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MODELLING CATEGORY-WISE EXPORT UNIT PRICE OF CEYLON BLACK TEA

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ABSTRACT

The tea industry is a key component in Sri Lankan economy, and is a leading foreign income generator. It contributes eighteen percent of world tea export shares. Being a crop which contributes greatly to the Sri Lankan economy, it is very important to be aware of the future fluctuations in tea export prices.

This study is an attempt to identify predictive models to forecast category-wise monthly export unit prices of Ceylon Black Tea using data obtained from Sri Lanka Tea Board for the period 1997-2015. There are mainly five export categories of Ceylon black tea namely bulk tea, tea packets, tea bags, instant tea and other tea. The study employed the conventional augmented dickey fuller (ADF) test to test for stationarity among the variables and Johensen co-integration technique to determine the co-integrating equation. Bulk tea, tea bags, tea packets and other tea series were found to be I(1). Two co-integrating relationships among these series which have the same integration order were evident but all four variables are not co-integrated at the same time. Hence two Vector Error Correction (VEC) models were fitted. One relationship is among bulk tea, tea bags and other tea. Other relationship is among tea packets, tea bags and other tea. Adequacies of the fitted VEC models were tested. LM Test, Portmanteau Autocorrelation Test and correlogram suggested that the error series were stationary. Comparative forecasting accuracy of VEC models were made in terms of their estimation accuracy based on MAPE. The results revealed that VEC models give more precise results than classical univariate time series models with least MAPE in forecasting export unit price of Ceylon black tea. Further, it was found that Bulk tea and Tea packets *exhibit long term co-movements. Thus, these identified forecasting models will help to study future fluctuations in the tea industry.*

KEYWORDS: Ceylon Black Tea**,** Co-integration,Export Unit Price**,** Forecasting, VECM

1. Introduction

Tea Industry is a major thrust industry in Sri Lanka which has a significant contribution to national economy. 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. There are five categories of export in Sri Lankan black tea. They are bulk tea, tea packets, tea bags, instant tea and other tea. Among them, tea packets, tea bags, instant tea and other tea belong to value added tea category and bulk tea is considered as non-value added tea.

Tea sector would contribute substantially to enhance export earnings of the country. To develop the world demand for Ceylon tea, it's needed to identify the temporal patterns of the export unit prices of each category as tea export unit prices change over time. Therefore, main focus of this study is to forecast export unit price of Ceylon black tea using time series techniques. Forecasting on export unit price of tea will be very important for economists, policy makers and scientists in the country for various purposes.

Wanninayake&Dissanayake (2006) have focused on identifying the present competitive situation of Sri Lankan value added tea sector compared to international competition and further it discusses the existing strategies followed by this sector in terms of international brand development.

Ganewatta (2002) has presented a discussion of the export supply and then an empirical relationship of export supply for value added tea was established. Next, therelevant concepts of time series which co-integration and error correction model were modeled to provide the methodological background of the estimation procedure of export supply function. Then a comparison has been made between the long run relationship of value added tea export supply with a bulk tea export supply function estimated.

Review of literature reveals that most of the studies related to production, supply and demand in tea industry. No research has been carried out in Sri Lanka with the use of category wise export unit prices of Ceylon black tea. If a well-organized method is formed, it will be given some idea to the giants in tea industry on temporal behavior of tea export prices.

2. Materials and Methods

2.1 Data used for the study

The data which are used for the purpose of this study was category-wise export unit price of Ceylon black tea. Data are used for nearly 19 years starting from January 1997 to December 2015 which consists of total 228 monthly observations. The data relevant to this study was soured from secondary sources as Statistical Bulletin 1997-2015 and Annual Reports of Sri Lankan Tea Export in Sri Lanka Tea Board.

2.2 Methods used

The descriptive analysis was used to identify the basic characteristics of the data. The data was analyzed by using multivariate time series.

2.2.1 Augmented Dickey Fuller Test

Stationarity of a series is a key phenomenon 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:

Ho: the variable has unit root (i.e. $\beta=0$)

H1: the variable doesn't has 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.

2.2.2 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 r+1 co-integrating relations for r = 0, 1,2…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…n-1.

2.2.3 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.

3. Results and Discussion

3.1 Stationarity Test:

As indicated above, before performing the analysis of co-integration, stationary test was carried out for each series under study. Testing of stationary of variables is done by ADF-Test. It is clear from Table 1 that the null hypothesis of no unit roots for all the time series are rejected at their first differences since ADF test statistic values are less than the critical values at 1% levels of significances. Thus, the series are non-stationary and integrated of the first order, i.e., I (1).

Table 1: Results of Unit Root Test

Category	Original Series		1st Difference Series		Integration Order
	ADF	P-Value	ADF	P-Value	
Bulk Tea	0.803066	0.9939	-12.95987	0.00	I[1]
Tea Packets	0.030165	0.9595	-17.33786	0.00	I[1]

Tea Bags	0.384811	0.9820	-11.46195	0.00	I[1]
Other Tea	-1.236565	0.6588	-13.63453	0.00	I[1]

3.2 Co-integration Test: Co-integration was formally tested using Johansen methodology. Johansen's approach derives two likelihood estimators, a trace test and a maximum Eigen value test. The results are presented in Table 2.

Table 2: Results of Johansen Co-integration Test

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.203001	97.72900	54.07904	0.0000
At most 1 *	0.132248	47.81047	35.19275	0.0014
At most 2	0.048692	16.60357	20.26184	0.1480
At most 3	0.025230	5.621811	9.164546	0.2220

Trace test indicates 2 co-integrating eqn(s) at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigen value)

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.203001	49.91853	28.58808	0.0000
At most 1 *	0.132248	31.20690	22.29962	0.0022
At most 2	0.048692	10.98176	15.89210	0.2532
At most 3	0.025230	5.621811	9.164546	0.2220

Max-eigen value test indicates 2 cointegratingeqn(s) at the 0.05 level

According to the co-integration test, trace test indicates that there are two co-integration equations at 5% level of significance. Maximum eigen value test also indicates that there are two co-integration equations. Thus, test results suggest that four variables are co-integrated.

Table 3:Co-integration Equations among Export Categories of Ceylon Black Tea

Co-integration equation	Bulk Tea	Tea Packets	Tea Bags	Other Tea	C
1	1.0000	0.0000	-0.3373 (0.04312)	-0.355882 (0.05207)	107.9514 (14.8440)
2	0.0000	1.0000	-0.473316 (0.03327)	-0.257342 (0.04017)	105.3837 (11.4512)

The above table indicates that Tea Packets has no effect to the first co-integration equation and also Bulk Tea has no effect to the second co-integration equation implying all four variables are not co-integrated at the same time. Since the variables are co-integrated, there must also be an Error Correction Model (ECM) which describes the long run and short run dynamics of the co-integrated variables.

3.3 Vector Error Correction Model:

The presence of co-integration between variables suggests a long term relationship among the variables under consideration. Then, the VECM discussed above can be applied for co-integrated variables. Since all four variables are not co-integrated at the same time, two VEC models have to be fitted, one is without tea packets and the other one is without bulk tea.

3.3.1 Fitting VEC model without Tea Packets

Variable coefficients in each equation are shown as follows.

Table 4: Variable Coefficients of VECM

	Lag	D(BT)	D(TB)	D(OT)	Z_t
D(BULK TEA)	1	0.200668 (0.06963) [2.88207]	-0.013748 (0.02371) [-0.57977]	-0.000558 (0.00808) [-0.06913]	-0.04514 (0.02144) [-2.10536]

	2	0.089622 (0.07034) [1.27418]	-0.002936 (0.02392) [-0.12276]	-0.005154 (0.00702) [-0.73446]	
D(TEA BAGS)	1	0.226382 (0.19865) [1.13962]	-0.371878 (0.06765) [-5.49683]	0.061869 (0.02305) [2.68422]	0.191072 (0.06116) [3.12394]
	2	0.256526 (0.20068) [1.27831]	-0.245053 (0.06824) [-3.59124]	0.022558 (0.02002) [1.12672]	
D(OTHER TEA)	1	-1.006065 (0.66677) [-1.50885]	0.063933 (0.22708) [0.28154]	-0.235267 (0.07737) [-3.04095]	1.118051 (0.20530) [5.44592]
	2	-0.96863 (0.67358) [-1.43803]	-0.425324 (0.22904) [-1.85699]	0.023103 (0.06720) [0.34379]	

$$D(BT)=-0.045Z_{t-1}+0.20D(BT)_{t-1}+0.09D(BT)_{t-2}-0.014D(TB)_{t-1}-0.003D(TB)_{t-2}-0.001D(OT)_{t-1}-0.005D(OT)_{t-2} \quad \textbf{(1)}$$

In the long run, the coefficient of disequilibrium term is negative (-0.045) revealing that there is a long run equilibrium relationship. It implies that the model identified the speed of adjustment by 4.5% of disequilibrium correction monthly for reaching long run equilibrium steady state position. Also, export unit price of bulk tea is positively and statistically significant at lags 1 and 2. It is affected by 20% when there is one unit change in its lagged values. It can also be inferred from the equation that tea bags and other tea have slight negative impact on export unit price of bulk tea.

$$D(TB) = 0.19\ Z_{t-1}+0.23\ D(BT)_{t-1}+0.26\ D(BT)_{t-2}-0.37\ D(TB)_{t-1}-0.245\ D(TB)_{t-2}+0.06\ D(OT)_{t-1}+0.023D(OT)_{t-2} \quad \textbf{(2)}$$

It can be realized from the above equation that export unit price of tea bags is affected positively by 23% of bulk tea when there is one unit change in its lagged values and 26% of bulk tea when there is two unit change in the lagged values. On the other hand, tea bags have considerable negative impact on export unit price of tea bags. In the long run, coefficient of disequilibrium term is positive (0.19) revealing that there is no long run equilibrium relationship among variables.

$D(OT) = 1.12\ Z_{t-1} - 1.01\ D(BT)_{t-1} - 0.97\ D(BT)_{t-2} + 0.064\ D(TB)_{t-1} - 0.425\ D(TB)_{t-2} - 0.235\ D(OT)_{t-1} + 0.023\ D(OT)_{t-2}$ **(3)**

According to the above equation, export unit price of other tea is positively affected by almost 6.4% of tea bags when there is one unit change in its lagged values and 2.3% when there is two unit change in its own lagged values. In the long run, positive coefficient of disequilibrium term indicates that there is no long run equilibrium relationship among variables.

Where the disequilibrium term is given by,

$$Z_{t-1} = BT_{t-1} - 0.34TB_{t-1} - 0.356OT_{t-1} + 107.95$$

3.3.2 Fitting VEC model without Bulk Tea

Variable coefficients in each equation are shown as follows.

Table 5: Variable Coefficients of VECM

	Lag	D(TP)	D(TB)	D(OT)	Z_t
D(TEA PACKETS)	1	-0.064861 (0.07259) [-0.89356]	-0.011836 (0.03503) [-0.33786]	-0.004844 (0.01129) [-0.42917]	-0.08745 (0.03626) [-2.41189]
	2	0.056232 (0.07136) [0.78800]	-0.016337 (0.03509) [-0.46561]	-0.003978 (0.01011) [-0.39364]	
D(TEA BAGS)	1	-0.102443 (0.14108) [-0.72616]	-0.324525 (0.06809) [-4.76636]	0.066272 (0.02193) [3.02130]	0.288961 (0.07047) [4.10054]
	2	0.035659 (0.13869) [0.25712]	-0.227699 (0.06819) [-3.33908]	0.026604 (0.01964) [1.35465]	
D(OTHER TEA)	1	-1.0285 (0.48143) [-2.13633]	0.157207 (0.23235) [0.67659]	-0.294009 (0.07485) [-3.92774]	1.150937 (0.24048) [4.78596]
	2	-0.780186 (0.47329) [-1.64844]	-0.370568 (0.23271) [-1.59239]	-0.004721 (0.06702) [-0.07044]	

$D(TP) = -0.09Z_{t-1} - 0.065D(TP)_{t-1} + 0.056D(TP)_{t-2} - 0.012D(TB)_{t-1} - 0.016D(TB)_{t-2} - 0.005D(OT)_{t-1} - 0.004D(OT)_{t-2}$ **(4)**

In the long run, the coefficient of disequilibrium term is negative (-0.09) revealing that there is a long run equilibrium relationship among variables. It implies that the model identified the speed of adjustment by 9% of disequilibrium correction monthly for reaching long run equilibrium steady state position. Export unit price of tea packets is positively affected by about 5.6% when there are two unit changes in its own lagged values. In addition, it is affected negatively by almost 6.5% when there is one unit change in its own lagged values. It can also be inferred from the equation that tea bags and other tea have slight negative impact on export unit price of tea packets.

$$D(TB)=0.3Z_{t-1}-0.1D(TP)_{t-1}+0.036D(TP)_{t-2}-0.325D(TB)_{t-1}-0.23D(TB)_{t-2}-0.066D(OT)_{t-1}-0.027D(OT)_{t-2} \quad (5)$$

When referring to the above equation, export unit price of tea bagsis positively affected by almost 3.6% of tea packets when there are two unit changes in its lagged values. It is affected positively by nearly 6.6% and 2.7% when there is one and two unit change in the lagged values of other tea. In the long run, positive coefficient of disequilibrium term indicates that there is no long run equilibrium relationship among variables.

$$D(OT)=1.15Z_{t-1}-1.03D(TP)_{t-1}-0.78D(TP)_{t-2}+0.16D(TB)_{t-1}-0.37D(TB)_{t-2}-0.3D(OT)_{t-1}-0.005D(OT)_{t-2} \quad (6)$$

By referring above equation, export unit price of other tea is positively affected by almost 16% of tea bags when there is one unit change in its lagged values. Lagged values of all the other variables have negative impact on export unit price of other tea. In the long run, positive coefficient of disequilibrium term indicates that there is no long run equilibrium relationship among variables.

Where the disequilibrium term is given by,

$$Z_{t-1} = TP_{t-1} - 0.5TB_{t-1} - 0.26OT_{t-1} + 105.4$$

Adequacy of the model was tested on the residuals of the VECM using Correlogram, Residual Portmanteau Tests for Autocorrelations, Residual Serial Correlation Lagrange Multiplier Tests. The analysis of residuals confirmed that the models were satisfactory.

The performance of the fitted models was evaluated by making prediction of five months ahead and best model was selected from the fitted models based on MAPE. In evaluating the performance of the forecasting models, the lower the MAPE the better the forecasting accuracy.

5. Conclusion

Tea industry mainly deals with production and exports. The tea export price in Sri Lanka has fluctuations although the general tendency is that of an increase over the years. With this background, this study examined useful models for accurate forecasting by using time series techniques. Forecasting is beneficial to alter their production plans in the market.

From the two fitted models for category-wise export unit price of Ceylon black tea, VEC model without tea packets was the best model for bulk tea as it gives least MAPE value. The least MAPE was given by VEC model without bulk tea for tea packets.

Out of the models fitted for tea bags smallest MAPE is given by VEC model without bulk tea. VEC model without bulk tea gives least MAPE for other tea category.

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