TESTING THE WEAK-FORM EFFICIENCY OF THE FINNISH AND SWEDISH STOCK MARKETS

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ABSTRACT

The theoretical models of Efficient Market Hypothesis (EMH) imply that the future price of a stock is unpredictable with respect to currently available information. In this study, the weak form efficiency of the Finnish and Swedish stock markets has been investigated by employing a serial correlation test, an Augmented Dickey-Fuller test and a variance ratio test proposed by Lo and Mckinlay (1988) for the hypothesis that the Finnish and Swedish stock market indices follow a random walk. The tests are performed using ten years' daily the OMX Helsinki and OMX Stockholm indices data from 2003 to 2012. Daily returns are found to violate the assumption of normal distribution. Overall, the results conclude that daily prices and returns do not follow random walks in any of the two countries. This implies that both the Finnish and Swedish stock markets are not weak form efficient.
Keywords: *Efficient Market Hypothesis, Variance ratio test, Unit root test, Serial correlation test.*

1. Introduction

The Efficient Market Hypothesis (EMH) is an important concept in economics and finance because the hypothesis that the securities markets are efficient represents the basis for most research that is made in financial economics. Due to its huge implications in operations of the financial markets, it proves to be one of the well-researched areas in finance by generating interesting debate among financial researchers. Various definitions of the concept have been developed by different researchers. The efficient-market hypothesis was first developed by Professor Eugene Fama at the University Of Chicago, Booth School of Business as an academic concept through his published Ph.D. thesis in the early 1960s at the same school. He defined efficient market as one, prices of which always fully reflect available information, and suggested three models for testing market efficiency: the Fair Game model, the Random Walk model and the Martingale model. Later, in 1970, Fama published a reassessment of both the theory and the evidence for the hypothesis. The paper broadened and refined the theory, included the definitions for three forms of financial market efficiency: weak, semi-strong and strong .These forms are described here below.

The weak form EMH assumes that the current market prices will incorporate all security market information including historical sequence of prices, rates of return, trading volume data & other market generated information (Cuthbertson 2002). It is the lowest form of efficiency that defines a market as being efficient if current prices fully reflect all information contained in the historical asset prices and a trading rule based on the past prices cannot be developed to identify mispriced assets. Market is semi-strong efficient if stock prices adjust rapidly any new publicly available information (Cuthbertson 2002). Thus, the current asset prices already reflect past prices and volume information This implies that neither fundamental analysis nor technical analysis techniques will be able to reliably produce excess returns. However, Strong form efficiency contends that stock prices fully reflect all information from both public and private sources. This is because private information is quickly incorporated by market prices and, therefore, cannot be used to reap abnormal trading profit (Cuthbertson 2002). This means that even the company's management (insiders) cannot make abnormal profit from internal information they hold. The strong form EMH encompasses both the weak form EMH & semi-strong form EMH.

This study investigates the weak form efficiency of the Finnish and Swedish stock markets by using the Variance ratio test proposed by Lo and Mackinlay (1988), which is demonstrated to be more reliable and more powerful than the traditional models. A study by Berglund, Wahlroos and Ornmark (1983) on the Finnish and Scandinavian markets reveals the Finnish stock market as the most inefficient of all the markets explored. In the case of Swedish market, Frennberg and Hansson (1993) concludes that within a period of seventy-two years (1919-1990) the Swedish stock market did not follow a random walk as there were strong evidence of positive autocorrelated returns for short investment horizons.

This paper is organized as follows. Section 2 presents previous studies. Section 3 introduces the methodology used for testing market efficiency. Then Section 4 discusses the data used for the study under review, the source of the data and the descriptive statistics. Afterwards, section 5 contains an extensive discussion of the results of the tests conducted while section 6 concludes on the research work.

2. Previous Studies

The EMH is one of the well-researched theories in finance and yet is still constantly been examined due to its huge implications in the operations of financial markets. Over the years, a number of researchers have investigated the existence of the theory in various markets, and different results have been found. Jennergren and Korsvold (1974) examined the random walk hypothesis (weak form efficiency) by means of a sample of forty-five stocks traded on the Stockholm and Oslo stock exchanges and found that majority of the stocks do not follow random walk. They employed the serial correlation and the non parametric runs test. Afterwards, Wahlroos and Ornmark (1983) reported that the Finnish stock market is weak form inefficient using the autocorrelation test and the runs test. Similarly, Frennberg and Hansson (1993) investigated the Swedish stock market using monthly data samples from 1919 to 1990 and concluded that the Swedish stock market is weak form inefficient. They employed the Lo and Mackinlay (1988) variance ratio test.

In recent years, Metghalchi, Chang and Marcucci (2008) examined the profitability of some technical trading rules in the Swedish stock market using data set from 1986 to 2004 and reported that the moving average rules indeed have predictive power and could discern recurring-price pattern for profitable trading. More recent evidence on other European markets are provided by Borges (2010) who found four markets, namely UK, Greece, France and Portugal, to be weak form inefficient. Germany and Spain were, however, found to be efficient. Also, Guidi, Gupta and Maheshwari (2011) tested the weak form of the efficient market hypothesis for Central and Eastern Europe (CEE) equity markets using autocorrelation analysis, runs test and variance ratio test and find that stock markets of the C.E.E do not follow a random walk process which indicates that some of these markets are not weak-form efficient and informed investor can make abnormal profits by studying the past prices of the assets in these markets.

In the case of emerging markets, Al-Khazali, Ding and Chong Soo (2007) conclude that a correction for thin (infrequent) trading makes all of the MENA markets; Bahrain, Egypt, Jordan, Kuwait, Morocco, Oman, Saudi Arabia, and Tunisia efficient in the weak form. Even though, all the series, in their raw state rejected the random walk. Additionally, Al-Jafari (2011) focused on the random walk hypothesis by testing the weak-form efficiency of Bahrain securities market using daily observations of Bahrain all share index. The empirical results suggest that Bahrain securities market is informational inefficient at the weak-level, implying that the prudent investor will realize abnormal returns by using historical sequences of stock prices, data related to trading volumes and other market generated information.

This research work is done on the weak form efficiency of the Finnish and Swedish stock markets using the Variance ratio test proposed by Lo and Mackinlay (1988). The sufficient condition for a particular stock market to be weakly efficient is that the random walk hypothesis holds for the stocks traded in that market (Jennergren and Korsvold 1947).

3. Methodology

Market efficiency under the random walk model (weak form EMH) implies that historical prices (returns) cannot be used to predict future prices (returns) of a stock. Therefore, price movements of a stock are independently and identically distributed (Fama 1970). In the empirical framework, there are a number of techniques available to determine patterns in time series data. Under the random walk hypothesis, a market is (weak form) efficient if the most recent price has all available information and thus the best forecaster of a future price is the most recent price. This study employs the variance ratio test proposed by Lo and Mackinlay (1988). Additionally, the autocorrelation and unit root tests have been used.

*3.1*Autocorrelation Test

The Autocorrelation (serial correlation coefficient) measures the relationship between a stock return in the current period and its value in the previous period. It is the first approach in detecting the random walk. The autocorrelation of a series Y at lag k is estimated by:

$$\rho_k = \sum_{t=1}^{N-k} (r_t - \bar{r})(r_{t+k} - \bar{r}) / \sum_{t=1}^{N} (r_t - \bar{r})^2 \qquad (1)$$

where $\rho_k$is the serial correlation coefficient of stock returns of lag k; N is the number of observations; r_t is the stock return over the period t; r_{t+k} is the stock return over the period t+k; $\bar{r}$ is the sample mean of stock returns; and k is the lag of the period. The test aims to determine whether the serial correlation coefficients are significantly different from zero. Statistically, if ρ_k is significantly different from zero, then the hypothesis of weak form efficiency should be rejected.

3.2 Unit root test

Theoretically, a time series that contains a unit root are often characterized as non-stationary processes that have no tendency to return to a long-run deterministic path. The variance of the series is said to be time-dependent and goes to infinity as time evolves. Non-stationarity is a necessary condition for a random walk and therefore, in this study, the Augmented Dickey Fuller (1979) is applied to all variables to verify stationarity. The ADF test equation is specified below.

$$\Delta x_t = p_0 + \mathrm{P} x_{t-1} + \sum_{t=1}^{n} \delta_i \Delta x_{t-1} + \varepsilon_t \qquad (2)$$

The dependent variable x is the trading volume or the return. The null hypothesis for the test is that the variables are non-stationary or have a unit root.

*3.3*Variance Ratio Test

The variance ratio test of Lo and MacKinlay (1988) is based on the property that the variance of increments of a random walk X_t is linear in its data interval. It is more powerful and reliable than the Dickey-Fuller unit root test in detecting violations of spot rates from a random walk (Al-Khazali and Koumanakos 2006). The variance ratio test is based on the underlying assumption that if a series follows a random walk, then the variance of its q-period difference should be q times the variance of its one period difference. It is denoted thus:

$$Var(\mathrm{P_t} - \mathrm{P_{t-q}}) = qVar(\mathrm{P_t} - \mathrm{P_{t-1}}) \qquad (3)$$

where q is any positive integer, the variance ratio, Var(q), is then estimated as follows:

$$VR(q) = \frac{\frac{1}{q} Var(\mathrm{P_t} - \mathrm{P_{t-q}})}{Var(\mathrm{P_t} - \mathrm{P_{t-1}})} = \frac{\sigma^2(q)}{\sigma^2(1)} \qquad (4)$$

4. Data and Descriptive Statistics

The time series data used in this study comprises of daily closing prices of the main market indices of Sweden and Finland. That is, OMXS30 and OMXH25 indices respectively. The sample period is from 1st January, 2003 to 1st January, 2013 in both markets. Data were collected from the Datastream of Hanken School of Economics (Finland) and all the tests were run by the statistical software Eviews7. Returns are proxied by the log difference change in the price index. The stock return is calculated as the continuously-compounded return using the closing price:

$$R_t = \ln(P_t/P_{t-1}) \qquad (5)$$

Where R_t is the return on the Price Indicess and P_t and P_{t-1} is the price indices at times t and $t-1$.

The basic descriptive analyses of the series are presented in Table 1. Mean returns in both markets over the ten year period are positive with positive kurtosis and high Jarque-Bera (JB) statistics indicating heavily tailed distribution. However, the OMXS30 returns has skewness of 0.050 which is close to normal. The JB normality test is necessary to show whether consecutive stock returns are independent of each other. The results in Table 1 show that the returns are not normally distributed, and even in the case of the OMXH25, the return is negatively skewed. This means that the null hypothesis of normality is rejected in both markets, as the p-value for the Jarque-Bera test is zero.

Table 1: Descriptive statistics and JB normality Test

Index	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
OMXH25	0.0002	0.015	-0.142	6.758	1473.230	00000
OMXS30	0.0003	0.015	0.050	7.252	1952.96	0000

The hypotheses for the JB-test are:

H_0 = normal distribution $\qquad$ H_1 = no normal distribution

5 Empirical Results

In this section, the empirical tests conducted have been presented and analyzed. The serial correlation test, which is the first approach in detecting the random walk, is the first to be conducted and it is followed by the unit root test which is a necessary condition for a random walk. The variance ratio test which is the main empirical method employed by this study is the last to be conducted.

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5.1 Results of autocorrelation test

The results of first ten sample autocorrelation and Ljung Box statistics for return series of both Finnish and Swedish stock markets for full sample period of 2003-2012 are presented in table 2. As shown in Table 2, the test has been conducted by including ten lags of the dependent variable in the test regression. After differencing the series once, the results in both markets indicate that there is significant autocorrelation in the series. Specifically, in the OMXH25 return index, highly significant negative autocorrelation is detected at the first three lags with high Q-statistics at all lags. For higher-order autocorrelations, up to lag 10, all return series show a consistent pattern of negative autocorrelation. Positive autocorrelation indicates predictability of returns in short horizon which is the general evidence against market efficiency. On the other hand, negative autocorrelation indicates mean reversion in return suggesting that prices and returns eventually move back towards the mean or average. Additionally, the p-values are zero at all lags indicating the existence of serial correlation in the series. Almost similar results are also found in the OMXS30 return index. Along with highly negative autocorrelation in first three lags, significant autocorrelation have been found in all the ten lags. It can, therefore, be concluded that the serial correlation test rejects the null of random walk in both the Swedish and Finnish stock markets.

Table 2: Summary of Autocorrelation Test

OMXH25 (Finnish stock market)

Lags	1	2	3	4	5	6	7	8	9	10
AC	-0.480	0.000	-0.051	0.070	-0.065	0.015	-0.001	0.043	-0.046	-0.003
Q-Stat	576.46	576.46	582.91	595.25	605.71	606.27	606.27	610.92	616.21	616.22
P-value	0	0	0	0	0	0	0	0	0	0

OMXS30 (Swedish stock market)

Lags	1	2	3	4	5	6	7	8	9	10
AC	-0.491	-0.012	-0.021	0.054	-0.051	0.025	-0.008	0.003	0.006	-0.029
Q-Stat	624.31	624.67	625.82	633.52	640.40	642.03	642.20	642.22	642.31	644.55
P-value	0	0	0	0	0	0	0	0	0	0

Note: The null hypothesis is rejected at the 1% significant level, taken the first difference. Both series exhibit significant autocorrelation in the 1st, 2nd and 3rd lags with high Q-statistics. The p-values are also very significant.

5.2 Results of **unit root test**

For the test of unit root in the series, this study employs the ADF test. The rationale behind this test is to examine whether the series is stationary or non stationary (random walk). The results of these tests are summarized in Table 3. Optimal lag length for the ADF test is selected with Schwartz info criteria and maximum lag is set to 27 and the test statistics are tested using the first difference of the series. The test is conducted under two specifications. First, an intercept was allowed in the test equation and in the second instance, both intercept and trend were included in the equation. In both the OMXS30 AND OMXH25 indices, the test statistics of the ADF are less than the critical values at the 1%, 5% and 10% significant levels. Specifically, it can be concluded that the OMXS30 and the OMXH25 return series reject the random walk hypothesis, thereby implying that all the price indices examined are stationary.

Table 3: Summary of ADF Unit Root Test

Specification	t-statistics (OMXS30)	P-value (OMXS30)	t-statistics (OMXH25)	P-value (OMXH25)
27 lags, with intercept	-19.677	0	-23.491	0
27 lags, intercept and trend	-19.673	0	-23.496	0

Note: ADF critical values for OMXS30

Intercept, no trend: -3.433, -2.862, -2.567 at 1%, 5% and 10% significant levels respectively.

Intercept and trend: -3.961, -3.412, -3.128, at 1%, 5% and 10% significance respectively.

ADF critical values for OMXH25

Intercept, no trend: -3.961, -3.411, -3.127 at 1%, 5% and 10% significant levels respectively.

Intercept and trend: -3.432, -2.862, -2.567 1%, 5% and 10% significant levels respectively.

5.3 Results of Variance Ratio Test

This study runs the Lo and Mackinlay (1988) variance ratio test for the null hypotheses of homoscedasticity and heteroscedasticity increments random walk. The test has been conducted using the specified lags of 2, 4, 8 and 16. First, the examination is done under the assumption of homoscedasticity and finally, under the assumption of heteroscedasticity. The approximate p-value is obtained using the studentized maximum modulus with parameter values of 4 and infinite degrees of freedom. The test results are summarized in Table 4 and Table 5.

As shown in Table 4 and 5, the maximum Z-statistic in all of the tests are greater than 1 and are associated with the second period with p-values equal to zero. This is indicative that the random walk pattern is nonexistent in all of the series. However, the rejection of null hypothesis under Homoscedasticity could result from heteroscedasticity and/or autocorrelation in the return series. After a heteroscedasticity is calculated null hypotheses are rejected under all intervals in both the Finnish and Swedish market. It is also can be observed that variance ratios of returns on indices seem to be decreasing with days indicating some form negative autocorrelation which is consistent with previous Ljung Box statistics test results. All estimated z statistic values indicate that random walk is strongly rejected for both the Swedish and Finnish stock markets for all four intervals examined. This result is consistent with Jennergren and Korsvold (1974);Wahlroos and Ornmark (1983); Frennberg and Hansson (1993);and Metghalchi, Chang and Marcucci (2008).

Table 4: Results of Variance Ratio Test under Homoscedastic Assumptions

Period	z-statistic (OMXH25)	P-value (OMXH25)	z-statistic (OMXH25)	P-value (OMXH25)
2	-23.95327	0	-24.97716	0
4	-19.90174	0	-20.64574	0
8	-14.77434	0	-15.09242	0
16	-10.64152	0	-10.87754	0

Table 5: Results of Variance Ratio Test under Heteroscedastic Assumptions

Period	z-statistic (OMXH25)	P-value (OMXH25)	z-statistic (OMXS30)	P-value (OMXS30)
2	-13.61107	0	-13.92132	0
4	-11.99197	0	-12.25927	0
8	-9.388396	0	-9.424720	0
16	-7.026393	0	-7.053606	0

6. Conclusion

This study examines random walk hypothesis and tests the weak-form efficiency of the two major stock markets in Scandinavia namely Finnish and Swedish stock markets by using the OMX Stockholm 30 and the OMX Helsinki 25 indices collated from the period 2003 to 2012. In order to detect the random walk pattern in the series, the study employs the Lo and Mackinlay (1988) variance ratio test which is proved to be more robust in detecting patterns in time series than the traditional methods. Additionally, the autocorrelation test is used to test the data for serial dependence, which when found to be negative, can be interpretated as a rejection of the random walk. The Augmented Dickey-Fuller is also used to test for non-stationarity, which is a necessary condition for random walk.

The results of the autocorrelation test strongly reject the presence of random walks in daily returns of the OMX Stockholm 30 return index and the OMX Helsinki 25 return series. The results of the unit root test show that unit root is absent from all the return series, indicating that the both the OMXS30 and OMXH25 return series are stationary. Finally, the variance ratio test conducted under varying distributional assumptions conclusively rejects the presence of a random walk in the series. The evidence from the study, therefore, shows that the Finnish and Swedish stock markets are not efficient in the weak form.

The findings of this empirical analysis is consistent with other similar research ((Jennergren and Korsvold (1974); Wahlroos and Ornmark (1983); Frennberg and Hansson (1993); and Metghalchi, Chang and Marcucci (2008)). Moreover, Borges (2010) shows that only few of the European markets (for example: Germany, Spain) may be consistent with the efficient market theory. This presents an interesting avenue for future research as does the attempt to examine whether market efficiency improved over time in any of these two markets.

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