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Testing Weak Form Information Memory: A Study of Indian Futures Market

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Abstract: The greatness and simplicity of EMH (Efficient Market Hypothesis) has surprised investors from time to time regarding the correct pricing and efficient strategies for investment. Applying the same logic to Indian Derivative market, the present paper makes an effort to examine the market efficiency of index futures. The study has undertaken tests of market efficiency of Nifty Index Futures contract from 1st January, 2018 to 1st January, 2021 Random walk theory is tried to be tested in this context and Ljung- Box test is applied to check the fluctuations in future contract prices. The background thought is kept like if market is inefficient at its weak-form that leads to the proof that market does have memory and future prices do not stick to random walk. Findings of the study reveals that past prices of future contracts cannot be used as base to forecast the terminal prices and abnormal profit can be made as they are random in nature.

1. Introduction

Fama (2010), in response to numerous criticisms of EMH, defended its role in the financial crisis (2007-2010) by claiming that it has few believers. As a result, it may be stated that this empirical prediction has already proven to be correct in the vast majority of real-world situations. EMH is the most studied as well as the most contentious topic in the financial sector and among finance stalwarts. However, EMH has the most significant benefit in its favour, which is its simplicity, and it has repeatedly demonstrated its robustness through implementation. Despite technological advancements in the stock trading process, no one can guarantee 100 percent market efficiency today because of the many components that make up a financial market, the most important is human emotions cannot be ignored in all these phenomena. Interestingly the belief that the financial market is not efficient and can be beaten insists the market functioning efficiently. If the underlying principle of Efficient Market Hypothesis would be carefully studied then it can be assertively said that the term "Efficient Market" does not necessarily cent percent efficient always as it seems quite impossible that stock prices will respond almost immediately to new information. (Fama, 1998) So, the strict definition may not hold true in case of market efficiency and the role of random events cannot be discarded as they are always acceptable while the prices need to move back to its true value (fair value). Another unexplored area under EMH is whether it allows environmental eventualities and random occurrences as the implications strongly support this component.

Keeping the above logic in thought the aim of the present paper is to test the weak form of EMH of Nifty Index Futures contract from 1st January, 2018 to 1st January, 2021. The study is to examine and analyze the index future price volatility and its randomness so as to interpret the same.

2. Review of Literature

Many a times Finance theories proved themselves more subjective because of lack of proven laws in the subject. However it provides ample ideas that can be used by the practitioners. Similar logic can be applied in case of Efficient Market Hypothesis (Fama 1965, 1970). Though it has certain limitations in explaining the behavior of stock prices yet many a times its accuracy has proved in modern investment world by investors and practitioners (Fama, 1991). A lot of research work has been done in this regard and tried to address various questions raised by the deficiencies of this hypothesis.

Assuming there exists no human emotion and technically advanced trading atmosphere many a times EMH has proved its durability. If the causality of stock prices can be divided into two segments (short run and long run) then weak form of the study provides more accurate result in short run causality than the long run (Mustafa and Ahmed, 2020). The logic holds true in Spanish Derivative Market (Angles and Jesus, 1998) and the result of the test achieves the efficient market state. In Indian market, Badla transactions were studied considering the effect of successive reintroduction and suspension (Berkman and Eleswarapu, 1998) where the result supported the market efficiency and concludes impact of Badla was to enhance the volatility as well as activity that influences the trend (noise on the market).

A compared study (Shah and Thomas, 1996) between Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) considered commencement of trading in NSE and initiation of trading through D-Mat Account in both the exchanges found that they cause enhancement of both liquidity as well as market efficiency in these two major stock exchanges in India. Information Dissemination Efficiency in Indian Future Market segment considering the equity futures is also proved (Choudhury, 2007) in terms of comparing the daily returns (log return) of all indices with that of specific equity future contracts in the market. The result administers to be abnormal and reacting asymmetrically to the new information (information shock). The study concludes in case of price discovery, Indian Derivative Market may not be an efficient one. Many a times use of leverage by firms put effect on traders in the stock market and they react more to the bad news, hence giving more importance to it. On the other hand good news or information makes them move cautiously in trading.

Further studies (Ahmed *et al.*, 2005) in these area states retail traders in Indian Equity Future market behave more carefully while dealing with leveraged securities in their portfolios as in a highly volatile market the above strategy helps them to make non-normal profit. The study also discovers a fact that designing a structure to trade in market in order to make abnormal profit may make sense for big players (institutions or big brokers). But, for individual uninformed investors it may not cater suitable returns. Another inter market segment comparison (Vipul, 2008) covers both the futures and options segment of NSE tested weak form of market efficiency using various model free tests. The result is quite surprising as it presents enormous opportunities to traders for arbitrage profit in option contracts (European Nifty Index Options) by examining various call-put parities. The result also indicated put options are being more overpriced than call option, the situation of mispricing leads to a particular pattern in timing, moneyness and time to expiry on a trading day.

Many recent studies (Gupta and Basu, 2007) favor presence of return (basically long term) anomalies in financial markets all over the world. These proclaim suggest that market efficiency cannot be abandoned. A number of studies (Agarwal and Singh, 2002) found in financial market and stock trading process long run return anomalies are so fragile that they disappear when necessary changes are introduced in their respective ways of measurement.

3. Objective and Hypothesis of the Study

3.1. Objective of the Study

All the above research studies lead to a research gap of lack of randomness study in Indian Index Futures market. Though few research works (Ahmed *et al.*, 2005; Choudhury, 2007) focused on testing semi-strong form of market yet works on weak form test or random walk test of market are limited. The scope is narrowed again when it comes to derivative market. So, the main objective of the study is:

- To check the weak form of market efficiency (Random Walk Theory) of Indian Futures Market.

3.2. Hypothesis of the Study

The framed hypothesis considering the objectives of the study is:

H_0: The price trend and lags of the sample future contracts are not significant individually.

4. Research Methodology

4.1. Data and Sample

Keeping the above objectives in mind, for the present study Nifty Index Futures is used as sample. All the future contracts traded from 1st January 2018 to 1st January 2021 have been used for the study. The background thought behind considering the above time period is to test the market efficiency post demonetization (October, 2016) period. The announcement caused lots of mental turmoil among the investors and a strong impact on Capital market (Bantwa, 2017). It is assumed that three year is quite a long period to test the randomness of the market and it can test towards the robustness of the study. The source of secondary data used in the study is National Stock Exchange and for this reason (nseindia.com, old website) data can be assumed as completely authentic. On each trading day there are three future contracts traded which mature in three consecutive months. So the whole data has been segregated into three series: The ones maturing in the same month henceforth referred to as the same month contract, the ones maturing in the next month henceforth referred to as the near month contract and the ones maturing in the last month henceforth referred to as the far month contracts. As the study period covers 3 years, the total data set consists of 36 different time series for each year (three for each month) i.e 108 in total, analyzed for stationary.

4.2. Tools of the Study

The analysis is prepared assuming weak form market efficiency on information of the EMH. The study employs the Ljung-Box test statistics (Ljung and Box, 1978; Dicky and Fuller, 1979) to probe the randomness of index futures price fluctuation. This statistics measures the stationary of a time series by looking at the Auto Correlation Coefficients (ACF) of it. It employ the following step by step approach to test for efficiency:

To test the randomness of daily returns the Serial Correlation Function has been primarily used. Auto correlation is a technique for determining whether or not successive numbers in a time series are related. If the successive numbers in a given time series are nonrandom, there may be some dependence between them. In general, the serial correlation coefficient measures the link between the value of a random variable at time t and its value at time *k*. In other words, it will show whether price changes at time 't' are influenced by price changes at time '*k*'. The Auto Correlation Function determines the serial correlation of a time series (ACF).

Following is the mathematical expression of ACF (ρ_k)

ρ_k^2 = Covariance at lag k / Variance

Where, co-variance: $Ck = \frac{1}{n}\sum_{t=i}^{n-k}(X_t - \bar{X})(X_{t+k} - \bar{X})$ and

Variance = $\Sigma\,(Xt - X)^2 / n$

n = sample size

X = sample Mean

This study uses lag value up to 10 to calculate the ACFs. The standard error of calculated coefficients is required for statistical testing of serial correlation coefficients.

$$\text{S. E. of } r_k = \frac{1}{\sqrt{n-k}}$$

If the calculated standard error exceeds three times the value of r_k, it will be considered significant. Hence the randomness hypothesis would be rejected. If calculated coefficient does not exceed three times the standard error, randomness hypothesis will be accepted.

As an additional measure of robustness, a test of joint hypotheses that all the ACFs (Auto Correlation Coefficients) are at the same time equal to 0 (indicating complete randomness), the LB-statistics developed by Ljung Box has been used, which is defined as (Ljung and Box, 1978)

$$Q_{lb} = n\ (n+2)\ \Sigma\ (\rho_k^{\ 2} / n - k)$$

$\rho_k^{\ 2}$ = Auto correlation function (ACF) at lag 'k'

In comparatively larger samples, Q statistics follows a Chi- Square distribution with "m" degree of freedom. Since Q statistics is a portmanteau test, it has less effect against alternatives that contain intermittent spikes in ACF (Ljung and Box 1978).

5. Results and Discussion

If the ACFs are not statistically different from zero, it is an indication that the returns and subsequently the prices are independent of each other and have no analytical value whatsoever in predicting the future prices or returns. Following three tables present the number of significant ACF values for the year of 2018-19, 2019-20 and 2020-21 respectively. In each month there are three types of contracts: the ones maturing in the same month, the ones maturing in the next month and the ones maturing two months later. Since the ACFs are calculated for lags of 1-10, there are 30 values reported in each month.

Table 1: ACF for the year 2018-19

Month	*No. of non-significant values*	*% of non-significant values*	*Number of Significant values*	*% of Significant values*
January	25	83.33	5	16.67
February	30	100	0	0
March	28	93.333	2	6.667
April	27	90	3	10
May	27	90	3	10
June	22	73.33	8	26.67
July	20	66.67	10	33.33
August	20	66.67	10	33.33
September	18	60	12	40
October	19	63.33	11	36.67
November	22	73.33	8	26.67
December	18	60	12	40

Source: Authors' Own Compilation

2018-19: A perusal of table 1 indicates that in the year 2018-19, for the month of February not a single The correlation coefficient is greater than three times the standard error calculated. Hence all values conform to randomness hypothesis. On the other hand, in rest of the months the maximum ACF values are significant. However, if the number is viewed from the perspective of percentage it amounts to 83.33% in the month of January, 93.33% in the month of March, 90% in the months of April and May, 73.33% in the month of June, 66.67% in the months of July and August, 60% in the month of September, 63.33% in the month of October, 73.33% in the month of November and 60% in the month December-18 of values are conforming to randomness. If we look at the broader picture, out of a total of 360 coefficients 84 coefficients do not conform to randomness. That is a percentage of only 23.33% values are significant and the remaining is non-significant. Hence we can safely accept the randomness hypothesis.

Table 2: ACF for the year 2019-20

Month	*No. of non-significant values*	*% of non-significant values*	*Number of Significant values*	*% of Significant values*
January	20	66.66	10	33.33
February	22	73.33	8	26.67
March	24	80	6	20
April	22	73.33	8	26.67
May	22	73.33	8	26.67
June	23	76.66	7	23.34
July	20	66.66	10	33.33
August	19	63.33	11	36.67
September	22	73.33	8	26.67
October	24	80	6	20
November	21	70	9	30
December	21	70	9	30

Source: Authors' Own Compilation

2019-20: Table 2 shows the calculated values for the year 2019-20. Here, in the month of January 66.66% values are confirming randomness. In the month of February and March 73.33% and 80% values respectively are not significant, where as for the months of April and May 73.33% values are confirming randomness. 76.66% values in the month of June , 66.66% values in the month of July , 63.33% values in the month of August , 73.33% values in the month of September , 80% values in the month of October, 70% values for the months of November and December (each) are confirming randomness. In a broader picture , in the year 2019-20 out of 360 values 100 ACF values i.e.27.77% values are significant while rest are non-significant , thus we can safely accept the randomness hypothesis.

2020-21: For the year 2020-21, the table 3 shows all the calculated ACF values. In a broader view out of 360 values 64 values are significant. So, here also maximum values i.e 296 values are non-significant and only 64 values are significant, thus accepting the randomness hypothesis.

For robustness, we have also used the Ljung-Box LB statistics which tests the combined hypothesis that all the calculated ACFs are at the same time equal to zero. The LB statistics approximates the chi-square distribution. So, if the computed LB value is greater than critical LB value, then null hypothesis would be rejected. Here the critical LB value is the chi square value at 5 % level of significance having

Table 3: ACF for the year 2020-21

Month	*No. of non-significant values*	*% of non-significant values*	*Number of Significant values*	*% of Significant values*
January	30	100	0	0
February	26	86.66	4	13.34
March	22	73.33	8	26.67
April	27	90	3	10
May	24	80	6	20
June	23	76.66	7	23.34
July	25	83.33	5	16.67
August	25	83.33	5	16.67
September	25	83.33	5	16.67
October	27	90	3	10
November	21	70	9	30
December	21	70	9	30

Source: Authors' Own Compilation

10 degrees of freedom (K=10) which is 18.307. Following tables are showing the LB values for all lags taken together for three years.

Table 4: Calculated Values of LB Statistics for the year 2018-19

Months	*Q1 values*	*Q2 values*	*Q3 values*
January	4.034	7.023	6.473
February	4.245	7.114	7.333
March	5.225	7.241	7.854
April	5.778	7.633	8.201
May	5.892	7.778	8.766
June	6.023	8.032	9.406
July	6.345	7.895	10.455
August	7.345	8.333	10.787
September	7.564	8.799	11.234
October	7.987	9.402	11.788
November	7.402	8.802	11.564
December	8.021	8.116	11.432

Source: Authors' Own Compilation

Table 5: Calculated Values of LB Statistics for the year 2019-20

Months	*Q1 values*	*Q2 values*	*Q3 values*
January	4.029	5.627	7.897
February	3.985	5.013	8.564
March	3.023	5.678	9.765
April	4.225	6.023	9.452
May	5.628	6.734	9.234
June	6.893	5.013	10.567
July	6.982	6.845	8.674
August	5.241	7.013	8.665
September	5.234	6.876	8.674
October	3.453	5.341	9.234
November	4.556	6.876	9.786
December	2.345	6.980	9.975

Source: Authors' Own Compilation

Table 6: Calculated Values of LB Statistics for the year 2020-21

January	3.002	4.287	6.397
February	2.014	4.287	9.212
March	3.002	6.676	9.054
April	4.117	3.802	8.052
May	6.423	5.605	7.033
June	2.014	4.287	7.033
July	2.014	4.287	6.241
August	4.117	2.854	8.052
September	2.014	3.802	7.033
October	3.002	5.675	8.052
November	4.261	6.247	9.607
December	4.256	6.252	9.712

Source: Authors' Own Compilation

A look at table 4, 5 & 6 i.e. for the year 2018-19, 2019-20 and 2020-21 reveal that all the computed LB values are less than that of the critical values, indicating randomness. Hence the null hypothesis that all the correlation coefficients at different lags (Lag1 – Lag10) are jointly not different from zero and hence are non-significant can be accepted. So, the evidence generated from all the above tables point to the stationarity of the time series under study. Hence the market can be categorized as one showing weak form efficiency.

6. Conclusion

To find out the state of efficiency in Indian Index Future market in the weak form, all the future contracts traded from 1st January, 2018 to 1st January, 2021 have been used for the study. The time period of the study is post financial crisis period. The index futures are chosen as they share the largest volume of derivative instruments traded in India. So, the test of efficiency would give us a general idea of market as a whole. After calculating the daily returns Auto Correlation Function (ACF) has been primarily used at lags 1 to 10. In order to test both the hypotheses (all the ACFs are simultaneously equal to 0, indicating complete randomness 0), we have used the LB- statistics developed by Ljung Box. While testing the significance level individually, we found maximum values are non-significant and thus the hypothesis of randomness is accepted. In the second phase when joint hypothesis was tested using LB statistics, all the computed values are less than critical values. So, here also null hypothesis of randomness was accepted.

In sum, after conducting all the above statistical tests we can safely conclude that Index futures are random in nature. It also indicates the series is a stationary one. We may implement the result to whole market condition and can say that the evidence produced by serial correlation test indicates that the future prices should not be a measurement tool to forecast the future price of the sample index future contracts. Hence, the Indian derivative market may be termed as weakly efficient in pricing of index futures.

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