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An Investigation of Statistical Behaviors of the Stock Market Fluctuations in the Colombo Stock Market: ARMA & PCA Approach

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RMKTR and DMKNS designed the study, wrote the protocol, managed the analysis and wrote the first draft of the manuscript. Author ZJW finalized the manuscript for publication. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Throughout the world, Equity markets have been advanced as the main forms of investment for numerous organizations and individuals arraying large investments and funds to the general public. The nature of the stock market becomes highly volatile. The demeanor of aggregate stock prices and trade volume behaviors play a significant role in stock market fluctuations. The main goal of this study is to investigate the directions and movements of market prices and trade volume rates in Colombo Stock Exchange (CSE) during 2007 to 2012. The results reveal that both micro and macro-economic factors directly impact on market volatility. The unit root test results found that, all the sectors in the CSE are highly stationary under the 0.05 level of significance. Moreover, results forecast suggest that Bank Finance and Insurance, Beverage Food and Tobacco, and Investment Trust sectors are most suitable sectors for investing capitals over a period of

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several months in the future.

Keywords: CSE; ARMA model; PCA approach;

1. INTRODUCTION

Economic growth of a country is mainly driven by accumulation of capital. Financial systems have their biggest effect on growth through capital allocation by reducing transaction cost and information asymmetry. Many companies raise their money needed operations, expansion and restructuring by offering their shares to the general public. When the company obtains the capital needed, the shareholders will benefit through dividends paid by company.

Stock market is the place where stocks and bonds are traded. Stocks are denoted as units of ownership for investors. They are long term investments for companies as well as individuals. Day by day, many companies have been listed regularly in the stock markets and offering large number of shares to general public and raise their money needed for restructuring, expansion for the new operations. The prices of the stocks mainly depend on the financial stability of the company, turn over value, share volume and other variety of financial and economic factors.

This study mainly focus an attempt to understand the trends and cycle patterns in the Colombo Stock market (CSE) in order to predict future behaviors. Comparing other markets around the world, Colombo stock market is well organized market. However, the Sri Lankan market, through responsible only for a very small percentage in terms of the total equality trade globally, is no exception from world equity markets in term of volatility. Therefore, it is important for the investors who are investing in the Sri Lankan stock market to make investment decisions to ensure a positive return for the risk which is undertaking.

The rest of the paper is organized as follows. Section II explains about brief overview of existing solutions with pros and cons. Section III explains about proposed work with Principal component analysis. Section IV explains about experimental results and Section V ends up with conclusion and future work.

2. LITERATURE REVIEW

The trend analysis of economic time series is an important research direction. Different type of macro and micro economic conditions with Government rules and regulations, political stability directly affect the behaviors of stock market fluctuations. Miscellaneous kind of research can be found in literature.

S. Poshakwale and co-workers have done various kind of studies based on different type of stock markets. By the end of 1999, Poshakwale et al. has done a case study to evaluate the market efficiency in the Bombay Stock exchange from 1987 to 1994. Their findings suggested that Bombay market (BSE) was not in a weak form efficient. In 2007, Hoqueet.al used random walk hypothesis to compare the market efficiency in Asia. Randomly selected eight markets in Asia were used as their research sample. Furthermore, market volatility was evaluated by ARCH model. According to their findings, random walk hypothesis rejected all the stock markets except Taiwan and Korea [1].

After 1980, Multivariate statistical models have been successfully applied to solve financial problems. Kerby et.al introduced the accurate method based on multivariate statistical techniques for the highly volatile and unpredictable markets to categorize their stocks asgood or bad [2]. In 2010, Pawelet.al developed the statistical techniques to investigate the properties of short term price trends in high frequency stock market data [3,4]. The approach has been implemented successfully in WIG20 index of Warsaw Stock Exchange (WSE) between 2003 and 2006 [5,6]. The Geometric Brownian motion assumptions suggested that the behaviors of real market data deviated from the Brownian property. These findings were coincided with economic model presented by Fischer and Myron in 1973 [7,8,9].

Currently, The Clustering methods are successfully applied to solve the real world problems. A clustering efficient portfolio management model was advanced by Nanda et.al in 2010. Data mining approach with data classification techniques were successfully applied to construct the portfolio management system for Indian Stock Market [10,11,12]. Their results showed that K-means clustering model is more efficient than the other clustering methods such as SOM and FUZZY [13,14].

3. METHODOLOGY

The current study is carried out on the basis of secondary data, which were obtained from CSE, annual reports of Central Bank of Sri Lanka, annual reports of listed companies and other relevant sources. Daily trading data for five year period from January 2008 to January 2013 were extracted and tabulated to calculate the monthly returns. Daily closing price values can be converted into monthly return as follows [15].

$$R_{it}=\left(\frac{Index_{it}-Index_{i(t-1)}}{Index_{i(t-1)}}\right)\times 100 \tag{1}$$

Where; R_{it} denote the market return index, $Index_{it}$ denote the index value at time t on the sectori and $Index_{i(t-1)}$ denote the index value at time t -1 on sector i respectively.

The methodology can be described as follows. In the First part of the research, Principal Component Analysis (PCA) is used to identify the similar behavioral groups, relationship between macro-economic variables and stock market validations. Various kinds of macro and micro economic variables, which are affecting the stock market fluctuations, are used. They are; GDP rates (GDPL), inflation rates (IF), unemployment rates (UR), Annual stock prices, consumer spending rates, crude oil important rates (COR- US Dollar Billions), Average consumer Spending (ASC), Government Revenue (GR) and Total investment Percent of GDP (INGDP), Gross income (GI), Net revenue and net as value per share (NPS) [17,18].

In the second part of this research, market validations were discussed using the 20 sector indexes data taken from the CSE. They are; Oil palms (OIL), Plantation(PLT), Motors(MTR), Manufacturing(MFG), land and property(L&P), Telecommunication (TLE), Stores supplies(S&S), Trading (TRD), Plantation(PLT), Services(SRV), Power and energy(P&E), Investment trust(INV), Hotels and Travels(H&T), Heath care(HLT), Footwear and textile(F&T), Information technology(IT), Diversified Holdings(DIV), Construction and

engineering(C&E), Chemicals and Pharmaceuticals(C&P), Beverage food and tobacco(BFT), Bank and finance and insurance (BFI).

3.1 Principal Component Analysis (PCA)

Principal Component Analysis is a common technique for finding patterns in data of high dimensions. It is a variable transformation technique which is having a combination of mathematical and statistical concepts. As a first step, check the normality using the Kolmogorov-Smirnov test under the 0.05 level of significance. If the variables which do not appear to be normal, it can be transformed in order to reach normality by using the log function or square root functions. After that PCA will be applied to find the patterns in data of high dimension. It reduces the dimensionality of the data set by linearly combing the original correlated variables into new variables, some of which are ignored. The new variables are linear independent of the one other whereas the original variables may have been dependent.

3.2 Stationary/Non Stationary Time Series Models

Financial time series plays a significant role in the financial data analysis such as economic forecasting and stock market predictions. As a first step of the economic time series, it is important to test series is stationary or not. In the statistics, two statistical methods are mainly used to measure the stationary and non-stationary demeanor of the return series. They are; Augmented Dickey – Fuller Test (ADF) and Phillips Perron Test (P-P). If the return series is not stationary, then different techniques such as 1st and 2nd differences were used to make the stationary series.

3.3 Accumulation and Test of Row Series: ARMA Model

ARMA models often used to discuss the behaviors in stationary data patterns. It is generally written as ARMA (p, q), where p and q represent the order of auto regressive process (AR (p)) and moving average process (MA (q)) respectively (Gujarati et al, 2010). The moving average process can be written as;

$$X_t = z_t + \theta_1 z_{t-1} + \theta_2 z_{t-2} + \cdots + \theta_q z_{t-q} \tag{2}$$

Furthermore, the auto regressive process can be written as;

$$X_t = \vartheta_1 x_{t-1} + \vartheta_2 x_{t-2} + \cdots + \vartheta_p x_{t-p} + z_t \tag{3}$$

Where; $z_t \sim WN(0, \sigma^2)$ and $\theta_1, \theta_2, \ldots, \theta_n, \vartheta_1, \vartheta_2, \ldots, \vartheta_n, \vartheta_1, \vartheta_2, \ldots, \vartheta_n$ are constants. ARMA (p,q) can be written as;

$$\vartheta(B) X_t = \theta(B) Z_t \tag{4}$$

Where; $\vartheta(z) = 1 - \vartheta_1 z - \cdots - \vartheta_p z^p$ and $\theta(z) = 1 + \theta_1 z + \cdots + \theta_q z^q$.

4. RESULTS AND DISCUSSION

There were 234, 258 and 283 companies listed in CSE in 2010, 2011 and 2012 respectively. Plots of the monthly returns are given in the Fig.1. It is impossible to see any patterns andtrends in stock returns and spot any groups of stocks that exhibit similar behavior by examining the plots.

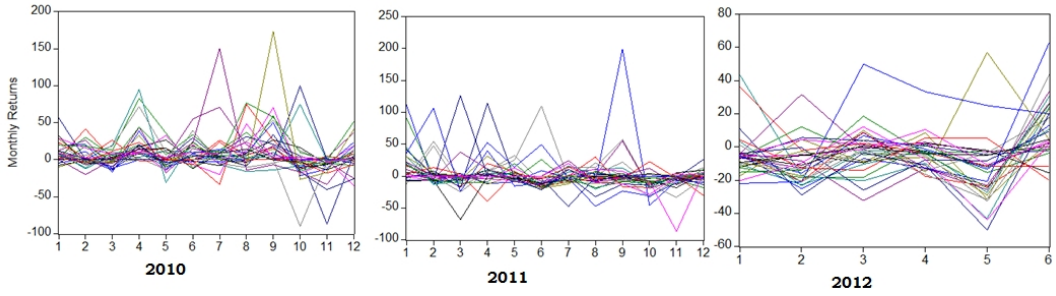

Fig. 1. Plots of the monthly returns
Source: CSE Annual Data -2010/2012.

The Fig. 1 (2010 plot) clearly shows that the first quarter of the year has shown flat returns close to zero. However, only a very few stocks display some positive and negative variation in the second half of the year.

In contrast to the previous years, stock returns have been highly volatile after the December, 2010. Data patterns clearly suggest that price returns move up and down with highly volatile fluctuations in 2011 and 2012. Specially, in the first half in 2011, price return fluctuates with high volatile fluctuations.

Because of this reasons, it is not possible to identify all groups of stocks by examining the Figure shown above. Moreover, the complexity of the covariance matrix makes it difficult to spot any correlations among stocks by examining the covariance matrix. So that, next step was to perform a PCA on the data for year 2012 in order to find any groups of stocks that exhibit similar patterns in returns based on 2010, 2011 results.

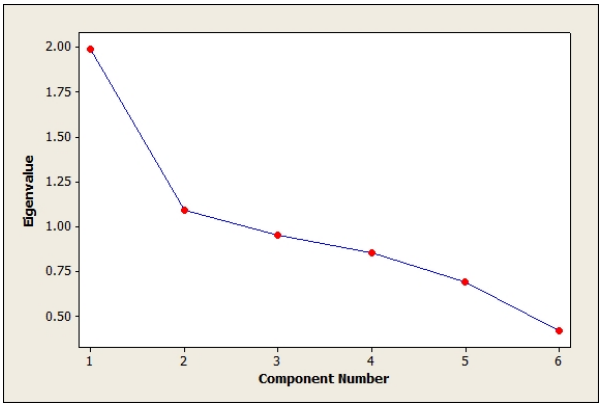

Fig. 2. Proportion of variation explained by each component-2012

Source: CSE Annual Data -2010/2012.

The eigenvalues of the covariance matrix and the proportion of variations explained by each principal component corresponding to each eigenvalues are given in the Table 1.

Table 1. Eigenvalues of the covariance matrix - 2012

Component number	1	2	3	4	5
Eigenvalue	135.51	36.33	34.10	26.32	23.74
Proportion	0.529	0.142	0.133	0.103	0.093
Cumulative Percentage	52.9	67.1	80.4	90.7	100.0

Table 1 indicates that the first three components collectively explain 80.4% of the total variation in the original data set. Furthermore, Fig. 2 results suggested that, the drop in the proportion of variation explained by each principal component is not significant when component moving from third to fourth. Hence up to three components will be considered for the further analysis.

Table 2. Most significant stocks- 2012

PC1	BOGA, CHMX , GRAN, LGL, LOLC, RHTL, BLUE, ECL, EMER, FLCH, GHLL, LALU, LMF, DCSL, CF, CARG, SAMPH, RCL, JKH, CLPL, LVEN, MBSL , ESL, PCL, SIGV
PC2	**GREG, COMB, SPEN, DCSL, CF**, CARG, **SAMPH, RCL, JKH**, CLPL, **DFCC, NDB, HNB, RCL, BOGA**, CHMX, GRAN**, CLDC, VONE, REXP, CFAB, VONE**

When the dataset was again projected, the number of components needed to adequately explain the total variation in the data set can be reduced. The most significant stocks included in each principal component of the projected data set are given in Table 2.

4.1 Multivariate Statistical Analysis: PCA Approach

In the next step, based on our PCA results most significant macro and micro economic variables related to the top level company were selected for our further analysis. Kolmogorov-Smirnov test and Anderson-Darling test results shows that selected variables are deviated with normality (net revenue (0.0031), Net profit (0.0002) and Net assets value per ordinary share (0.0001)). Log transformation is applied for the transform skewed data into normal. Equation 1 shows the PCA results.

PC= 0.34GDPL+0.34 UR + 0.19 Log (ACS) - 0.043 COR- 0.128 Log (GR) +0.002 INGDP - 0.427GNSP-0.286 Log(IF) +0.356 (ASPL G) + 0.506 Log (ASPL) +0.293 Log (NPS) (5)

Equation 5 suggests that Net revenue, Gross values, Crude oil imports rates, inflation rates of the country and gross national servings are the most significant variables which are directly affecting the stock prices movements. Furthermore, results suggest that not only macro variables but also the micro variables influence to the market movements.

Fig. 3, clearly shows that data points has appeared to be with three data patterns in the periods 2002-2005, 2006-2008 and 2009-2011. There were many political and economic reasons that directly involved changing these patterns. For example, after end of the civil war in the north part of the country on 18th May 2009, Colombo Stock indices were increased

rapidly with high fluctuations. As a result end of the October in 2009; market capitalization reached over one trillion Sri Lankan Rupees for the first time of the CSE history. Moreover ASPI (3549.27) and MPI (4214.8) also come to their highest points on the 11th January 2010. Because of these performances, it become a best performing stock exchange in the world in 2009 with 125.2 present of positive jumped compared with 2008.

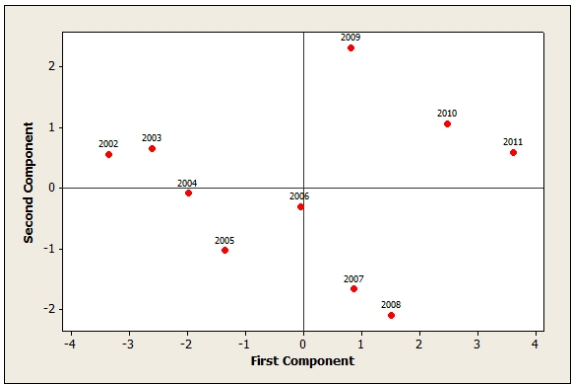

Fig. 3. PC Representation of individuals
Source: CSE Annual Data -2010/2012.

4.2 Sector Vice Data Analysisusing ARMA Model

In this part we have done comparative study to identify the market validations using the 20 sector indexes represented from the CSE. According to the unit root test results, all the sectors in CSE significantly accept the alternative hypothesis under the 0.05 level of significance. Hence, all the sectors of CSE have stationary under the levels. Based on these results, we can suggest that ARMA model is suitable model for predicting future results.

Table 3. Eigenvalues of the covariance matrix - 2012

Sec	Fitted model	Error =(Res. S)/N	Sec	Fitted model	Error= (Res.S)/N
ASPI	ARMA (1,1)	.0055	IT	ARMA (0,1)	.1337
MPI	ARMA (1,1)	.0063	**L&P**	ARMA (0,1)	.0014
BFI	ARMA (0,4)	.0085	**MFG**	ARMA (1,1)	.0054
BFT	ARMA (0,4)	.0085	MTR	ARMA (1,0)	.0143
C&P	ARMA (0,1)	.0106	OIL	ARMA (1,4)	.0167
C&E	ARMA (1,1)	.0097	PLT	ARMA (1,5)	.0127
DIV	ARMA (1,0)	.0001	**P&E**	ARMA (0,1)	.0089
F&T	ARMA (2,2)	.0068	SRV	ARMA (1,2)	.0114
HLT	ARMA (2,2)	.0048	S&S	ARMA (1,1)	.0217
H&T	ARMA (4,0)	.0076	TLE	ARMA (1,0)	.0042
INV	ARMA (1,0)	.0096	**TRD**	ARMA (1,0)	.0074

According to Table 3 results, ARMA (1,1) model is best fitted model for the ASPI, MPI, C&E, MFG and S&S sections and ARMA (1, 0) model is suitable for DIV, INV, MTR, TLE and TRD sections. Moreover, C&P, L&P, and P&E sectors fitted with ARMA (0, 1). Comparing

with others the sector C&P, IT, MTR, OIL, PLT and S&S error values significantly higher than other sectors.

5. CONCLUSION

The study sheds light on economic relationships between macro-economic variables that affect to the market fluctuations with respect to the Colombo stock exchange. Multivariate statistical techniques were widely applied to predict the future results under different types of stationary and non-stationary conditions.

Stocks from the Manufacturing(MFG), Hotels and Travels(H&T), Beverage food and tobacco(BFT), Plantation(PLT), Information technology(IT), Telecommunication (TLE), Oil palms(OIL) and Bank and finance and insurance (BFI) are important in explaining the variations in the CSE. Moreover, Principal component results suggest that GDP rates, inflation and consumer spending rates directly involve changing stock market prices and trade volume rates in the Colombo Stock exchange. Furthermore, our results indicated that political situation and political stability of the country also directly affect the market fluctuations. Many economic and political changes have happened during our sample period. Study results clearly shows that by the end of the civil war in the north part of the country in 2009, the Colombo Stock indices were increased rapidly with high fluctuations.

Moreover, results suggested that, ARMA (1,1) model is best fitted model for the ASPI, MPI, Construction and engineering(C&E), Manufacturing(MFG) and Stores supplies(S&S) sections and ARMA (1, 0) model is suitable for Diversified Holdings(DIV), Investment trust(INV), Motors(MTR), Telecommunication (TLE) and Trading (TRD) sections. Moreover, Chemicals and Pharmaceuticals(C&P), land and property(L&P) and Power and energy(P&E) sectors fitted with ARMA (0, 1).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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