

The Efficiency of Developed Markets: Empirical Evidence from FTSE 100

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Abstract—This paper endeavors to examine weak form efficiency in the Financial Times Stock Exchange 100 (FTSE 100) under the ongoing theory of efficiency, namely the Efficient Market Hypothesis (EMH). In particular, this paper aims to examine the presence of random walk in FTSE 100 during the period from 2001 January to 2009 November which could be the end of the peak of the global financial crisis. Unit root tests such as ADF and PP shows that the market is non-stationary and therefore, random walk hypothesis is accepted. According to GARCH (1, 1) outcomes, in all condition the market prices follow the random walk supporting the weak form market efficiency hypothesis. It can be concluded that in developed markets such as FTSE 100, the existence of weak form market efficiency is evident.

Index Terms—random walk, efficient market hypothesis, GARCH (1, 1)

I. INTRODUCTION

There have been many studies on the issue of weak form market efficiency. It refers that previous data of a security is reflected in current security price. Thus, it can be claimed that past data analysis is not enough to predict future outcome of stock. It is, however, argued that stock returns can follow similar paths as supported by remarkable evidence that large (small) returns can be predicted by determination of preceding large (small) return. It allows us to make technical analysis so as to identify and measure stock's volatility or stability level [1]. In this piece of work, we will endeavour to investigate this hypothesis in the context of leading stock exchange indices throughout the world, namely FTSE 100. We employed daily close price for each indices from January, 2000 to November, 2009 to investigate both markets' volatility in order to relate that into market efficiency hypothesis. In our case, initially we applied two unit root testing methods, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP), to exhibit trending movement or nonstationarity in chosen indices, under the weak form market efficiency hypotheses [2]. Notably, it can be claimed that these testes can allow us to check the chosen data sets reliability. It can be added that BDS, [3] diagnostic test was also employed to figure out whether true innovations are i.i.d or not and obtain some information on Random Walk Hypothesis (RWH) [4].

Another method which is so-called GARCH model (the Generalized Autoregressive Conditional Heteroscedasticity) can also be used to highlight the markets' and stocks' movements in financial time series such as stationarity and fattails [5]. Specifically, in order to identify the volatility existence in the markets, basic GARCH (1, 1) is employed. The confirmation of validity of using GARCH model is then justified by performing a non linear statistical test for independence of the series, BDS test. The rest of this paper follows in this order. Section 1 discusses the past literature on random walk and market efficiency, Section 2 examines the data and methodology of the paper, Section 3 presents the results of the models and finally Section 4 concludes this paper with a discussion.

II. LITERATURE REVIEW

There have been many debates on whether stock price behaviour can be predicted or not. In that case, the efficient market hypothesis (EMH) can shed light on this controversial issue in the finance world. EHM was formulated and improved by [6]. In the theory, Efficient Market represents that all marketable assets reflect new released information in relevant market immediately [7]. In other words, it is impossible to beat the market by using information which has been already known or used in the market [8]. However, many studies show, specifically last three decades, that some constant anomalies such as turn of the month effect have been found by [9] for US Market, [10] for Canadian market, and [11] found it for Asian Pacific Market and so on. Therefore, it can be argued that each market should be analysed in order to figure out whether random walk exist or not. The study makes use of the basic random walk hypothesis to check the Market Efficiency. The weak form of efficient market hypothesis suggests that the latest price will provide the information to predict the future prices under random walk. The random walk hypothesis holds if there is a unit root present and will behave random. Unit root test are useful to determine the non-stationary which is an important condition underlying the random walk. The non -stationary are mainly of two types the trend stationary and the difference stationary. Trend stationary follows linearity and so it is predictable. Difference stationary if present requires further testing to satisfy the condition of random walk even though a unit root may be present. The study

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involves the use of nonlinear independence test like BDS test for confirming the presence of random walk. There are many studies using alternative methods to do unit root tests to examine the random walk hypothesis before. Ref. [12] has tested the random walk hypothesis in seventeen emerging markets through employing unit root tests. They found that only seven markets have the stationarity after rejecting the null hypothesis. Ref. [13] found that the sock prices in South Korea have a unit root and resulted in that there was weak form efficiency in South Korea stock market. Ref. [14] tested market efficiency in four southern Asian countries. Through applying ADF test, PP test and other unit root tests, they found weak-form efficient stock markets appearing in India, Sri Lanka and Pakistan, while Bangladesh's stock market was not weak-form efficiency.

The stationarity is checked by using the PP (Phillips Perron) Test and the ADF (Augmented Dick Fuller) Test. Further the GARCH (1, 1) model is used to evaluate the stationarity, volatile clustering of the prices and fattails in the data. The assumption of the model states that the time varying variance is dependent upon the lagged variance [15].

III. DATA AND METHODOLOGY

The FTSE 100 price data is used for our analysis of market efficiency. It is one the largest market in terms of the blue chip companies covering almost 81% in UK market. Over 100 companies from UK trade in the market. The data for our study is taken from 2001 January to 2009 November. The market is assumed to be highly efficient as the index represents the major companies from UK. The index prices are used to analyse our hypothesis of efficient market. The index started in 1984 with a base level price of 1000. The prices are calculated on real time basis and reported every 15 seconds. The information flows on real time basis supports the assumption of market efficiency.

The initiation of this paper follows the investigating of a simple random walk model to test market efficiency. Referring to the theory, the price changes are independent and independence of the past price movements. This paper test this theory by using the following formula,

$$p = p_{t-1} + \varepsilon_t \quad (1)$$

where "p" is the natural log of the time series, "R" and " ε_t " represents a stochastic white noise term. With the existence of random walk theory, we expect that a single unit root will be present and according to [1], Is also expected to be random.

$$\Delta p = p_t - p_{t-1} = \ln(p_t / p_{t-1}) \quad (2)$$

A. GARCH: Generalised Auto-Regressive Conditional Hetroskedasticity

This study used *Generalised autoregressive conditional hetroskedasticity* (GARCH) introduced by [15] as a generalised version of ARCH model pioneered by [16]. Since inception, the model has been widely used

in finance literature with one of the reasons being the consideration of time variant values of conditional variance and it also takes leptokurtosis, skewness and volatility into account [17]. Basic GARCH (1, 1) specification is used in this study since it allows the model to identify the volatility occurrence throughout the data [18]. It can be written as,

$$R_t = \theta_0 + \theta_1 R_{t-1} + \varepsilon_t \quad (3)$$

$$h^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}^2 \quad (4)$$

where $\omega > 0$, $\alpha \geq 0$, $\beta \geq 0$ and the condition $\alpha + \beta < 1$ tends to be adequate enough to classify GARCH (1,1) as weakly stationary. Furthermore, the large values of $\alpha + \beta$ towards 1 from the analysis of the model indicates the great level of volatility clustering being present in the data and demonstrate the stationarity leading to the market inefficiency [5].

For using the model the skewness should be considered, as high positive or negative values of the skewness distorts the forecast of the model. The value of skewness is found to be 0.099374 which is insignificant and therefore the use of GARCH is said to be justified as this view is supported by [19]. The value of kurtosis obtained is 6.13 which is greater than zero suggesting a fat tailed (leptokurtic) distribution. But the GARCH test takes into consideration the peak values and nullifies the effect of kurtosis.

B. BDS Test

In order to verify the validity of GARCH (1,1) model, statistical tests such as nonparametric BDS test should be employed. It was introduced by [20] to test whether the residuals of a time series is identical and independently distributed (iid). This test allows the researchers to receive the necessary information such as the ability to carry out non-linear models, for instance, GARCH models would be suitable in the case of null hypothesis of iid is being rejected.

C. Unit Root Tests

Stationarity is fundamental in implementing the hypothesis of market efficiency. To find the stationarity, unit root tests have to be engaged. The Phillips-Perron test (PP test) is a method to do stationarity test. It is used in time series analysis to test the null hypothesis that a time series is integrated of order. And pp test is robust with respect to unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation. is the Phillips-Perron (PP) test [21]. The PP test model is below:

$$y_t = c + dt = ay_{t-1} + e(t) \quad (5)$$

where, e(t) is the innovations process.

Dickey-Fuller test (ADF test) is another method to carry out stationarity test. The more negative the tau value is in the test, there is the higher possibility to reject the hypothesis that there is a unit root at some level of confidence.

The well-known methods to do the unit root test is the Augmented Dickey-Fuller (ADF) test [22]. The model of Augmented Dickey-Fuller (ADF) test is below:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \dots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t$$

where, “y” is the stock price index at time “t”. The equation includes “a” trend term “(a)”, “p” denotes the number of lagged terms.

IV. RESULTS AND ANALYSIS

A. PP-Test

First of all, we assumed the lag is long and the mode is trend, and then we employed R to calculate the tau of FTSE100 and as follows:

From the Table I above, z-tau value is less than the critical values no matter under which significant levels and therefore, it is evident that FTSE 100 contains a unit root implying the random walk path.

TABLE I. OUTCOMES OF PP-TEST

Critical values for Z statistics	1pct	5pct	10pct
FTSE100			
Critical values	-3.967169	-3.414228	-3.128874
Z-tau value			-1.2917

B. ADF Test

Firstly, we assumed the lag is 3 and the mode is trend, and then we used R to calculate the t-statistic of FTSE100 as follows:

TABLE II. OUTCOMES OF ADF-TEST

Critical values for test- statistics	1pct	5pct	10pct
FTSE100			
Tau (critical)	-3.96	-3.41	-3.12
Phi2 (critical)	6.09	4.68	4.03
Phi3	8.27	6.25	5.34
Test-statistics			
Tau value			-1.2085
Phi2			0.7586
Phi3			0.9826

According to Table II, the t-statistics of ‘phi3’ is smaller than the critical values at any significant levels. Therefore, we can describe the FTSE 100 has a unit root as null hypothesis is not rejected. It is also confirmed by the greater value of tau stats than critical value. Moreover, the phi2 value from test-statistics is much smaller than those of critical value leading us to determine that this time series display the pure random walk with no trend or drift.

First difference series of original time series is also used to find the stationarity in the series. The results are shown in the following Table III and they validate the condition I (1), a single unit root, in the original time

series as the stationarity has been found for the differenced series.

TABLE III. OUTCOMES OF PP-TEST

Critical values for test- statistics	1pct	5pct	10pct
FTSE100			
Tau (critical)	-3.96	-3.41	-3.12
Phi2 (critical)	6.09	4.68	4.03
Phi3	8.27	6.25	5.34
Teststatistics			
Tau value			-25.7765
Phi2			221.4766
Phi3			332.2148

Random walk model also produces significant values for the dependent lagged model, leading to the assumption that the current prices can be predicted by the past price and therefore, random walk hypothesis holds.

It should also be noted that “a” and “b” values of ARCH and GARCH terms for both series appear to be greater than zero. The sum of those two parameters in the difference series model is below one indicating that the difference series is stationary with close value towards showing the high volatility clustering in the series. However, the sum of those in the normal series exceeds 1 which may imply random walk hypothesis is true and there seems to be the efficiency in the market.

The Table IV illustrates that the BDS test employed for the serial independence of residuals test attempted to figure out whether residuals of random walk model are iid or not. m, embedding dimension, is assumed to be ‘6’ and the results of p-values point out that null hypothesis of residuals being iid is rejected. Therefore, we can conclude that the use of non-linear model to test market efficiency is justified.

TABLE IV. OUTCOMES OF BDS-TEST

BDS test	
Asymptotic theory (p-values)	m=6
Random Walk	0.0000

V. CONCLUSION

The main objective of this paper is to identify whether FTSE 100 index prices are stationary and to test the random walk hypothesis and efficient market hypothesis. In doing so, a number of tests were used. Unit root tests such as ADF and PP shows that the market is non-stationary and therefore, random walk hypothesis is accepted. GARCH (1, 1) is also employed to investigate volatility clustering in searching for random walks. It is found that in all condition the market prices follow the random walk supporting the weak form market efficiency hypothesis. The apparent market efficiency of FTSE 100 is also reinforced by the similar results of test for S&P 500 as mentioned. These findings are against the view of [1] and [5] where it was established that Greek and Ghana stock markets were inefficient in weak-form. In this case we assume that the large difference in the nature

of development between those stock exchanges and FTSE, situated in one of the largest and oldest financial district in the world, may have a part in explaining why contradiction exists. Nevertheless, more tests and research such as inclusion of structural breaks in the time series analysis, using multivariate analysis and/or cointegration method's, are definitely needed in order to receive the wider picture of market efficiency. On this note, this paper concludes that, in developed markets such as FTSE 100, the existence of weak form market efficiency is evident.

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