ISSN No:-2456-2165

Modeling Tea Export Earnings by Category in Sri Lanka: Vector Error Correction Model (VECM) Approach

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Abstract:- Tea industry is a major thrust industryin Sri Lanka which has a significant contribution Sri Lankan economy. Therefore, it is vital to study the behavior of tea export earnings. The study attempts to forecast tea export earnings by category namely Bulk tea, Tea bags, Tea packets and Total exports. The data was obtained from Sri Lanka Tea Board from January 2005 to October 2019. The Vector Autoregressive model was adopted initially by consideringlong run and short run relationship among category-wise tea export earnings via the Johansen co-integration technique. To further explore the dynamic co-movement among variables, Vector Error Correction model was used. Residual analysis was carried outwith Residual plot, Correlogram, Residual portmanteau test and the results indicated that model was satisfactory. The analysis revealed that category-wise tea export earnings are co-integrated. Hence, there is a long-run equilibrium relationship between them. Further, bulk tea earnings positively relate to tea packets earnings whereas tea bags earnings negative relate to tea packets earnings in long run.The studyproduced an out-of-sample forecast to analyze and compare the statistical results to determine the precision of the fitted model. Thus, it can be concluded that the fitted VEC model can be used to predict tea export earnings by category in Sri Lanka with significant accuracy.

Keywords:- *Tea Export Earnings; Co-integration; Vector Error Correction Model.*

I.INTRODUCTION

Ceylon tea is considered as the most excellent type of tea in the world because of its unique characteristics and reputation running through more than hundred years. There are four varieties of Ceylon tea namely Black tea, Oolong tea, green tea and white tea. Among them, black tea is the main type of tea export in Sri Lanka as it is stronger in flavour.

Out of total tea exports 98% was black tea and rest is instant tea and green tea. The black tea is exported by three major types which are Bulk Tea (BT), Tea Packets (TP) and Tea Bags (TB). Until 2010, bulk tea was the major type exported by both in volume and value, but now the tea packets have become forward.Sri Lanka is exporting tea to various countries in the world. While major importing countries are consuming Sri Lankan tea and some of major countries that import Sri Lankan tea re-export to various countries as value added tea for which the demand is growing to a large extent internationally. Some of Sri Lanka’s major markets include Russia, United Arabic Emirates, Syria and Turkey.

Tea industry in Sri Lanka caters to both local and international markets. Tea sector would contribute substantially to enhance export earnings of the country. Many families’ incomes depend on the price of tea. Subsequently, the variability of the price of tea markers a significant risk to producers, traders, consumers, and others who involved in tea industry.

Samarasinghe and Abeynayake (2017) has attempted to forecast tea export using Vector Autoregression (VAR) model. Extent, production and cost of production in Sri Lanka has been considered as main internal factors and competitors' productions like Indian and Indonesian production has been considered as external factors to develop the VAR model.Aponsu and Jayasundara (2012) have examined on predictive models to forecast monthly tea production, prices and exports. Seasonal Auto Regressive Integrated Moving Average (SARIMA) models were fitted to forecast the monthly tea production and tea exports.The study “Forecasting Production, Exports and Domestic Consumption of Major Plantation Crops in Sri Lanka” (Wimalasena, Herath & Edirisinghe, 2011) has pointed out that Box and Jenkins’ Autoregressive Integrated Moving Average (ARIMA) models can be used for forecasting production, exports and domestic consumption of plantation crops.

Tea sector has a tremendous impact on Sri Lankan economy. To develop the world demand for Ceylon tea, it’s needed to identify temporal patterns of export earnings of each category as tea export prices change over time. With large price volatility, it is important to statistically and accurately forecast tea export earnings. Most of studies have been carried out to predict production supply and demand in tea industry of Sri Lanka based on classical time series methods. According to the literature, not many studies have done which focus on tea export earnings. Therefore, an attempt was taken to forecast export earnings of tea by category using multivariate time series techniques. Forecasting on tea export earnings by category will be very important for economists, policy makers and scientists in the country for various purposes.

Thus, it would be more worth to carry out an analysis based on time series techniques. If a well-organized method is formed, it will be given some idea to the giants in tea industry on temporal behaviour of tea export earnings.

Thus, this study will provide a better understanding to all groups of actors in tea industry regarding tea export earnings in the Sri Lanka. This study will help producestatistics, which will be useful in designing appropriate procedures on how support Sri Lankan tea industry and improve the performance of tea exports. Furthermore, this study can be introduced to Sri Lanka Tea Board where certain policies can be implemented to maximize category wise tea export earnings.

II. METHODS

The time series of monthly tea export earnings by category in Sri Lanka are employed in this study. The data are obtained from sources: Sri Lanka Tea Board website and Annual statistical bulletins. The data set consists of four-time series, 173 observations for each series over the period of January 2005 to October 2019. The monthly export earnings are given in Million Rupees. For convenience, earnings of bulk tea, earnings of tea bags, earnings of tea packets and total export earnings are denotedas BTV, TBV, TPV and TEV respectively.The descriptive analysis was used to identify the basic characteristics of the data. The data was analyzed by using multivariate time series.

A. Augmented Dickey Fuller Test

Stationarity of a series is a key tool because it can influence its behavior. The study employed the conventional Augmented Dickey Fuller test to test for stationarity as most of financial time series showing trend or seasonal patterns are non- stationarity. ADF test simply adds lagged dependent variables to the DF regression. This test is based on the regression of$\Delta Y_t = \beta Y_{t-1} - \sum_{i=1}^{n} \alpha_j \Delta Y_{t-j} + \varepsilon_t$.

The hypotheses to be tested are:
H_0: the variable has unit root (i.e.,$\beta = 0$)
H_1: the variable doesn't have unit root (i.e.,$\beta < 0$)

Test statistic: $ADM(m) = \frac{\hat{\beta}}{std\ error(\hat{\beta})}$

The test statistic is tested against the DF tables. The decision rule is, to reject the H_0, if ADF < critical value at the relevant significance level.

B. Johansen Test of Co-integration

If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be co-integrated. The Johansen test is more informative in the sense that it finds all possible co-integrating relationships.

Thus, for this study, Johansen's co-integration test was primarily employed for testing the co-integration between variables under study.The procedure uses two tests to determine the number of co-integration vectors: the Maximum Eigenvalue test and the Trace test. The Maximum Eigen value statistic tests the null hypothesis of r co-integrating relations against the alternative of $\mathrm{r} + 1$co-integrating relations for $\mathrm{r} = 0, 1, 2 \ldots \mathrm{n} - 1$.

Trace statistics investigate the null hypothesis of r co-integrating relations against the alternative of n co-integrating relations, where n is the number of variables in the system for$r = 0, 1, 2 \ldots n - 1$.

C. Vector Error Correction Model (VECM)

Co-integration is the fundamental of VECM approach. VECM is a kind of VAR where restrictions of co-integration are determined in it. VECM contains both long-run and a short-run relation among variables set in vector x. It is useful when long-run forecast is desired as VAR doesn't explicitly takes into account the long-run relationship. General form of VECM is:

$$\Delta x_{nt} = c + \sum_{i=1}^{k} \beta_{1i} \Delta x_{1t-1} + \sum_{i=1}^{k} \beta_{2i} \Delta x_{2t-1} + \sum_{i=1}^{k} \beta_{3i} \Delta x_{3t-1} + \sum_{i=1}^{k} \beta_{4i} \Delta x_{4t-1} + \gamma_n z_{t-i}$$

Where $n = 1, 2, 3, 4$(No. of Variables)
K = maximum lag length
Δ = first differenced operator
$z_t = x_{1t} - \sum_{i=2}^{n} \alpha_i x_{it} + c$is the disequilibrium term

Data analysis under this study was performed with aid of E-views, Excel and Minitab statistical software.

III. RESULTS

A. Stationarity Test

This study is fully based on time series data and hence there arises a need to check for the stationarity in the series. In this analysis, the ADF test was performed to identify the stationarity in the series of data. The results of the test for the variables in levels are depicted in the table below.

Category	Original Series		1st Difference Series		Integration Order
	ADF	P-Value	ADF	P-Value	
Bulk Tea	-2.140068	0.2294	-15.05132	0.00	I [1]
Tea Packets	-0.790543	0.8189	-17.03307	0.00	I [1]
Tea Bags	-1.200231	0.6740	-16.46012	0.00	I [1]
Total Export Earnings	-1.101255	0.7150	-17.48068	0.00	I [1]

Table 1: Results of unit root test

ADF test results revealed that no variable is stationary at levels. But all the variables are stationary after differencing once. All the series are integrated of order one i.e. I [1].

B. Selection of optimal lag length

The optimal number of lags which should be included in the model has to be identified first before performing co-integration test and VEC modelling. In this study, lowest SIC value is used as primary concern to determine the optimal lag length in the estimation. The results of lag selection criteria are presented in Table 2.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5234.036	NA	4.41e+22	63.49135	63.56664	63.52191
1	-4975.859	500.7067	2.34e+21	60.55587	60.93235	60.70869
2	-4928.769	89.04395	1.61e+21	60.17901	60.85667*	60.45410*
3	-4905.065	43.67200	1.46e+21*	60.08564*	61.06448	60.48298
4	-4897.008	14.45468	1.61e+21	60.18191	61.46194	60.70152
5	-4889.552	13.01369	1.80e+21	60.28548	61.86668	60.92734
6	-4881.360	13.90169	1.98e+21	60.38012	62.26251	61.14425
7	-4862.438	31.19167*	1.92e+21	60.34471	62.52828	61.23110
8	-4846.966	24.75645	1.95e+21	60.35110	62.83585	61.35975

Table 2: Lag order selection

According to the results in Table 2, the optimal lag order determined by the Schwarz Information Criterion (SIC) is at two. So, further tests are preceded with lags two.

C. Co-integration Test

Johansen's co-integration test was applied to confirm that series are co-integrated. Johansen test provides estimates of all such co-integrating equations and provides a test statistic for the number of co-integrating equations. The result of the cointegration test (that is the existence of a long-term linear relation) is presented in Table 3 below using methodology proposed by Johansen.

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.220231	80.90431	47.85613	0.0000
At most 1 *	0.160850	38.61543	29.79707	0.0038
At most 2	0.046290	8.803262	15.49471	0.3839
At most 3	0.004378	0.745938	3.841466	0.3878

Trace test indicates 2 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.220231	42.28888	27.58434	0.0003
At most 1 *	0.160850	29.81217	21.13162	0.0023
At most 2	0.046290	8.057323	14.26460	0.3729
At most 3	0.004378	0.745938	3.841466	0.3878

Table 3: Results of co-integration test

Max-eigenvalue test indicates 2 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

According to the results in Table 3, the Trace test indicates that two co-integrating equations at the 5% level and Max-eigenvalue test indicates two co-integrating equations at the 5% level. From the co-integration result, it is clearly shown that both trace statistic and maximum Eigen value statistic indicate two cointegration equations at 5% level of significance, suggesting that there are two co-integrating relationships between variables under consideration.

The existence of co-integration between the variables suggests a long-term relationship among the variables. Therefore, the long-run equilibrium relation was estimated which illustrates in Table 4 below.

Vector Error Correction Estimates
Sample (adjusted): 2005M04 2019M05
Included observations: 170 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
BTV(-1)	1.000000	0.000000
TBV(-1)	0.000000	1.000000
TEV(-1)	-0.694344	-0.041581
	(0.03346)	(0.01859)
	[-20.7493]	[-2.23660]
TPV(-1)	0.752769	-0.192335
	(0.05605)	(0.03114)
	[13.4314]	[-6.17715]
C	-99.34554	-247.1534

Table 4: Vector error correction estimates

The above table indicates that bulk tea value shows significantly positive relation with tea packets value in long run. Based on the coefficients, it can be interpreted that one-unit increase in tea packets value leads to 0.75 units increase in bulk tea value in the long run. Tea bags value shows significantly negative relation with tea packets value in long run. By looking at the coefficient of TPV (-1), it can be interpreted that one-unit increase in tea packets value leads to 0.19 units increase in tea bags value in long run.

D. Vector Error Correction Model (VECM)

Having determined the co-integration among the variables, there is an existence of a long-term equilibrium relation between the series as evident in previous section. A VECM was implemented instead of VAR model in order to avoid misspecification errors in the analysis.Using the SIC criterion, VEC model is estimated with two lags to examine the short run and long run relationship between the variables.

- **Model I:** The VECM equation for the dependent variable as Bulk Tea Revenue is:

D(BTV) = C(1)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(2)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(3)*D(BTV(-1)) + C(4)*D(BTV(-2)) + C(5)*D(TBV(-1)) + C(6)*D(TBV(-2)) + C(7)*D(TEV(-1)) + C(8)*D(TEV(-2)) + C(9)*D(TPV(-1)) + C(10)*D(TPV(-2)) + C(11) **(1)**

Table 5 shows vector error correction model for BTV with significant error correction terms, showing explicit information on the long run and short-run dynamic interactions among those variables. The information about the long-run dynamic of the process is indicated by the sign and magnitude of this error correction coefficient. It indicates the direction and speed of adjustment towards the long-run equilibrium path which should be negative and significant.

The coefficients C(1) and C(2) ofTable 5 are the one period lag of residuals of the co-integrating equation. Those are the error correction coefficients measuring the speed of convergence to the long-run steady state or speed of adjustment of disequilibrium in the period of study.

ISSN No:-2456-2165

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.808688	0.265318	-3.047999	0.0027
C(2)	-0.398256	0.440831	-0.903420	0.3677
C(3)	-0.020019	0.248595	-0.080528	0.9359
C(4)	-0.386679	0.418404	-0.924176	0.3568
C(5)	-0.383680	0.188664	-2.033671	0.0436
C(6)	0.493804	0.205862	2.398720	0.0176
C(7)	0.018932	0.218197	0.086768	0.9310
C(8)	-0.329925	0.353671	-0.932857	0.3523
C(9)	-0.117472	0.170923	-0.687283	0.4929
C(10)	0.000677	0.186894	0.003621	0.9971
C(11)	58.48743	56.98969	1.026281	0.3063

Determinant residual covariance	512819.6

Equation: D(BTV) = C(1)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(2)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(3)*D(BTV(-1)) + C(4)*D(TBV(-1)) + C(5)*D(TEV(-1)) + C(6) *D(TPV(-1)) + C(7)*D(BTV(-2)) + C(8)*D(TBV(-2)) + C(9)*D(TEV(-2)) + C(10)*D(TPV(-2)) + C(11)

Observations: 170

R-squared	0.353047	Mean dependent var	29.02876
Adjusted R-squared	0.312358	S.D. dependent var	892.9499
S.E. of regression	740.4713	Sum squared resid	87179336
Durbin-Watson stat	1.963212		

Table 5: VECM estimates of model I

The above table presents the VECM, its coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the co-integrated model (long run) with Bulk tea value as the dependent variable while C(3), C(4), C(5), C(6), C(7), C(8), C(9) and C(10) are short run coefficients. C(1) is the speed of adjustment towards long run equilibrium which is negative and highly significant at 1% which implies that total tea export revenue and tea packets revenue have long run influence on the bulk tea revenue.

- **Model II:** The VECM equation for the dependent variable as Tea Bags Revenue is:

D(TBV) = C(12)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(13)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(14)*D(BTV(-1)) + C(15)*D(BTV(-2)) + C(16)*D(TBV(-1)) + C(17)*D(TBV(-2)) + C(18)*D(TEV(-1)) + C(19)*D(TEV(-2)) + C(20)*D(TPV(-1)) + C(21)*D(TPV(-2)) + C(22) **(2)**

Table 6 shows vector error correction model for TBV with significant error correction terms, showing explicit information on the long run and short-run dynamic interactions among those variables. The coefficients C(12) and C(13) of Table 6 are the one period lag of residuals of the co-integrating equation.

	Coefficient	Std. Error	t-Statistic	Prob.
C(12)	-0.242961	0.088570	-2.743140	0.0068
C(13)	-0.508112	0.147162	-3.452744	0.0007
C(14)	0.299752	0.082988	3.611995	0.0004
C(15)	0.032553	0.072840	0.446904	0.6556
C(16)	-0.117453	0.139675	-0.840900	0.4017
C(17)	-0.086572	0.118065	-0.733256	0.4645
C(18)	-0.250151	0.062981	-3.971836	0.0001
C(19)	-0.027303	0.057059	-0.478505	0.6329
C(20)	0.114986	0.068722	1.673204	0.0963
C(21)	-0.075682	0.062390	-1.213038	0.2269
C(22)	23.91577	19.02475	1.257087	0.2106
Determinant residual covariance		57149.20		

Equation: D(TBV) = C(12)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(13)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(14)*D(BTV(-1)) + C(15)*D(BTV(-2)) + C(16)*D(TBV(-1)) + C(17)*D(TBV(-2)) + C(18)*D(TEV(-1)) + C(19)*D(TEV(-2)) + C(20) *D(TPV(-1)) + C(21)*D(TPV(-2)) + C(22)

Observations: 170

R-squared	0.456874	Mean dependent var	10.98406
Adjusted R-squared	0.422715	S.D. dependent var	325.3387
S.E. of regression	247.1900	Sum squared resid	9715364.
Durbin-Watson stat	1.920812		

Table 6: VECM estimates of model II

The table 6 presents the VECM, its coefficients as well as their t-statistic and p-value. C(12) and C(13) are the coefficient of the co-integrated model (long run) with tea bags value as the dependent variable while C(14), C(15), C(16), C(17), C(18), C(19), C(20) and C(21) are short run coefficients.

As both error correction terms are highly significant at 1% with negative sign as indicated in the table 6, results of VEC model depicted that the adjustments in TBV are due to both error correction terms. As specified in Table 6, the estimates of C(12) and C(13) which are the adjustment coefficients associated with TBV are -0.242961 and -0.508112 respectively and both are statistically significant.

- **Model III:**

The VECM equation for the dependent variable as Tea Packets Revenue is:

D(TPV) = C(34)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(35)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(36)*D(BTV(-1)) + C(37)*D(BTV(-2)) + C(38)*D(TBV(-1)) + C(39)*D(TBV(-2)) + C(40)*D(TEV(-1)) + C(41)*D(TEV(-2)) + C(42)*D(TPV(-1)) + C(43)*D(TPV(-2)) + C(44) **(3)**

	Coefficient	Std. Error	t-Statistic	Prob.
C(34)	-0.263955	0.295403	-0.893540	0.3729
C(35)	0.724410	0.490819	1.475921	0.1419
C(36)	0.271316	0.276785	0.980241	0.3285
C(37)	0.019473	0.242940	0.080157	0.9362
C(38)	-0.488477	0.465849	-1.048573	0.2960
C(39)	-0.368950	0.393776	-0.936954	0.3502
C(40)	-0.256552	0.210057	-1.221342	0.2238
C(41)	-0.029314	0.190304	-0.154038	0.8778
C(42)	-0.176806	0.229205	-0.771387	0.4416
C(43)	-0.307480	0.208087	-1.477651	0.1415
C(44)	88.37503	63.45203	1.392785	0.1656
Determinant residual covariance		635716.0		

Equation: D(TPV) = C(34)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(35)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(36)*D(BTV(-1)) + C(37)*D(BTV(-2)) + C(38)*D(TBV(-1)) + C(39)*D(TBV(-2)) + C(40)*D(TEV(-1)) + C(41)*D(TEV(-2)) + C(42) *D(TPV(-1)) + C(43)*D(TPV(-2)) + C(44)

Observations: 170

R-squared	0.355600	Mean dependent var	46.22653
Adjusted R-squared	0.315071	S.D. dependent var	996.1730
S.E. of regression	824.4370	Sum squared resid	1.08E+08
Durbin-Watson stat	1.996821		

Table 7: VECM estimates of model III

It can be realized from equation (3) and table 7 that export earnings of tea packets is affected positively by 27% of bulk tea export earnings when there is one unit change in its lagged values. On the other hand, export earnings of tea packets have considerable negative impact on total export earnings and tea bags. In the long-run, coefficient of disequilibrium terms are -0.263955 and 0.724410 and both are statistically insignificant revealing that there is no long run equilibrium relationship among variables.

- **Model IV:** The VECM equation for the dependent variable as Total Export Revenue is as follows:

D(TEV) = C(23)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(24)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(25)*D(BTV(-1)) + C(26)*D(BTV(-2)) + C(27)*D(TBV(-1)) + C(28)*D(TBV(-2)) + C(29)*D(TEV(-1)) + C(30)*D(TEV(-2)) + C(31)*D(TPV(-1)) + C(32)*D(TPV(-2)) + C(33) **(4)**

	Coefficient	Std. Error	t-Statistic	Prob.
C(23)	-0.775227	0.575868	-1.346188	0.1802
C(24)	-0.122740	0.956818	-0.128279	0.8981
C(25)	0.548690	0.539573	1.016896	0.3107
C(26)	0.209279	0.473594	0.441894	0.6592
C(27)	-0.771055	0.908140	-0.849048	0.3971
C(28)	-0.602486	0.767639	-0.784856	0.4337
C(29)	-1.013660	0.409493	-2.475405	0.0144
C(30)	-0.388285	0.370985	-1.046634	0.2969
C(31)	0.544375	0.446820	1.218334	0.2249
C(32)	-0.162463	0.405651	-0.400498	0.6893
C(33)	178.3916	123.6953	1.442185	0.1512

Determinant residual covariance 2415899.

Equation: D(TEV) = C(23)*(BTV(-1) - 0.6943435757*TEV(-1) + 0.7527691183*TPV(-1) - 99.34554268) + C(24)*(TBV(-1) - 0.04158057932*TEV(-1) - 0.1923352569*TPV(-1) - 247.1533556) + C(25)*D(BTV(-1)) + C(26)*D(BTV(-2)) + C(27)*D(TBV(-1)) + C(28)*D(TBV(-2)) + C(29)*D(TEV(-1)) + C(30)*D(TEV(-2)) + C(31) *D(TPV(-1)) + C(32)*D(TPV(-2)) + C(33)

Observations: 170

R-squared	0.382687	Mean dependent var	87.64983
Adjusted R-squared	0.343862	S.D. dependent var	1984.119
S.E. of regression	1607.183	Sum squared resid	4.11E+08
Durbin-Watson stat	1.962634		

Table 8: VECM estimates of model IV

According to the equation (4) and table 8, In the long-run, coefficients of disequilibrium terms C(23), C(24) are negative and statistically insignificant. Thus, there is no long run equilibrium relationship among variables.

E. *Residual Analysis*

Adequacy of the model was tested on the residuals of the VECM using correlogram, residual portmanteau test for autocorrelations, residual serial correlation LM tests.

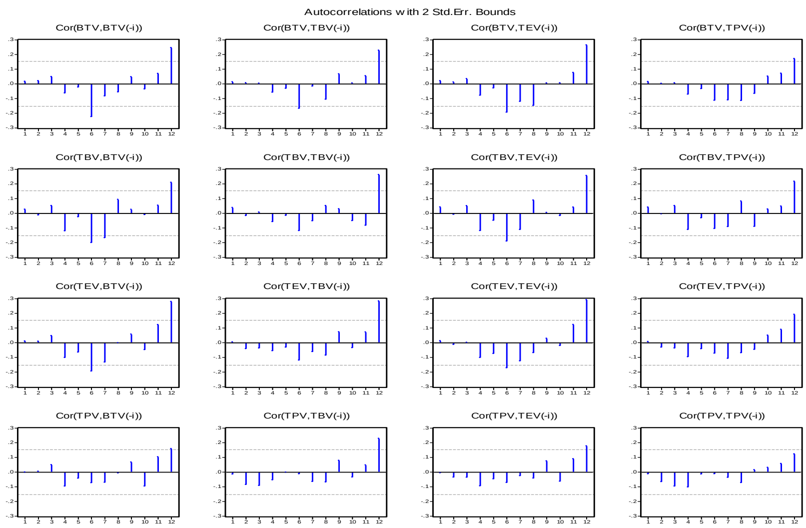

Fig. 1: Residual correlograms of the VEC model

As figure 1 depicts, correlogram supports the adequacy of the model. Apart from very few data points most of the data points are inside the bandwidth, indicating that auto correlation function supports the stationary of the fitted model.

VEC Residual Portmanteau Tests for Autocorrelations
H0: no residual autocorrelations up to lag h
Sample: 2005M01 2019M05
Included observations: 170

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	1.132073	NA*	1.138772	NA*	NA*
2	5.257580	NA*	5.313391	NA*	NA*
3	17.55862	0.3504	17.83541	0.3336	16
4	23.54012	0.8606	23.96104	0.8458	32
5	33.85844	0.9389	34.59203	0.9267	48
6	56.83186	0.7255	58.40595	0.6737	64
7	88.15151	0.2495	91.07061	0.1867	80
8	115.5663	0.0848	119.8392	0.0502	96
9	131.2442	0.1033	136.3935	0.0584	112
10	144.6349	0.1494	150.6211	0.0839	128
11	164.2610	0.1188	171.6050	0.0580	144
12	195.2163	0.0303	204.9114	0.0095	160

Table 9: Results of Portmanteau Test of the VEC model

When examining Table 9, it can be seen that the null hypothesis of no autocorrelation is not rejected up to lag 11 as p-values go beyond the 5% level of significance. This implies that residuals do not suffer from auto-correlation problem up to lag 11. Therefore, model is adequate since residual series is not auto correlated.

VEC Residual Serial Correlation LM Tests
H0: no serial correlation at lag order h
Sample: 2005M01 2019M05
Included observations: 170

Lags	LM-Stat	Prob
1	12.87063	0.6822
2	17.88178	0.3309
3	23.65298	0.0974
4	6.895494	0.9752
5	10.28908	0.8511
6	25.01120	0.0696
7	33.01896	0.0873
8	30.31254	0.0764
9	17.50616	0.3536
10	14.19272	0.5844
11	21.99617	0.1433
12	35.49296	0.0634

Table 10: Results of the residual LM test of the VEC model

According to the table 10, it can be clearly seen that p value of all the lags are greater than 0.05. Hence, null hypothesis of no serial correlation is not rejected up to lag 12. Hence, the test indicates that there is no serial correlation among residuals. Therefore, model is adequate according to the LM test. Thus, the analysis of residuals confirms that the model is satisfactory.

The model building process reveals that Vector Error Correction Model (VECM) fits the data adequately. Therefore, the performance of the fitted model was evaluated by making prediction of five months ahead. The accuracy of the forecasts was tested using Mean Absolute Percentage Error.

IV. DISCUSSION

Economic behaviour of the plantation sector is important. Tea industry mainly deals with production and exports. Tea export earnings in Sri Lanka have fluctuations although the general tendency is that of an increase over the years. This study mainly focuses on determining appropriate statistical methods for modelling tea export earnings by category. The presence of co-integration between variables suggests a long-term relationship among the variables under consideration which made it possible to fit an Error Correction Model.Results of the fitted model for bulk tea revealed that there is a long run equilibrium relationship. Bulk tea revenue is positively affected by 49% of tea packets when there is one unit change in its lagged values. Export earnings of tea bags is positively affected by almost 30% of bulk tea when there is one unit change in its lagged values and affected negatively by about 25% of total export when there is one unit change in its lagged values. export earnings of tea packets are positively affected by almost 37% of bulk tea when there is one unit change in its lagged values. It is also affected negatively by almost 49% and 37% when there is one and two units change in the lagged values of tea bags. Results of VEC model for total export earnings revealed that total export earnings are positively affected by almost 55% of bulk tea and tea packets when there is one unit change in its lagged values. It is also affected negatively by 77% and 60% when there is one and two units change in the lagged values of tea bags. According to the results of analysis, it is found that the VEC model is well fitted the trend in tea export earnings in Sri Lanka. The comparison between the original series and forecasted series shows the fitted model behaved statistically well and suitable to forecast tea export earnings in Sri Lanka i.e., the models forecast well beyond the estimation period. Thus, this model can be used for tea planters, policy makers to make appropriate decisions for tea industry.

V. CONCLUSION

On the basis of overall analysis, the main points of the study as noted in the discussion are as follows:

- Co-integration relationships reflect the long-term relationship between relevant variables.
- Bulk tea and Tea bags exhibit long term co-movements.
- Vector Error Correction Models give more accurate results with least MAPE.

This study provides useful guidance for tea planters and policy makers in Sri Lankan tea industry. Forecasting tea export earnings is beneficial to alter their production plans in the market. These findings can be useful to Sri Lanka Tea Board in formulating plans to maintain or enhance competitiveness in international market also.

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