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DYNAMIC RELATIONS BETWEEN MACROECONOMIC VARIABLES AND THE STOCK MARKET INDEX: EVIDENCE FROM SRI LANKA

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ABSTRACT

This study examines whether the performance of Colombo Stock Exchange(CSE), as measured by the All Share Price Index (ASPI), is affected by a set of macroeconomic variables namely, Interest rate, Broad money supply, Index of Industrial Production and Inflation by using quarterly data from 2004:Q1 to 2016:Q3. The Vector Autoregressive (VAR) framework was adopted by initially looking at the long run and short run relationship between stock market and the macroeconomic variables via the Johansen cointegration technique. To further explore the dynamic co-movement among the variables and the adjustment process towards the long run equilibrium, vector error-correction model (VECM) was used. Finally, Impulse Response Function (IRF) and Variance Decomposition (VDC) were employed in order to illustrate the importance of each macroeconomic variable to the stock market movement when a shock is imposed to the system. The analysis reveals that macroeconomic variables and the stock market index are co-integrated and, hence, a long-run equilibrium relationship exists between them. It is observed that the stock prices positively relate to the industrial production but negatively relate to inflationin the long run. The interest rate and money supply are found to be insignificant in determining stock prices in the long run. The results showed that both inflation and money supply significantly and inversely affect stock return in the short run. Furthermore, based on the results of impulse response function and variance decomposition analysis, it is confirmed that that stock market *index has stronger dynamic relationship with industrial production index and inflation as compared to money supply and interest rate. Therefore Central Bank of Sri Lanka must undertake pragmatic policies aimed at controlling inflation within acceptable limits, since inflation is seen to inversely affect stock return.*

Key Words: All Share Price Index, Causality, Cointegration, Macroeconomic, VAR

INTRODUCTION

The interaction of share returns and the macroeconomic variables has been a subject of interest among academics and practitioners over the past few decades. It is often argued that stock prices are determined by some fundamental macroeconomic variables. The critical importance of the relationship of share returns and the macroeconomic variables has attracted attention of policy makers, investment analysts and economists as well. Stock exchange performance has attained significant role in global economics and financial markets, due to their impact on corporate finance and economic activities [9].

Investigations of relationship between macroeconomic factors and performance of stock markets of many emerging economies including Sri Lanka are relatively limited. Though there are empirical studies in Sri Lanka investigating the impact of macroeconomic factors on stock prices or stock market behavior, the findings may differ when it is repeated with different sample periods and also in different frequency of the data. This study aims to establish the relationship between macroeconomic indicators and share price movement of CSE.

Several techniques, methods and models used in order to see the relationship between stock market and macroeconomic variables are available in the literature such as Unit Root test, cointegration test, VECM, Granger causality tests and Innovation Accounting. Al-Majali and Al-Assaf, Sohail and Hussain, Gan et al., Akbar et al., Jahufer and Irfan, Ali et al., Chen et al. and Maysami and Koh are few of the researchers who used above techniques to find the relationship between macroeconomic variables and stock market index.

The objective of this study is to examine the existence of long-run and short-run relationship between macroeconomic variables and stock market index.

MATERIALS AND METHODS

Data Description

This study aims at testing the long and short run relationship between the stock index and main macroeconomic variables in Sri Lanka. Quarterly time series data for the period of 2004:Q1 to 2016:Q3 were used in exploring the relationship between the macroeconomic variables and ASPI index relating CSE. The description of variables used in this research study is given below.

LNY– Log of ASPI

LNX_1 – Log of Interest rate (91 day T-Bill rate)

LNX_2 – Log of Broad money supply (M2)

LNX_3 – Log of Index of Industrial Production (IIP)

LNX_4 – Log of Colombo Consumer Price Index (CCPI)

Stationarity Test

The most popular and widely used test for stationarity is the unit root test. The presence of unit root indicates that the data series is non-stationary. Two standard procedures of unit root test namely the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests were performed to check the stationary nature of the series.

Cointegration Test and Vector Error Correction Model

Cointegration analysis has been used to examine whether there is any long run relationship exists. However, a necessary condition for the use of cointegration technique is that the variable under consideration must be integrated in the same order and the linear combinations of the integrated variables are free from unit root. To conduct the co-integration test, the Johansen (1991) approach was used. The Johansen method of cointegration can be written as the following vector autoregressive framework of order$p(VAR(p))$.

$$X_t = A_0 + \sum_{j=1}^{p} B_j X_{t-j} + e_t \qquad (1)$$

where X_t is an $n \times 1$ vector of non stationary $I(1)$ variables, A_0 is an $n \times 1$ vector of constants, p is the maximum lag length, B_j is an $n \times n$ matrix of coefficient and e_t is a $n \times 1$ vector of white noise terms.

The equation (1) can be re-written in a vector error correction model (VECM) format as,

$$\Delta X_t = A_0 + \sum_{j=1}^{p-1} \Gamma_j \Delta X_{t-j} + \Pi X_{t-p} + e_t \qquad (2)$$

where, Δ is the first difference operator, $\Gamma_j = -\sum_{i=j+1}^{p} B_j$ and $\Pi = -\mathrm{I} + \sum_{i=j+1}^{p} B_j$, and I is an $n \times n$ identity matrix. The Π matrix reveals the adjustment to disequilibrium following an exogenous shock.

The test for cointegration between the X's is calculated by observing the rank of the Π matrix via its eigenvalues. The rank of a matrix is equal to the number of its characteristic roots that are different from zero.

The number of characteristic roots can be tested by considering the following trace statistic and the maximum eigenvalue test.

$\lambda_{trace}(r) = -T\sum_{i=j+1}^{p} \ln(1-\hat{\lambda}_j)$ and $\lambda_{max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1})$

where, r is the number of cointegrating vectors, T is the number of usable observations and $\hat{\lambda}_j$ is the estimated value for the j^{th} ordered characteristic roots or the eigenvalue from the Π matrix.

A significantly non-zero eigenvalue indicates a significant co-integrating vector.The presence of cointegrating vectors supports the application of a dynamic VECM that depicts the feedback process and speed of adjustment for short run deviation towards the long run equilibrium and reveals short run dynamics in any variables relative to others [12].

Innovation Accounting

The cointegration analysis only captures the long-run relationship among the variables and it does not provide information on responds of variables in the system to shocks or innovations in other variables. To find how the stock index responds to shocks or innovation in the macroeconomic variables, Innovation Accounting such as Impulse Response Function (IRF) and forecast error variance decompositions (VDC) based on VECM was evaluated.

Jarque-Bera test

The normality of the returns can be tested using the Jarque-Bera test for normality. This test will measure the skewness and kurtosis of the series compared to the normal distribution.

Jarque-Bera test statistic is given by,

$$L = \frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$$

where$S$ is for Skewness, K is for Kurtosis and N is the number of observations.

Breusch-Godfrey Serial Correlation Lugrange Multiplier (LM) Test

Breusch-Godfrey LM test is used to test the serial correlation among error terms of a model. The null hypothesis of the Breusch-Godfrey LM test is that there is no serial correlation among residuals up to the specified number of lags.

Breusch-Pagan-Godfrey Heteroscedasticity Test

Breusch-Pagan-Godfrey heteroscedasticity test is used to check the constant variance of error terms where the null hypothesis is there is no heteroscedasticity in the residuals.

RESULTS AND DISCUSSION

This section describes the results of this research study. Data analysis and outputs of statistical tests which are used to analyze the data are discussed under this section.

Test for Stationarity - Unit Root Test

An important concern in data analysis is to know whether a series is stationary (do not contain a unit root) or not stationary (contains a unit root).The study used two different tests, such as Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test for finding unit roots in time series. Both tests were performed on the examined variables at level and also at first difference series. The unit root test results are presented in table 1.

Table 1: ADF and PP unit root test results

Variables	Augmented Dickey-Fuller test statistic				Philips-Perron test statistic			
	H0: Variable is Non-Stationary				H0: Variable is Non-Stationary			
	Level		First Difference		Level		First Difference	
	Test Statistic	P-value	Test Statistic	P-value	Test Statistic	P-value	Test Statistic	P-value
lnY	-1.62671	0.4616	-5.91428	0.0000	-1.62084	0.4647	-5.93637	0.0000
lnX1	-1.71287	0.4187	-6.41439	0.0000	-1.88667	0.3358	-6.38928	0.0000
lnX2	-0.56958	0.8679	-6.35406	0.0000	-0.59708	0.8618	-6.35091	0.0000
lnX3	-2.20378	0.2076	-5.58254	0.0000	-3.39741	0.1157	-3.78376	0.0056
lnX4	-2.15851	0.2236	-6.02309	0.0000	-2.15874	0.2235	-6.02309	0.0000

The ADF and PP results show that all variables arenonstationary in levels, but stationary in first–difference form. Hence, the two tests declared that all the variables are integrated of order one, i.e. $I(1)$and thus we may proceed with testing of cointegration.

Determining the order of lags of the VAR

Before proceeding with test of cointegration, the number of lags to be used in the vector autoregression (VAR), should be determined.

Table 2: Lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	68.01173	NA	4.71e-08	-2.68135	-2.484526	-2.607284
1	380.3011	544.8454	2.33e-13	-14.90643	-13.72549*	-14.46203
2	412.3611	49.11315	1.79e-13	-15.20686	-13.04179	-14.39213
3	457.4676	59.50213*	8.38e-14*	-16.06245*	-12.91326	-14.87739*
4	480.4931	25.47506	1.11e-13	-15.97843	-11.84512	-14.42304

As per the table 2, results show that sequential modified LR test statistic (LR), Final prediction error (FPE), Akaike information criterion (AIC)and Hannan-Quinn information criterion (HQ) recommend lag length of 3.

Cointegration Analysis

Table 3: Johansen cointegration test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.610489	109.8840	69.81889	0.0000
At most 1 *	0.463344	65.56944	47.85613	0.0005
At most 2 *	0.373296	36.31672	29.79707	0.0077
At most 3	0.262663	14.35451	15.49471	0.0737
At most 4	0.000704	0.033110	3.841466	0.8556
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.610489	44.31458	33.87687	0.0020
At most 1 *	0.463344	29.25272	27.58434	0.0303
At most 2 *	0.373296	21.96221	21.13162	0.0382
At most 3 *	0.262663	14.32140	14.26460	0.0490
At most 4	0.000704	0.033110	3.841466	0.8556
Max-eigenvalue test indicates 4 cointegratingeqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

The results of stationarity analysis presented in the table 1 show that all the variables are integrated of same order. Therefore the Johansen cointegration test was used to explore the long-run relationships among the variables. In order to find out the number of cointegrating vectors, Trace statistic and Maximum Eigen value tests were used and the results are reported in table 3.

According to the results of table 3, the Trace test indicates 3 cointegrating equations at the 5% level and the maximum-eigenvalue test indicates 4 cointegrating vectors at the 5% level. It is clearly shown that both trace and maximum-eigenvalue tests suggest at least three cointegration vectors. This result suggests that at least three cointegration vectors exist among stock market index and other macroeconomic variables.

Long Run Relationship

After normalization the cointegrating vectors on LNY and normalized cointegrating coefficients were estimated as reported in table 4.

Table 4: Normalized cointegration coefficients

Cointegrating Eq:	CointEq 1	CointEq2	CointEq3
LNY(-1)	1.000000	0.000000	0.000000
LNX1(-1)	0.000000	1.000000	0.000000
LNX2(-1)	0.000000	0.000000	1.000000
LNX3(-1)	-2.3103	2.089160	-3.03349
	(0.17004)	(0.70553)	(0.81458)
	[-13.5866]	[2.96110]	[-3.72400]
LNX4(-1)	0.797451	0.071844	-1.98937
	(0.29030)	(1.20451)	(1.39067)
	[2.74697]	[0.05965]	[-1.43050]
C	6.648983	-19.7805	20.60142

The first normalized equation was estimated as below:

LNY(-1) = -6.65 + 2.31 LNX3(-1) - 0.80 LNX4(-1)

According to the first normalized equation, stock return shows significantly negative relation with Colombo consumer price index in long-run which suggested that stock market did not provide hedge against inflation and there is a statistically significant positive relationship between stock returns and index of industrial production.

The second normalized equation is estimated as below:

LNX1(-1) = 19.78 - 2.09 LNX3(-1) - 0.07LNX4(-1)

According to the second normalized equation, 91-day treasury bill rate shows significantly negative relation with index of industrial production in the long-run. The negative relationship between 91-day treasury bill rate and Colombo consumer price index is not significant in the long run.

The third normalized equation is estimated as below:

LNX2(-1) = -20.60 + 3.03LNX3(-1) + 1.99 LNX4(-1)

According to the third normalized equation, Broad money supply shows significantly positive relation with index of industrial production in long-run. The negative relationship between Broad money supply and Colombo consumer price index is not significant in the long run.

Vector Error Correction Model (VECM)

The VECMs provide the correction terms that reflect influences of deviation of the relationship among the variables from long-run equilibrium and short-run parameters. The relationship between ASPI and the other macroeconomic variables can be given in the following model.

D(LNY) = C(1)*(LNY(-1) - 2.31*LNX3(-1) + 0.80*LNX4(-1) + 6.65) + C(2)*(LNX1(-1) + 2.09*LNX3(-1) + 0.07*LNX4(-1) - 19.78) + C(3)*(LNX2(-1) - 3.03*LNX3(-1) - 1.99*LNX4(-1) + 20.60) + C(4)*D(LNY(-1)) + C(5)*D(LNY(-2)) + C(6)*D(LNX1(-1)) + C(7)*D(LNX1(-2)) + C(8)*D(LNX2(-1)) + C(9)*D(LNX2(-2)) + C(10)*D(LNX3(-1)) + C(11)*D(LNX3(-2)) + C(12)*D(LNX4(-1)) + C(13)*D(LNX4(-2)) + C(14)

The parameters of this model were estimated and shown in the table 5 below.Table 5 shows vector error correction model for stock market index with significant error correction terms, showing explicit information on the long run and short-run dynamic interactions among those variables. As only the first error correction term is significant with negative sign, the results of vector error correction model (VECM) depicted that the adjustments in LNY are due to the first error correction term. This implies that long run movements of the variables are determined by one equilibrium relationship.

As indicated in table 5, the estimate of C(1) which is the adjustment coefficient associated with the stock price index is -0.3805 and statistically significant. This suggests that with absence of changes in independent variables IIP (LNX3) and inflation (LNX4)), deviation of the model from the long-run path is corrected by 38.05% increase in LNY per quarter. This means that deviation from the long run relationship takes approximately three quarters (1/0.3805 = 2.628) to eliminate the disequilibrium.

Table 5: VECM estimates

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.380569	0.133815	-2.844003	0.0075
C(2)	-0.029504	0.094055	-0.313685	0.7557
C(3)	0.095017	0.088472	1.073978	0.2904

C(4)	0.218215	0.166477	1.310779	0.1987
C(5)	0.148196	0.154728	0.957781	0.3449
C(6)	0.001919	0.175179	0.010952	0.9913
C(7)	-0.190984	0.161159	-1.185065	0.2442
C(8)	-2.837205	1.437114	-1.974238	0.0565
C(9)	2.813922	1.353365	2.079204	0.0452
C(10)	0.630537	0.529814	1.190110	0.2422
C(11)	-1.029013	0.490610	-2.097416	0.0435
C(12)	-0.053313	0.385690	-0.138227	0.8909
C(13)	-1.007149	0.343855	-2.928996	0.0060
C(14)	0.043283	0.079843	0.542093	0.5913
R-squared	0.580264	Mean dependent var		0.030188
Adjusted R-squared	0.419777	S.D. dependent var		0.138773
S.E. of regression	0.105707	Akaike info criterion		-1.417805
Sum squared resid	0.379912	Schwarz criterion		-0.872038
Log likelihood	48.02733	Hannan-Quinn criter.		-1.211559
F-statistic	3.615641	Durbin-Watson stat		2.102164
Prob(F-statistic)	0.001292			

Test of Short Run Relationship Between the Variables

Wald test was used to identify any significant short run relationship between each macroeconomic variable and ASPI. The results are presented as follows.

Table 6: Wald test for the relationship between interest rate and ASPI

Test Statistic	Value	df	Probability
F-statistic	0.702382	(2, 34)	0.5024
Chi-square	1.404765	2	0.4954

According to the results in table 6, the p-value of Chi-square test statistic is 0.4954 > 0.05. Therefore $H_0: C(6) = C(7) = 0$ is not rejected at 5% level of significance and can be concluded that there is no short run relationship from LNX1 (91-day treasury bill rate) to LNY (ASPI).

Table 7: Wald test for the relationship between money supply and ASPI

Test Statistic	Value	df	Probability
F-statistic	3.994501	(2, 34)	0.0277
Chi-square	7.989002	2	0.0184

Results in table 7 indicates that the p-value of Chi-square test statistic is 0.0184 < 0.05. Therefore $H_0: C(8) = C(9) = 0$ is rejected at 5% level of significance and can be concluded that there is a short run relationship from LNX2 (broad money supply) to LNY (ASPI).

Table 8: Wald test for the relationship between industrial production and ASPI

Test Statistic	Value	df	Probability
F-statistic	2.376504	(2, 34)	0.1081
Chi-square	4.753008	2	0.0929

According to the results of table 8, the p-value of Chi-square test statistic is 0.0929 < 0.1. Therefore $H_0: C(10) = C(11) = 0$ is rejected at 10% level of significance and can be concluded that there is a short run relationship from LNX3 (IIP) to LNY (ASPI).

Table 9: Wald test for the relationship between inflation and ASPI

Test Statistic	Value	df	Probability
F-statistic	4.588027	(2, 34)	0.0172
Chi-square	9.176054	2	0.0102

The results in table 9 indicates that the p-value of Chi-square test statistic is 0.0102 < 0.05. Therefore $H_0: C(12) = C(13) = 0$ is rejected at 5% level of significance and can be concluded that there is a short run relationship from LNX4 (CCPI) to LNY (ASPI).

Impulse Response Function Analysis

To study the dynamics of the effects of shocks of macroeconomic variables on stock index, Impulse Response Function (IRF) analysis was used. Figure 1 depicts the IRF of stock index to one generalized standard deviation shock in each macroeconomic variables.

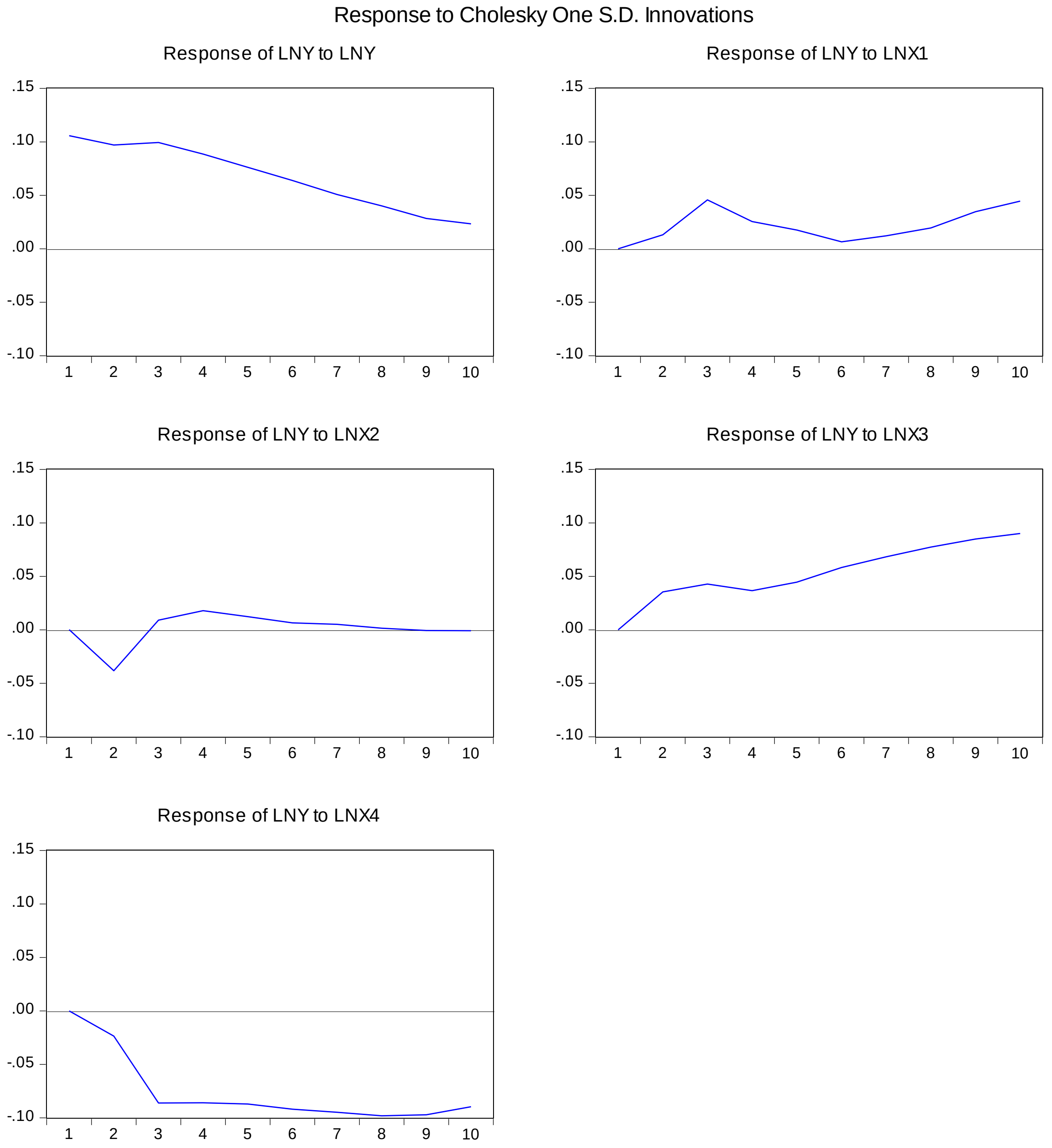

Figure 1: Impulse Response Function

The IRF shows that stock market prices (LNY) respond negatively to inflation (LNX4). The stock market responds negatively to shocks from money supply during the first two quarters, and the response becomes positive from the third quarter onwards. The response of stock market prices to 91-day T-bill rate and IIP is positive.

Variance Decompositions

Variance decompositions serve as a tool for evaluating the dynamic interactions and strength of causal relations among variables in the system.

Table 10: Variance decomposition of ASPI

Period	S.E.	LNY	LNX1	LNX2	LNX3	LNX4
1	0.105707	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.155065	85.65974	0.710536	6.085265	5.216458	2.327996
3	0.212886	67.21963	4.969266	3.409442	6.790859	17.61080
4	0.250753	60.93265	4.599916	2.964106	7.032903	24.47043
5	0.280545	56.04617	4.065590	2.558444	8.130772	29.19903
6	0.307765	50.87330	3.421715	2.170284	10.33905	33.19565
7	0.333353	45.67500	3.046325	1.873900	13.01332	36.39145
8	0.358814	40.67245	2.922981	1.619209	15.88080	38.90456
9	0.383926	36.07207	3.364665	1.414707	18.75200	40.39656
10	0.407533	32.33875	4.177663	1.256073	21.52926	40.69825

Results in table 10 shows that the stock index (LNY) is relatively less exogenous in relation to the shocks of macroeconomic variables in the short run. Because if considering only two quarters, the stock index (LNY) is the most important variable to account for its own innovation, which accounts for 85.65%. Broad money supply (LNX2) only contributes 6.08% to the forecast error variance while IIP (LNX3) accounts for 5.22% of the forecast error variance.

At the end of 10 quarters, 32% of the variance of stock index (LNY) is explained by its own shock and IIP (LNX3) and inflation (LNX4) are the next two important variables to be considered in explaining the forecast error variance, which accounts for 22% and 41% impact on stock index respectively. This implies that IIP and inflation prove to be the most significant factors that explain the movement in stock prices in the long run.

Residual Diagnostics

To confirm and trust the results from the VECM, it is necessary to make sure that the residuals are white noise. Therefore, following diagnostic checks were carried out to justify the accuracy of the fitted model.

By looking at the figure 2, the histogram clearly shows that residuals are normally distributed. Skewness and Kurtosis values of residuals are closer to 0 and 3 respectively. The normality of residuals is also confirmed by the Jarque-Bera test since the p-value (0.846383) is greater than the critical value at the 5% level. Therefore it can be concluded that the residuals are normally distributed.

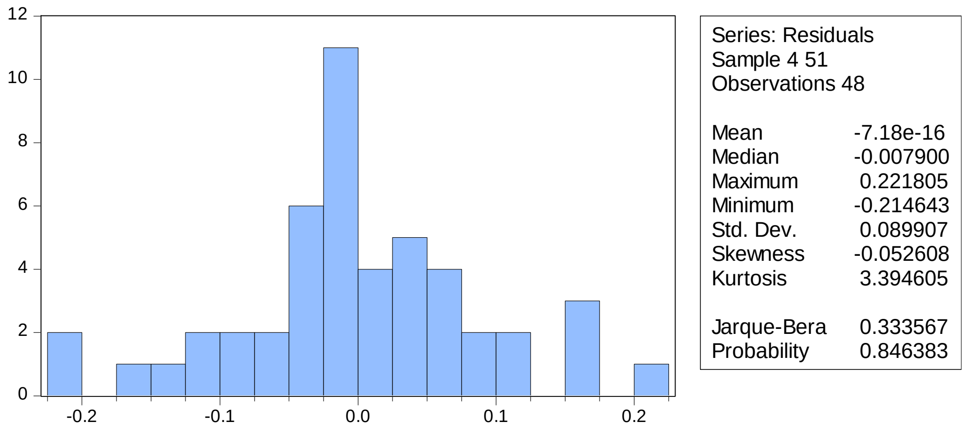

Figure 2: Histogram of residuals

The results of table 11 indicate that the p-value is 0.3895 which is greater than critical value 0.05. Therefore, the null hypothesis is not rejected and the absence of autocorrelation of residuals can be concluded.

Table 11: Breusch-Godfrey serial correlation LM test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.971274	Prob. F(2,32)	0.3895
Obs*R-squared	2.747063	Prob. Chi-Square(2)	0.2532

Results in table 12 indicate that the p-value is 0.2068 which is greater than critical value 0.05. Therefore, it can be concluded that there is no ARCH effect in the residuals. The results shown above indicate that the model passes the diagnostic tests of serial correlation, Normality of residuals and heteroscedasticity test at 5% significance level.

Table 12: Breusch-Pagan-Godfrey heteroskedasticity test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.3989	Prob. F(15,32)	0.2068
Obs*R-squared	19.00984	Prob. Chi-Square(15)	0.2133
Scaled explained SS	11.41978	Prob. Chi-Square(15)	0.7223

CONCLUSION

This study investigated long-run and short-run relationships between four macroeconomic variables such as interest rate, broad money supply, IIP and inflation and stock market index (ASPI) in Colombo Stock Exchange. All the series used in this analysis were found non-stationary at levels but stationary at first difference. The Johansen's cointegration test suggests that the stock market index has cointegrated with the macroeconomic variables. In the long-run, inflation had a negative impact on stock prices while IIP affected stock returns positively. The interest rate and broad money supply are not turning out to be the significant determinants of stock prices in the long run. The VECM analysis depicted that the coefficient of error correction term was significant showing speedy adjustment. The results showed that both inflation and money supply significantly and inversely affect stock return in the short run. The impulse response function in figure 1 shows that the shock of inflation has a negative impact on the stock index throughout the testing period and this negative impact reached a maximum in the eighth quarter. The variance decomposition analysis revealed that a major proportion of the variability in the market index was explained by its own innovations while only a minority was explained by macroeconomic variables in the short run and IIP and inflation are the most significant factors that explain the movement in stock prices in the long run. The present study confirms the beliefs that macroeconomic factors continue to affect the Sri Lankan stock market. On the basis of the above overall analysis, it can be concluded that two out of the four selected macroeconomic variables are relatively significant and likely to influence the stock prices of the CSE in the long run. These macroeconomic variables are inflation and IIP. The study provides useful guidance for key stake holders such as investors, government and firms listed on the CSE. It is proposed that appropriate monetary measures should be adopted by monetary managers to control inflation so that the volatility of the stock markets can be minimized.

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