient-market hypothesis (EMH) proposed by Fama, Eugene (Financial Analysts Journal (1965), pp. 55-59) stocks always trade at their fair value as the markets react instantaneously to all news. Researchers have relaxed this hypothesis by introducing the "semi-strong" version of the argument stating that stock prices reflect all publicly available information and that prices instantly change to reflect new public information. The latter provides grounds for arguing that the basic time series models like ARMA, ARCH and GARCH models are capable of effectively formulating the stock price behavior based on the historical data of stock prices and without incorporating other independent variables. Nevertheless, in this paper, the author will go beyond this basic model and will try to examine the suitability of including select independent variables for producing more robust outcomes.

In recent years, we also witness an increase in the usage of non-conventional methods for analyzing stock price movements. In particular, Tsai and Wang (Stock price forecasting by hybrid machine learning techniques, 2009) did a research where they tried to predict stock prices by using ensemble learning composed of decision trees and artificial neural networks. In addition, Min and Lee made analysis and predictions using machine learning. They evaluated methods based on SVM, multiple discriminant analysis, logistic regression analysis, and three-layer fully connected back-propagation neural networks concluding that vector machines outperform other approaches for this kind of analysis.

Research methodology: As already presented in the preceding sections of this paper, we will be basing our analysis on the historical data from the Dutch company Royal Dutch Shell. The company is one of the six oil and gas "supermajors" and the sixth-largest company in the world measured by 2016 revenues (and the largest based in Europe). Hence, in the framework of the ARIMAX model, we will also examine the possible relationship between the stock price movements and the dynamics of S&P500 index and the prices for West Texas Intermediate Futures.

The S&P500 Index is a capitalization-weighted index of the stocks of 500 U.S. based companies. The index is widely used to measure the performance of the global economy through changes in the aggregate market value of 500 stocks representing all major industries. We have also incorporated a variable for the prices of the West Texas Intermediate Futures as we assume that for a multinational oil and gas company like Royal Dutch Shell the situation in the oil market has an instrumental effect in the variation of stock prices. Both the stock index and the indicator for oil prices were selected based on the level of correlation with the stock prices under consideration (the variables with the highest correlation are used, however models with the other indicators have also been constructed and are presented in the following section).

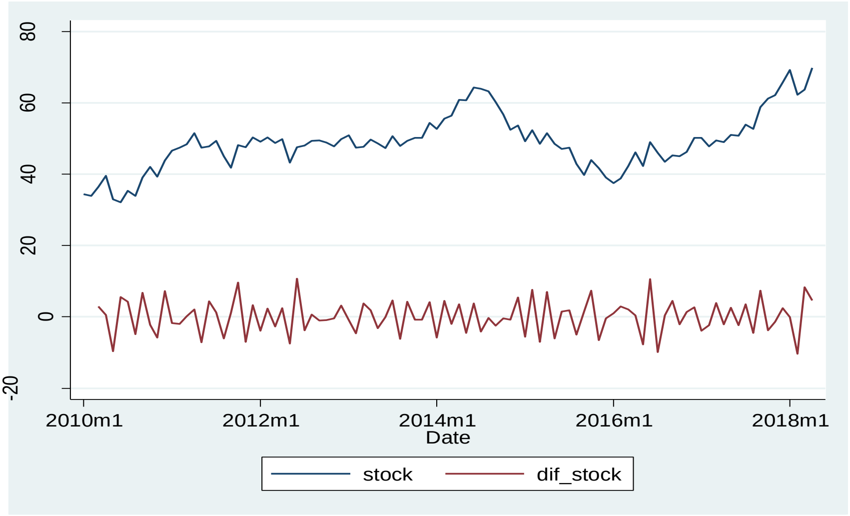
In this paper, we have used the monthly data of the aforementioned indicators ranging from 01/01/2010 to 04/01/2018. Hence, overall, we have 100 observations that have been obtained from the Yahoo Finance platform. The data is chosen to be monthly because of the nature of these indices - they change very quickly and the investor is always interested for its quick results. It is worth noting that the adjusted closing prices of the stocks will be discussed in the frames of the model. In this paper, we have used the following time series analysis methods-ARIMA/ARIMAX, ARCH/GARCH/T-GARCH, ECM etc.

To begin with, ARIMA models are widely regarded as the most general class of models for forecasting a time series which can be made to be "stationary". ARIMA models are often referred to as Box-Jenkins models. The general transfer function model employed by the ARIMA procedure was discussed by Box and Tiao (1975). ARIMA (Auto Regressive Integrated Moving Average) model is a generalization of an autoregressive moving average (ARMA) model. An ARMA model expresses the conditional mean of y_t as a function of both past observations $y_{t-1},\ldots,y_{t-p}$ and past innovations, $\varepsilon_{t-1}, \ldots \varepsilon_{t-q}$. The number of past observations that y_t depends on, p, is the AR degree. The number of past innovations that $y_t$depends on, is the MA degree. In the next section of the paper, a step-by-step approach has been employed to present the model building process. We have used different tests to identify the correct number of lags to be incorporated in the model. The models have then been compared to identify the most robust version using the Akaike Information Criteria as the main criteria (the reported log likelihood coefficients can be used as well).

Afterwards, the models of ARCH/GARCH family have been used to formulate the behavior of stock prices. ARCH models are commonly employed in modeling financial time series that exhibit time-varying volatility and volatility clustering, i.e. periods of swings interspersed with periods of relative calm. Like most financial time series, the simple line plot of adjusted closing prices of Royal Dutch Shell stocks show considerable volatility, thereby we will also examine the suitability of this model for the purposes of this analysis.

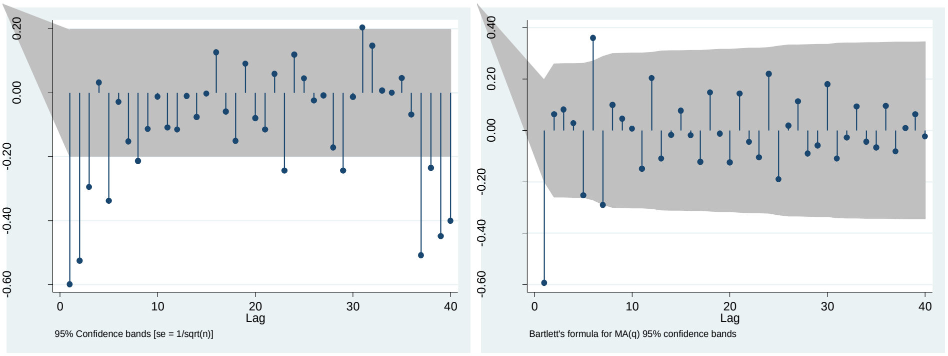
As a final step, the identified models will be used to conduct in-sample predictions to reveal how robust these models are and whether they can be used to make reliable predictions for future market movements. All the statistical evaluations have been done using the STATA software package.

Findings and analysis: We begin our analysis by testing for stationarity in the select variables. Below attached is a graph presenting the movement of adjusted closed prices of Royal Dutch Shell stocks. It is apparent from visual inspection, that the stock prices do not constitute a I(0) stationary process. We have employed a more formal Augmented Dickey Fuller test to establish our initial evaluation. Following the generally accepted methodology, we will difference the variable to get a stationary variable. The stationarity of the differenced variable has been proved by both the formal ADF test, and can be inspected visually from the below graph.



Graph 1: ***A time plot of the RDS stock price and the twice differentiated version of the variable***

The same procedure was employed to stationarize the variables for S&P500 index and the monthly prices for West Texas Intermediate Futures. After these initial diagnostic and corrective steps that were undertaken to avoid using outputs of spurious regression for the purposes of our analysis, STATA software package has been used to produce the correlogram and partial correlogram for the sock variable.



Graph 2: ***The correlogram and partial correlogram of the differenced stock variable***

The respective graphs show that for the MA part of the model we shall use the first lag. However, the partial correlogram is comparatively ambiguous, thereby we have run the ARMA model with different lag specifications for the AR process. After quietly running the regression for the models, we have employed the Akaike Information criteria to identify the most robust model. The model with the lowest AIC coefficient or the biggest log likelihood coefficient turns out to be ARMA (1,1) model. To exhaust all the possible versions of suitable ARMA models, we have constructed MA(1) AR(1), AR(2) and AR(3) models for the variable under discussion. Using the same criterion, it has been identified that AR(3) is most fit to explain the behavior of stock prices (refer to the table below). It is worth noting that the AR (3) model has a higher coefficient of log likelihood than the ARMA(1,1) model.

Moving forward, we firstly try to incorporate the time series of FTSE1000 index as an independent explanatory variable. According to the results of the regression, the link between the FTSE1000 stock index and the RDS stocks is quite weak. The variable seems to be statistically not significant with a P-value of around 0,197. Moving forward, we decided to resort to the S&P500 stock index as an indicator of the conjecture of financial markets that may have significant relationship with the stock variable. Based on the regression results, the variable is significant with 90% confidence interval. Overall, the log likelihood of this ARMAX model is equal to -246.05 which is quite close to what we have calculated for the ARMA (1,1) model.

Augmenting the frames of our research, we have also conducted regression using the monthly prices for West Texas Intermediate Futures as an independent variable. The independent variable is significant with 95% confidence interval, however we can see that the log likelihood of the model has comparatively decreased (please refer to the summary table below).

As outlined in the previous sections of this paper, we will also use models from ARCH/GARCH family. The time plot of the stock variable presented at the beginning of this section provides grounds to believe that we have considerable volatility and these models may prove to be quiet robust. Having already established that the variable is stationary, we try to identify the correct number of lags for this model. To accomplish that, we have regressed the stock variable against nothing in particular and used the LM test. According to the test results, lags beyond 15 have P-values around 0.05. We accept this as a signal that GARCH lag should definitely be incorporated into the model. We have run different specification of the GARCH model, and have concluded that GARCH (1,1) is the best model for our data (please refer to the summary table below).

As a final step, we have also run a co-integration test between the stock prices and the S&P500 series to examine whether an Error Correction Model can be applied to this case. To accomplish that, we have regressed the stock variable on the S&P500 variable, from which the residuals have then been calculated. The residuals were tested by the Augmented Dickey Fuller test for stationarity. With a P-value 0.63 for the ADF test, we conclude that co-integration is not present.

The outcomes of the above-discussed model specifications are discussed in the table 1.

Consistent with the objectives of our research, we have also conducted in-sample simulations to assess how fit the models are for making predictions about the future movements of the variable under discussion. This type of forecasts utilize a subset of the available data to forecast values outside of the estimation period and compare them to the corresponding known or actual outcomes. This is done to assess the ability of the model to forecast known values. In our analysis, we decided to use the data on the first 84 observations to try and predict the values of the remaining 16 values. Afterwards, the predicted values are being compared with the actual numbers, based on which we obtain a practical real-world instrument to assess how robust the model is.

Table 1

Summary statistics of the model specifications

	Model 1	Model 2	Model 3	Model 4	Model 5
stock_1	ARMA(1,1)	AR(3)	ARMAX	ARMAX	GARCH(1,1)
ARMAX					
Constant	0.0059	0.0019	0.0054	0.0045	0.1678
AR 1	-0.242	-1.0594	-0.2416	-0.2775	---
AR 2	---	-0.7915	---	---	---
Ar 3	---	-0.3067	---	---	---
MA 1	-0.945	---	-0.9408	-0.9999	---
MA 2	---	---	---	---	---
sp500_1	---	---	0.0429	---	---
wti_1	---	---	---	0.2792	---
GARCH					
Constant	---	---	---	---	42.4643
ARCH 1	---	---	---	---	0.1928
GARCH 1	---	---	---	---	0.9463
N	98	98	98	98	98
Log likelihood	-247.245	-251.0541	-246.059	-225.39	-287.4316
% of correct prediction (out of 16)	66.67%	66.67%	66.67%	66.67%	73.33%

Based on the information of the developed models, and the conducted in-sample predictions, we conclude that the “best” model for formulating the path movement of the stock prices of Royal Dutch Shell is the GARCH(1,1) model.

Conclusions: The drastic increase in the volume of transactions in the financial markets have prompted more and more analysts to examine the suitability of using time series models in predicting the movements of the prices of stocks and other financial derivatives. As stated, the technical analysis school of thought posits that the historic data of stock price movements can be used to predict their future behavioral patterns. Some analysts argue that technical analysis can present trustworthy information when market forces (supply and demand) are in the play and external factors do not drastically alter the market environment. Examples of the latter can include unexpected events such as rapid political developments, terrorist acts, changes in the legislation and financial regulations as well as various incidents impacting individual companies (splits, mergers, unexpected resignation of company CEO or other instrumental figures).

In this paper, an attempt has been made to utilize some of the conventional time series analysis methods, specifically those from the ARIMAX and ARCH-GARCH families as well as the Error Correction Model, to predict the stock price movements of the Royal Dutch Shell Company. The results indicate that in line with the more sophisticated approaches of machine learning, time series models can also be successfully used for this purpose.

More specifically, the in-sample predictions show that the ARMA (1,1), AR(3) and ARMAX models were able to yield correct predictions for the 66,67% of the values under consideration. It is also worth noting that the inclusion of additional independent variables – the S&P500 stock index and the price of West Texas Intermediate Futures, did not enhance the model's predictive capacity substantiating the argument that the past values of the dependent variable are able to provide enough insights for forecasting purposes. The time plot of the monthly price of the Royal Dutch Shell Company obviates a considerable level of volatility and we thereby hypothesized that models from ARCH/GARCH family can be quiet suitable for the purposes of our analysis. Our further analysis has proven the hypothesis as the GARCH (1,1) model renders better results with an increased level of correct predictions of 73,33%.

Building models with high level of predictive capacity can have a crucial importance for both market dealers and the company managers in their effort of making more precise calculations and developing a more informed and reasonable line of actions. With the ever-increasing level of competition in the global financial markets, having such informational framework can equip companies with considerable competitive advantages in comparison with other market players.

Bibliography

1. Adebiyi A., Adewumi A.O., Stock Price Prediction Using the ARIMA Model, 16th International Conference on Computer Modelling and Simulation, 2014.
2. Christodoulos C., Michalakelis C., Varoutas D., Forecasting with Limited Data: Combining ARIMA and Diffusion Models, Journal of Technological Forecasting and Social Change, Vol. 77, 2010.
3. Devi B. Uma, Sundar D., Alli P., An Effective Time Series Analysis for Stock Trend Prediction Using ARIMA Model for Nifty Midcap-50, International Journal of Data Mining and Knowledge Management Process, Vol. 3, No. 1, 2013.
4. Yen G., Lee Ch., Efficient Market Hypothesis (EMH): Past, Present and Future, Review of Pacific Basin Financial Markets and Policies, Vol. 11, Issue 2, 2008.
5. Box G.E.P., Jenkins G.M., Time Series Analysis: Forecasting and Control, Holden Day, San Francisco, 1970.
6. Meade N., Islam T., Modelling and Forecasting the Diffusion of Innovation – a 25-year Review, International Journal of Forecasting, Vol. 22, 2006.
7. Pai P., Lin C., A Hybrid ARIMA and Support Vector Machines Model in Stock Price Prediction, Omega, Vol. 33, 2005.
8. Pham Ly, Time Series Analysis with ARIMA – ARCH/GARCH Model in R, L-Stern Group, 2013.
9. Yule G.U., On the Method of Investigating Periodicities in Disturbed Series, with Special Reference to Wolfer's Sunspot Numbers, Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character, Vol. 226, 1927.

ԱՆԴՐԱՆԻԿ ՄԱՆՈՒԿՅԱՆ
ՀՊՏՀ միջազգային տնտեսական հարաբերությունների ամբիոնի ասպիրանտ

Արժեթղթերի գների կանխատեսումը միջազգային ֆինանսական շուկաներում («Ռոյալ Դաթչ Շելլ» կազմակերպության օրինակով).– Ժամանակային շարքերի վրա հիմնված մոդելները տրամադրում են հետազոտությունների իրականացման հարուստ գործիքակազմ, որն ակտիվորեն օգտագործվում է գիտության տարբեր ասպարեզներում, այդ թվում՝ ֆինանսական էկոնոմետրիկայում և վերլուծության մեջ: Մատնանշելով տեխնիկական վերլուծության արդյունավետությունը՝ շատ ֆինանսիստներ այժմ հենվում են ժամանակային շարքերի վրա՝ կանխատեսելու համար արժեթղթերի և ֆինանսական այլ ածանցյալ գործիքների գների շարժընթացը: Սույն հետազոտությունը դիտարկում է այս գործում ARMA և ARCH/GARCH մոդելների կիրառման նպատակահարմարությունը՝ հենվելով «Ռոյալ Դաթչ Շելլ» կազմակերպության արժեթղթերի գների ամսական շարժընթացի վրա: Հետազոտությունում նաև իրականացվել են սիմուլյացիաներ՝ գնահատելու համար կառուցված մոդելների արդյունավետությունը: Արդյունքները վկայում են, որ «Ռոյալ Դաթչ Շելլ» կազմակերպության պարագայում GARCH (1,1) մոդելը բավականաչափ վստահելի է՝ տրամադրելով 73,3%-ով ճշգրիտ կանխատեսումներ: Այս տվյալները հիմնավորում են այն փաստարկը, որ ժամանակային շարքերի վրա կառուցված մոդելները կարող են միջազգային ֆինանսական շուկաներում գործող գործակալներին արժեքավոր տեղեկություն տրամադրել՝ դարձնելով նրանց գործունեությունը առավել հիմնավոր և շահավետ:

Հիմնաբառեր. *ֆինանսական կանխատեսումներ, ARIMA և ARCH/GARCH մոդելներ, ներընտրանքային կանխատեսումներ*
JEL C53, G17

АНДРАНИК МАНУКЯН
Аспирант кафедры международных экономических отношений АГЭУ

Прогнозы цен акций на международных финансовых рынках (на примере компании Royal Dutch Shell).– Модели временных рядов предоставляют богатый инструментарий для проведения исследований, который активно используется в различных областях науки, включая финансовую эконометрику и анализ. Указывая на эффективность проведения технического анализа, многие финансисты сейчас опираются на временные ряды для прогнозирования динамики стоимости ценных бумаг и других производных финансовых инструментов. В данном исследовании рассматривается целесообразность применения в этом деле моделей ARMA и ARCH/GARCH на основе ежемесячной динамики стоимости ценных бумаг организации Royal Dutch Shell. В ходе исследования также были проведены симуляции для оценки эффективности построенных моделей. Результаты свидетельствуют о том, что в случае с организацией Royal Dutch Shell модель GARCH (1,1) достаточно надежна, представляя прогнозы с точностью 73,33%. Эти данные обосновывают аргумент о том, что модели временных рядов могут предоставлять ценную информацию агентам, работающим на международных финансовых рынках, делая их деятельность более обоснованной и рентабельной.

Ключевые слова: *финансовые прогнозы, модели ARIMA и ARCH/GARCH, вне-выборочные прогнозы.*
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