MODELLING CATEGORY WISE TEA EXPORT EARNINGS IN SRI LANKA: VECTOR ERROR CORRECTION MODEL (VECM) APPROACH

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Degree of Master of Science

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Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Financial Mathematics

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Name of the supervisor: Mr. Rohana Dissanayake

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ABSTRACT

Tea industry is a strong pillar in Sri Lankan economy in terms of foreign earnings and employment. Millions of people are employed directly and indirectly in the tea industry. Therefore, it is important to study about the behavior of tea export earnings and forecast tea export earnings for several months. This study is an attempt to identify predictive models to forecast category wise tea export earnings namely Bulk tea, Tea bags, Tea packets and Total exports using monthly data obtained from Sri Lanka Tea Board covering the period January 2003 to October 2017. The study employed the conventional augmented dickey fuller (ADF) test to test for stationarity among the four variables and Johensen co-integration technique to determine the co-integrating equation. All the series were found to be I(1) and two co-integrating relationships among these series were evident. Hence Vector Error Correction (VEC) model was fitted. For the validation of the VEC model, residual analysis was carried out using Residual plot, Correlogram, Residual portmanteau test for autocorrelation and Serial Correlation LM Test. The results indicated that model was satisfactory. Finally, Impulse Response Function (IRF) and Variance Decomposition (VDC) were employed in order to illustrate the importance of each variable to tea export earnings when a shock is imposed to the system. The analysis revealed that bulk tea earnings positively relate to tea packets earnings but negatively relate to total export earnings whereas tea bags earnings negative relate to tea packets earnings in long run. The results showed that tea packets earnings significantly and directly affect both bulk tea and tea bags earnings in the short run. The study also generated an out-of-sample forecast to analyze and compare the statistical results in order to determine the accuracy of the fitted model. The accuracy of the forecasts was tested using MAPE. Therefore, it can be concluded that the developed VEC model can be used to forecast tea export earnings in Sri Lanka with considerable accuracy.

Keywords: Co-integration, Impulse Response Function, Tea Export Earnings, Variance Decomposition, Vector Error Correction Model (VECM)

Dedicated to my parents

for their love, endless support

and encouragement…

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LIST OF ABBREVIATIONS

ACF	Autocorrelation Function
ADF	Augmented Dickey Fuller
AIC	Akaike's Information Criterion
AR	Autoregressive
ARIMA	Autoregressive Integrated Moving Average
ARMA	Autoregressive Moving Average
BT	Bulk Tea
BTV	Bulk Tea Value
FPE	Final Prediction Error
HQC	Hannan-Quinn Criterion
IRF	Impulse Response Function
LM	Lagrange's Multiplier
MA	Moving Average
MAPE	Mean Absolute Percentage Error
PACF	Partial Auto Correlation Function
SARIMA	Seasonal Autoregressive Integrated Moving Average
SBC	Schwartz's Bayesian Criterion
SLTB	Sri Lanka Tea Board
TB	Tea Bags
TBV	Tea Bags Value
TEV	Total Export Value
TP	Tea Packets
TPV	Tea Packets Value
VAR	Vector Autoregressive
VDC	Variance Decompositions
VECM	Vector Error Correction Model

CHAPTER 1
INTRODUCTION

In this chapter, fundamental information of the study will be introduced such as background, motivation, significance of the study and objectives of the study. It would be supported to gain a basic idea and develop a sight about the study. At the end of this chapter, an overview of the whole study will be provided.

1.1 Background of the study

The tea industry initiated by the British played an important role in the economy of pre and post-independence Sri Lanka. For more than a century, tea has been the biggest provider of employment, export earnings and government revenue. By the independence of Sri Lanka in 1948, tea along with rubber and coconut contributed more than 92% of total export earnings of the country [9]. The tea sector still continues to occupy an important place in the economy.

1.1.1 Export quantity and value of tea by category

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. Low domestic consumption of tea has allowed Sri Lanka to maintain relatively high export share. The average consumption of tea is estimated around 5% of gross output. However, it is difficult to estimate actual amount, as data is not available on direct factory sale and inventory holdings each year.

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 has become forward.

From 2015 to 2016, the total quantity of exports had increased by 2.1%, and that had taken place due to the increments of 2% of black tea, 4% of instant and green tea. The increased of black tea 2% is caused by the growths of tea packets by 4.9% and tea bags by 9.9%. The value of exports had increased by 6.6%.

1.1.2 Tea exports by destination

Top thirty tea importing countries from Sri Lanka shared 89% of total exports of Sri Lankan own made tea in the year 2014. As far as the top thirty export destinations are concerned, in 2009 the year which world economic recession was severely affected total tea imports declined to 280 mnkg. However, since then in the past three years the level of total imports remained the same. Since 2003 to 2013, even in 2010 the top five tea export destinations of Sri Lanka were Russia, UAE, Syria, Turkey and Iran.

United Kingdom was the largest tea importer from Sri Lanka with declining share over the time. Sri Lanka exported large quantities to U.S.A. Pakistan, Iraq and Australia too until recently. With the emergence of African producers, traditional suppliers like India and Sri Lanka have lost the share in the major traditional markets. Reduced tea imports from Sri Lanka to the United Kingdom are not only the result of reducing tea consumption but also changing trading pattern with the dominant role of multinational firms in tea trade. Sri Lanka has lost its market share in Australia, Canada and Pakistan too during the same period while Middle East countries like Iran, U.A.E. have emerged as major buyers of Sri Lanka tea.

Sri Lanka has increased its share of value added forms of tea export over the time to earn higher income. As a result of value added tea export, Sri Lanka remains as highest export earner from tea compare to Kenya that export almost same amount of tea in last few years. This indicates the importance of value adding process within the country. Progress of Sri Lanka not only as a producer but also as a value added tea product exporters are important to gain higher income to the country from tea industry.

1.1.3 Sri Lanka's tea export markets

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. Major re-exporting countries are United Kingdom, USA and Germany.

According to the statistical database of the Food and Agricultural Organization, major country markets for tea in the international market are the Russian Federation, United Kingdom and United Arab Emirates and USA in the world. Sri Lanka is exporting to Russian Federation only 26.8% (Calculated based on the Sri Lanka Tea Board Statistics) of total tea exported to that country and other rest of the tea is being exported other major producers specially by Kenya. United Kingdom is also one of the major tea consuming countries in the world. This country's tea need mostly fulfilled by Kenya. This unpleasant situation also stresses the urgent need for competitive strategy to uplift the tea industry of Sri Lanka.

When Pakistan is taken into consideration, it is one of the major tea consuming countries in the world and it is one of lucrative markets for Sri Lankan tea. In fact, the market size of the Pakistan tea is 160 – 170 million Kilogram annually. Tea import of Pakistan is also drastically increasing annually. Interesting point is that the import from Sri Lanka is falling from 3640 MT to 702 MT in 2007 with market share of merely 0.66% [21].

Sri Lanka is exporting most of the tea as bulk and not in the form of value addition. Therefore, it is extremely difficult for Sri Lankan tea industry to compete with other major tea exporters in the world. For instant, Kenya, India, China, Vietnam, Malawi and other tea producing countries are exporting bulk as well as value added tea at a lower prices comparing with Sri Lanka. Hence, the competition among exporting countries is taking place on price not on quality. This is one of the foremost reasons of declining in competitiveness of Sri Lankan tea in the global market.

1.1.4 Role in the economy

The tea industry played an important role and still continues to occupy an important place in the economy of Sri Lanka even though relative contribution has declined in recent years. Tea utilizes large quantity of resources and provides relatively high return to the country. Tea uses larger area of wet zone arable land available for the agriculture. Sri Lanka exports more than 90% of its production annually.

With the changes of the Sri Lanka economy since 1980's, value of industrial export has increased dramatically. The tea exports account for about 15% percent for the total exports and about 65% contributes for the total agriculture exports in the country [22]. According to the research done by Sri Lanka Customs, country earned a highest ever Rs. 233.3 billion from tea exports in 2017. It is a massive 26% or Rs. 48 billion more than 2016 figure of Rs. 184 billion.The previous rupee record was Rs. 212 billion in 2014 earned from an export quantity of 327 mnkg compared with 288 mnkg in 2017. The approximate Dollar value of all exports is $ 1.53 bln, the highest since 2014 value of $1.63 bln. In that year the country exported a highest ever 327 mnkg, 12% more.

This makes 2017 FOB value a record $ 5.30 well above the previous record of $ 5 achieved in 2014 and much more than the FOB price of $ 4.39 achieved in 2016. This year’s figure is the lowest since 2009 when 289.6 mnkg was exported. The countries export quantities peaked at 327.4 mnkg in 2014 but have been sharply lower since then. Reviews of the different segments have bulk tea shipments at 43% with Packets at 47%. [9].

1.1.5 Problems in exports of Sri Lankan tea

Sri Lanka has already lost its major markets such as United Kingdom and Pakistan due to high cost of production. Interview with exporters done by Hilal and Mubarak emphasized that these two major country markets are no longer international market for Sri Lankan tea. It was also revealed that high cost of production and low productivity lead to high price and hence, bulk tea prices reached to the maximum. While Sri Lankan companies which export bulk tea are straggling in finding investment to export value added tea products to the world.

It is explicable from the interviews with exporters that iron filing is affecting Sri Lankan bulk tea exports. International markets are reluctant to accept tea that contained iron filing. The iron filing should not exceed the prescribed limit. Sri Lankan tea contains iron filing above the limits. Hence, it is also a biggest problem for Sri Lankan tea and it affects the export of tea.

Competition on price is another reason that affects the tea exports. Sri Lanka has high cost of production and thus, it is compulsory for the exporters to price the tea at high level. As a result, Sri Lankan tea has been pushed to the price competition. Other tea producers such as Kenya, Vietnam and other cheaper tea producing nations are utilizing this as an opportunity and export tea to country markets at low price.

Interviewees revealed that reasons for decreasing demand for the Sri Lankan tea in the world market is sky rocketing cost of production in Sri Lanka and increased production of Kenya with its virgin soil. It was exposed that Sri Lankan tea had increasing demand before 1998 and then gradually decreased due to the inability of paying high price of Sri Lankan tea and it had gone up from US $ 2.5 to US $ 3.8.

Sri Lanka is principally being an exporter of bulk tea. However, there has been a gradual shift in consumption patterns with several countries switching to the use of more convenient form of the beverages such as tea bags. Hence, Sri Lanka has problems in marketing tea in the global market.Since Sri Lanka is having the highest cost of production in the tea industry, Sri Lankan tea is sold at expensive prices compared to the other origin tea. As a result, the price competition arises between tea producing nations. Tea producing nations such as Vietnam, Indonesia and Kenya have lower cost of production and thereby they price their tea products at lower price [11].

1.2 Motivation of the study

Tea industry in Sri Lanka caters to both local and international markets. Tea sector would contribute substantially to enhance export earnings of the country. Millions of families' incomes are dependent on the price of tea. Consequently, the instability of the price of tea posts a significant risk to producers, traders, consumers and others who involved in tea industry.

To develop the world demand for Ceylon tea, it's needed to identify temporal patterns of export earnings of each category as tea export unit prices change over time. With large price volatility, it is important to statistically and accurately forecast tea export earnings. 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.

1.3 Significance of the study

As already indicated before, tea sector has a tremendous impact on Sri Lankan economy. More than half a million small scale farmers are engaged in production of this vital commodity. This sector performance is therefore crucial to the overall growth of the economy. 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. Yet, there are not many studies which focus on forecasting tea export earnings. Therefore, main focus of this study is 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 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 generate information, which will be useful in designing appropriate measures 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.

1.4 Objectives of the study

This study is conducted with the aim of achieving the main objective of forecasting tea export earnings by category using suitable time series model. The main objective can be further elaborated and achieved through the following objectives.

- ✓ To examine whether the category-wise tea export earnings are co-integrated
- ✓ To investigate long run and short run relationship between category-wise tea export earnings

- ✓ To identify an appropriate model to forecast category-wise tea export earnings
- ✓ To evaluate the forecasting accuracy of the fitted model for tea export earnings

1.5 The database

The time series of monthly export earnings of Bulk tea, Tea bags, Tea packets and total export earnings in Sri Lanka are implemented in this study. The data are drawn from sources: Sri Lanka Tea Board website and Annual statistical bulletins. In essence, the data consists of four-time series, 173 observations for each series over the period of January 2003 to October 2017. 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 notedas BTV, TBV, TPV and TEV respectively.

1.6 Outline of the study

The study consists of six chapters including this Introduction chapter. Following is the list of the chapters included in the thesis with a very brief description.

Chapter 1 provides an introductory approach to the study. It consists of background of the study, motivation of the study, significance of the study, objectives of the study and data used for the study. This gives an overview about this research. Chapter 2 will give a review of past studies and published papers which are related to this study. Furthermore, it will give summary of the chapter. There are special methodologies and statistical concepts which are needed to apply during the analysis stage. Those are explained in the Chapter 3. Before carrying out the advanced analysis, preliminary analysis should be done to get the fundamental overview about the data set. Chapter 4 will bear up to do the role of preliminary analysis part. Chapter 5, Further analysis will be performed for the identification of the key tools and techniques that could be used in modelling category-wise tea export earnings in Sri Lanka. It discusses the study in more advanced. Chapter 6 will give general discussion, results and outcomes of this study. Finally, the conclusion of the study will be given.

CHAPTER 2

LITERATURE REVIEW

This chapter is divided into three sections. The first section deals with reviewed earlier studies on Tea Industry. The second section deals with theoretical literature review. The review covers some of the commonly used techniques Vector Error Correction Model (VECM), Co-integration, Impulse response function and Variance decomposition. The last section is the synopsis, where a summary of the literature review is presented.

2.1 Review on previous studies in tea industry

The tea industry in Sri Lanka is almost completely oriented to the export market. Tea is supplied to the export market either in bulk or value added forms. The export of value added tea products has helped Sri Lanka to earn a higher return from its tea exports compared to other competitive producer countries.

Uwimana, Mugemangango, Kipsat, Sulo and Nsabimana (2018) have explored the causality between tea exports and their determinants in Rwanda. Tea exports are volatile and are influenced by the real effective exchange rate, incomes of major trading patterns, total investments as a proportion of GDP, tea world market prices and coffee world market prices. The study has applied a causal research design and used time series data collected from different sources. Granger causality test has been performed to test for predictability between exports and their factors. The study concludes that non-causality in the long term was possible because before the late 1980s Rwanda had an economy that was based on a prestructural adjustment program when exports were under total control. Short-run causality was possible because after the 1980s, a decline in world tea prices may have led to an increase in exports as demand increased in the short run.

Tea exports are highly perspective to the external and internal factors and therefore, forecasting of export is a challenging task. The study done by Samarasinghe and Abeynayake (2017) has attempted to forecast the 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. Stationary of the time series data is a major requirement for developing the VAR model. Therefore, the non-stationary data have been converted to stationary data using the 1st difference. AR Roots Graph has been used to identify the stationary condition of the data set. The appropriate Lag order length for the VAR model was selected by considering Akaike Information Criterion (AIC) and Hannan- Quinn information criterion with the lowest values. The suitable Lag Length was two which means for every variable, the data of previous two years have affected. For the validation of the VAR model, residual analysis was done using three tests namely, Serial Correlation LM Test, Heteroskedasticity Test and Histogram-Normality Test. Further, the study has explored the factors which influence the export in the long-term and the short-term. Results of the Ganger Causality test showed that the tea production of Sri Lanka and the production of India have a short-term impact on tea exports of Sri Lanka and the Johansen Co-integration test has proved that all the factors considered in the model are directly affecting the export in the long-term. Trend analysis has revealed that the tea exportation showed an increasing trend during the early period but in the recent period, it showed a declining trend. MAPE of the developed VAR model was 1.85% which implies the high accuracy forecasting according to the Lewis classification of forecasting accuracy. Therefore, findings of this study revealed that the developed VAR model can be used to forecast the tea export in Sri Lanka with high accuracy.

The determinants of tea production vary according tea geographic elevation-low, medium and high. Silva and Cooray (2017) have attempted to quantify the impact of supply and demand factors affecting the production of tea taking elevation factor into consideration. In doing so, they have estimated an econometric model taking annual elevation wise data from 1970 to 2014 and then simulate the estimated model to examine the impact of government policies on the tea production. They have utilized commonly used yield and area approach in perennial crops modelling for estimation of tea production. The findings of the study suggest that the average temperature and usage of fertilizer are significantly affecting the yield of all three elevations while rainfall is not highly contributing for the tea yield of all three elevations. Average tea price is significant for replanting and new planting of all three elevations.

The cost factor as expected is negatively effecting the production of both low and medium elevations. The government subsidy schemes for tea replanting and new planting are positively effecting tea replanting and tea new planting of high elevation and low elevation. The simulation results have showed that 10% increase of subsidy for replanting would increase the production in high grown, medium grown and low grown areas by 5%, 4%, and 2% respectively.

Padmanaban, Supriya, Dhekale & Sahu (2015) have investigated export performance of tea in India using secondary data for the period from 1981 to 2010. The trend present in the export of tea was confirmed by fitting the original value with linear trend equation. Then double exponential smoothing technique (Holt's) was applied to forecast the export of tea from India up to year 2020. The result revealed that export of tea shows the declined to the value of 30328 for the year 2020 compare to the base year value of 30387 in the year 2010. The findings of this study suggest that among exponential models, double exponential model will be a good technique to use in generating tea export forecast.

The industry mainly consists of tea production, tea export and tea auctions. Being a crop which contributes greatly to the Sri Lankan economy, it is very important to be aware of the future fluctuations in tea production, prices and exports. Aponsu and Jayasundara (2012) have examined on predictive models to forecast monthly tea production, prices and exports. As Aponsu and Jayasundara (2012) illustrated Seasonal Auto Regressive Integrated Moving Average (SARIMA) models were fitted to forecast the monthly tea production and tea exports. The study has been undertaken by using the data from the Sri Lanka Tea Board. Monthly black tea production and price data were considered from 1988 to 2009, and tea export data for six tea categories namely Bulk, Green, Instant, Packed, Other tea and Tea bags, were considered from 1996 to 2010. Findings of the study suggest that most suitable model to forecast the monthly black tea production is SARIMA $(3,0,3)\,(0,1,1)_6$ and the best model to forecast total tea export is SARIMA $(1,0,2)\,(0,1,1)_{12}$.

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. Annual time series data on total production (1962-2010), total exports (1980-2010) for tea, rubber and coconut and annual time series data on domestic consumption (1980-2010) for rubber and coconut has been used in this study. Further, they have illustrated that an increase can be expected in the domestic consumption of rubber and coconut in 2011 while they will be steady during 2012 and 2013. An improvement in tea and coconut exports would be expected during next three years.

Wanninayake & Dissanayake (2006) have focussed 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. Finally, they have found major findings like the relative importance of value added tea in Sri Lankan tea industry has been growing tremendously. It has achieved relatively higher net gain by Sri Lankan value added tea than other competitive countries. Sri Lankan tea sector is following tea import strategy and re-export them with added values successfully. The overall brand development in Sri Lankan tea industry should be further developed so that it can acquire a higher competitive share.

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, the relevant 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.

2.2 Theoretical literature review

The study is based on tea export earnings. This section reviews various theories in regards to model tea export earnings by category. Several techniques, methods and models are used by the researches in order to model time fluctuate data such as Unit Root test, co-integration test, Vector Error Correction Model, Impulse Response Function, Variance Decomposition and a number of other methods. Here, some previous research works and their empirical conclusions that are related to current study are discussed.

Chamalwa and Bakari (2016) have recently investigated the relationship between economic growth (GDP) and some financial deepening indicators (money supply and credit to private sector) using a data obtained from the Central Bank of Nigeria (CBN) statistical bulletin for the period 1981-2012. They have used conventional augmented dickey fuller test to check for stationarity among the three variables (GDP, money supply and credit to private sector, Johensen co-integration technique to determine the order or the co-integrating equation. Granger causality test was used to check for causal relationship among the variables (i.e. uni-directional, bi-directional or feedback) and then the Vector Error Correction to check for a short-run or long-run relationship among the three variables. The results indicated that all the three variables are non-stationary at levels, but became stationary after first differencing once. The three variables are co-integrated with at most one co-integrating equation, bi-directional causality runs among the three variables. Further, they have found that VECM suggests a long-run relationship among the three.

Ahmad and Ghazi (2014) investigated whether the Amman Stock Exchange in Jordan affected by a set of macroeconomic variables namely, Real Gross Demotic Product, Consumer Price Index, Credit to Privet Sector, Weighted Average Interest Rate on Time Deposit and dummy variable which explain the global financial crises period using quarterly data by employing Johansen co-integration test, Vector Error Correction model (VECM), Impulse Response Function (IRF) and Variance Decomposition (VDC). They found that there was a bi-directional long run relationship exists between stock price index and credit to the private sector, weighted average interest rate on time deposits and consumer price index.

The study "Price modeling: Analysis with a Vector Error Correction Model" done by Mohamed, Skima, Saafi and Farhat (2014) have focused on the relationship between gold and four explanatory variables such as oil, platinum, palladium and silver. In this study, they have used Johansen multivariate approach (VECM), co-integration and Granger causality test. Findings of the study suggest that gold only depends on WTI prices. Further, Johansen approach result has revealed the existence of a long-run relationship between analysed variables.

Adam and George (2008) examined the role of macroeconomic variables on stock prices movement in Ghana. They used the Databank stock index to represent Ghana stock market and inward foreign direct investments, the Treasury bill rate (as a measure of interest rates), the consumer price index (as a measure of inflation) and the exchange rate as macroeconomic variables. They analyzed both long-run and short-run dynamic relationships between the stock market index and the macroeconomic variables from1991: Q1 to 2006: Q4 using Johansen's multivariate co-integration test and innovation accounting techniques. They found that there is co-integration between macroeconomic variables identified and Stock prices in Ghana indicating long run relationship. Results of Impulse Response Function (IRF) and forecast error Variance Decomposition (VDC) indicated that the macroeconomic variables identified significantly influence on share price movements in Ghana.

Gunasekarage et al. (2004) examined the influence of macroeconomic variables on stock market equity values in Sri Lanka. They used money supply, Treasury bill rate (as a measure of interest rates), consumer price index (as a measure of inflation) and exchange rate as macroeconomic variables and Colombo all share price index (ASPI) to represent the stock market. Unit root test, co-integration, vector error correction models (VECM), impulse response functions (IRF) and variance decompositions (VDC) techniques were used in their analysis and found both long-run and short-run relationships between the stock market index and the macroeconomic variables.

2.3 Synopsis

According to the literatures that have been described above, many studies have been done related to tea export in various countries and a few studies in Sri Lanka. It is clear that varied approaches have been applied in analysing tea export earnings. Literature reveals that no research has been carried out in Sri Lanka with the use of category-wise tea export earnings. In this study, an attempt has been taken to identify the relationship among category wise tea export earnings and then suggest a suitable forecast model for tea export earnings. Ultimately, the recommendations are made to the best models based on the Mean Absolute Percentage Error (MAPE) values.

By extracting the summary of above mentioned studies it can be concluded that they are closely related with this study when identifying techniques to be followed for assessing the co-integrated relationship among the category-wise tea export earnings.

Next chapter opens to methodologies and techniques that are going to be applied in the study. The techniques going to be applied are extracted from the studies discussed above.

CHAPTER 3
METHODOLOGY

There are many important methods and general materials which are applied to carry out any study. In this chapter, it is expected to present the methodology and the techniques applied for this study. It would be given a great value when understanding the application way of these methods in the analysis part. Each and every material which is used for this study will be discussed in this chapter.

3.1 Preliminary procedures

3.1.1 Stationary of a time series

A common assumption in many time series techniques is that the data are stationary. A Stationary process has the property that the mean, variance and autocorrelation structure do not change over time.

Usually time series showing trend or seasonal patterns are non-stationary in nature. In such cases, differencing and power transformations are often used to remove the trend and to make the series stationary.

Tests for stationary (Unit Root Test)

Before building a model to time series data, it is important to check the stationarity of data. There are generally three tools to track the presence of unit root. They are:

- Testing the order of integration of the series of the selected variables. If a variable is found I(0) at its level form then the variable is considered as stationary.
- If a variable is not found I(0) at its level form then the variable is considered as non-stationary. But if the first difference of the non-stationary variable is found I(0) then it is of I(1) and it becomes stationary.
- The Stationarity of the series of a variable can be examined by the Dicky Fuller (DF) unit root test, Augmented Dicky Fuller (ADF) unit root test or by Phillips-Perron (PP) unit root test.

The Augmented-Dicky Fuller test (ADF) is superior to Dickey Fuller (DF) test as it can remove the serial autocorrelation successfully. So, in this study Augmented Dickey Fuller (ADF) statistics will be used to trace out whether the time series has a unit root or not.

Augmented Dickey Fuller (ADF) Test

ADF test simply adds lagged dependent variables to the DF regression.

H_0: Series has a unit root (i.e. $\beta = 0$)

H_1: Series does not have a unit root (i.e. $\beta < 0$)

The test statistic is computed and compared to the relevant critical value for the Dickey Fuller test. The decision rule is, to reject the H_0, if the test statistic is less than the critical value at the relevant significance level.

Transforming non-stationary time series

In order to study a time series in detail, it is helpful to remove any trend and seasonal components from the data first. There are a variety of ways this can be done such as Differencing, Transforming.

In this study, to remove the trend component from the series differencing techniques was used which is explained here.

Differencing

Differencing is a popular and effective method of removing trend and the seasonal component from a time series until it becomes stationary. This provides a clearer view of the true underlying behaviour of the series. As an example the first order differencing given by $\nabla X_t = X_t - X_{t-1}$ is sufficient to remove the trend, more commonly.

3.1.2 Pearson correlation coefficient

The correlation coefficient measures the strength of the linear relationship between two variables. Correlations are always between -1 and 1 but can take any value in between. A positive correlation indicates that as one variable increases the other increases also. A negative correlation indicates that one variable increases as the other decreases.

For Pearson's correlation coefficient,
$H_0 : \rho = 0$ *Vs* $\mathrm{H}_1 : \rho \neq 0$, where ρ is the correlation coefficient between a pair of variables.

A small *p*-value is an indication that the null hypothesis is false. If the correlation coefficient is different from zero, then it can conclude that a linear relationship exists.

3.2 Univariate time series model

In general, models for time series data can have many forms and represent different stochastic processes. There are two widely used linear time series models, Auto Regressive (AR) and Moving Average (MA) models. Combining these two, the Autoregressive Moving Average (ARMA) and Auto Regressive Integrated Moving Average (ARIMA) models have been developed.

Auto Regressive Model (AR Model)

Autoregressive (AR) process is a regression process with lagged values of the dependent variable in the independent variable positions; hence it is named autoregressive process.

The expression of a p^{th} order autoregressive process, $\mathrm{AR}(p)$ is,

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_p Y_{t-p} + \varepsilon_t \qquad (3.1)$$

Where Y_t - Response variable at time *t*

Y_{t-k} - Observation (Predictor variable) at time *t-k*

ϕ_i - Regression coefficients to be estimated

ε_t - Error term at time *t*

Identifying AR order

PACF is an excellent tool in identifying the order of a $\mathrm{AR}(p)$ process. Hence for a $\mathrm{AR}(p)$ model the PACF between Y_t and Y_{t+k} for $k > p$ should be equal to zero.

Moving Averages Model (MA Model)

Moving Averages (MA) model is also a regression process with the dependent variable, Y_t depending on previous values of the errors rather than on the variable itself. The expression of a q^{th} order moving average process $\mathrm{MA}(q)$ is:

$$Y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} \qquad (3.2)$$

Where Y_t - Response variable at time t

μ - Constant mean of the process

θ - Regression coefficients to be estimated

ε_{t-k} - Error term at time t-k

Identifying MA order

ACF is useful in identifying the order of an MA model. For a time series Y_t with ACF ρ_l, if $\rho_q \neq 0$, but $\rho_l = 0$ for $l > q$, then Y_t follows an MA (q) model.

Auto Regressive Moving Average Model (ARMA Model)

Autoregressive (AR) and moving average (MA) models can be effectively combined together to form a general and useful class of time series models, known as the ARMA models.

An ARMA (p, q) model is a combination of AR (p) and MA (q) models and is suitable for univariate time series modeling. In an AR (p) model the future value of a variable is assumed to be a linear combination of p past observations and a random error together with a constant term. Mathematically an ARMA (p, q) model is represented as,

$$Y_t = c + e_t + \sum_{i=1}^{p} \alpha_i Y_{t-i} - \sum_{j=1}^{q} \beta_j e_{t-j} \qquad (3.3)$$

Where p, q refers to p autoregressive and q moving average terms.

3.2.1 Model identification

Generally, building any time series model has 3 stages, which are: Model Identification, Parameter Estimation and Residual Analysis. Tentative model is identified through analysis of historical data. It is useful to look at a plot of the series along with the sample ACF and PACF. Once a stationary series has been obtained, it is necessary to identify the form of the model to be used through the sample ACF and PACF for the various AR, MA and ARMA models. According to these plots the tentative model can be identified. Different models can be obtained for various combinations of AR and MA individually and collectively. The relevant properties are given below.

Table 3.1 Model identification

Model	ACF	PACF
AR(*p*)	Exponential Decay	P significant lags before dropping to zero
MA(*q*)	q significant lags before dropping to zero	Exponential Decay
ARMA(*p*,*q*)	Decay after q^{th} lag	Decay after p^{th} lag

3.2.2 Model selection

In time series analysis, sometimes more than one model can fit the data equally well. Under those circumstances, system knowledge can help to choose the more relevant model. While building a proper time series model, always the model with smallest possible number of parameters is to be selected so as to provide an adequate representation of the underlying time series data.

Out of a number of suitable models, one should consider the simplest one, still maintaining an accurate description of inherent properties of the time series. For this purpose, numerical criterion such as the Akaike information criterion (AIC) and the Schwartz's Bayesian criterion (SBC) are used to select the best model.

The best model is the one which gives the lowest AIC and SBC values. The coefficient of determination (R^2) is also taken into account for the section of best model. The best model gives the largest R^2value.

Akaike Information Criterion (AIC)

In order to choose a model from several competing models, a popular criterion for making the decision is to use AIC. The AIC is used in a wide variety of settings, not just time series analysis. The model with the minimum value of AIC is selected as the best one among many possible models.

Schwartz's Bayesian Criterion (SBC)

In statistics, Schwarz Bayesian Criterion (SBC) is another mostly used criterion for model selection among a class of parametric models with different number of parameters. Choosing a model to optimize SBC is a form of regularization.

Coefficient of determination (R^2)

The coefficient of determination (R^2) is a commonly used statistic to measure goodness of fit of a stationary model. It gives the proportion of the variance (fluctuation) of one variable that is predictable from the other variable. Typically, a larger R^2 indicates that the model provides a closer fit to the data.

3.2.3 Residual analysis

The third and the last stage of model building is residual analysis. Once a model (AR, MA, ARMA) is fitted to the raw data (or the transformed data), one should check that the accurate model has been specified. This is typically done using residual analysis. The following tests are carried out for the residual analysis:

Box –Pierce or Ljung box test

This computes the multivariate Box-Pierce/ Ljung-Box Q-statistics for residual serial correlation up to the specified order. The modified statistic is given by;

H_0: Residuals are not random

H_1: Residuals are random

The Q statistic is compared to the critical value from chi-square distribution. If the model is good, residuals should be uncorrelated and Q should be small.

Normality of residuals

Looking at the histogram or normal probability plot of residuals, normality of residuals can be checked. Bell shape in histogram or straight line pattern in normal probability plot suggests the normality of residuals. And also the values of Skewness and Kurtosis are considered to check the normality of the residuals. The value of skewness close to 0 and the value of kurtosis close to 3 suggest the residuals follow a normal distribution.

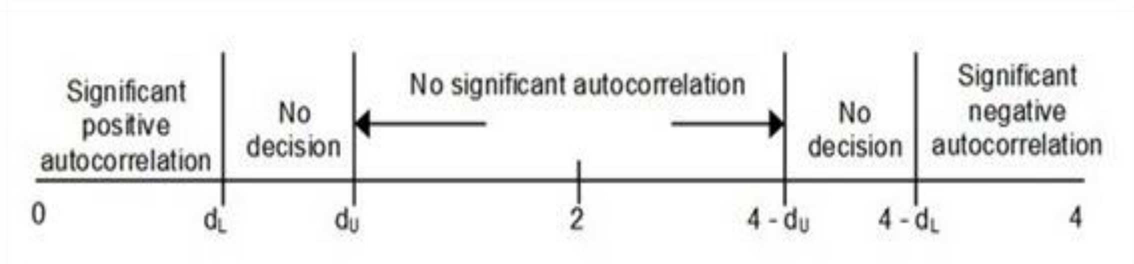
Durbin-Watson statistic

Another popular test for residuals is the Durbin-Watson test statistic which is an important test for detecting serial correlation.

H_0: Residuals are not serially correlated

H_1: Residuals are serially correlated

The Durbin Watson test reports a test statistic *(d)*, with a value from 0 to 4, where:



Lagrange's Multiplier test (LM Test)

Lagrange's Multiplier (LM) test is used to test the independency of residuals. It is an alternative test of Durbin Watson test for auto correlation among residuals.

H_0: No serial correlation of residuals of any order

H_1: Presence of serial correlation of residuals

The individual residual autocorrelations should be small. Significant residual autocorrelations at low lags or seasonal lags suggest that the model is inadequate.

3.3 Multivariate time series model

When concerning more than one variable, if they contain highly trended patterns, then most of them are series-correlated. So to model those kinds of series, multivariate time series modelling technique can be used.

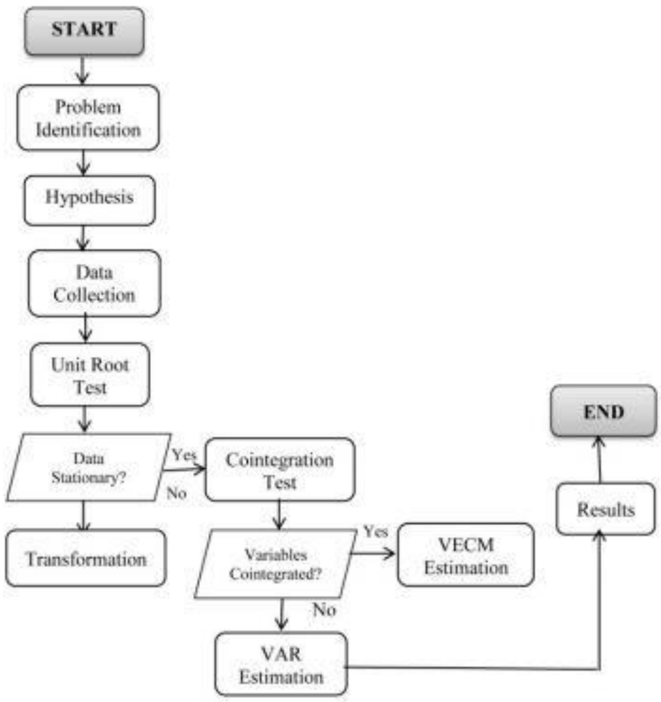


Figure 3.1: Research framework

A multivariate time series is a vector $\{(y_{1,t}, y_{2,t}, \ldots\ldots, y_{n,t})\}$ of n different time series that are measured concurrently. Each should be stationary or has the same order of integration. Figure 3.3 above shows the steps through which the study has been structured.

3.3.1 Lag order selection

The model estimating the causal relationship between variables is highly sensitive to the lag length involved. This implies how many lagged values should enter the system of equation. There are several criterions for choosing the optimal lag length in a time series such as Schwarz's Bayesian information criterion (SBC), Akaike information criterion (AIC) and Hannan–Quin information criterion (HQC). The lag length that minimizes SBC is chosen for the co-integrated VAR model.

3.3.2 Co-integration

With the non-stationary series, co-integration analysis is used to examine whether there is any long run relationship exists. However, a necessary condition for the use of co-integration 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.

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. Co-integration measures the long run co-movements in time series.

Long-Run equilibrium

When two or more series are co-integrated, a multivariate model will be worthwhile, since it reveals information about the long run equilibrium in the system. The linear combination of I(1) variables that is stationary is denoted by Z. It is called the disequilibrium term, because it captures deviation from the long run equilibrium in the Error Correction Model (ECM). The expectation of Z gives the long run equilibrium relationship among series. If more co-integration relationships found, that means the greater co-dependency among the process.

Test for co-integration

Standard statistical test for co-integration is to identify the linear combinations of the integrated series which best defines the long run equilibrium relationships between the variables.

Johansen Test for co-integration:

The Johansen test is more informative in the sense that it finds all possible co-integrating relationships. When there are many variables in the system, and there is no clear indication of which should be the dependent variable, Johansen test is more suitable. Also Johansen test seeks the linear combination which is more stationary. Thus for this study, it is selected the Johansen test for testing the co-integration.

This procedure uses two tests to determine the number of co-integration vectors: The Maximum Eigenvalue test and the Trace test. The Maximum Eigenvalue 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.

In some cases, Trace and Maximum Eigen value statistics may yield different results. In this case the results of trace test should be preferred [5].

3.3.3 Error correction model

Granger Representation Theorem implies that a VAR model on differences on I(1) variables will be miss-specified if the variables are co-integrated; an equilibrium specification is missing in the model. But when lagged disequilibrium terms are added as explanatory variables, the model becomes well specified. Such a model is called an Error Correction Model.

Error Correction Model is structured in such a way that short-run deviations from the long run equilibrium are corrected. The VEC model for the four variables investigated in this study will be in the form as follows.

$$\Delta X_{nt} = c + \sum_{i=1}^{k} \beta_{1i} \Delta X_{1t-1} + \sum_{i=1}^{k} \beta_{2i} \Delta X_{2t-1} + \sum_{i=1}^{k} \beta_{3i} \Delta X_{3t-1} + \sum_{i=1}^{k} \beta_{4i} \Delta X_{4t-1} + \gamma_n Z_{t-i} \tag{3.4}$$

Where n – 1,2,3,4 (no. of variables)

k – Maximum lag length

Δ - First differenced operator

$$Z_t = X_{1t} - \sum_{i=2}^{n} \alpha_i X_{it} + c, \textit{disequilibrium term} \tag{3.5}$$

Lag lengths and coefficients are determined by testing down OLS regression. The magnitude of the coefficients α_i determines the speed of adjustment back to the long run equilibrium following a market shock.

When these coefficients are large adjustment is quick so z will be highly stationary and reversion to the long run equilibrium will be rapid.

Short Run relationship

The short run causality is also tested using Wald test. The Wald test computes a test statistic based on the unrestricted regression. The Wald statistic measures how close the unrestricted estimates come to satisfy the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfy the restrictions.

Wald Test

Wald test is used to determine whether a certain predictor variable is significant or not. It rejects the null hypothesis of the corresponding coefficient being zero.

H_0: The coefficients of variables = 0

H_1: At least one coefficient of variables ≠ 0

3.3.4 Diagnostic checking

Diagnostic tests are applied to check the adequacy of the fitted model. They are as follows:

Residual Serial Correlation Lagrange Multiplier Test

This test is an alternative to the Q-statistic for testing the serial correlation.

H_0: There is no residual correlation up to lag h

H_1: There is residual correlation up to lag h

Portmanteau Autocorrelation Test

This computes the multivariate Box-Pierce/ Ljung-Box Q-statistics for residual serial correlation up to the specified order. It reports both the Q-statistics and the adjusted Q-statistics with a small sample correction.

H_0: There is no residual correlation up to lag h

H_1: There is residual correlation up to lag h

The MAPE (Mean Absolute Percentage Error)

Error measurement statistics play a critical role in tracking forecast accuracy. The question "How good is a forecast?" comprises two separate aspects: firstly, measuring predictive accuracy; secondly, comparing various forecasting models. The most commonly reported measure of predictive accuracy is Mean Absolute Percentage Error (MAPE). The MAPE measures the size of the error in percentage terms.

Generally, if MAPE is less than 10% then the fitted model is acceptable. However less than 15% also can be considered and this decision is purely subjective.

3.3.5 Innovation accounting

The co-integration 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 exogenous variables, Innovation Accounting such as Impulse Response Function (IRF) and Forecast Error Variance Decompositions (VDC) based on VECM is evaluated.

Impulse response function (IRF)

The impulse response functions are responses of all variables in the model to a one-unit structural shock to one variable in the model. This function investigates the time horizon of variables and their response for any sudden shock in any variable in the model with time passes. The impulse responses are plotted on the Y-axis with the periods from the initial shock on the X-axis [7].

An impulse response gives the response of one variable, to an impulse in another variable in a system that may involve a number of other variables as well.

A plot of row i, column j element of Ψ_s as a function of s is called the impulse response function, and gives the cumulative effect on variable i of an innovation in j.

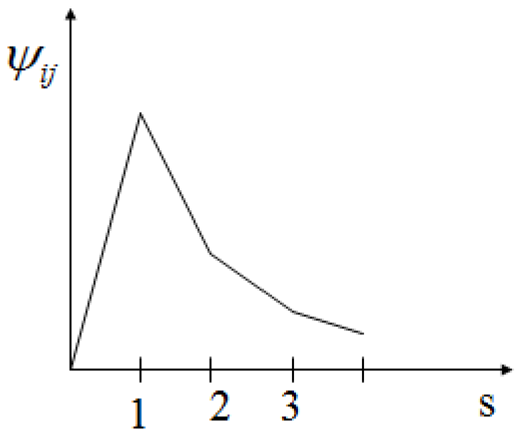


Figure 3.2: Impulse response function

Variance decomposition (VDC)

Granger causality tests of the VECM can indicate only Granger exogeneity or endogeneity of the dependent variables within the sample period. They cannot gauge the degree of exogeneity among the variables beyond the sample period. In order to provide further evidence on the relationships of the variables under investigation, the VDC is used to judge the consistency of causality tests. The VDC exhibits the proportion of the forecast error of each variable that is accounted for by each of the other variables.

Therefore, the VDC enables us to determine the relative importance of each variable in generating fluctuations in other variables in VECM [15].

3.4 Synopsis

In this Chapter, almost all the tests, relevant to preliminary analysis, prior to time series model development were explained. All the techniques for each and every modeling method were separately described with statistical methodologies. MINITAB and EViews software were used for all analysis adopted during the study.

Based on these criteria, tea export earnings by category will be analysed in the next chapter.

CHAPTER 4
PRELIMINARY ANALYSIS

Preliminary analysis is the most eye catching area of the data analysis. It would be helpful to gain a better understanding of the data that would give an insight in selecting the most appropriate methods for analysing the data. Initially general description about data will be given in this chapter. Then the behaviour of tea export earnings by category will be analysed to gain knowledge of the basis of data patterns and variations during the study period. It would be guided to find a path to build a suitable forecast model.

4.1 Data description

The study applies time series data running from 2003 to 2017. This period was preferred due to availability of variables that have been measured consistently. The variable of great interest is the tea export earnings. This variable is obtained from Monthly Bulletins of Sri Lanka Tea Board. In essence, the data consists of four-time series Bulk Tea, Tea Bags, Tea Packets and Total Export Value, 173 observations for each series over the period of January 2003 to May 2017.

For convenience, variables under consideration were coded as follows.

Bulk Tea Value – BTV

Tea Bags Value – TBV

Tea Packets Value – TPV

Total Export Value – TEV

4.2 Forecasting period

In order to evaluate the out-of-sample forecasting ability of the models, some observations at the end of the sample period are not used in estimating the models. Thus, there are two periods in the analysis: an in-sample period (January 2003 to May 2017) and an out-of-sample period (June 2017 to October 2017). The series from the in-sample period is used to generate the forecasting models where the out of-sample forecasts can be used to check against actual data.

4.3 Correlation matrix

The correlation matrix is an important indicator that tests the linear relationships, between the variables. The matrix also helps to determine the strength of the variables in the model, that is, which variable best explains the relationship between tea export earnings. This is important and helps in deciding which variable(s) to drop from the equation. The correlation matrix of the variables is presented in the table below.

Table 4.1: Correlation matrix

Correlations

		BTV	TPV	TBV	TEV
BTV	Pearson Correlation	1	.718**	.745**	.884**
	Sig. (2-tailed)		.000	.000	.000
	N	173	173	173	173
TPV	Pearson Correlation	.718**	1	.956**	.952**
	Sig. (2-tailed)	.000		.000	.000
	N	173	173	173	173
TBV	Pearson Correlation	.745**	.956**	1	.946**
	Sig. (2-tailed)	.000	.000		.000
	N	173	173	173	173
TEV	Pearson Correlation	.884**	.952**	.946**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	173	173	173	173

**. Correlation is significant at the 0.01 level (2-tailed).

From Table 4.1 above, it can be observed the relationship existing between various variables used by this study. It shows that there is positive high correlation between Bulk Tea, Tea Packets, Tea Bags and Total Export Earnings. All these correlations are significant at 1% level of significance.

4.4 Trends in the variables used in the study

Furthermore, examining the plots of the data is important; the graphical results provide visual evidence as to whether there exist any structural breaks, outliers or data errors. One can also detect a significant seasonal pattern from a time series plot. Visual plots also suggest potential relationships among the time series data.

This section analyses the movements in the variables under study. The trend runs from January 2003 to May 2017. To illustrate these trends, line graphs have been used.

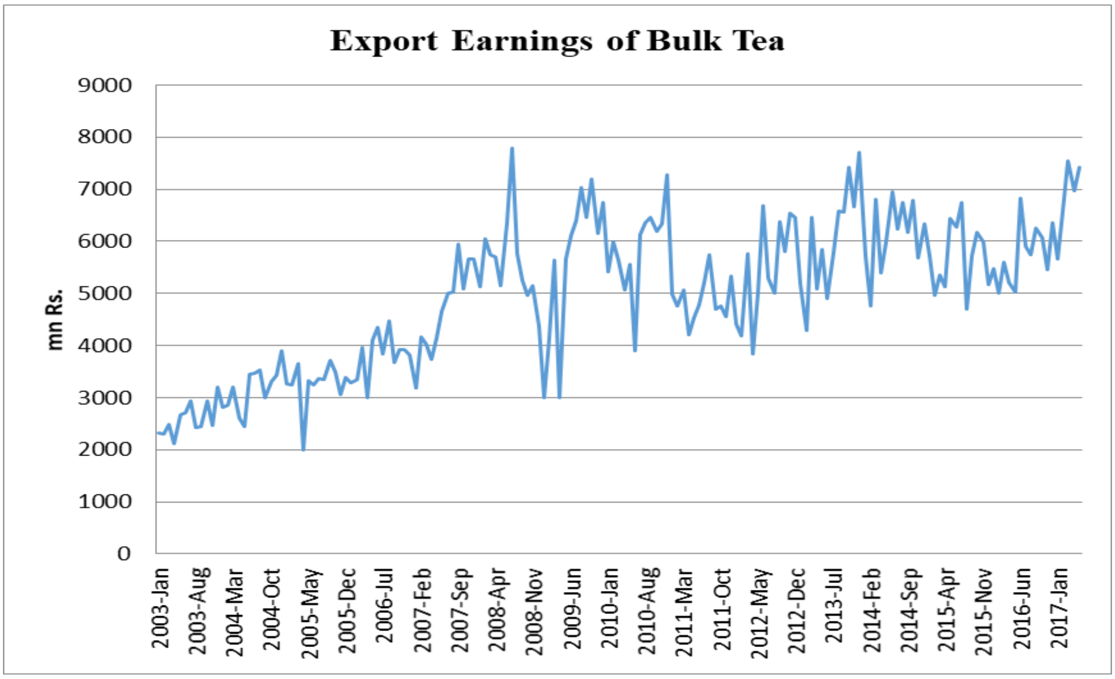


Figure 4.1: Variation of export earnings of bulk tea

As indicated by figure 4.1, it is clear that the series has an upward trend. A steep increment of export earnings can be observed during the period of February 2008 to July in 2008. Then, a sudden huge decrement of the export earnings of bulk tea can be observed from October 2008 to January in 2009 because of the production drop during this period. Tea outputs nosedived in 2009 because of extended drought in tea growing areas. Export earnings of bulk tea were at its highest level of 7788.36 mnRs in July 2008.

Figure 4.2: Variation of export earnings of tea bags

Figure 4.2 illustrates behaviour of export earnings of tea bags from January 2003 to May 2017. An upward trend can be seen through the graph. And also a sudden increment from 596.39 mnRs to 2198.00 mnRs can be observed during the period of June 2010 to August 2010. The unit FOB price was increased by 5.8% in the year 2010 than 2009. The enhancement of unit FOB price was result an upsurge in export earnings (SLTB, 2011). Further, it can be clearly seen that there is a drastic shift in export earnings of tea bags after 2010.

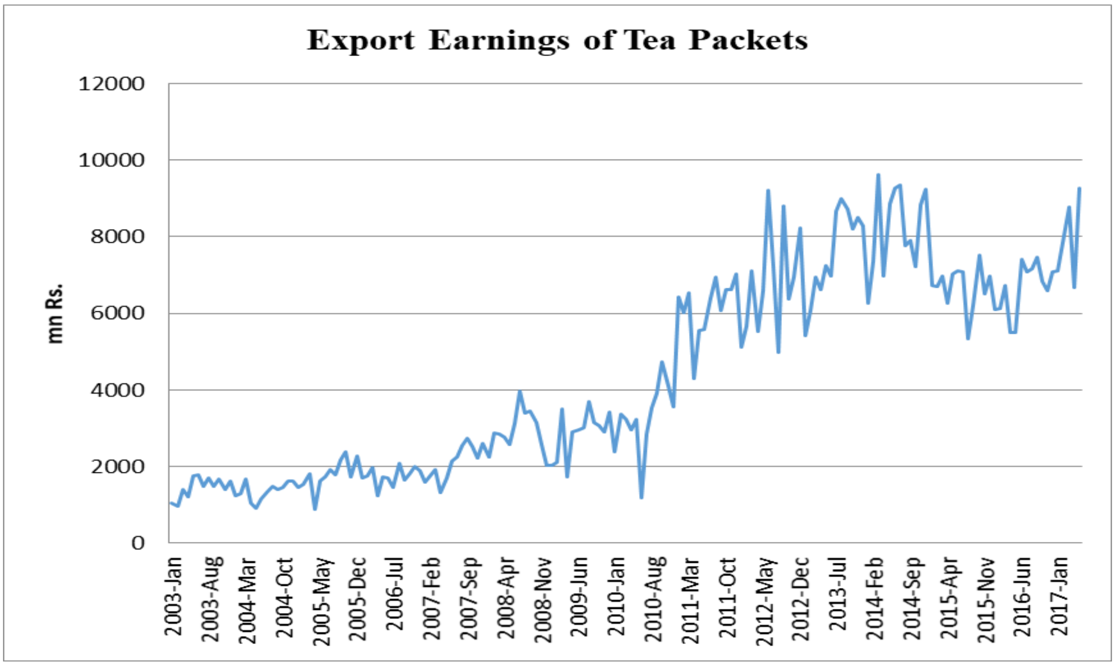


Figure 4.3: Variation of export earnings of tea packets

According to figure 4.3, it can be seen that export earnings of tea packets gradually increases from 2003 to 2010 and thereafter there was a significant increase in export earnings of tea packets until it reached its highest value in December 2012. The similar pattern can be observed in export earnings of tea bags.

Figure 4.4: Variation of total tea export earnings

Figure 4.4 reflect the total earnings from tea exports. Export earnings in million rupees have been increasing overtime with little fluctuations. It shows slight decrease in 2009. The highest levels were reached in 2017. The increase in Tea export earnings in Sri Lanka can be linked to the Sri Lanka Tea Board strategic plan which was aimed at marketing and promoting Ceylon tea in order to obtain maximum returns (SLTB, 2011). In addition the positive trend in tea export earnings may be linked to high quality and bright colour of Sri Lankan tea. According to Sri Lanka Tea Board (2011), high quality and bright colour of Sri Lankan tea has increased its demand in the international market since it is used to blend other tea in the global market.

4.5 Identification of integration order

The study is fully based on time series data and hence there arises a need to check for the stationarity in the series. It is important for the time series data to be stationary. A stationary time series is one with a constant mean, variance and a covariance that does not depend on time. Non-stationarity of time series data is often regarded as a problem in empirical analysis. Working with non-stationary variables may lead to spurious results from which further inference is worthless. The test for the order of integration is the first step in any time series analysis. An integrated series is non-stationary series. In the case of non-stationary time series, the data are transformed by differencing to induce stationary.

There are several methods to test for stationary, including the AugmentedDickey-Fuller (ADF) test and the Phillips-Perron Test. The Phillips-Perron method suffers from severe size distortions when there are negative moving average errors.

In this analysis, the ADF test was performed to identify the stationarity in the series of data since it is generally the most reliable and it is easy to implement and interpret. The results of the test for the variables in levels are presented in the table below.

Table 4.2: Results of unit root test

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 4.2 summarizes the results obtained by applying unit root test for export earnings of each category. The test statistic of each has been given with their p-value at 5% level of significance.

Hypothesis of this test will be as follows.

H_0: Series is non-stationary Vs

H_1: Series is stationary

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

The next step after finding out the order of integration was to establish whether the non-stationary variables at levels are co-integrated. Differencing of variables to achieve stationarity leads to loss of long-run properties.

4.6 Synopsis

In the section of preliminary analysis, all the relevant tests prior to time series model development were carried out separately for variables under consideration. It includes descriptive statistics, correlation among category-wise tea export earnings, behaviour of category-wise tea export earnings and stationarity of each series. Through the process of empirical data analysis in this chapter, it was discovered that there are positive relationships among category wisetea export earnings and an upward trend can clearly be seen in all series. Further, the analysis revealed that four series are non-stationary originally but become stationary after first difference. This implies that all the series are integrated of order one. i.e. I [1].

The next chapter provides analysis of modelling category-wise tea export earnings. The results obtained in this chapter were used for further analysis.

CHAPTER 5
FURTHER ANALYSIS

In previous chapter, behaviour of category wise tea export earnings was descriptively analysed using basic concepts of time series. This chapter is aimed to analyse data in more advanced employing time series techniques to identify useful models for accurate forecasting.

As was evident in chapter 4, all the series were non-stationary at their level but became stationary after first differencing which implies all the series are I [1]. It makes sense to fit a multivariate time series model when the series are integrated of the same order.

If the series are integrated of the same order, next stage of analysis is to test whether the series are co-integrated. When the variables are co-integrated, the appropriate model would be Vector Error Correction (VEC) model. If no co-integration exists, then suitable model would be the Vector Autoregressive (VAR) model.

5.1 Selection of optimal lag length

The model estimating the causal relationship between variables is highly sensitive to the lag length involved. Thus, 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. The lag selection criteria considered include Sequential Modified LR, Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQ). Lowest SIC value is used as primary concern to determine the optimal lag length in the estimation. The lag selection criteria results are presented in Table 5.1.

Table 5.1: Lag order selection

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

Based on the results of lag order selection in Table 5.1, the optimal lag order determined by the Schwartz's Bayesian Criterion (SBC) is at two. So, further tests are preceded with lags two.

5.2 Testing for co-integration

The concept of cointegration implies that if there is a long-run relationship between two or more non stationary variables, deviations from this long-run path is stationary. This involves testing the presence of cointegration between the series of the same order of integration through forming a cointegration equation. The basic idea behind cointegration is that if in the long-run two or more series move closely together even though the series themselves are trended, the difference between them is constant. It is possible to consider these series as defining a long-run equilibrium relationship, as the difference between them is stationary.

Here, the testing procedure was carried out in two phases. In the first step, it was tested whether all the series are integrated of the same order i.e. I[1]. As the second step, the co-integration of the series was tested. 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 co-integration test (that is the existence of a long term linear relation) is presented in Table 5.2 below using methodology proposed by Johansen.

Table 5.2: Results of co-integration test

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 cointegrating eqn(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

Max-eigenvalue test indicates 2 cointegrating eqn(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 5.2, 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 cointegrating (or long run) relationships between variables under consideration.

As a result, since the four-variable model exhibits a co-integrating relationship between the variables, it can be moved to a step further for the estimation of a VEC model which requires not only the variables to be linked in the short run, but to be related in the long run via the existence of cointegration.

5.3 Testing long run relationship

With an existence of co-integration between the variables, it suggests a long-term relationship among the variables. It reflects attempts to correct deviations from the long-run equilibrium and its coefficient can be interpreted as the speed of adjustment or the amount of disequilibrium transmitted each period tea export earnings. Therefore, the long-run equilibrium relation is estimated which illustrates in Table 5.3.

Table 5.3: Vector Error Correction estimates

Vector Error Correction Estimates
Date: 02/07/18 Time: 08:07
Sample (adjusted): 2003M04 2017M05
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

BTV (-1) = -99.35 – 0.69 TEV (-1) + 0.75 TPV (-1) *(5.1)*

According to the above equation, 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 a 0.75 units increase in bulk tea value in the long run. There is also statistically significant negative relationship between bulk tea value and total export value. Based on the coefficients, bulk tea value decreases by 0.69 units when total export value increases by one unit in the long run.

TBV (-1) = -247.15 – 0.04 TEV (-1) - 0.19 TPV (-1) *(5.2)*

According to the second co-integrating equation, 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 a 19% decrease in tea bags value in long run. The negative relationship between tea bags value and total export value is not significant in long run.

5.4 Vector error correction model (VECM)

Having determined the co-integration among the variables which involves in a multivariate model, there is an existence of a long-term equilibrium relation between the series as evident in previous section. In that case, a VECM is 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 causal relationship between the variables.

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

D(BTV) = C(1)*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)+C(2)*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+C(3)*D(BTV(-1))+C(4)*D(BTV(-2))+C(5)*D(TBV(-1))+C(6)*D(TBV(-2))+C(7)*D(TPV(-1))+ C(8)*D(TPV(-2))+C(9)*D(TEV(-1))+C(10)*D(TEV(-2))+C(11) *(5.3)*

The parameters of this model were estimated and shown in the Table 5.4 below. Table 5.4 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) of Table 5.4 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.

Table 5.4: VECM estimates of model I

	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)	0.018932	0.218197	0.086768	0.9310
C(5)	-0.386679	0.418404	-0.924176	0.3568
C(6)	-0.329925	0.353671	-0.932857	0.3523
C(7)	0.493804	0.205862	2.398720	0.0176
C(8)	0.000677	0.186894	0.003621	0.9971
C(9)	-0.383680	0.188664	-2.033671	0.0436
C(10)	-0.117472	0.170923	-0.687283	0.4929
C(11)	58.48743	56.98969	1.026281	0.3063
Determinant residual covariance		512819.6		

Equation: D(BTV) = C(1)*(BTV(-1) + 0.752769118275*TPV(-1) - 0.69434357566*TEV(-1) - 99.3455426767) + C(2)*(TBV(-1) - 0.192335256863*TPV(-1) - 0.0415805793168*TEV(-1) - 247.153355612) + C(3)*D(BTV(-1)) + C(4)*D(BTV(-2)) + C(5)*D(TBV(-1)) + C(6)*D(TBV(-2)) + C(7)*D(TPV(-1)) + C(8)*D(TPV(-2)) + C(9)*D(TEV(-1)) + C(10)*D(TEV(-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		

D(BTV) = - 0.81*(BTV(-1) +0.75*TPV(-1)-0.70*TEV(-1)-99.35)-0.40*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)-0.02*D(BTV(-1))+0.019*D(BTV(-2))-0.39*D(TBV(-1))-0.33*D(TBV(-2))+0.50*D(TPV(-1))+0.00067*D(TPV(-2))-0.38*D(TEV(-1))-0.18 * D(TEV(-2))+58.49 *(5.4)*

The table 5.4 presents the VECM and its coefficients as well as their t-statistic and p-value. 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. It can be realized from equation 5.4 that BTV is positively affected by 50% of TPV when there is one unit change in the lagged values. On the other hand, TBV have considerable negative impact on BTV.

The VEC model was employed to examine how category-wise tea export earnings are related in short run. Wald test was performed to identify any significant short-run relationship among tea export earnings by category. The results are presented as follows.

$H_0 : C(7) = C(8) = 0$

$H_1 : At\ least\ one\ C(i) \neq 0\ for\ i = 7, 8$

Table 5.5: Short run relationship between TPV and BTV

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	7.427549	2	0.0244

Null Hypothesis: C(7)=C(8)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7)	0.493804	0.205862
C(8)	0.000677	0.186894

Restrictions are linear in coefficients.

According to the results in Table 5.5, the p-value of Chi-square test statistic is significant at 5% level. Therefore, H_0 is rejected at 5% level of significance and can be concluded that there is a short-run relationship (causality) from TPV (-1) and TPV (-2) to BTV. Thus, it can be said that lag 1 and 2 of TPV jointly affect the BTV in short run.

Model II:

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

D(TBV) = C(12)*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)+C(13)*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+C(14)*D(BTV(-1))+C(15)*D(BTV(-2))+C(16)*D(TBV(-1))+C(17)*D(TBV(-2))+C(18)*D(TPV(-1))+C(19)*D(TPV(-2))+C(20)*D(TEV(-1))+C(21)*D(TEV(-2))+C(22) *(5.5)*

The parameters of the above model were estimated and shown in the Table 5.6 below. It 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 5.6 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.

Table 5.6: VECM estimates of model II

	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)	0.114986	0.068722	1.673204	0.0963
C(19)	-0.075682	0.062390	-1.213038	0.2269
C(20)	-0.250151	0.062981	-3.971836	0.0001
C(21)	-0.027303	0.057059	-0.478505	0.6329
C(22)	23.91577	19.02475	1.257087	0.2106
Determinant residual covariance		57149.20		

Equation: D(TBV) = C(12)*(BTV(-1) + 0.752769118275*TPV(-1) - 0.69434357566*TEV(-1) - 99.3455426767) + C(13)*(TBV(-1) - 0.192335256863*TPV(-1) - 0.0415805793168*TEV(-1) - 247.153355612) + C(14)*D(BTV(-1)) + C(15)*D(BTV(-2)) + C(16) *D(TBV(-1)) + C(17)*D(TBV(-2)) + C(18)*D(TPV(-1)) + C(19)*D(TPV(-2)) + C(20)*D(TEV(-1)) + C(21)*D(TEV(-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		

D(TBV) = -0.24*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)-0.51*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+0.30*D(BTV(-1))+0.033*D(BTV(-2))-0.12*D(TBV(-1))-0.086*D(TBV(-2))+ 0.115*D(TPV(-1))-0.076*D(TPV(-2))-0.25*D(TEV(-1))-0.027*D(TEV(-2))+23.92 *(5.6)*

The table 5.6 presents the VECM and its coefficients as well as their t-statistic and p-value. As both error correction terms are highly significant at 1% with negative sign as indicated in the table 5.6, results of VEC model depicted that the adjustments in TBV are due to both error correction terms. The estimates of C(12) and C(13), adjustment coefficients associated with TBV are negative (–0.242961 and -0.508112) and statistically significant. This implies that long run movements of the variables are determined by both equilibrium relationships.

It can be observed from equation 5.6 that TBV is significantly affected positively by 30% when there is one unit change in lagged values of BTV. It can also be inferred from the equation that TBV is affected negatively by almost 12% when there is one unit change in its lagged values.

Wald test was performed to test whether BTV, TPV and TEV has any short run effect on TBV. Results of the Wald test were as follows.

$$H_0 : C(14) = C(15) = 0$$
$$H_1 : At\ least\ one\ C(i) \neq 0\ for\ i = 14, 15$$

Table 5.7: Short run relationship between BTV and TBV

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	17.09305	2	0.0002

Null Hypothesis: C(14)=C(15)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	0.299752	0.082988
C(15)	0.032553	0.072840

Restrictions are linear in coefficients.

Results in Table 5.7 indicate that the p-value of Chi-square test statistic is significant at 5% level. Therefore, H_0 is rejected at 5% level of significance and can be concluded that there is a short run relationship (causality) from BTV (-1) and BTV (-2) to TBV. Hence, it can be said that lag 1 and 2 of BTV jointly affect the TBV in short run.

$$H_0 : C(18) = C(19) = 0$$
$$H_1 : At\ least\ one\ C(i) \neq 0\ for\ i = 18, 19$$

Table 5.8: Short run relationship between TPV and TBV

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	8.018524	2	0.0181

Null Hypothesis: C(18)=C(19)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(18)	0.114986	0.068722
C(19)	-0.075682	0.062390

Restrictions are linear in coefficients.

According to the table 5.8, it can be clearly seen that p value of Chi-square test statistic is significant at 5% level. Hence, H_0 is rejected at 5% level of significance implying there exist a short run relationship (causality) from TPV (-1) and TPV (-2) to TBV. Thus, it can be said that lag 1 and 2 of TPV jointly affect the TBV in short run.

$$H_0 : C(20) = C(21) = 0$$
$$H_1 : At\ least\ one\ C(i) \neq 0\ for\ i = 20, 21$$

Table 5.9: Short run relationship between TEV and TBV

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	19.46476	2	0.0001

Null Hypothesis: C(20)=C(21)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(20)	-0.250151	0.062981
C(21)	-0.027303	0.057059

Restrictions are linear in coefficients.

Results in Table 5.9 indicate that the p-value of Chi-square test statistic is significant at 5% level. Hence, H_0 is rejected at 5% level of significance and can be concluded that there is a short run relationship (causality) from TEV (-1) and TEV (-2) to TBV. Hence, it can be said that lag 1 and 2 of TEV jointly affect the TBV in short run.

Model III:

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

D(TPV) = C(23)*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)+C(24)*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+C(25)*D(BTV(-1))+C(26)*D(BTV(-2))+C(27)*D(TBV(-1))+C(28)*D(TBV(-2))+C(29)*D(TPV(-1))+C(30)*D(TPV(-2))+C(31)*D(TEV(-1))+C(32)*D(TEV(-2))+C(33) *(5.7)*

According to the equation 5.7 and table 5.10, coefficient of disequilibrium terms are -0.26 and 0.72 and both are statistically insignificant revealing that there is no long run equilibrium relationship among variables.

Table 5.10: VECM estimates of model III

	Coefficient	Std. Error	t-Statistic	Prob.
C(23)	-0.263955	0.295403	-0.893540	0.3729
C(24)	0.724410	0.490819	1.475921	0.1419
C(25)	0.271316	0.276785	0.980241	0.3285
C(26)	0.019473	0.242940	0.080157	0.9362
C(27)	-0.488477	0.465849	-1.048573	0.2960
C(28)	-0.368950	0.393776	-0.936954	0.3502
C(29)	-0.176806	0.229205	-0.771387	0.4416
C(30)	-0.307480	0.208087	-1.477651	0.1415
C(31)	-0.256552	0.210057	-1.221342	0.2238
C(32)	-0.029314	0.190304	-0.154038	0.8778
C(33)	88.37503	63.45203	1.392785	0.1656
Determinant residual covariance		635716.0		

Equation: D(TPV) = C(23)*(BTV(-1) + 0.752769118275*TPV(-1) - 0.69434357566*TEV(-1) - 99.3455426767) + C(24)*(TBV(-1) - 0.192335256863*TPV(-1) - 0.0415805793168*TEV(-1) - 247.153355612) + C(25)*D(BTV(-1)) + C(26)*D(BTV(-2)) + C(27) *D(TBV(-1)) + C(28)*D(TBV(-2)) + C(29)*D(TPV(-1)) + C(30)*D(TPV(-2)) + C(31)*D(TEV(-1)) + C(32)*D(TEV(-2)) + C(33)

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		

D(TPV) = -0.26*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)+0.72*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+0.27*D(BTV(-1))+0.019*D(BTV(-2))-0.488*D(TBV(-1))-0.37*D(TBV(-2))-0.177*D(TPV(-1))-0.307*D(TPV(-2))-0.26*D(TEV(-1))-0.03*D(TEV(-2))+88.375 *(5.8)*

It can be realized from equation 5.8 that TPV is affected positively by 27% of BTV when there is one unit change in its lagged values. On the other hand, TPV have considerable negative impact on TEV and TBV. It can be inferred from the equation that TPV is affected negatively by almost 48% when there is one unit change in the lagged values of TBV.

Model IV:

The VECM equation for the dependent variable as Total Export Revenue is as follows:

D(TEV) = C(34)*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)+C(35)*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+C(36)*D(BTV(-1))+C(37)*D(BTV(-2))+C(38)*D(TBV(-1))+C(39)*D(TBV(-2))+C(40)*D(TPV(-1))+C(41)*D(TPV(-2))+C(42)*D(TEV(-1))+C(43)*D(TEV(-2))+C(44) *(5.9)*

Table 5.11: VECM estimates of model IV

	Coefficient	Std. Error	t-Statistic	Prob.
C(34)	-0.775227	0.575868	-1.346188	0.1802
C(35)	-0.122740	0.956818	-0.128279	0.8981
C(36)	0.548690	0.539573	1.016896	0.3107
C(37)	0.209279	0.473594	0.441894	0.6592
C(38)	-0.771055	0.908140	-0.849048	0.3971
C(39)	-0.602486	0.767639	-0.784856	0.4337
C(40)	0.544375	0.446820	1.218334	0.2249
C(41)	-0.162463	0.405651	-0.400498	0.6893
C(42)	-1.013660	0.409493	-2.475405	0.0144
C(43)	-0.388285	0.370985	-1.046634	0.2969
C(44)	178.3916	123.6953	1.442185	0.1512
Determinant residual covariance		2415899.		

Equation: D(TEV) = C(34)*(BTV(-1) + 0.752769118275*TPV(-1) - 0.69434357566*TEV(-1) - 99.3455426767) + C(35)*(TBV(-1) - 0.192335256863*TPV(-1) - 0.0415805793168*TEV(-1) - 247.153355612) + C(36)*D(BTV(-1)) + C(37)*D(BTV(-2)) + C(38) *D(TBV(-1)) + C(39)*D(TBV(-2)) + C(40)*D(TPV(-1)) + C(41)*D(TPV(-2)) + C(42)*D(TEV(-1)) + C(43)*D(TEV(-2)) + C(44)

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		

D(TEV) = -0.775*(BTV(-1)+0.75*TPV(-1)-0.70*TEV(-1)-99.35)-0.12*(TBV(-1)-0.19*TPV(-1)-0.04*TEV(-1)-247.15)+0.55*D(BTV(-1))+0.20*D(BTV(-2))-0.77*D(TBV(-1))-0.60*D(TBV(-2))+ 0.54*D(TPV(-1))-0.16*D(TPV(-2))-1.014*D(TEV(-1))-0.388*D(TEV(-2))+178.40 *(5.10)*

According to the equation 5.10 and table 5.11, coefficients of disequilibrium terms (-0.775 and -0.12) are negative but statistically insignificant which indicates that there is no long run equilibrium relationship among variables. It can be observed from equation 5.10 that TEV is significantly affected positively by 55% when there is one unit change in the lagged values of BTV and 20% when there is two units change in the lagged values of BTV. It can also be inferred from the equation that TEV is affected positively by almost 54% when there is one unit change in the lagged values of TPV.

5.5 Model diagnostics

Having identified the VEC model and having satisfactorily estimated its parameters, a model is examined for improvement. If there is evidence of autocorrelation or statistical insignificance, one needs to go back to the identification stage and modify the model.

There are a number of diagnostic tools available for ensuring that VEC model is statistically adequate. A first check is to simply plot residual plots of the fitted model. The residuals of an estimated model should resemble a white noise process if the model is correctly specified followed by Correlogram, Portmanteau Tests for Autocorrelations and Residual Serial Correlation LM Tests were carried out to justify the accuracy of the fitted model.

I. Residual Plot

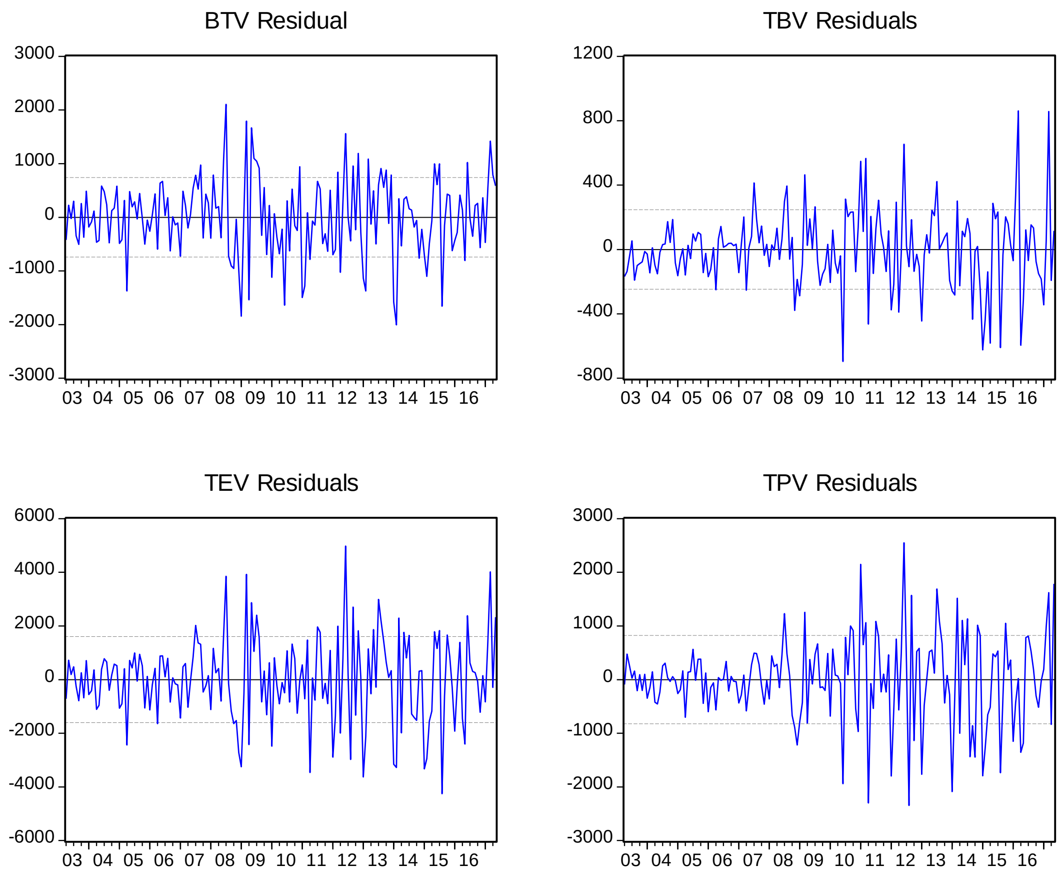


Figure 5.1: Residual plots of the VEC model

As seen through the figure 5.1, residual plots depict that they deviate from white noise since mean and variance of residuals are not constant. Therefore, residual plots indicate that model is not adequate. But, it is not possible to declare that the model is not adequate only by looking at residual plots. It is needed to test other adequate methods also.

II. Correlogram

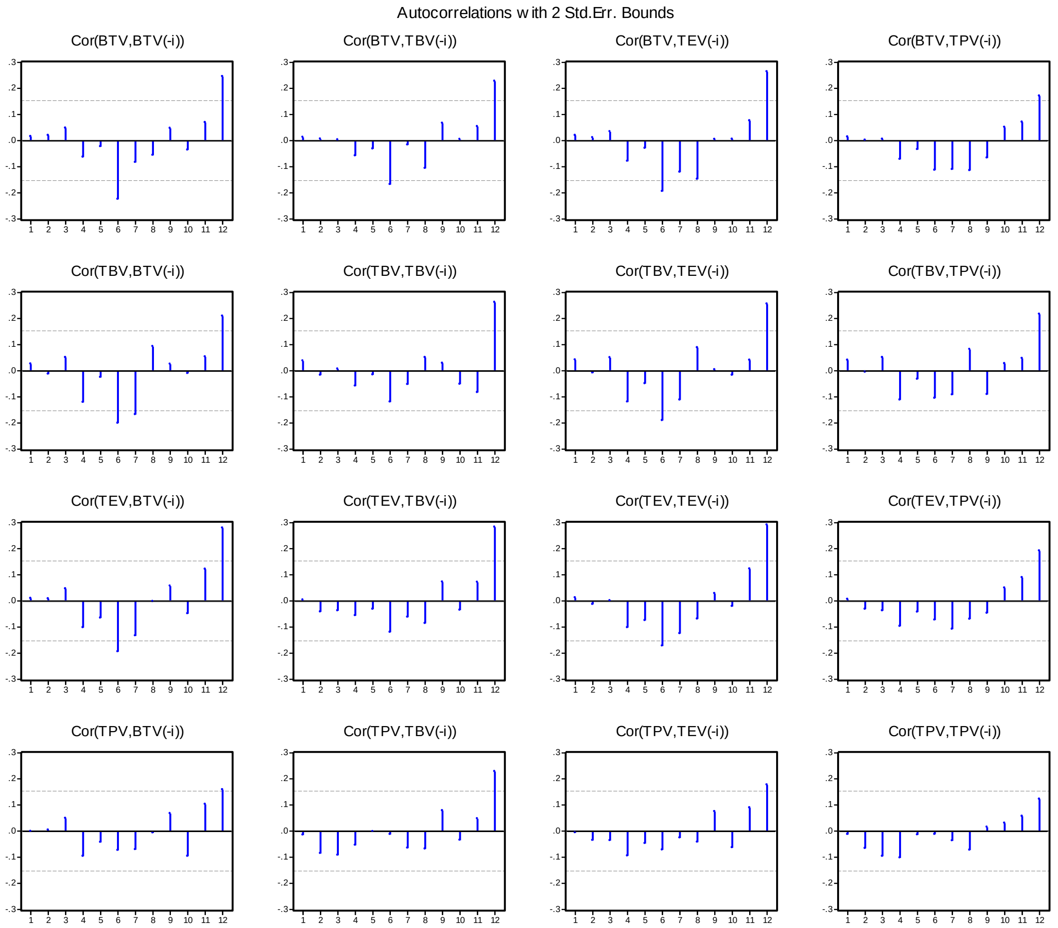


Figure 5.2: Residual correlograms of the VEC model

As figure 5.2 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.

III. Residual Portmanteau Test for Autocorrelation

It is tested for autocorrelation in residuals of the model using portmanteau test.

H_0: Residual series is not auto-correlated

H_1: Residual series is auto-correlated

Table 5.12: Results of portmanteau test of the VEC model

VEC Residual Portmanteau Tests for Autocorrelations
H0: no residual autocorrelations up to lag h
Date: 02/07/18 Time: 09:04
Sample: 2003M01 2017M05
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

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

When examining Table 5.12, 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.

IV. Residual Serial Correlation LM Tests

H_0: Residuals are not serially correlated

H_1: Residuals are serially correlated

Table 5.13: Results of the residual LM test of the VEC model

VEC Residual Serial Correlation LM Tests
H0: no serial correlation at lag order h
Date: 02/07/18 Time: 09:04
Sample: 2003M01 2017M05
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

Probs from chi-square with 16 df.

According to the table 5.13, 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.

Analysis of residuals confirms that the model is satisfactory. So, the next step is to predict tea export earnings by category based on the fitted model for several months ahead.

5.6 Forecasting from the model

The model building process reveals that Vector Error Correction Model (VECM) fits the data adequately. Therefore, to evaluate the forecasting ability of the model the available data was divided into two sub samples. Thus, the data from January 2003 up to May 2017 were utilized to estimate the VEC model and then forecast was performed for the time period June 2017- October 2017.

I. Bulk Tea

Table 5.14: Actual & Predicted export earnings of bulk tea

Actual(Mn Rs)	Predicted(Rs kg)	Difference	Absolute Percent Error
8389.36	7852.15	537.21	6.40
9090.00	8621.44	468.56	5.15
7687.22	8084.36	-397.14	5.17
8349.73	8652.70	-302.97	3.63
8799.15	8911.84	-112.69	1.28
		MAPE	**4.33**

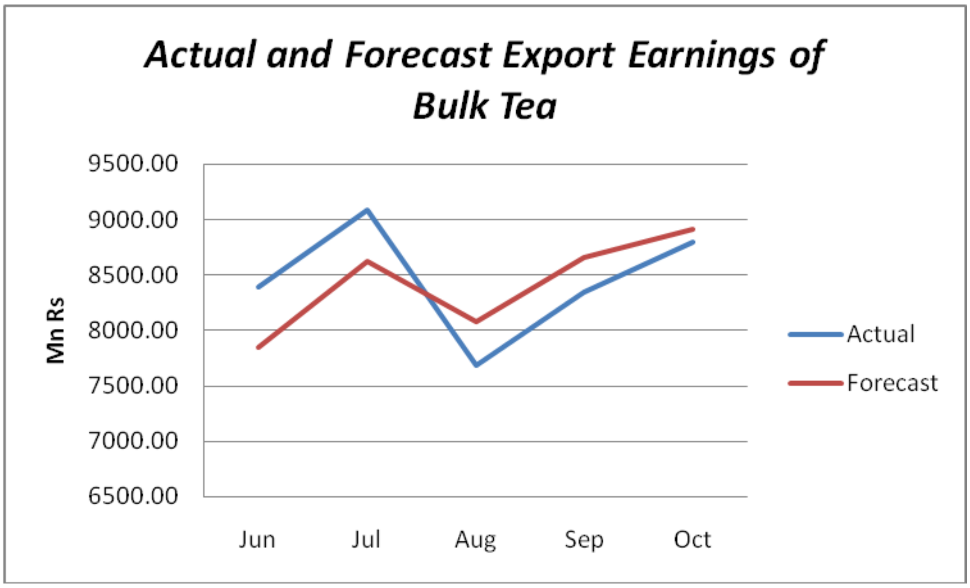


Figure 5.3: Plot of actual and forecast values of BTV

As seen through the table 5.14 and figure 5.3, forecasting values of Bulk Tea export earnings is slightly different from actual values. Although there is a gap between actual and forecast values, both plots exhibit the same pattern implying that forecast values have captured the shape of the actual values.

II. Tea Bags

Table 5.15: Actual & Predicted export earnings of tea bags

Actual(Mn Rs)	Predicted(Rs kg)	Difference	Absolute Percent Error
2545.67	2486.36	59.31	2.33
2776.82	2598.17	178.65	6.43
2553.77	2823.85	-270.08	10.58
2192.93	2437.75	-244.82	11.16
2535.29	2641.61	-106.32	4.19
		MAPE	**6.94**

According to the table 5.15, forecast values of monthly export earnings of tea bags are more close to actual values. Results can be compared graphically better than comparing values.

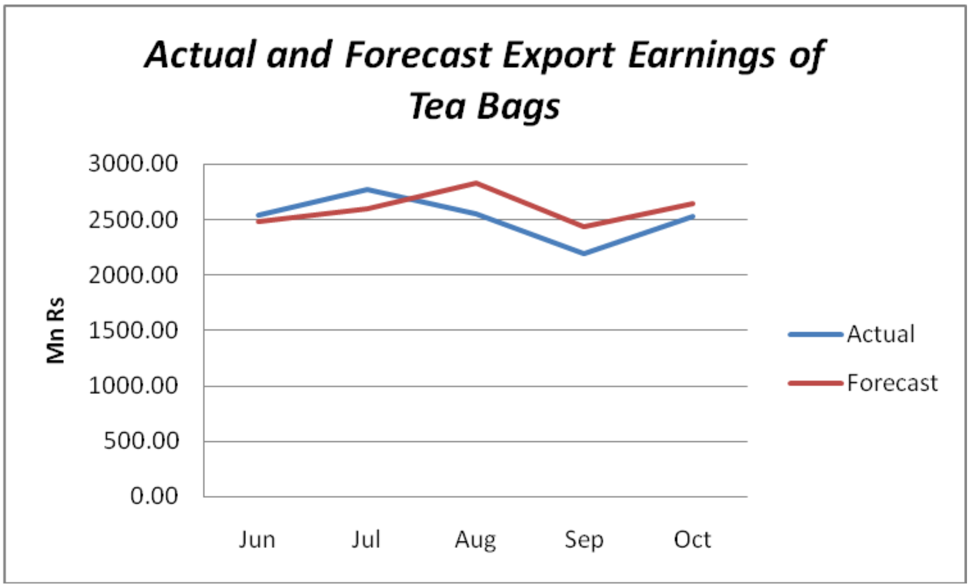


Figure 5.4: Plot of actual and forecast values of TBV

As seen through the figure 5.4, forecast values of export earnings of tea bags are somewhat close to actual values. It can also be seen that actual shape of export earnings variation has captured by the forecast values for last three months.

III. Tea Packets

Forecasted values for export earnings of tea packets are represented in the below table.

Table 5.16: Actual and Predicted export earnings of tea packets

Actual(Mn Rs)	Predicted(Rs kg)	Difference	Absolute Percent Error
9568.08	8642.54	925.54	9.67
9035.83	8413.63	622.20	6.89
8968.56	8608.54	360.02	4.01
9383.63	9743.95	-360.32	3.84
8688.68	8919.68	-231.00	2.66
		MAPE	**5.41**

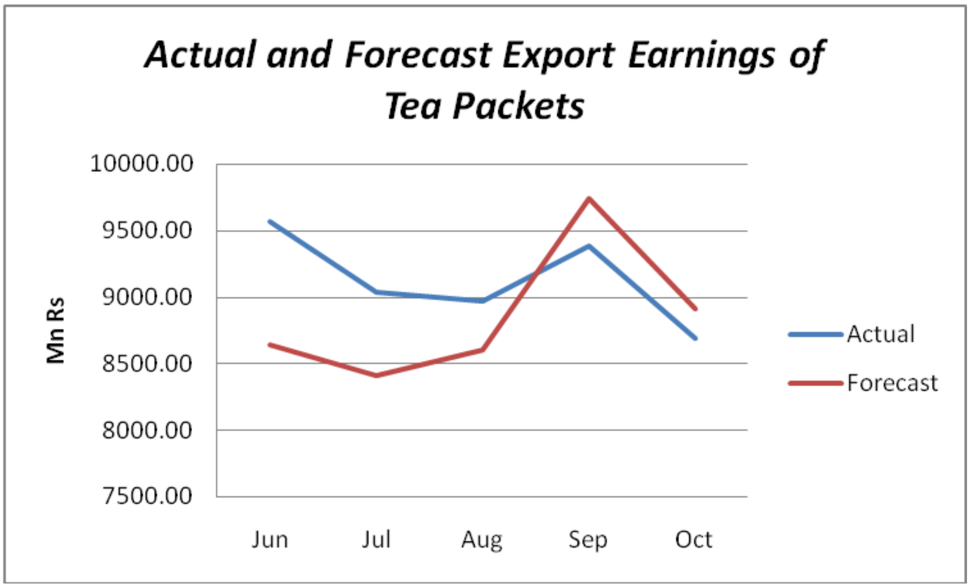


Figure 5.5: Plot of actual and forecast values of TPV

By referring to the figure 5.5, it can be clearly seen that the actual shape of export earnings variation has captured by the forecast values. Forecast value for the month of June is far away from the actual value. But, the gap between forecast and actual values has decreased over the time period.

IV. Total Export Revenue

Table 5.17: Actual and Predicted total tea export earnings

Actual(Mn Rs)	Predicted(Rs kg)	Difference	Absolute Percent Error
21178.71	20824.58	354.13	1.67
21975.35	20830.42	1144.93	5.21
20118.34	21924.73	-1806.39	8.98
20933.36	19909.49	1023.87	4.89
20917.17	20713.10	204.07	0.98
		MAPE	**4.35**

By referring to the table 5.17, it can be seen that except the first and last values other predicted values considerably differ from actual values.

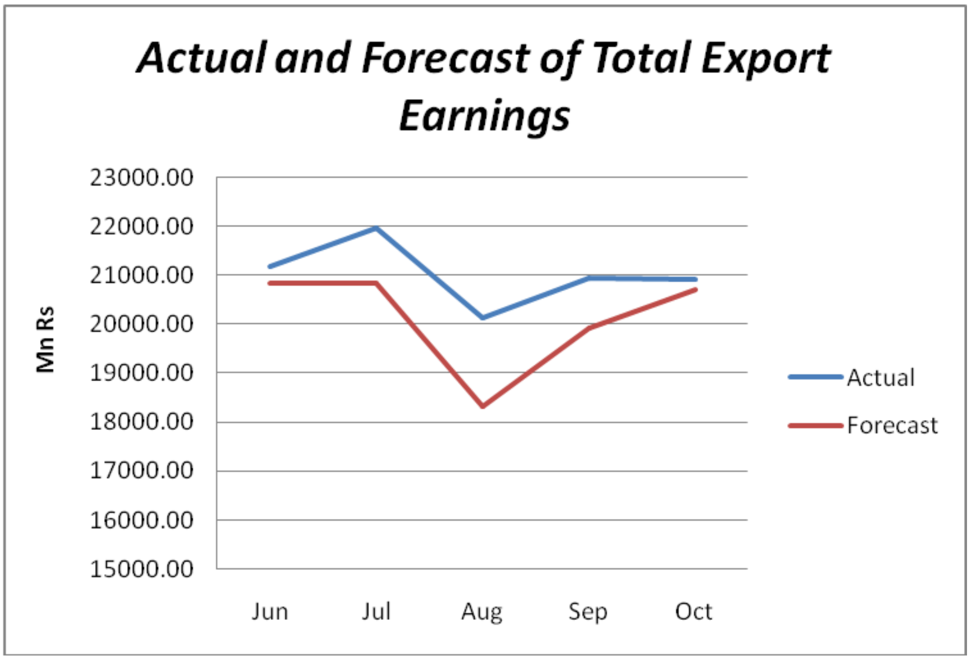


Figure 5.6: Plot of actual and forecast values of TEV

By looking at the figure 5.6, forecast values for the month of June and October are somewhat close to actual values. It can also be seen that actual shape of export earnings variation has captured by the forecast values.

5.7 Innovation accounting

Innovation accounting such as the Impulse Response Function (IRF) and the forecast error variance decompositions (VDC) is used in analyzing the interrelationships among the variables under consideration.

5.7.1 Impulse response function analysis

Impulse response function is usually made after any vector model of VECM which is used to check the impact of the coefficient over time. An impulse response function traces the effect of a one standard deviation shock to one of the innovations (shock, impulse, residual and error term) on current and future values of the endogenous variables.

Results of Impulse response function can be interpreted graphically. Figure 5.7 depicts impulse response functions of variables under investigation. For each variable shown in the rows, the effect of a one-standard deviation shock to each of the four equations shown in the columns is computed. The horizontal axis for each graph is in the units of time that VECM is estimated in, in this case months. Hence, the impulse response graph shows the effect of a shock over a 10 months period. The vertical axis is in units of the variables in the VECM; in this case, everything is measured in Sri Lankan Rupees, so the vertical units in all panels are Sri Lankan Rupees changes.

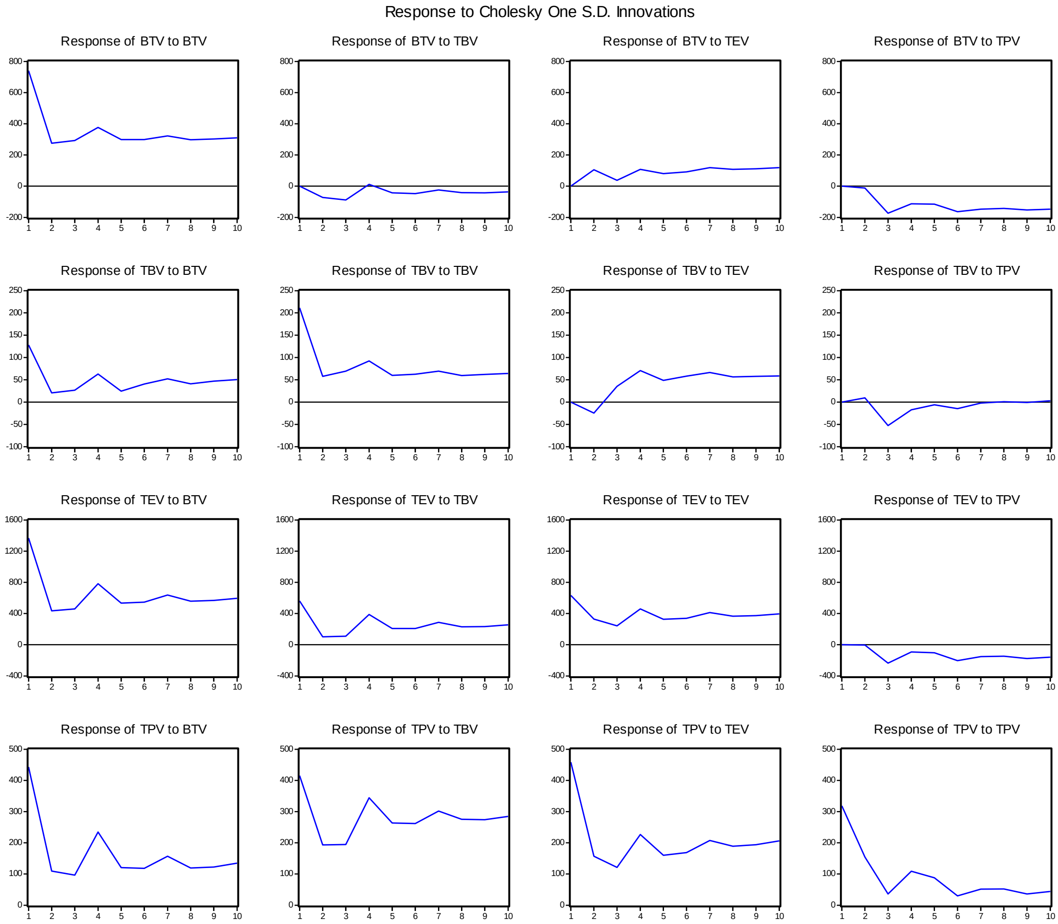


Figure 5.7: Impulse Response Function

Effect of a Shock to export earnings of Bulk Tea (BTV)

The first column of figure 5.7 gives the reaction of four endogenous variables (export earnings of bulk tea, tea bags, tea packets and total export earnings) to a one standard deviation shock to export earnings of bulk tea. The response of all endogenous variables is positive at responsive period. There is a highest positive effect on the first month.

Effect of a Shock to export earnings of Tea Bags (TBV)

The second column of the figure 5.7 gives the reaction of the endogenous variables to a one standard deviation shock to export earnings of tea bags. The response of endogenous variables of TBV, TPV and TEV is positive at responsive period while the influence of export earnings of BTV on TBV is negligible after first four months. As can be observed from the figure 5.7, there is a highest positive effect on the first month.

Effect of a Shock to total export earnings (TEV)

The third column of the figure 5.7 gives the reaction of the endogenous variables to a one standard deviation shock to total export earnings. The impact of export earnings of BTV on TEV fluctuates during the first four months and afterwards it continues to maintain a constant level. The effect of export earnings of TPV on TEV has decreased much during the first month and afterwards it fluctuates, but still positive. The impact of export earnings of TBV is comparatively evident and strength of impact increases from second month to fourth month and after that it continues to maintain a constant level.

Effect of a Shock to export earnings of Tea Packets (TPV)

The final column of the figure 5.7 gives the reaction of the endogenous variables to a one standard deviation shock to export earnings of tea packets. The impact of changes in export earnings of tea bags on tea packets is negligible after first four months. The effect of export earnings of TBV and TEV on TPV is negative and has constantly decreased at responsive period.

5.7.2 Variance decomposition

Forecast error variance decompositions measure the contribution of each type of shock to the forecast error variance. It tells how much of a change in a variable is due to its own shock and how much due to shocks to other variables. The variance decomposition provides further evidence of relationships among the variables under investigation. It makes possible to determine the relative importance of each variable in creating fluctuations in other variables.

Following are the variance decompositions of tea export earnings by category. The forecast period will be in months.

Table 5.18: Variance decomposition of bulk tea

Variance Decomposition of BTV:

Period	S.E.	BTV	TBV	TEV	TPV
1	740.4713	100.0000	0.000000	0.000000	0.000000
2	800.2787	97.41323	0.826946	1.736558	0.023266
3	874.8275	92.69600	1.718060	1.638550	3.947387
4	965.3846	91.37253	1.425367	2.590834	4.611265
5	1021.130	90.21187	1.449543	2.932007	5.406575
6	1081.527	88.05840	1.487855	3.328978	7.124766
7	1144.482	86.55317	1.374984	4.049057	8.022790
8	1196.855	85.34789	1.380278	4.505768	8.766067
9	1249.515	84.14962	1.384853	4.927045	9.538482
10	1301.741	83.20215	1.356721	5.374524	10.06661

Referring to the table 5.18, it can be seen that shock to BTV account for 92.69% variation of the fluctuation in BTV (own shock), shock to TPV can cause 3.94% fluctuation in BTV and shock to TEV can cause 1.63% fluctuation in BTV in short run. In the long run, shock to BTV can contribute 83.20% variation of the fluctuation in BTV (own shock), shock to TPV can contribute 10.06% fluctuation in BTV and shock to TEV can cause 5.37% fluctuation in BTV. In short run, TBV can cause 1.71% in the fluctuation of BTV. But, in the long run also shock to TBV can contribute 1.35% fluctuation in BTV implying it remains unchanged.

Table 5.19: Variance decomposition of tea bags

Variance Decomposition of TBV:

Period	S.E.	BTV	TBV	TEV	TPV
1	247.1900	26.86907	73.13093	0.000000	0.000000
2	256.0345	25.70489	73.24056	0.917125	0.137425
3	274.1324	23.36439	70.32240	2.466435	3.846774
4	304.8113	23.14076	66.05561	7.371070	3.432567
5	315.4186	22.21012	65.29506	9.254019	3.240795
6	329.5862	21.86482	63.37655	11.59284	3.165790
7	347.2391	21.95643	61.09194	14.09497	2.856658
8	359.0765	21.82933	59.85625	15.64273	2.671684
9	371.8795	21.95757	58.57347	16.97726	2.491698
10	385.2946	22.17798	57.36148	18.13418	2.326363

As Table 5.19 depicts, In the short run, shock to BTV account for 23.36% variation of the fluctuation in TBV, shock to TBV can cause 70.32% fluctuation in TBV (own shock) and shock to TEV can cause 2.46% fluctuation in TBV.

In the long run, shock to BTV can contribute 22.17% variation of the fluctuation in TBV, shock to TBV can contribute 57.36% fluctuation in TBV and shock to TEV can cause 18.13% fluctuation in TBV. TPV can cause 3.84% in the fluctuation of TBV in short run. In long run, shock to TPV can also contribute 2.32% fluctuation in TBV.

Table 5.20: Variance decomposition of total export earnings

Variance Decomposition of TEV:

Period	S.E.	BTV	TBV	TEV	TPV
1	1607.183	72.30475	12.18742	15.50783	0.000000
2	1700.029	71.16248	11.25118	17.58549	0.000851
3	1796.359	70.27589	10.44553	17.55582	1.722756
4	2051.343	68.40350	11.56649	18.50050	1.529517
5	2157.426	67.98332	11.38291	19.02847	1.605301
6	2269.998	67.19803	11.11139	19.42414	2.266447
7	2415.189	66.29184	11.23583	20.07608	2.396252
8	2520.548	65.76373	11.15422	20.54535	2.536704
9	2627.110	65.22729	11.04536	20.93769	2.789652
10	2739.288	64.72164	11.02346	21.34990	2.904999

As indicated by Table 5.20, shock to BTV account for 70.27% variation of the fluctuation in TEV, shock to TBV can cause 10.44% fluctuation in TEV and shock to TEV can cause 17.55% fluctuation in TEV (own shock) in short run. In the long run, shock to BTV can contribute 64.72% variation of the fluctuation in TEV, shock to TBV can contribute 11.02% fluctuation in TEV and shock to TEV can cause 21.34% fluctuation in TEV (own shock). TPV can cause 1.72% in the fluctuation of TEV in short run. In long run, shock to TPV can also contribute 2.90% fluctuation in TEV.

Table 5.21: Variance decomposition of tea packets

Variance Decomposition of TPV:

Period	S.E.	BTV	TBV	TEV	TPV
1	824.4370	28.88986	25.33082	30.87500	14.90432
2	881.7085	26.79725	26.94700	30.15744	16.09832
3	916.8629	25.88986	29.43474	29.63382	15.04159
4	1037.902	25.31565	33.96296	27.88381	12.83759
5	1093.063	24.04319	36.44904	27.28902	12.21875
6	1143.112	23.04844	38.57624	27.13546	11.23986
7	1211.605	22.19334	40.53686	27.08506	10.18474
8	1263.442	21.30144	42.02315	27.13899	9.536414
9	1313.591	20.57759	43.23721	27.28746	8.897742
10	1367.216	19.96791	44.25210	27.46350	8.316495

In the short run, shock to BTV account for 25.88% variation of the fluctuation in TPV, shock to TBV can cause 29.43% fluctuation in TPV, shock to TEV can cause 29.63% fluctuation in TPV and shock to TPV can cause 15.04% fluctuation in TPV (own shock) as indicated by Table 5.21. In the long run, shock to BTV can contribute 19.96% variation of the fluctuation in TPV, shock to TBV can contribute 44.25% fluctuation in TPV, shock to TEV can cause 27.46% fluctuation in TPV and shock to TPV can contribute 8.31% fluctuation in TPV (own shock).

CHAPTER 6
DISCUSSION AND CONCLUSION

This section provides discussion about entire study in brief. It incorporates an overview of the study, general discussion, conclusion, limitations of the study and areas for further study.

6.1 Overview of the study

This study mainly focuses on determining appropriate statistical methods for modelling tea export earnings by category. In this study, monthly export earnings of bulk tea, tea bags, tea packets and total export earnings from January 2003 to October 2017 were considered. Thus, each series consists of 178 data points. First 173 data values were used to build the model and remaining five data values were used to validate the forecasting model. Preliminary analysis has initially been carried out and it helped to acquire basic understanding of available data. Then, further analysis has been performed to build up suitable statistical techniques to forecast category-wise tea export earnings. Various time series methods including stationarity, co-integration, Granger causality, Impulse response function, and variance decomposition were used in the analysis.

It is important to mention the results and findings which wereobtained from this study. Those results and outputs will be explained in this chapter.

6.2 General Discussion

Economic behaviour of the plantation sector is important. Tea industry mainly deals with production and exports. The tea export earnings in Sri Lanka have fluctuations although the general tendency is that of an increase over the years. Therefore, it is vital to be aware of the future fluctuations in tea export earnings. Forecasting is beneficial to alter their production plans in the market. With this background this study was conducted with the objectives of identifying appropriate models for accurate forecasting by using time series techniques.

In order to gain a fundamental idea about behaviour of tea export earnings over the past few years preliminary analysis was initially carried out. Upward trend with little fluctuations were observed in all categories. The study employed the conventional Augmented Dickey Fuller (ADF) test to check for stationarity among the variables under consideration and Johensen co-integration technique to determine the co-integration relationships between variables.

The results pointed out that all variables are non-stationary at levels, but became stationary after first differencing implying Bulk tea, Tea bags, Tea packets and total export earnings were I(1). The study identified that the four variables (Bulk tea, Tea bags, Tea packets and Total Export) are co-integrated with two co-integrating relationships. According to the results of Johensen co-integration test, bulk tea earnings have significantly positive relation with tea packets earnings which implies one-unit increase in tea packets earnings leads to a 0.75 units increase in bulk tea earnings whereas tea bags earnings have significantly negative relation with tea packets value in long run.

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. Test for adequacy performed on the residuals of the VECM using Correlogram, Residual Portmanteau Tests for Autocorrelations, Residual Serial Correlation Lagrange Multiplier Tests. The results indicated that the models were satisfactory.

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. It is negatively affected by 38% of tea bags and total exports when there is one unit change in its lagged values. The fitted model for bulk tea revenue gives MAPE value of 4.33%.

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. VEC model for tea bags gives MAPE value of 6.94%. Further, results of model indicated that there is a long run equilibrium relationship.

According to the results of analysis, export earnings of tea packets is 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. Moreover, results indicates that there is no long run equilibrium relationship among variables. The fitted model for tea packets gives MAPE value of 5.41%.

Also, 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. It further indicates that there is no long run equilibrium relationship among variables. The fitted model for total export earnings gives MAPE value of 4.35%.

Based on the results of analysis, it is found that the VEC model is well reflected the trend in tea export earnings in Sri Lanka. The comparison between the original series and forecasted series shows the same manner indicating 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.

Wald test results indicate that there exist short run relationships (causality) from tea packets earnings to both bulk tea and tea bags earnings. Also, there are short run relationships from bulk tea earnings and total export earnings to tea bags earnings.

Impulse Response Function analysis was performed to analyze the dynamic behavior of a variable due to a random shock or innovation in other variables. Specifically, the Impulse Response Functions trace out the effects on current and future values of the endogenous variables of one standard deviation shock to a variable.

The impact of all endogenous variables (TPV, TBV and TEV) on BTV is positive at responsive period. The effect of TPV on TBV continue to maintain a high level after first four months while the effect of BTV on TBV is negligible after first four months.The effect of export earnings of TPV on TEV has decreased much during the first month and afterwards it fluctuates, but still positive.

The impact of BTV, TBV and TEV is negative at responsive period whereas the effect of TBV on TPV is negligible after first four months.

Further evidence is provided with Variance Decomposition Analysis which is another way to characterize the dynamic behavior of the model. The variance decomposition analysis revealed that a major proportion of the variability in export earnings of bulk tea and tea bags was explained by its own innovations while only a minority was explained by other categories in short run and long run. In the long run, the variation of TPV depends largelyon shocks to TBV. Specifically, this percentage increases through time and, in the last period, 44% of the total change on the variance is due to TBV. The role of BTV shocks becomes more significant for TEV. It is 64% of the variation of TEV is due to BTV. Consequently, in the long run, the link between the variables becomes more significant, since the variation of a variable is due not only to own, but to shocks from other variables too.

On the basis of the above overall analysis, the 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.

6.3 Conclusion

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 (they moved together in the long run).
- Bulk tea and Tea bags exhibit long term co-movements.
- Vector Error Correction Models give more accurate results with least MAPE.

6.4 Areas for further study

The study did not investigate univariate time series models for each category since variables are co-integrated each other. But, further study can include univariate time series models for each category to see whether they will give best predictions than the fitted model.

The present study is limited only to forecast tea export earnings by category. Tea export earnings fluctuate over time due to various factors. This study has not dealt with the factors that determine tea export earnings in the country. Such factors include exchange rate, inflation rate, foreign income, agriculture value addition, price of tea and volume of tea exported which the study didnot capture due to data problems. With the availability of reliable information about those factors, this can be incorporated in the model and their effects on the export earnings can be estimated. It would be able to have more comprehensive result if the data used can be extended over a longer period with inclusion of more variables.

Another research area would be the incorporation of weather and reforms in the tea sector in the model to be able to examine to what degree weather and reforms in tea affect tea export earnings in Sri Lanka. Thus variables which have not been examined in this study can be investigated by future researchers.

6.5 Synopsis

In this chapter, researcher invented the conclusion with a new perspective for tea planters and policy makers on the findings made in the study to enhance tea export earnings in Sri Lankan tea industry. Further, researcher opened the possibilities for future researchers by disclosing uncovered and untouched areas for future directions.

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