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Covariance Structure of Sri Lankan Share Market Returns

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Abstract: **Covariance measures the dependence between two or more random variables. Stock market is a population consist mutually exclusive subsets (business sectors). Elements within these subsets are homogeneous in nature of business and heterogeneous between subsets. These sub sets or elements of the sub sets are not independent. Therefore occurrence or non occurrence of one event may depend on the others. This study focused on identifying the covariance structure of the Sri Lankan share market and making use it for forecasting returns. Covariance between individual company returns, sector returns and total market returns were studied and regression analysis was conducted between variables with significant relationships.**

Keywords: **Covariance, correlation, homogeneous, heterogeneous, independent, mutually exclusive.**

I. INTRODUCTION

Covariance and correlation measure a certain kind of dependence between two or more random variables. The sign of the covariance or correlation shows the tendency in the linear relationship between two variables. Both covariance and correlation indicate whether variables are directly or inversely related. Correlation also tells the degree to which the variables tend to move together (John, 2003).

Covariance plays a key role in financial economics. In financial markets covariance is a measure of the degree to which returns on two or more risky assets move in tandem. A positive covariance means that asset returns move together. A negative covariance means returns move inversely. For example, if stock X's return is high whenever stock Y's return is high and the same can be said for low returns, then these stocks are said to have a positive covariance. A portfolio is a combination of individual assets or securities. If an investor wants a portfolio whose assets have diversified earnings, he or she should pick financial assets that have low covariance to each other.

Study of Markovitz (1952) was the first study based on portfolio selections by covariance structure of assets or securities. Markowitz (1952) method was extended by Tobin (1958), Treynor (1961), Sharpe (1964), Lintner (1965), Mossin (1966), Black (1972) and many others. Their combined output is known as Capital Asset Pricing Model (CAPM) which is given by the formula;

$$E(R_i) = R_f + \beta_i (R_M - R_f) \quad (1)$$

Where; E (R_i)= Expected return of i^{th} company security,

$$\beta_i = \frac{Cov(R_i, R_M)}{\sigma_M^2} \quad (2)$$

R_M = Total market return , R_f = Return of risk free asset.

CAPM is based on the assumption that there exist a linear relationship between expected return and its market (risk). It is the mostly used model in financial markets. But it has been subject to large number of arguments in past few decades. This was first argued by Banz (1981). Introducing the size effect for the explanation of returns, he has found that average returns of stocks are negatively related to the market equity (ME). Fama and James (1973) have found that CAPM was hold for pre – 1969 period, but not afterwards. Another contradiction of CAPM model was the positive relationship between average return and the leverage found by Bhandari (1988). He has found that risk (β), market equity and leverage together explain average returns better. These authors and many others have given evidence that risk itself cannot explain returns of individual securities, portfolio returns as well as total market returns.

Forecasting returns in Sri Lankan stock market has been based on CAPM. But Nimal (1997), Samarakoon (1997) and Konarasinghe & Abeynayake (2014) have pointed out the incapability of CAPM in Sri Lankan context.

Problem Statement:

Stock market is a population, divided into number of subsets (sectors). For example, Colombo Stock Exchange (CSE) has 20 sectors namely; Bank Finance and Insurance, Telecommunication, Hotels and Travels etc. These subsets are defined in a way that they are mutually exclusive and elements of these subsets (listed companies of these sectors) are homogeneous in nature of business. But these sets or elements of the sets are not independent. Therefore occurrence or non occurrence of one event has to be dependent on the others. In other words, returns of single securities, returns of sectors and returns of total market may be covariate and have joint probability distributions. Therefore incapability of covariance in explaining the expected returns can be hardly believed. Even though CAPM fails in forecasting stock returns, Markovitz (1959) application of covariance in forecasting returns cannot be easily neglected.

This study was focused on identifying the covariance structure of Sri Lankan share market. Objectives of the study were;

i. Identification of the covariance between sector returns and total market returns.

ii. Identification of the covariance between individual security returns and total market returns.

iii. Identification of the covariance between individual security returns and corresponding sector returns.

iv. Forecasting sector returns and individual company (security) returns.

Significance of the study:

Share trading is an important part of the economy of a country. From the point of view of economy in general, a healthy stock market has been considered indispensable for economic growth and is expected to contribute to improvement in productivity.

Forecasting share prices or share returns is innumerable importance to the investors. As such a healthy forecasting technique plays a vital role in a share market. But it has happened for the Sri Lankan stock market to depend on unreliable forecasting technique due to lack of knowledge. Therefore this study which aims for filling the existing knowledge gap and finding the new knowledge is highly important to Sri Lankan share market as well as the others.

II. METHODOLOGY

Suppose that X and Y are real-valued, jointly distributed random variables with means E (*X*), E (*Y*) and variances var (*X*), var (*Y*), respectively, then covariance between X and Y are defined as;

$$Cov(XY) = E[X - E(X)][Y - E(Y)] \quad (1)$$

For a population of size N covariance can be written as $Cov(X,Y) = \frac{\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})}{N}$ (2)

And for samples of size n, it is given as; $Cov(X,Y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1}$ (3)

In the special case when X=Y,

$$Cov(X,X)=\frac{\sum_{i=1}^{N}(x_i-\bar{x})^2}{N}=\sigma_x^2 \quad (4)$$

Where σ^2 is the population variance and $Cov(X,X)=\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}=\hat{\sigma}_x^2$ (5)

Is the sample variance

Correlation is a scaled version of covariance. Correlation between X and Y defined as;

$$Cor(X,Y)=\frac{Cov(X,Y)}{\sqrt{Var(X).Var(Y)}} \quad (6)$$

(Stephen, 1998), (Kapur & Saxena, 2003).

It was intended to find the covariance structure of Sri Lankan share market in three stages; identification of covariance between sector returns and total market returns, identification of covariance between individual company returns and total market, identification of covariance between individual company returns and corresponding sector returns. Also it was attempted to forecast sector returns on total market returns, forecast individual company returns on total market returns and forecast individual company returns on sector returns.

Hypotheses tested in the study were;

Hypothesis 1

H_0: There is no association between sector returns and total market returns.

H_1: There is an association between sector returns and total market returns.

Hypothesis 2

H_0: There is no association between individual company returns and total market returns.

H_1: There is an association between individual company returns and total market returns.

Hypothesis 3

H_0: There is no association between individual company returns and sector returns.

H_1: There is an association between individual company returns and sector returns.

Listed companies of Colombo Stock Exchange (CSE) in year 2011 were the population of study. The population consist 20 business sectors. They were; Plantation (PLT), Oil palms (OIL), Land and Property (L&P), Motors (MTR), Manufacturing (MFG), Telecommunication (TLE), Stores supplies (S&S), Trading (TRD), 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, Finance and Insurance (BFI).

Monthly All Share Price Index (ASPI) and Sector indices data from year 2003 to 2011 were obtained from CSE data library. Monthly returns of all twenty business sectors of sectors (R_s) were calculated by the formula;

$$R_S=\left(\frac{I_t-I_{t-1}}{I_{t-1}}\right).100 \quad (7)$$

Where; I_t is the sector index of the month t.

Total Market Return on month t, ($R_{m,}$) was calculated by; $R_m=\left(\frac{ASPI_t-ASPI_{t-1}}{ASPI_{t-1}}\right).100$ (8)

Where; ASPI is All Share Price Index on month t.

Firstly, covariance structure of sector returns and total market were studied. Secondly a random sample of five sectors was selected and their returns were regressed on total market returns. Then a random sample of 15 companies was selected, representing seven business sectors of CSE. Covariance and correlation between individual company returns and total market returns, covariance and correlation between individual company returns and sector returns were studied. Hence individual company returns were regressed sector returns. Two thirds of the data sets were used for model fitting and the rest of the data were used for model validation.

STATISTICAL MODELS AND TECHNIQUES USED IN THE STUDY:

Generalized Linear Models have been tested in the study. Histogram of residuals, Normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test was used to test the normality of residuals. Forecasting ability of the models was assessed by Adjusted R^2 and two absolute measures of errors, Mean Square Error (MSE) and Mean Absolute Deviation (MAD). Graphs of actual values Vs fitted values and actual values Vs forecasted values also obtained for visual representation of the forecasting ability of the models.

Generalized Linear Models:

Simple Regression model which has been tested in the study is a Generalized Linear Model (GLM). GLM's are a large class of statistical models for relating responses to linear combinations of predictor variables, including many commonly encountered types of dependent variables and error structures as special cases. The development of GLMs is based upon the Exponential family of distributions and they are based on the assumption that a random variable Y_i identically independently distributed, that is,

$$Y_i \sim iid(\mu, \sigma^2)$$

A simplest generalized linear model is the Linear Regression model , $Y = \alpha + \beta X + \varepsilon$ (9)

where Y is the dependent variable, X is the independent variable, β is the regression coefficient or parameter and ε is a white noise, $\varepsilon \sim N(0, \sigma^2)$.

Goodness of Fit Tests:

The goodness of fit of a statistical model describes how well it fits a set of observations. Measures of goodness of fit typically summarize the discrepancy between observed values and the values expected under the model in question. Residual plots; Histogram of residuals, Normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test is used for normality of residuals.

Measurements of Forecasting Errors:

Forecasting is a part of a larger process of planning, controlling and/ or optimization. Forecast is a point estimate, interval estimate or a probability estimate. One of the fundamental assumptions of statistical forecasting methods is that an actual value consists of forecast plus error; In other words, "Error = Actual value – Forecast". This error component is known as the residual. A good forecasting model should have a mean error of zero because it should over forecast and under forecast approximately the same (Stephen, 1998).

Measuring errors is vital in forecasting process. Measurements of errors are divided into two parts as absolute measures of errors and relative measures of errors.

III. FINDINGS

Data analysis consists five parts;

i. Identification of covariance between sector returns and total market returns.

ii. Model fitting for sector returns on total market returns.

iii. Identification of covariance between individual company returns and total market returns.

iv. Identification of covariance between individual company returns and sector returns.

v. Model fitting for individual company returns on sector returns.

Data analysis was done by statistical software MINITAB.

IDENTIFICATION OF COVARIANCE BETWEEN SECTOR RETURNS AND TOTAL MARKET RETURNS

Covariance and correlation analysis was conducted between sector returns of CSE and total market returns. Summary of outputs given in Table I;

TABLE I: COVARIANCE AND CORRELATION BETWEEN SECTOR RETURNS AND TOTAL MARKET RETURNS

Sector	Covariance between Sector Returns and Total Market Return	Pearson Correlation between Sector Returns and Total Market Return	P value of correlation (α= 0.05)
PLT	28.53	0.622	0.000
OIL	3.93	0.497	0.000
L&P	38.60	0.731	0.000
MTR	33.83	0.648	0.000
MFG	41.23	0.833	0.000
TLE	58.65	0.719	0.000
S&S	41.04	0.386	0.000
TRD	76.52	0.745	0.000
SRV	66.85	0.666	0.000
P&E	35.04	0.421	0.000
INV	88.86	0.631	0.000
H&T	73.65	0.757	0.000
HLT	36.33	0.534	0.000
F&T	60.10	0.620	0.000
IT	64.46	0.392	0.000
DIV	38.39	0.897	0.000
C&E	50.13	0.611	0.000
C&P	66.57	0.792	0.000
BFT	50.65	0.877	0.000
BFI	68.44	0.907	0.000

Returns of all twenty sectors were positively covariate and correlate with returns of total market. It means sector returns increase with increasing total market returns and sector returns decrease with decreasing total market returns. P values of correlations were obtained to test the significance of the association between sector returns and total market return. If p value of correlation analysis is less than the significance level, it confirms the significance of the association between two

variables. In Table I, all the p values were less than the significance level (α=0.05), indicated the significant correlation between sector returns and total market return.

MODEL FITTING FOR SECTOR RETURNS ON TOTAL MARKET RETURNS:

Random sample of five business sectors were selected for model fitting. Box plots were obtained to identify the outliers of the data sets. Outliers are the extremely large or extremely small values of data sets which mislead the data analysis. Therefore outliers were removed before model fitting. For example; Figure 1 is the Box-plot for returns of sector PLT and data points marked with asterisks are the outliers.

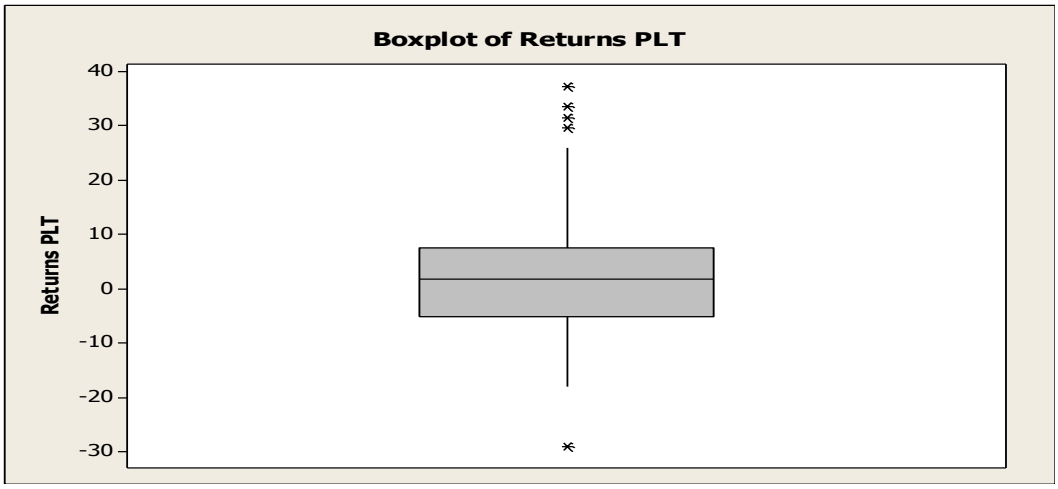

Figure i: box-plot of returns-plt

Two thirds of the data sets were used for model fitting and rest of the data for model verification. Sector returns were regressed on total market returns and Table II is the summary of outputs.

TABLE II: SUMMARY OF REGRESSION ANALYSIS

Model	Adjusted R^2	P value of regression	Model Fitting		Model Verification		P value of Anderson Darling Test
			MSE	MAD	MSE	MAD	
$R_{PLT} = 0.591 + 0.845R_m$	37.7	0.00	37.5	4.3	46.7	5.8	<0.005
$R_{L\&P} = -0.585 + 1.01R_m$	53.9	0.00	30.5	4.1	32.0	4.2	0.137
$R_{MFG} = 0.33 + 0.742R_m$	68.7	0.00	12.5	2.7	17.2	3.3	0.305
$R_{MTR} = 1.2 + 0.826R_m$	43.2	0.00	32.8	4.5	38.8	4.9	0.177
$R_{DIV} = -0.085 + 1.04R_m$	78.9	0.00	10.1	2.6	7.9	2.2	0.911

If p value of a regression model is less than the significance level, it can be concluded that there exist a liner relationship between variables of the simple linear regression model. In Table 3, p values of all the regression models were less than significance level (0.05); confirmed the linear relationship between sector returns and total market returns of all the models.

The goodness of fit of a statistical model describes how well it fits a set of observations. Measures of goodness of fit typically summarize the discrepancy between observed values and the values expected under the model in question. Residual plots; Histogram of residuals, Normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test was used for normality of residuals. For example, Figure 2 is the residual plots of model $R_{PLT} = 0.591 + 0.845R_m$ (20)

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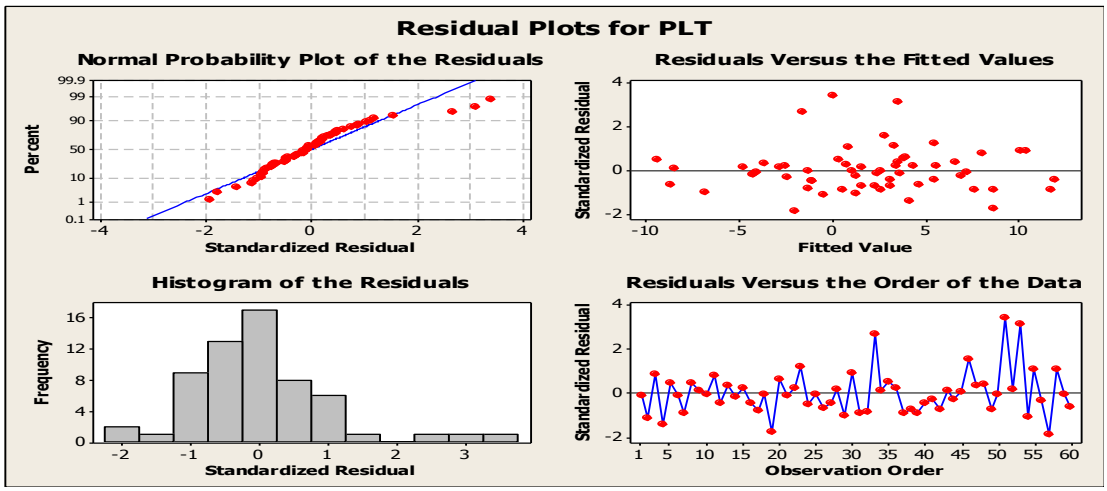

Figure ii: residual plots for plt

In Normal Probability Plot of Residuals, some points were not on a straight line. Long tail to the right of Histogram of Residuals suggests skewness in residuals. Also p value of Anderson Darling test was lower than the significance level (0.05). Therefore it was concluded that the residuals of the model (20) are not normally distributed. Plot of Residual Vs Fitted Values did not show any pattern and they lie on both sides of zero. It confirmed that residuals are uncorrelated (random).

Same procedure was repeated for other models and found that; residuals were normally distributed in four of the five fitted models; residuals were random in models for PLT, DIV and not random in models for L&P, MFG, MTR. MAD were low in model fitting as well as model verification in all five cases but MSE were quite high. Adjusted R^2 were not satisfactory except the fitted model of sector DIV. Therefore forecasting sector returns on total market returns may not be very reliable.

IDENTIFICATION OF COVARIANCE BETWEEN INDIVIDUAL COMPANY RETURNS AND TOTAL MARKET RETURNS

Random sample of twelve companies were selected and covariance and Pearson's correlation coefficients were obtained for returns of individual companies and total market returns. Table III is the summary of outputs.

TABLE III: COVARIANCE AND CORRELATION BETWEEN INDIVIDUAL COMPANY RETURNS AND TOTAL MARKET RETURNS

Company	Covariance	Pearson Correlation	P value of correlation (α= 0.05)
COMBANK	-1.82	-0.037	0.623
DFCC	-3.57	-0.068	0.357
HNB	-1.63	-0.05	0.521
AGAL	1.86	0.474	0.000
BOGAW	1.52	0.325	0.004
WATA	2.26	0.525	0.000
PEGASUS	1.97	0.438	0.000
TRANS ASIA	1.67	0.372	0.001
CLND	-4.39	-0.068	0.544
KELSEY	-0.380	-0.030	0.776
TWOD	-0.572	-0.085	0.460
KELANI	0.14	0.02	0.846
SUGAR	0.16	0.029	0.778
DIALOG	0.34	0.007	0.995
DISTILLER	7.25	0.124	0.266

Results in Table III clearly show that covariance between individual company returns and total market returns were very low. Returns of COMBANK, DFCC, HNB, CLND, KELSEY and TWOD were negatively covariate with total market returns. It means returns of these companies' decreases with increasing total market returns and vice versa. Correlation between returns of only five companies; AGAL, BOGAW, WATA, PEGASUS and TRANS ASIA were significant with returns of total market. Therefore individual company returns were not regressed on total market returns.

IDENTIFICATION OF COVARIANCE BETWEEN INDIVIDUAL COMPANY RETURNS AND SECTOR RETURNS:

Random sample of seven business sectors of CSE was selected and sample of few companies were selected from each sector, based on its size. Covariance and Pearson's correlation coefficients were obtained for returns of individual company and returns of sector, given in Table IV;

TABLE IV: SUMMARY OF COVARIANCE AND CORRELATION ANALYSIS BETWEEN INDIVIDUAL COMPANY AND SECTOR RETURNS

Sector	Company	Covariance	Pearson correlation coefficient	P value of correlation (α= 0.05)
BFI	COMBANK	38.2	0.773	0.000
	DFCC	40.99	0.819	0.000
	HNB	10.38	0.253	0.001
PLT	AGAL	3.73	0.722	0.000
	BOGAW	3.00	0.541	0.000
	WATA	3.19	0.614	0.000
H&T	PEGASUS	2.48	0.498	0.000
	TRANS ASIA	2.76	0.529	0.000
L&P	CLND	7.22	0.104	0.353*
	KELSEY	6.81	0.493	0.000
	TWOD	3.58	0.556	0.000
MFG	KELANI	3.22	0.535	0.000
	SUGAR	2.37	0.519	0.000
TELECOM	DIALOG	17.53	0.482	0.000
BFT	DISTILLER	12.37	0.308	0.005

Returns of all the companies were positively covariate with returns of corresponding sector. It means individual company returns increase with increasing sector returns and decrease with decreasing sector returns. Except in CLND, p values of correlation analysis were less than the significance level (α=0.05).It confirms the significant correlation between individual company returns and corresponding sector returns. Therefore individual company returns were modeled on their sector returns.

MODEL FITTING FOR INDIVIDUAL COMPANY RETURNS ON SECTOR RETURNS:

Returns of all the companies in Table 4 were modeled on corresponding sector returns. Outliers were removed from data sets and two thirds of the data sets were used for model fitting and rest of the data for model verification. Table 5 is the summary of outputs.

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TABLE V: FORECASTING INDIVIDUAL COMPANY RETURNS ON SECTOR RETURNS

Model	Adjusted R^2	P value of regression	Model Fitting		Model Verification		P value of Anderson Darling Test
			MSE	MAD	MSE	MAD	
$R_{COMBANK} = 0.06 + 0.88R_{BFI}$	56	0.00	25.4	3.4	19.6	2.9	0.05
$R_{DFCC} = -1.05 + 1.11R_{BFI}$	68.9	0.00	20.1	3.2	26.6	3.6	0.02
$R_{HNB} = 0.66 + 0.47R_{BFI}$	20.6	0.00	43.4	5.4	29.4	4.6	0.36
$R_{AGAL} = -0.13 + 0.06R_{PLT}$	63	0.00	0.23	0.4	0.16	0.3	0.22
$R_{BOGAW} = -0.08 + 0.06R_{PLT}$	35.2	0.00	0.35	0.4	0.41	0.4	0.42
$R_{WATA} = 0.14 + 0.05R_{PLT}$	36.6	0.00	0.24	0.3	0.39	0.4	0.31
$R_{PEGAS} = -0.08 + 0.03R_{H\&T}$	11.8	0.05	0.58	0.6	0.21	0.3	0.03
$R_{TRANS} = 0.06 + 0.05R_{H\&T}$	25.5	0.00	0.42	0.5	0.25	0.3	0.72
$R_{KELSEY} = 0.34 + 0.93R_{L\&P}$	23.2	0.00	63.8	6.1	55.9	6.0	<0.005
$R_{TWOD} = 0.04 + 0.05R_{L\&P}$	33	0.00	0.37	0.4	0.47	0.5	0.02
$R_{KELANI} = 0.03 + 0.06R_{MFG}$	42	0.00	0.68	0.6	0.22	0.3	0.33
$R_{SUGAR} = 0.03 + 0.06R_{MFG}$	30.2	0.00	0.33	0.4	0.31	0.4	0.01
$R_{DIALOG} = -1.09 + 0.39R_{TELECOM}$	19.8	0.00	26.3	4.4	20.0	3.8	0.09
$R_{DISTILLER} = 0.92 + 0.40R_{BFT}$	8.4	0.00	54.3	5.8	27.6	4.2	0.07

P-values of all the fitted linear regression models were significant; confirmed the linear relationship between individual company returns and sector returns. Histogram of residuals, Normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test was used for normality of residuals. Residuals were normally distributed in nine models and not normally distributed in six models; COMBANK, DFCC, PEGASUS, KELSEY, TWOD and SUGAR. Residuals were independent in majority of the cases. MAD's were very low in model fitting and model verification of all the models. MSE's also not high in many cases. Therefore forecasting individual company returns on sector returns is reliable.

IV. CONCLUSION

This study aimed to find the covariance structure of Sri Lankan share market and forecast share returns based on covariance. It was concluded that individual company returns, sector returns and total market returns were covariate. Also it was concluded that individual company returns were directly related to the corresponding sector returns. Individual company returns can be successfully forecasted by corresponding sector returns.

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