

LB/TH/31/2022

DMA 05/59

UNIVERSITY OF MORATUWA



LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
MORATUWA

Price Forecasting for Selected Up Country Vegetables of Sri Lanka: An Application of Time Series Analysis

Author:

Dilini Saranga
Widanaarachchige

Supervisor:

Dr. D M P V Dissanayaka

Index No: 168869N

*This dissertation is submitted in partial fulfilment of the requirements
for the M.Sc. in Financial Mathematics*

University of Moratuwa



TH4873

in the

Department of Mathematics
Faculty of Engineering
University of Moratuwa

2021

51st 2021st
336:51(043)

TH4873

+

CD ROM

TH4873



December 2021

Candidate's Declaration

I, the undersigned, hereby declare that the work submitted herein is my original work and that I have not plagiarized any work of another person. I have also declared that I have not used any unauthorized materials or information in the preparation of this work. I have also declared that I have not used any unauthorized materials or information in the preparation of this work.

Signature: _____
Date: _____

Supervisor's Recommendation

I, the undersigned, hereby recommend the work submitted herein for consideration for the award of a degree. I have also declared that I have not used any unauthorized materials or information in the preparation of this work.

Signature: _____
Date: _____

Candidate's Declaration

I, Dilini Saranga Widanaarachchige, declare that this thesis report titled, 'Price Forecasting for Selected Up Country Vegetables of Sri Lanka: An Application of Time Series Analysis' is the report of the research carried out under the supervision of Dr. D M P V Dissanayaka, as a partial fulfilment of the requirements of the M.Sc. in Financial Mathematics at the University of Moratuwa. It has not been submitted to any other institution or any other degree at a university by me for any other purpose.

Signed: _____

UOM Verified Signature

Date: _____

16/12/2021

UOM Verified Signature

Supervisor's Recommendation

I certify that this study was carried out by Ms. Dilini Saranga Widanaarachchige under my supervision.

Dr. D M P V Dissanayaka
Department of Statistics and Computer Science
University of Kelaniya

Signature: _____

UOM Verified Signature

Date: _____

16/12/2021



Acknowledgement

First, I would like to thank Dr. D M P V Dissanayaka, Senior lecturer at University of Kelaniya, for her brilliant ideas, patience, guidance, motivations, comments and suggestions on the research work. I am thankful for her enormous support lend to me to do this research.

I like to thank Mrs. Harshana Munasinghe, Lecturer at University of Kelaniya for helping me to select the path and topic of my research and giving me the opportunity to do this thesis and the subject knowledge. I am thankful for her encouragement and guidance to do this research study.

I would also like to express my deep and heartiest thanks to Mr. Malinda Seneviratna, Director of Hector Kobbakaduwa Agrarian Research and Training Institute for great advice and motivations and for helping me to get the data of Vegetable prices and allowing me to access the information relating to this topic from their institute.

I am ever so grateful to my immediate boss, Mrs. Lakmini Karunarthna who encouraged me to complete my Master's degree. It would not be a success without her kind advice and motivation.

My heartiest thanks goes to Mr.R. Dissanayake and Dr. Miuran Dencil, the two coordinators of my research for their support in my research and thesis submission.

I would also like to express my heartiest gratitude to Eng. Mr. Seneth Jayakodi, my cousin brother, who is currently reading for his Ph.D. at James Cook University, Australia, for helping me with this research despite his busy schedule.

Also, I thank my best friends who helped me immensely in my research. None of these things could have happened if not for their help to collect data and to find information regarding the topic, speeches of motivation, love, understanding and I am fortunate enough to have them in my life.

Last but not least, I am extremely grateful and appreciate my parents and my dear husband for all the sacrifices, support and for continuous encouragement throughout the process of research work and for the help to make it a real success.

Thank you so much...

Abbreviations

HARTI	Hector Kobbekaduwa Agrarian Research and Training Institute
MA	Moving Average
VAR	Vector Auto Regressive
ARIMA	Auto Regressive Integrated Moving Average
SARIMA	Seasonal Auto Regressive Integrated Moving Average
VECM	Vector Error Correction Model
WWW	World Wide Web

Contents

1. Introduction
2. Chapter 1
3. Chapter 2
4. Chapter 3
5. Chapter 4
6. Chapter 5
7. Chapter 6
8. Chapter 7
9. Chapter 8
10. Chapter 9
11. Chapter 10
12. Chapter 11
13. Chapter 12
14. Chapter 13
15. Chapter 14
16. Chapter 15
17. Chapter 16
18. Chapter 17
19. Chapter 18
20. Chapter 19
21. Chapter 20
22. Chapter 21
23. Chapter 22
24. Chapter 23
25. Chapter 24
26. Chapter 25
27. Chapter 26
28. Chapter 27
29. Chapter 28
30. Chapter 29
31. Chapter 30
32. Chapter 31
33. Chapter 32
34. Chapter 33
35. Chapter 34
36. Chapter 35
37. Chapter 36
38. Chapter 37
39. Chapter 38
40. Chapter 39
41. Chapter 40
42. Chapter 41
43. Chapter 42
44. Chapter 43
45. Chapter 44
46. Chapter 45
47. Chapter 46
48. Chapter 47
49. Chapter 48
50. Chapter 49
51. Chapter 50
52. Chapter 51
53. Chapter 52
54. Chapter 53
55. Chapter 54
56. Chapter 55
57. Chapter 56
58. Chapter 57
59. Chapter 58
60. Chapter 59
61. Chapter 60
62. Chapter 61
63. Chapter 62
64. Chapter 63
65. Chapter 64
66. Chapter 65
67. Chapter 66
68. Chapter 67
69. Chapter 68
70. Chapter 69
71. Chapter 70
72. Chapter 71
73. Chapter 72
74. Chapter 73
75. Chapter 74
76. Chapter 75
77. Chapter 76
78. Chapter 77
79. Chapter 78
80. Chapter 79
81. Chapter 80
82. Chapter 81
83. Chapter 82
84. Chapter 83
85. Chapter 84
86. Chapter 85
87. Chapter 86
88. Chapter 87
89. Chapter 88
90. Chapter 89
91. Chapter 90
92. Chapter 91
93. Chapter 92
94. Chapter 93
95. Chapter 94
96. Chapter 95
97. Chapter 96
98. Chapter 97
99. Chapter 98
100. Chapter 99
101. Chapter 100

To
Thatthi and Amma
for always being with me
in every step in my life
and also to
my loving husband
and baby...

Contents

Candidate's Declaration	i
Supervisor's Recommendation	i
Acknowledgement	ii
Abbreviations	iii
Contents	v
List of Figures	ix
List of Tables	xv
1 Introduction	1
1.1 Background	1
1.2 Research Objectives	2
1.3 Ethical Clearance	3
1.4 Organization of Chapters	3
2 Relevance and Significance	4
2.1 What is "Price"?	4
2.2 What is "Demand"?	4
2.3 What is "Supply"?	5
2.4 Connection between supply and demand	5
2.5 Connection between weather and vegetable supply	6
2.6 Why Up-Country vegetable price forecasting?	6
2.7 What is price forecasting?	6
2.8 What is the importance of price forecasting?	6
2.9 Strategies that use to forecast price in present	7
2.10 Who are the users of this system?	7
3 Literature Review	8
3.1 History of Forecasting	8
3.2 What is price forecasting of vegetables?	10
3.3 Relationship between Computers and Forecasting	10
3.4 Matching the Situations with Forecasting Methods	10



3.5	Six major factors which are considered important in forecasting:	11
3.6	Forecasting Tools:	12
3.7	Computers and Forecasting:	12
3.8	Using R Software for Time Series Analysis:	13
3.9	Up-country vegetables:	13
3.10	The Law of Supply	17
3.11	The Law of Demand	19
	3.11.1 Movement along the Demand Curve	19
	3.11.2 Shift in the Demand Curve	19
3.12	Law of Supply and Law of Demand: Equilibrium	20
3.13	SWOT Analysis	20
4	Methodology	23
4.1	Statistical Modelling	23
4.2	Time Series Modelling	23
4.3	Components of a Time Series	24
4.4	The Time Plot	24
4.5	Auto Correlation Function and Partial Auto Correlation Function	25
	4.5.1 Autocorrelation function	25
	4.5.2 Partial Autocorrelation function	25
4.6	Stationary of a Time Series	25
	4.6.1 Tests for Stationarity (Unit Root Test)	26
	4.6.2 Augmented Dickey Fuller (ADF) Test	26
	4.6.3 The Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test	27
4.7	Transforming Non-Stationary Time Series	27
	4.7.1 Box-Cox Transformation	27
4.8	Univariate Time Series Models	28
	4.8.1 Auto Regressive Model (AR Model)	28
	4.8.2 Moving Averages Model (MA Model)	29
	4.8.3 Autoregressive Moving Average Model (ARMA Model)	29
	4.8.4 Seasonal Autoregressive Moving Average Model (SARIMA model)	30
4.9	Model Identification	30
4.10	Model Selection	31
	4.10.1 Akaike Information Criterion (AIC)	31
	4.10.2 Coefficient of determination (R^2)	31
4.11	Residual Analysis	32
	4.11.1 Box -Pierce or Ljung box test	32
	4.11.2 Normality of Residuals	32
	4.11.3 Durbin-Watson statistic	33
	4.11.4 Lagrange's Multiplier test (LM Test)	33
4.12	Vector Autoregressive Models	33
	4.12.1 Lag selection for VAR models	34
4.13	Vector Error Correction Models (VECM)	34
4.14	Johanson's Cointegration Test	35
4.15	Autoregressive Conditional Heteroscedasticity (ARCH)	35
4.16	Breusch-Godfrey serial correlation LM test	36
4.17	Data collection	36

5	Analysis of Data	38
5.1	Properties of Weather Data	38
5.1.1	Properties of Monthly Average Temperature Data	39
5.1.2	Properties of Monthly Average Rainfall Data	42
5.2	Analysis for Price of Cabbage	45
5.2.1	Properties of Monthly Price of Cabbage	45
5.2.2	SARIMA model for Cabbage	48
5.2.2.1	Model Development	48
5.2.2.2	Model Diagnosis	54
5.2.2.3	Forecasting	56
5.2.3	VEC model for Cabbage Price	57
5.2.3.1	Model Development	57
5.2.3.2	Model Diagnosis	64
5.2.3.3	Forecasting	65
5.2.4	Comparison of the two models for Cabbage	67
5.3	Analysis for Price of Leeks	68
5.3.1	Properties of Monthly Price of Leeks	68
5.3.2	SARIMA model for Leeks	71
5.3.2.1	Model Development	71
5.3.2.2	Model Diagnosis	77
5.3.2.3	Forecasting	79
5.3.3	VEC model for Leeks Price	80
5.3.3.1	Model Development	80
5.3.3.2	Model Diagnosis	88
5.3.3.3	Forecasting	90
5.3.4	Comparison of the two models for Leeks	91
5.4	Analysis for Price of Beetroot	92
5.4.1	Properties of Monthly Price of Beetroot	92
5.4.2	SARIMA model for Beetroot	95
5.4.2.1	Model Development	95
5.4.2.2	Model Diagnosis	101
5.4.2.3	Forecasting	104
5.4.3	VEC model for Beetroot Price	105
5.4.3.1	Model Development	105
5.4.3.2	Model Diagnosis	113
5.4.3.3	Forecasting	114
5.4.4	Comparison of the two models for Beetroot	115
5.5	Analysis for Price of Carrot	117
5.5.1	Properties of Monthly Price of Carrot	117
5.5.2	SARIMA model for Carrot	120
5.5.2.1	Model Development	120
5.5.2.2	Model Diagnosis	127
5.5.2.3	Forecasting	130
5.5.3	VEC model for Carrot Price	131
5.5.3.1	Model Development	131
5.5.3.2	Model Diagnosis	139
5.5.3.3	Forecasting	141

5.5.4	Comparison of the two models for Carrot	142
5.6	Analysis for Price of Green Beans	143
5.6.1	Properties of Monthly Price of Green Beans	143
5.6.2	SARIMA model for Green Beans	146
5.6.2.1	Model Development	146
5.6.2.2	Model Diagnosis	153
5.6.2.3	Forecasting	155
5.6.3	VEC model for Green Beans Price	156
5.6.3.1	Model Development	156
5.6.3.2	Model Diagnosis	163
5.6.3.3	Forecasting	164
5.6.4	Comparison of the two models for Green Beans	166
5.7	Analysis for Price of Potatoes	167
5.7.1	Properties of Monthly Price of Potatoes	167
5.7.2	SARIMA model for Potatoes	171
5.7.2.1	Model Development	171
5.7.2.2	Model Diagnosis	178
5.7.2.3	Forecasting	180
5.7.3	VEC model for Potatoes Price	181
5.7.3.1	Model Development	181
5.7.3.2	Model Diagnosis	188
5.7.3.3	Forecasting	189
5.7.4	Comparison of the two models for Potatoes	191
6	Discussion and Conclusions	192
6.1	Conclusions of Analysis	192
6.1.1	Final VEC Models to predict the Price of Vegetables	193
6.2	Recommendations for Future Improvements	195
A	Interviews	197
	Bibliography	201

List of Figures

2.1	Supply Curve	5
3.1	: Structure of Traditional Vegetable Supply chains operating in Sri Lanka.	15
3.2	: Structure of Traditional Vegetable Supply chains operating in Sri Lanka II	16
3.3	Law of Supply	18
3.4	Law of Demand	20
3.5	Law of Supply and Law of Demand: Equilibrium	21
4.1	Time Plot	24
4.2	Plots of ACF and PACF	26
5.1	Time Plot for monthly average temperature	39
5.2	Decompostion of Temperature	40
5.3	ACF and PACF of Monthly Average Temperature	40
5.4	ACF and PACF of First Difference of Temperature	41
5.5	ACF and PACF of First Difference of log of Temperature	41
5.6	Time Plot for monthly average Rainfall	42
5.7	Decompostion of Rainfall series	43
5.8	ACF and PACF of Monthly Average Rainfall	43
5.9	ACF and PACF of First Difference of Rainfall	44
5.10	ACF and PACF of First Difference of log of Rainfall	44
5.11	Time plot of Monthly Price of Cabbage	45
5.12	Decompostion of Monthly Price of Cabbage	46
5.13	ACF and PACF of Price of Cabbage	46
5.14	ACF and PACF of First Difference of Cabbage Price	47
5.15	ACF and PACF of First Difference of log of Cabbage Price	47
5.16	BoxCox Lambda for Cabbage Price	48
5.17	Seasonal plot of Price of Cabbage	49
5.18	Time plot of First and 6th Differenced Series of log Price of Cabbage	49
5.19	KPSS Test for Price of Cabbage	50
5.20	ADF Test for Price of Cabbage	50
5.21	PP Test for Price of Cabbage	50
5.22	Correlogram for $D(\log(\text{Price of Cabbage})_{1,6})$	51
5.23	SARIMA model Equation for $D(\log(\text{Price of Cabbage})_{1,6})$	53
5.24	SARIMA Model coefficients for $D(\log(\text{Price of Cabbage})_{1,6})$	53
5.25	ARCH Test for residuals of SARIMA for $D(\log(\text{Price of Cabbage})_{1,6})$	54
5.26	Normality Test for residuals of SARIMA for $D(\log(\text{Price of Cabbage})_{1,6})$	54
5.27	Correlogram for residuals of SARIMA for $D(\log(\text{Price of Cabbage})_{1,6})$	55

5.28	Forecasted values from SARIMA for $D(\log(\text{Price of Cabbage}))_{1,6}$	56
5.29	Actual and fitted values for cabbage price of SARIMA for $D(\log(\text{Price of Cabbage}))_{1,6}$	56
5.30	VAR lag order selection For Cabbage	57
5.31	VAR Model For Cabbage	58
5.32	Cointegration test for Cabbage price , Rainfall and Temperature	59
5.33	VECM for Cabbage price , Rainfall and Temperature	60
5.34	VECM for Cabbage price , Rainfall and Temperature	61
5.35	VECM for Cabbage price , Rainfall and Temperature	62
5.36	VECM Equations for Cabbage price , Rainfall and Temperature	62
5.37	VECM LM for Cabbage price , Rainfall and Temperature	63
5.38	ARCH test for VECM for Cabbage price , Rainfall and Temperature	64
5.39	Normality test for VECM for Cabbage price , Rainfall and Temperature	65
5.40	Serial Correlation test for VECM for Cabbage price , Rainfall and Temperature	65
5.41	Forecasted values for VECM for Cabbage price , Rainfall and Temperature	66
5.42	Forecasted values for VECM for Cabbage price , Rainfall and Temperature	66
5.43	Time plot of Monthly Price of Leeks	68
5.44	Decomposition of Monthly Price of Leeks	68
5.45	Time plot of first difference of Price of Leeks	69
5.46	Time plot of log of Price of Leeks	69
5.47	ACF and PACF of Price of Leeks	70
5.48	ACF and PACF of First Difference of Leeks Price	70
5.49	ACF and PACF of First Difference of log of Leeks Price	70
5.50	Seasonal plot of Price of Leeks	71
5.51	Time plot of First and 12th Differenced Series of log Price of Leeks	72
5.52	KPSS Test for Price of Leeks	73
5.53	ADF Test for Price of Leeks	73
5.54	PP Test for Price of Leeks	73
5.55	Correlogram for $D(\log(\text{Price of Leeks}))_{1,12}$	74
5.56	SARIMA model Equation for $D(\log(\text{Price of Leeks}))_{1,12}$	76
5.57	SARIMA Model coefficients for $D(\log(\text{Price of Leeks}))_{1,12}$	76
5.58	ARCH Test for residuals of SARIMA for $D(\log(\text{Price of Leeks}))_{1,12}$	77
5.59	Normality Test for residuals of SARIMA for $D(\log(\text{Price of Leeks}))_{1,6}$	77
5.60	Correlogram for residuals of SARIMA for $D(\log(\text{Price of Leeks}))_{1,6}$	78
5.61	Forecasted values from SARIMA for $D(\log(\text{Price of Leeks}))_{1,12}$	79
5.62	Actual and fitted values for Leeks price of SARIMA for $D(\log(\text{Price of Leeks}))_{1,12}$	79
5.63	VAR lag order selection For Leeks	80
5.64	VAR Model For Leeks	81
5.65	Cointegration test for Leeks price , Rainfall and Temperature	82
5.66	VECM for Leeks price , Rainfall and Temperature	83
5.67	VECM for Leeks price , Rainfall and Temperature	84
5.68	VECM for Leeks price , Rainfall and Temperature	85
5.69	VECM LM for Leeks price , Rainfall and Temperature	87
5.70	ARCH test for VECM for Leeks price , Rainfall and Temperature	89
5.71	Normality test for VECM for Leeks price , Rainfall and Temperature	89

5.72	Serial Correlation test for VECM for Leeks price , Rainfall and Temperature	89
5.73	Forecasted values for VECM for Leeks price , Rainfall and Temperature . .	90
5.74	Forecasted values for VECM for Leeks price , Rainfall and Temperature . .	90
5.75	Time plot of Monthly Price of Beetroot	92
5.76	Decompostion of Monthly Price of Beetroot	92
5.77	Time plot of first difference of Price of Beetroot	93
5.78	Time plot of log of Price of Beetroot	93
5.79	ACF and PACF of Price of Beetroot	94
5.80	ACF and PACF of First Difference of Beetroot Price	94
5.81	ACF and PACF of First Difference of log of Beetroot Price	94
5.82	Seasonal plot of Price of Beetroot	96
5.83	Time plot of First and 6th Differenced Series of log Price of Beetroot . . .	96
5.84	KPSS Test for Price of Beetroot	97
5.85	ADF Test for Price of Beetroot	97
5.86	PP Test for Price of Beetroot	97
5.87	Correlogram for D(log(Price of Beetroot)1,6)	99
5.88	SARIMA model Equation for D(log(Price of Beetroot)1,6)	100
5.89	SARIMA Model coefficients for D(log(Price of Beetroot)1,6)	101
5.90	ARCH Test for residuals of SARIMA for D(log(Price of Beetroot)1,6) . .	102
5.91	Normality Test for residuals of SARIMA for D(log(Price of Beetroot)1,6)	102
5.92	Correlogram for residuals of SARIMA for D(log(Price of Beetroot)1,6) . .	103
5.93	Forecasted values from SARIMA for D(log(Price of Beetroot)1,6)	104
5.94	Actual and fitted values for Beetroot price of SARIMA for D(log(Price of Beetroot)1,6)	104
5.95	VAR lag order selection For Beetroot	105
5.96	VAR Model For Beetroot	106
5.97	Cointegration test for Beetroot price , Rainfall and Temperature	107
5.98	VECM for Beetroot price , Rainfall and Temperature	108
5.99	VECM for Beetroot price , Rainfall and Temperature	109
5.100	VECM for Beetroot price , Rainfall and Temperature	110
5.101	Model Equation for Beetroot price , Rainfall and Temperature	111
5.102	ARCH test for VECM for Beetroot price , Rainfall and Temperature . . .	113
5.103	Nomality test for VECM for Beetroot price , Rainfall and Temperature .	114
5.104	Serial Correlation test for VECM for Beetroot price , Rainfall and Temperature	114
5.105	Forecasted values for VECM for Beetroot price , Rainfall and Temperature	115
5.106	Forecasted values for VECM for Beetroot price , Rainfall and Temperature	115
5.107	Time plot of Monthly Price of Carrot	117
5.108	Decompostion of Monthly Price of Carrot	117
5.109	Time plot of first difference of Price of Carrot	118
5.110	Time plot of log of Price of Carrot	118
5.111	ACF and PACF of Price of Carrot	119
5.112	ACF and PACF of First Difference of Carrot Price	119
5.113	ACF and PACF of First Difference of log of Carrot Price	119
5.114	Seasonal plot of Price of Carrot	120
5.115	Time plot of First and 6th Difference Series of log Price of Carrot	121

5.116	KPSS Test for Price of Carrot	122
5.117	ADF Test for Price of Carrot	122
5.118	PP Test for Price of Carrot	122
5.119	Correlogram for $D(\log(\text{Price of Carrot})1,6)$	123
5.120	SARIMA model Equation for $D(\log(\text{Price of Carrot})1,6)$	126
5.121	SARIMA Model coefficients for $D(\log(\text{Price of Carrot})1,6)$	126
5.122	ARCH Test for residuals of SARIMA for $D(\log(\text{Price of Carrot})1,6)$	127
5.123	Normality Test for residuals of SARIMA for $D(\log(\text{Price of Carrot})1,6)$	128
5.124	Correlogram for residuals of SARIMA for $D(\log(\text{Price of Carrot})1,6)$	129
5.125	Forecasted values from SARIMA for $D(\log(\text{Price of Carrot})1,6)$	130
5.126	Actual and fitted values for Carrot price of SARIMA for $D(\log(\text{Price of Carrot})1,6)$	130
5.127	VAR lag order selection For Carrot	131
5.128	VAR Model For Carrot	132
5.129	Cointegration test for Carrot price , Rainfall and Temperature	133
5.130	VECM for Carrot price , Rainfall and Temperature	134
5.131	VECM for Carrot price , Rainfall and Temperature	135
5.132	VECM for Carrot price , Rainfall and Temperature	136
5.133	Model Equation for Carrot price , Rainfall and Temperature	137
5.134	VEC Model Coefficients for Carrot	138
5.135	ARCH test for VECM for Carrot price , Rainfall and Temperature	140
5.136	Nomality test for VECM for Carrot price , Rainfall and Temperature	140
5.137	Serial Correlation test for VECM for Carrot price , Rainfall and Temperature	140
5.138	Forecasted values for VECM for Carrot price , Rainfall and Temperature	141
5.139	Forecasted values for VECM for Carrot price , Rainfall and Temperature	141
5.140	Time plot of Monthly Price of GreenBeans	143
5.141	Decompostion of Monthly Price of GreenBeans	143
5.142	Time plot of first difference of Price of GreenBeans	144
5.143	Time plot of log of Price of GreenBeans	144
5.144	ACF and PACF of Price of GreenBeans	145
5.145	ACF and PACF of First Difference of GreenBeans Price	145
5.146	ACF and PACF of First Difference of log of GreenBeans Price	145
5.147	Seasonal plot of Price of GreenBeans	147
5.148	Time plot of First and 6th Difference Series of log Price of GreenBeans	147
5.149	KPSS Test for Price of GreenBeans	148
5.150	ADF Test for Price of GreenBeans	148
5.151	PP Test for Price of GreenBeans	148
5.152	Correlogram for $D(\log(\text{Price of GreenBeans})1,6)$	150
5.153	SARIMA model Equation for $D(\log(\text{Price of GreenBeans})1,6)$	152
5.154	SARIMA Model coefficients for $D(\log(\text{Price of GreenBeans})1,6)$	152
5.155	ARCH Test for residuals of SARIMA for $D(\log(\text{Price of GreenBeans})1,6)$	153
5.156	Normality Test for residuals of SARIMA for $D(\log(\text{Price of GreenBeans})1,6)$	153
5.157	Correlogram for residuals of SARIMA for $D(\log(\text{Price of GreenBeans})1,6)$	154
5.158	Forecasted values from SARIMA for $D(\log(\text{Price of GreenBeans})1,6)$	155
5.159	Actual and fitted values for GreenBeans price of SARIMA for $D(\log(\text{Price of GreenBeans})1,6)$	155

5.160	VAR lag order selection For GreenBeans	156
5.161	VAR Model For GreenBeans	157
5.162	Cointegration test for GreenBeans price , Rainfall and Temperature	158
5.163	VECM for GreenBeans price , Rainfall and Temperature	159
5.164	VECM for GreenBeans price , Rainfall and Temperature	160
5.165	VECM for GreenBeans price , Rainfall and Temperature	161
5.166	Model Equation for GreenBeans price , Rainfall and Temperature	162
5.167	VEC Model Coefficients for GreenBeans	162
5.168	ARCH test for VECM for GreenBeans price , Rainfall and Temperature	163
5.169	Nomality test for VECM for GreenBeans price , Rainfall and Temperature	164
5.170	Serial Correlation test for VECM for GreenBeans price , Rainfall and Temperature	164
5.171	Forecasted values for VECM for GreenBeans price , Rainfall and Temper- ature	165
5.172	Forecasted values for VECM for GreenBeans price , Rainfall and Temper- ature	165
5.173	Time plot of Monthly Price of Potato	167
5.174	Decomposition of Monthly Price of Potato	168
5.175	Time plot of first difference of Price of Potato	168
5.176	Time plot of log of Price of Potato	169
5.177	ACF and PACF of Price of Potato	170
5.178	ACF and PACF of First Difference of Potato Price	170
5.179	ACF and PACF of First Difference of log of Potato Price	170
5.180	Box Cox Lambda of Potato Price	171
5.181	Seasonal plot of Price of Potato	172
5.182	Time plot of First and 6th Difference Series of log Price of Potato	172
5.183	KPSS Test for Price of Potato	173
5.184	ADF Test for Price of Potato	173
5.185	PP Test for Price of Potato	173
5.186	Correlogram for $D(\log(\text{Price of Potato})_{1,3})$	175
5.187	SARIMA model Equation for $D(\log(\text{Price of Potato})_{1,3})$	177
5.188	SARIMA Model coefficients for $D(\log(\text{Price of Potato})_{1,3})$	177
5.189	ARCH Test for residuals of SARIMA for $D(\log(\text{Price of Potato})_{1,3})$	178
5.190	Normality Test for residuals of SARIMA for $D(\log(\text{Price of Potato})_{1,3})$	178
5.191	Correlogram for residuals of SARIMA for $D(\log(\text{Price of Potato})_{1,3})$	179
5.192	Forecasted values from SARIMA for $D(\log(\text{Price of Potato})_{1,3})$	180
5.193	Actual and fitted values for Potato price of SARIMA for $D(\log(\text{Price of}$ $\text{Potato})_{1,3})$	180
5.194	VAR lag order selection For Potato	181
5.195	VAR Model For Potato	182
5.196	Cointegration test for Potato price , Rainfall and Temperature	183
5.197	VECM for Potato price , Rainfall and Temperature	184
5.198	VECM for Potato price , Rainfall and Temperature	185
5.199	VECM for Potato price , Rainfall and Temperature	186
5.200	VEC Model Coefficients for Potato	187
5.201	ARCH test for VECM for Potato price , Rainfall and Temperature	189
5.202	Nomality test for VECM for Potato price , Rainfall and Temperature	189

5.203	Serial Correlation test for VECM for Potato price , Rainfall and Temperature	189
5.204	Foreasted values for VECM for Potato price , Rainfall and Temperature .	190
5.205	Foreasted values for VECM for Potato price , Rainfall and Temperature .	190

List of Tables

List of Tables

3.1	R Packages for Time series Analysis	13
3.2	Cultivated Extent and production of Up-Country vegetables in Nuwara-Eliya district at National level in 2017	14
3.3	Cultivated Extent and production of Up-Country vegetables in Badhulla district at National level in 2017	14
3.4	Production of Up-Country vegetables, National total and percentage from the National total	14
4.1	Box-Cox Transformations	28
4.2	Model Identification	30
5.1	Stationarity of Temperature series	39
5.2	Stationarity of Rainfall series	42
5.3	Stationarity of Price of Cabbage Series	48
5.4	Model Identification	52
5.5	Stationarity of Price of Cabbage Series	67
5.6	Stationary of Price of Leeks Series	71
5.7	Model Identification	75
5.8	Stationarity of Price of Leeks Series	91
5.9	Stationary of Price of Beetroot Series	95
5.10	Model Identification	100
5.11	Stationarity of Price of Beetroot Series	115
5.12	Stationary of Price of Carrot Series	120
5.13	Model Identification	125
5.14	Stationarity of Price of Carrot Series	142
5.15	Stationary of Price of GreenBeans Series	146
5.16	Model Identification	151
5.17	Stationarity of Price of GreenBeans Series	166
5.18	Stationary of Price of Potato Series	171
5.19	Model Identification	176
5.20	Stationarity of Price of Potato Series	191

