Exploring volatility in crop prices for farmers' benefit

A REPORT SUBMITTED TO

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OF

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IN THE FACULTY OF SCIENCE AND TECHNOLOGY

SUBMITTED BY

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UNDER THE GUIDENCE OF

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CENTRE FOR ADVANCED STUDIES IN STATISTICS,

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MAY, 2023

Certificate of the Guide

This is to certify that, the following students of M.Sc. Statistics,

(1) Ayshik Neogi (2102)

(2) Saurav Jadhav (2120)

have successfully completed their project titled **Exploring volatility in crop prices for farmers' benefit** under the guidance of **Dr. Madhuri Kulkarni** and have submitted this project report on the **27th of July, 2023** as a part of the course ST-402, towards partial fulfillment of requirements for degree of M.Sc. Statistics in Savitribai Phule Pune University in academic year 2022-2023.

Dr. Madhuri Kulkarni
(Project Guide)

Prof. T. V. Ramanathan
(Head of the Department)

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Chapter 1

Introduction and Summary

India ranks second worldwide in farm outputs Wikipedia (2023). As per the Indian economic survey 2018, agriculture employed more than 50 percent of the Indian workforce and contributed 17–18 percent to the country's GDP Wikipedia (2023).

In India, farming involves various types of risks. And price volatility is one of the substantial risks. The majority of farmers, 86 percent, are small and marginal with declining and fragmenting landholdings, these uncertainties make them even more vulnerable and risk-prone to the price volatility of crops Business Standard (2017). In India, a farmer faces a huge problem due to price fluctuations. India Today (2022) Zhang et al. (2014) stated that accurate price prediction of agricultural products is useful for planning agricultural production and for developing a balance between supply and demand.

■

Chapter 2

Objectives

2.0.1 Motivation

- The majority of farmers, 86 percent are small and marginal with declining and fragmenting landholdings, these uncertainties make them even more vulnerable and risk-prone to the price volatility of crops.[Business Standard, 2017]
- In India, a farmer faces a huge problem due to price fluctuations.

Figure 2.1: India Today (2022)

2.0.2 Objectives

The goal of our project is to give suggestions to an individual farmer about possible actions to avoid low prices. Advice includes a window for sowing potatoes and forecasting potato, banana, and spinach prices so that a farmer can avoid losses by taking the produce to the market at the right time.

■

Chapter 3

Literature Review

1. **'Favorit': farmers' volatility risk treatment**
   Godase et al. (2022)
   Introduction: The aim of this paper is not maximizing profit but reducing losses. The attempt is to use analytics, not to discover any new macroeconomic insight, but to suggest a small change in a farmer's approach.

   Data: This research uses daily-price data for tomato, onion, and coriander:

   - For tomato, 11 years of data was considered from 2011 to 2021
   - For onion as well, data from 2011 to 2021 is considered
   - For coriander, 100 days of data is used

   Ranking of Months:

   1 Rule 1: If the lower limit of the confidence interval for a month A is higher than the upper limit of the confidence interval for month B, then A should have a better rank than B. This will resolve the

question only in some cases. When it doesn't, we need the next rule which is slightly less stringent.

2 Rule 2: If the mean for a month A is higher than the upper limit of the confidence interval for B, then the rank of A should be higher than the rank of B. These two rules may not sort out all comparisons. For resolving the remaining comparisons, we propose an index of the attractiveness of a month.

3 Rule 3: Month A is ranked higher than month B if the FLAP index of A is higher than that of B.

FLAP INDEX: We are trying to combine two dimensions of price (mean and volatility). Let us define a new index to be named the FLAP index. FLAP is the acronym for Fluctuation Adjusted Price. We define it as mean/sd. Note that it is the inverse of the Coefficient of Variation (sd /mean). Using this index, we give the last rule.

Based on the above ranking methodology we rank months for specific crops on the basis of prices, and prices and locations.

2. **Time Series Forecasting of Price of Agricultural Products Using Hybrid Methods**
Sourav Kumar Purohit and Beheraa (2021)
Introduction:

- Accurate prediction of crop prices assists farmers to decide the best time to sell their products to get maximum benefit and assists Government with post-harvest storage and management of the product so as to stabilize the price volatility throughout the year.
- Hence, the prediction of crop prices is a challenging and important problem.
- Inspired by this, in this study, they have proposed two additive hybrid methods (Additive-ETS-SVM, Additive-ETS-LSTM) and five

multiplicative hybrid methods (Multiplicative-ETS-ANN, Multiplicative-ETSSVM, Multiplicative-ETS-LSTM, Multiplicative-ARIMA-SVM, Multiplicative-ARIMA-LSTM) to predict the monthly retail and wholesale price of three most commonly used vegetable crops of India, namely, tomato, onion, and potato (TOP).

Data: Yearly data on the yield of tomatoes, onions, and potatoes from 2013 to 2018 were collected from the report of Horticultural Statistics Division, Department of Agriculture, Cooperation and Farmer Welfares, Govt. of India (available at: `http://agricoop.gov.in/`, accessed March 12, 2020) and Database of National Horticulture Board (NSB) (available at: `http://nhb.gov.in/`, accessed March 12, 2020).

■

Chapter 4

Data & Methodology

We consider three crops for the analysis: Potato, Banana, and Spinach. And the data we consider is the daily price (per quintal) data. The data is collected for the Pune and Ahmednagar regions from:
`https://agmarknet.gov.in/PriceAndArrivals/DatewiseCommodityReport.aspx`,
a website handled by the Directorate of Marketing & Inspection (DMI), Ministry of Agriculture and Farmers Welfare, Government of India regarding regular prices of crops.

4.1 Information about the crops:

- For potatoes, we consider prices from January 3, 2011, to February 13, 2023. Prices are per quintal.
- For bananas, we consider prices from September 22, 2021, till February 16, 2023. Prices are per quintal.
- For spinach, we consider prices from July 24, 2016, to February 20, 2023. Prices are per single bunch.

4.2 Missing value information:

For potatoes, seven missing values. For bananas, no missing values. For spinach, one missing value.

4.3 Methodology:

4.3.1 Train-Test split

We first divide the price data of all three crops into train and test parts. And do the analysis on the train part.

- The train part for potatoes is from 3rd January 2011 to 30th October 2020. And the test part is from 1st November to 13th February 2023.
- The train part for bananas is from 22nd September 2021 to 8th November 2022. And the test part is from 9th November 2022 to 16th February 2023.
- The train part for spinach is from 24th July 2016 to 21st October 2021. And the test part is from 22nd October 2021 to 20th February 2023.

4.3.2 EDA part:

- We compute a 95 percent confidence interval of monthly prices for all three commodities i.e. potato, banana, and spinach.
- We do the box plot of monthly prices for all three crops. We also rank the months according to the FLAP index and make suggestions accordingly.

- We are trying to combine two dimensions of price (mean and volatility). Let us define a new index to be named the FLAP index. FLAP is the acronym for Fluctuation Adjusted Price. We define it as mean/sd. Note that it is the inverse of the Coefficient of Variation (sd/mean) Godase et al. (2022)

- We decompose our daily price data into the trend, seasonality, and the remainder component. We identify whether the seasonality is additive or multiplicative from the generalized decomposition plots. We do the ACF plot of the prices for all three crops.

4.3.3 Forecasting

In this study, we have considered two most popular statistical forecasting models, namely, ARIMA, exponential smoothing with error, trend, and seasonality (ETS).

Two popular machine learning models, namely, support vector machine for regression (SVM), and long short-term memory (LSTM) are also considered. The machine learning models (LSTM and SVM) are considered the additive and multiplicative parts of the hybrid methods along with the aforementioned statistical models.

After modeling, we compare all these models using the rolling window technique.

We choose the model which has the least RMSE. We visualize the results for the chosen model.

4.3.4 Contagion Effect

In the contagion effect, we test whether the local correlations between two financial time series are different before and during crisis times. In our case, we compare potato prices for Pune and Ahmednagar markets as the two time series for the contagion effect.

4.3.5 Spatio-FLAP Index

Spatio-FLAP Index is the FLAP index constructed for the markets across different months. We rank the best 3 markets in Maharashtra for each month and suggest to the farmer where to sell the crop in which month to gain maximum profit with more consistency.

Similar to the FLAP index the Spatio-FLAP index is defined as, mean/sd. Hence, it prescribes a value for a market for a given month taking both the average and the variation of the prices in the market for that month into consideration at the same time. A higher value of the Spatio-FLAP index would indicate a market with a higher average price and lesser variation i.e. greater precision.

If Market A has a higher Spatio-FLAP index than Market B for month X, we rank Market A over Market B for month X.

Chapter 5

Data Analysis, Modelling, and Interpretation

5.0.1 95 percent confidence intervals for potato, banana, and spinach

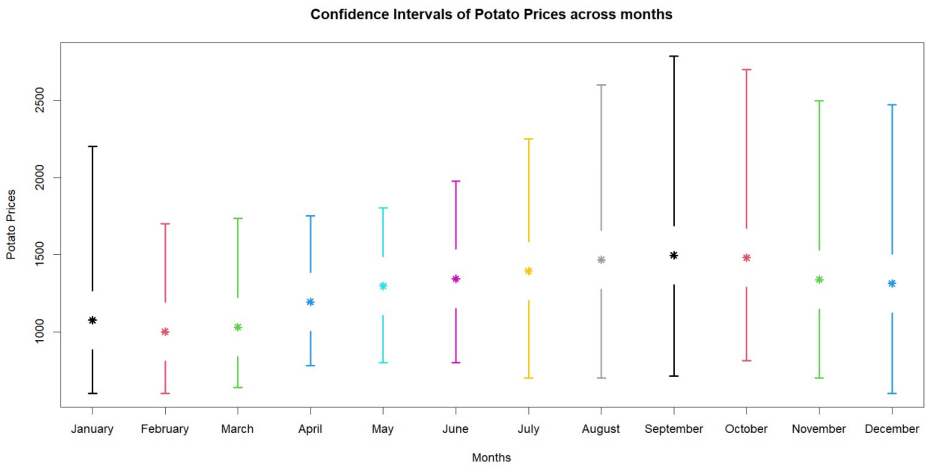

Figure 5.1: Confidence Interval for the monthly average price of potato (Rs/Quintal) for the Pune market

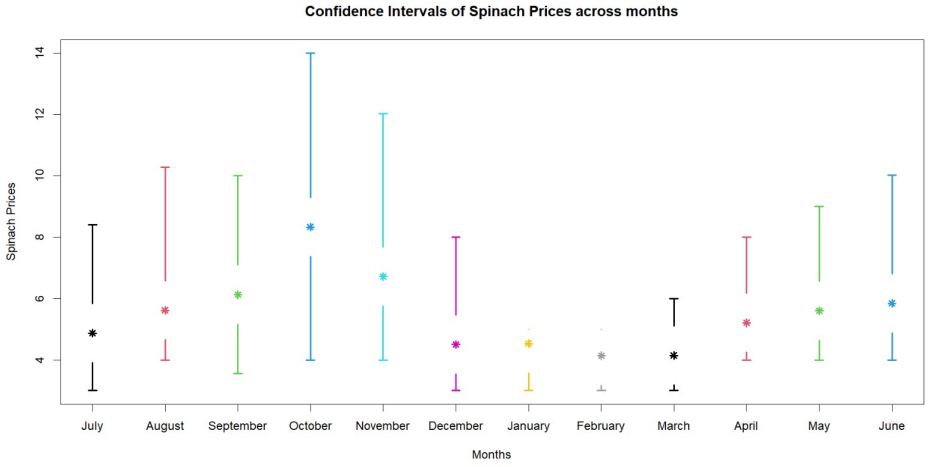

Figure 5.2: Confidence Interval for the monthly average price of spinach (Rs/Bunch) for the Pune market

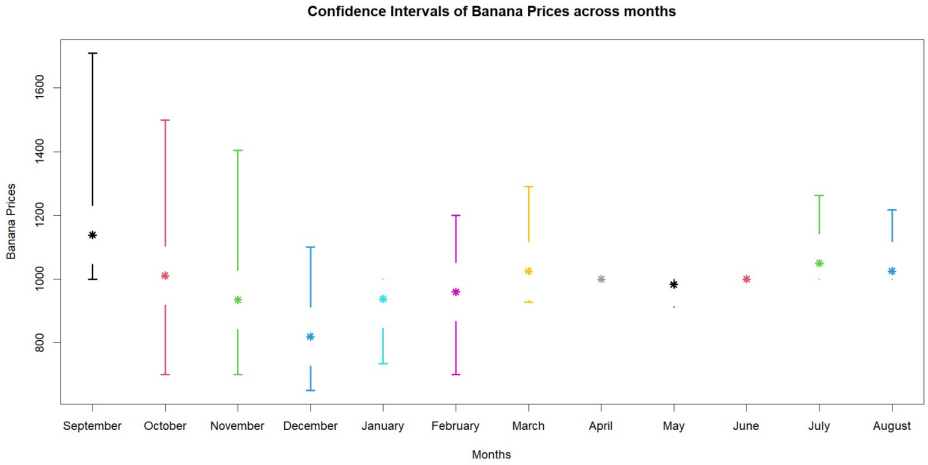

Figure 5.3: Confidence Interval for the monthly average price of banana (Rs/Quintal) for the Pune market

5.0.2 Box Plots:

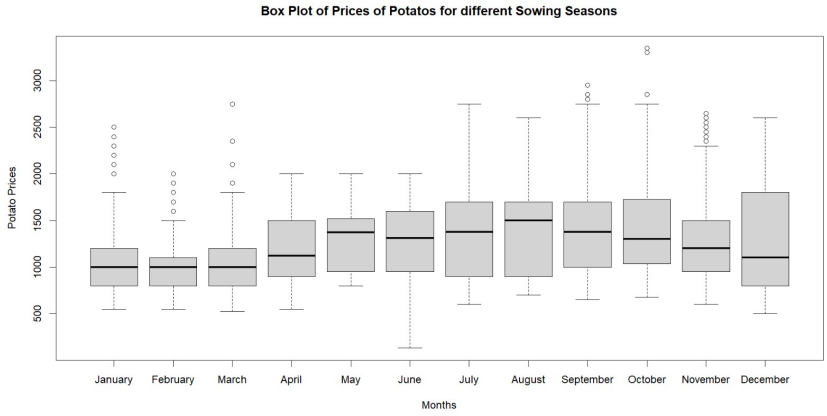

Figure 5.4: Box Plot for the monthly average price of Potato (Rs/Quintal) for the Pune market

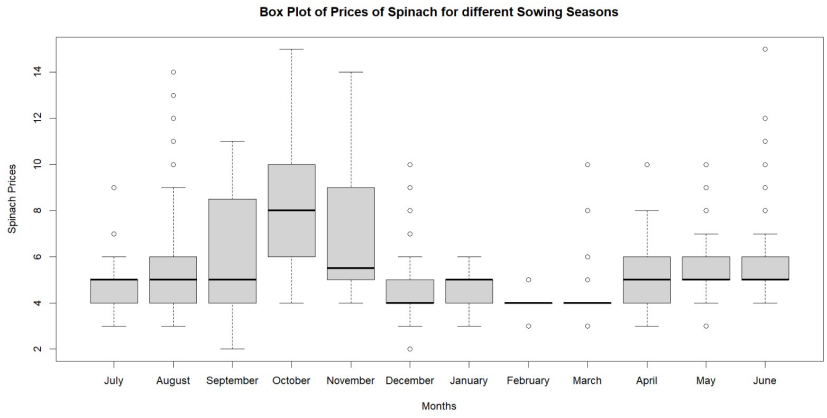

Figure 5.5: Box Plot for the monthly average price of Spinach (Rs/Bunch) for the Pune market

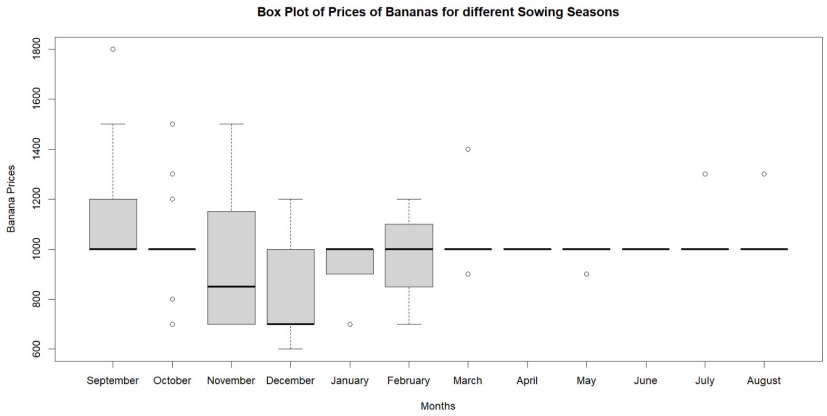

Figure 5.6: Box Plot for the monthly average price of Banana (Rs/Quintal) for the Pune market

5.0.3 Ranking of months for all three crops based on the FLAP Index

Note that the FLAP Index measures the fluctuation in the monthly mean, where a higher value indicates a higher degree of fluctuation. Therefore, it may be useful to consider not only the mean and the confidence intervals but also the FLAP Index when making decisions based on the data provided.

Table 5.1: The tables below show the average prices, the 95 percent confidence interval, and the FLAP Index for potato

Month	**Mean**	**Lower_CI**	**Upper_CI**	**FLAP Index**	**Rank**
May	1297.474747	800	1803.75	4.056450202	1
April	1193.891753	782.5	1750	3.97660274	2

Continued on next page

Table 5.1 Continues

Month	**Mean**	**Lower_CI**	**Upper_CI**	**FLAP Index**	**Rank**
June	1343.409091	800	1976.25	3.606516349	3
February	1000.536585	600	1700	3.436861076	4
March	1029.911894	641.25	1735	3.41580275	5
July	1393.409091	700	2250	2.891048276	6
August	1466.25	700	2600	2.580895851	7
January	1076.234043	600	2200	2.553474197	8
October	1480.977273	811.875	2700	2.54297825	9
November	1337.892157	700	2496.25	2.516327245	10
September	1494.929245	713.75	2786.25	2.47528401	11
December	1312.840376	600	2470	2.298183438	12

We can see the month of May as the preferable month to sell. So based on that, the farmer can plan the sowing of potatoes in January-February so that he/she can maximize the profit.

Table 5.2: The tables below show the average prices, the 95 percent confidence interval, and the FLAP Index for spinach

Month	**Mean**	**Lower_CI**	**Upper_CI**	**FLAP Index**	**Rank**
February	4.136752137	3	5	7.899384273	1
January	4.52991453	3	5	7.105584437	2
March	4.141666667	3	6	4.800121025	3
April	5.206185567	4	8	4.376061556	4

Continued on next page

Table 5.2 Continues

Month	Mean	Lower_CI	Upper_CI	FLAP Index	Rank
May	5.602150538	4	9	4.21809896	5
July	4.872180451	3	8.4	3.873619295	6
June	5.841666667	4	10.025	3.251991134	7
December	4.503937008	3	8	3.225021071	8
October	8.328244275	4	14	2.877623852	9
September	6.125874126	3.55	10	2.655386139	10
August	5.613333333	4	10.275	2.620724752	11
November	6.716666667	4	12.025	2.542683606	12

We can see even though the month of October has a lower value on the FLAP index, It is still a good time to sell based on the higher value of the lower confidence interval. Hence, a farmer can plan the sowing around July-August so that the profits can be maximized.
Spinach is a perishable vegetable. And it is very seasonal, hence it is not very practical for the farmer to vary the sowing of spinach by months.

Table 5.3: The tables below show the average prices, the 95 percent confidence interval, and the FLAP Index for banana

Month	Mean	Lower_CI	Upper_CI	FLAP Index	Rank
April	1000	1000	1000	Inf	1.5
June	1000	1000	1000	Inf	1.5
May	983.3333333	912.5	1000	24.08664914	3
August	1025	1000	1217.5	11.83568052	4

Continued on next page

Table 5.3 Continues

Month	**Mean**	**Lower_CI**	**Upper_CI**	**FLAP Index**	**Rank**
January	937.5	735	1000	8.838834765	5
July	1050	1000	1262.5	8.5732141	6
March	1025	927.5	1290	8.43322185	7
February	960	700	1200	5.206330988	8
December	819.047619	650	1100	5.020106095	9
October	1010.810811	700	1500	4.60348614	10
September	1138.461538	1000	1710	4.492072961	11
November	935	700	1405	3.413538461	12

We can see even though the month of September has a lower value on the FLAP index, It is still a good time to sell based on the higher value of the lower confidence interval. Hence, a farmer can plan the sowing in such a way that the profits are maximized.

Note: The FLAP Index value is Inf for the month of April and June because there's no variation in the banana prices for those months with a lower number of samples.

5.0.4 Decomposition of the price data into trend, seasonality, and the remainder component

For the decomposition of the time series data, we use the LTS method.

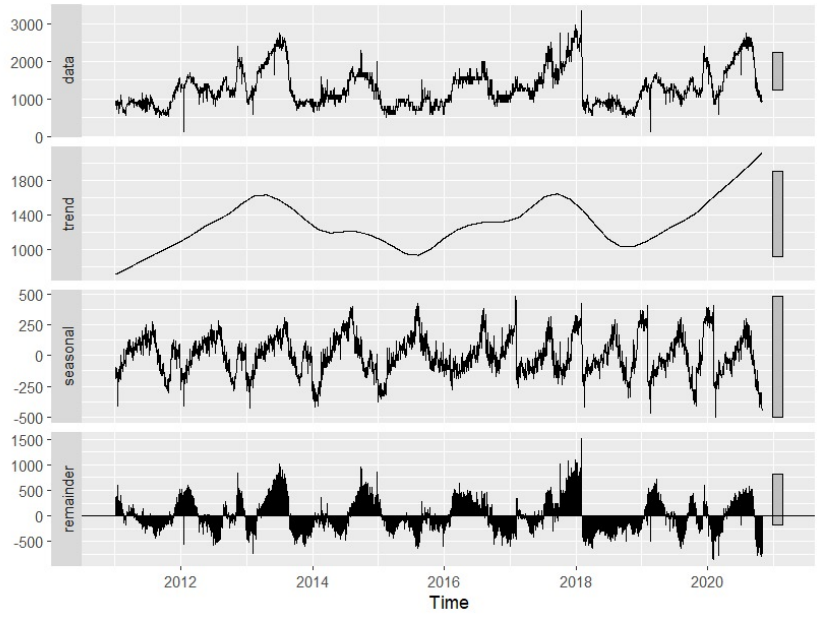

Figure 5.7: Decomposition of potato price data into a trend, seasonal, and remainder component.

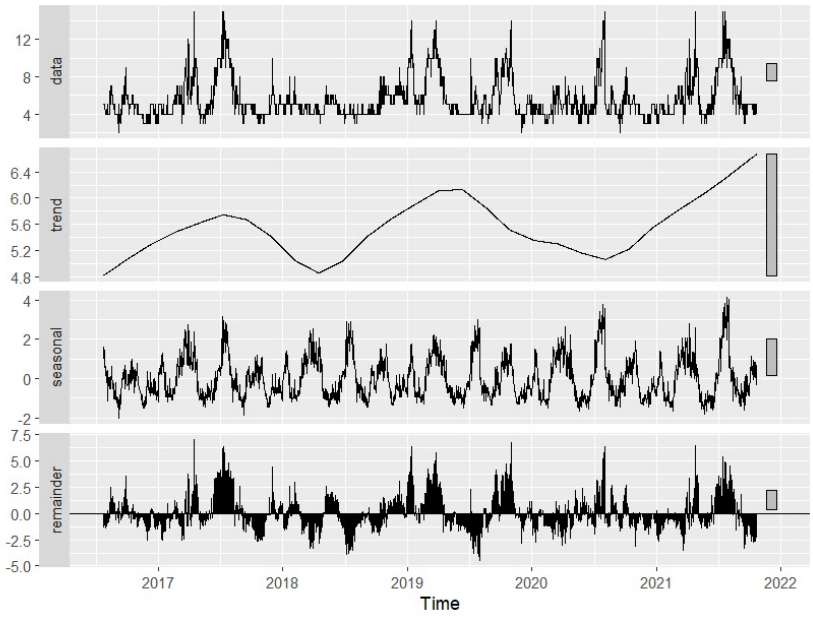

Figure 5.8: Decomposition of spinach price data into a trend, seasonal, and remainder component.

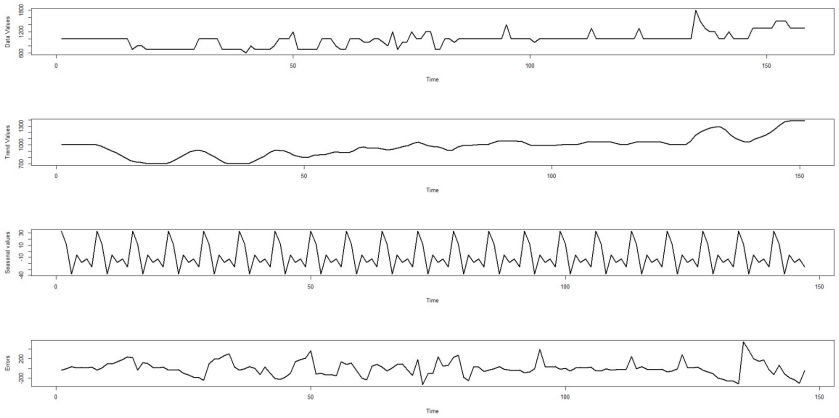

Figure 5.9: Decomposition of banana price data into a trend, seasonal, and remainder component.

5.0.5 ACF Plots for all three crops

ACF Plots

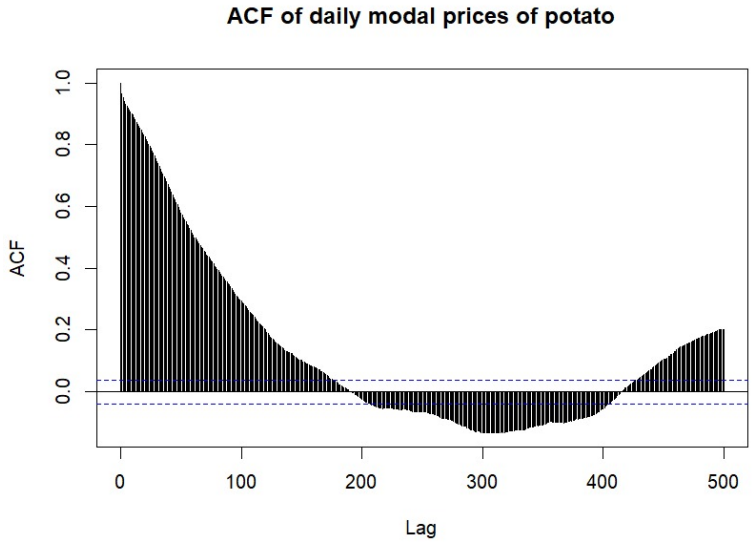

Figure 5.10: ACF of daily prices of potato

From the ACF plot of potato prices, we can see that there's a positive dependence on the price of potatoes until around the last 180 days. But the dependency becomes negative when we look after the last 180 days.

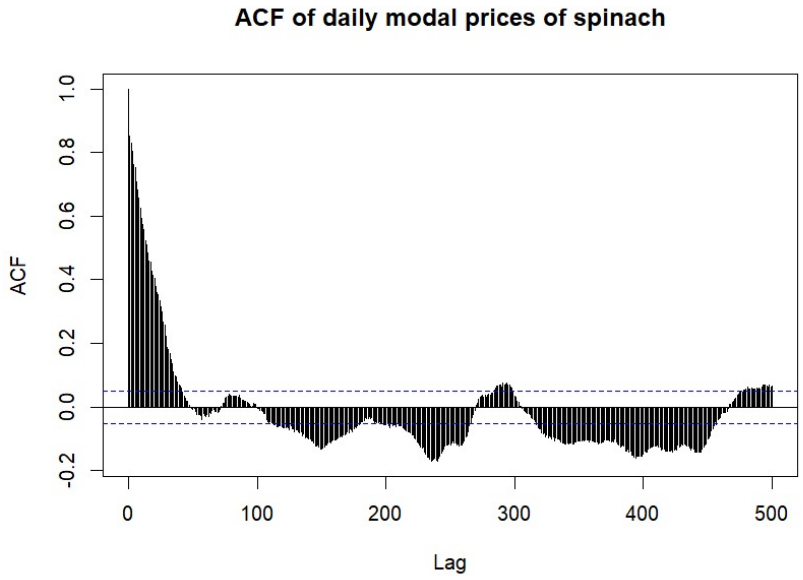

Figure 5.11: ACF of daily prices of spinach

From the ACF plot of spinach prices, we can see that there's a significant positive dependence on the price of bananas until around the last 50 days. But the dependency becomes negative when we look after the last 100 days. Interestingly, we also know that spinach is very seasonal, which is also reflected in the ACF plot above. The dependency changes it's in very short intervals throughout the year.

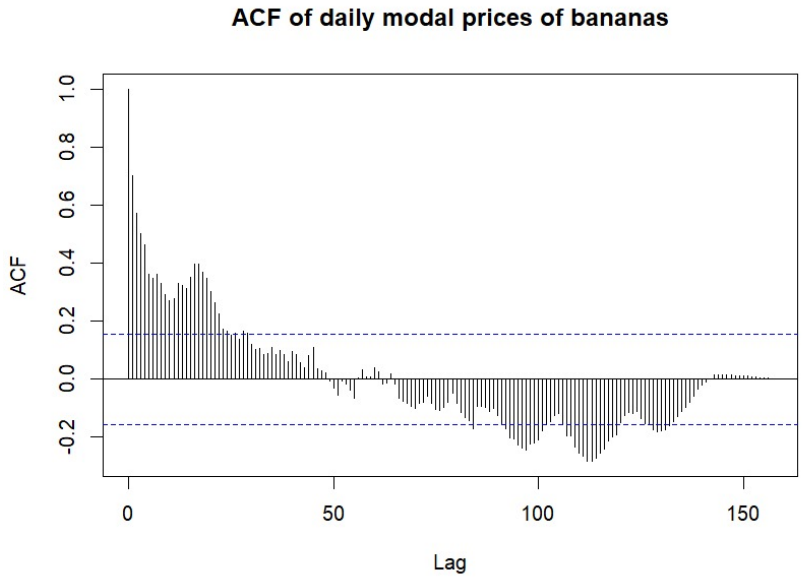

Figure 5.12: ACF of daily prices of banana

From the ACF plot of banana prices, we can see that there's a significant positive dependence on the price of bananas until around the last 25 days. But the dependency becomes negative when we look after the last 60 days.

5.0.6 Forecasting in detail

1. **ARIMA (Autoregressive Integrated Moving Average)** - ARIMA models are typically used for stationary time series data, which means the statistical properties of the data such as mean, variance, and autocorrelation remain constant over time.

2. **ETS (Error-Trend-Seasonality)** - ETS models are based on decomposing a time series into its underlying components, such as trend, seasonality, and error. ETS models can be useful for making short-term forecasts.

3. **LSTM (Long Short-Term Memory)** - LSTM is a type of recurrent

neural network (RNN) that is commonly used for time series analysis and forecasting. This allows LSTM models to handle long-term dependencies in the data, making them useful for making long-term forecasts.

4. **SVM (Support Vector Machine)** - SVM is a machine learning algorithm that is often used for classification and regression tasks. SVM can also be used for time series forecasting by treating it as a regression problem. In this approach, the SVM algorithm tries to find a hyperplane that maximizes the margin between the predicted values and the actual values. SVM can be useful for making both short-term and long-term forecasts.The Startup (2020)

5. **Additive Hybrid Models:**

   - The time series:

     $$y = [y_1, y_2, ..., y_n]^T$$

     is considered as an addition of a linear (L) and a nonlinear(N) component as in Equation (1).

     $$y = L + N \tag{1}$$

   - First, a linear model is applied to the time series to obtain the forecasts on linear components (L).
   - Then, the residual series(e) is computed by subtracting the forecasts on linear component (L) from the original time series y as in Equation (2).

     $$e = y - \hat{L} \tag{2}$$

   - A nonlinear model uses the residual series to obtain the forecasts on nonlinear component N.

- Then, the final forecasts are obtained by adding the forecasts on a linear component with the forecasts on the nonlinear component as in Equation (3).

$$\hat{y} = \hat{L} + \hat{N} \tag{3}$$

- A total of four different combinations, namely, Additive-ARIMA-SVM, Additive-ARIMA-LSTM, Additive-ETS-SVM, and Additive-ETS-LSTM are obtained and used for forecasting.

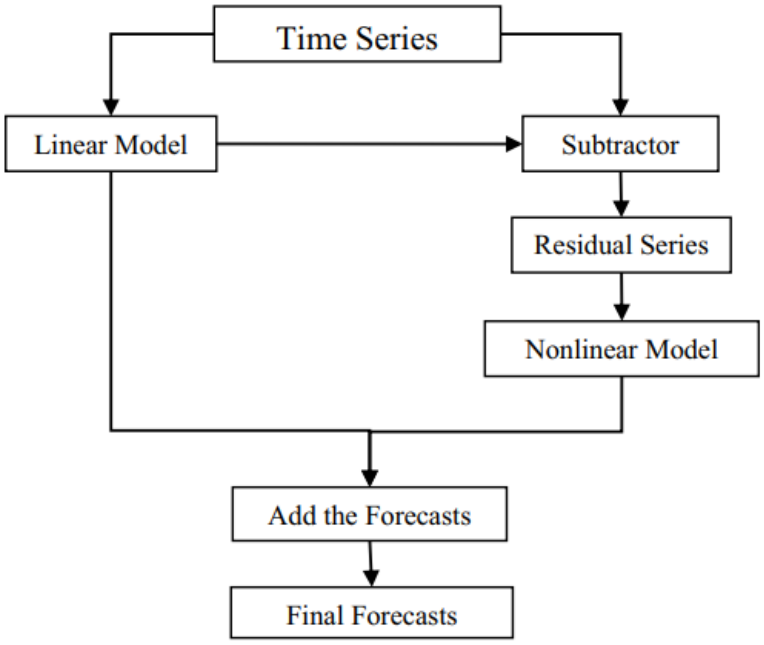

Figure 5.13: Schematic representation of additive hybrid method

6. **Multiplicative Hybrid Models:**

- The time series:

$$y = [y_1, y_2, ..., y_n]^T$$

is considered as a multiplication of a linear (L) and a non-linear (N)

component as in Equation (4).

$$y = L \times N \tag{4}$$

- First, a linear model is applied on the time series to obtain the forecasts on linear component (L).
- Then the residual series (e) is computed by dividing the forecasts on linear component (L) from the original time series y as in Equation (5)

$$e = y \div \hat{L} \tag{5}$$

- The residual series is used by a nonlinear model to obtain the forecasts on nonlinear component N.
- Then, the final forecasts are computed by multiplying the linear component forecasts with nonlinear component forecasts as in Equation (6)

$$\hat{y} = \hat{L} \times \hat{N} \tag{6}$$

- A total of four different combinations namely, Multiplicative-ARIMA-SVM, Multiplicative-ARIMA-LSTM, Multiplicative-ETS-SVM, and Multiplicative-ETS-LSTM are obtained and used for forecasting.

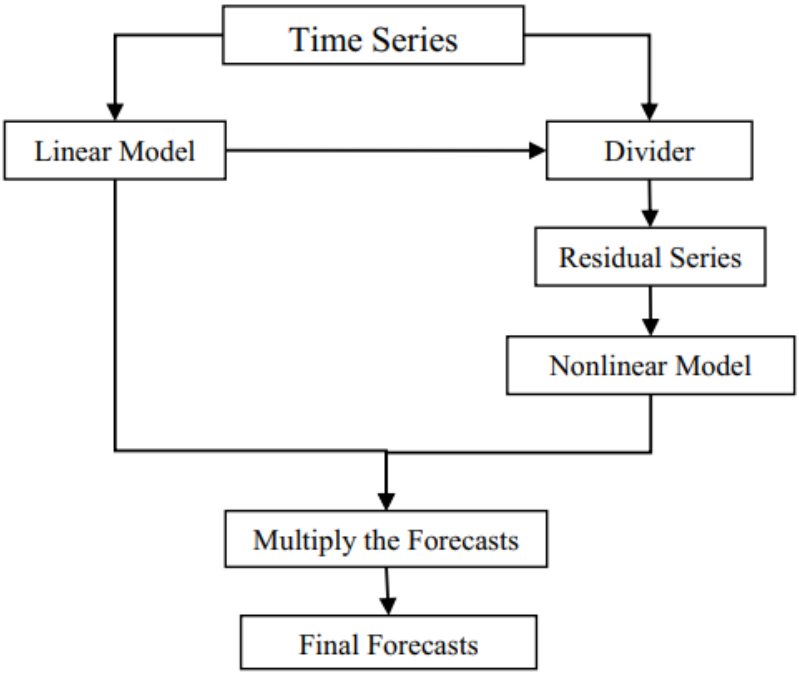

Figure 5.14: Schematic representation of multiplicative hybrid method

5.0.7 Results

We use RMSE (Root Mean Square Error) for the purpose of comparison of different models.

Table 5.4: Mean RMSE, MAE, and other error measures for different methods by considering monthly potato wholesale price time series data.

Models	**ME**	**RMSE**	**MAE**	**MPE**	**MAPE**
additive-arima-svm	-3.597655	160.06147	111.77186	29.677753	157.72741
additive-arima-LSTM	4.841429	158.51416	110.40244	-275.333962	437.75647
additive-ETS-SVM	3.099478	153.71833	110.84233	19.449771	173.30553

Continued on next page

Table 5.4 Continues

Models	ME	RMSE	MAE	MPE	MAPE
additive-ETS-LSTM	3.129231	149.92315	106.94896	21.498918	162.4202
multiplicative-ETS-SVM	7.536162	206.68799	126.45176	16.404822	164.36847
multiplicative-ETS-LSTM	-239.649601	442.69333	305.91347	112.839006	161.95554
multiplicative-ARIMA-LSTM	-243.685945	441.38057	305.16839	114.727442	155.4074
multiplicative-ARIMA-SVM	-1.803844	164.05367	114.36722	18.807944	145.23027
ARIMA	-5.444247	158.458	110.63089	34.993484	147.70135
ETS	2.618045	149.85507	107.09062	22.741815	163.10125
SVM	2.681208	156.7514	113.4488	21.54436	168.9744

From the above table, we observe that the minimum error (RMSE) is for the ETS model for the potato prices. The additive ETS LSTM model is also highlighted since it also has an RMSE closer to ETS one, and the MAE (Mean Absolute Error) lower than the ETS.

Table 5.5: Mean RMSE, MAE and other error measures for different methods by considering monthly spinach wholesale price time series data.

Models	ME	RMSE	MAE	MPE	MAPE
additive-arima-svm	-0.007003269	0.2055419	0.1557875	-2.712849	16.17959
additive-arima-LSTM	0.508757572	0.52882	0.5091569	34.607601	34.64556
additive-ETS-SVM	-0.002939364	0.2049198	0.1534565	-2.069983	15.85964

Continued on next page

Table 5.5 Continues

Models	**ME**	**RMSE**	**MAE**	**MPE**	**MAPE**
additive-ETS-LSTM	-0.504595996	0.5266201	0.5056692	-56.194016	56.28236
multiplicative-ETS-SVM	-0.006131052	0.20617	0.1542131	-2.396852	15.93838
multiplicative-ETS-LSTM	0.257613341	0.2881159	0.2596611	26.56386	26.83265
multiplicative-ARIMA-LSTM	0.254765462	0.2889435	0.2578662	25.874192	26.26538
multiplicative-ARIMA-SVM	-0.009276335	0.2064728	0.1561608	-2.982419	16.20012
ARIMA	-0.008451525	0.2053519	0.1552723	-3.169802	16.10508
ETS	-0.005174755	0.2014087	0.1521999	-2.596708	15.7763
SVM	0.00576156	0.2101209	0.1593828	-2.272723	16.41694
LSTM	0.2631166	0.3186313	0.2642644	23.66169	23.89638

From the above table, we observe that the minimum error (RMSE) is for the ETS model for the spinach prices.

Table 5.6: Mean RMSE, MAE and other error measures for different methods by considering monthly banana wholesale price time series data.

Models	**ME**	**RMSE**	**MAE**	**MPE**	**MAPE**
additive-arima-svm	19.518324	192.2893	130.0519	216.05007	325.45785
additive-arima-LSTM	-11.862716	168.2785	109.89956	-1237.39385	3317.1712
additive-ETS-SVM	2.749681	218.5617	154.03328	402.83891	538.14465

Continued on next page

Table 5.6 Continues

Models	**ME**	**RMSE**	**MAE**	**MPE**	**MAPE**
additive-ETS-LSTM	-3.245315	196.9014	136.64043	352.71477	449.04052
multiplicative-ETS -SVM	23.936024	239.03	161.00958	489.61753	617.01015
multiplicative-ETS -LSTM	-17.07907	161.8675	114.10793	231.23492	254.55153
multiplicative-ARIMA- LSTM	-3.497777	152.0597	106.77522	146.35164	155.11653
multiplicative-ARIMA -SVM	6.09329	190.8033	126.54003	187.44903	280.17709
ARIMA	11.400195	169.9867	112.49731	161.91365	204.60412
ETS	-3.944912	198.8039	139.08359	358.4874	457.63603
SVM	7.424217	183.5404	130.80513	272.65453	362.68361
LSTM	-0.2348989	138.5148	97.12898	92.67164	92.67164

From the above table, We observe that the minimum error (RMSE) is for Multiplicative ARIMA LSTM for the banana prices.

5.0.8 Forecast Plot for the optimal model

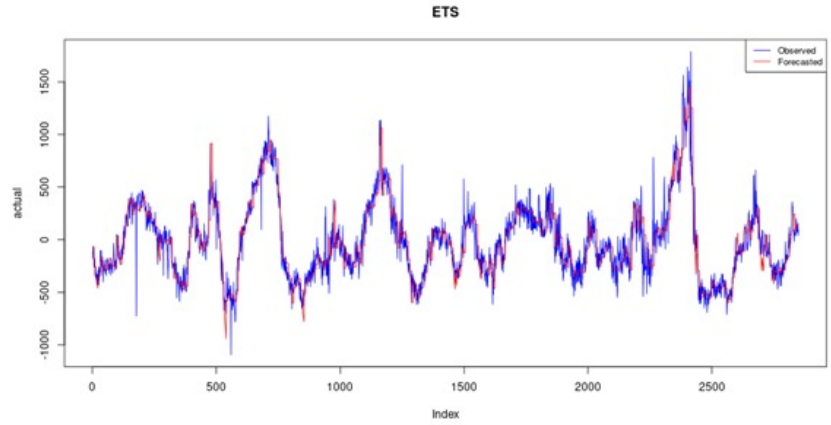

Figure 5.15: Forecasting on Potato prices using the ETS model

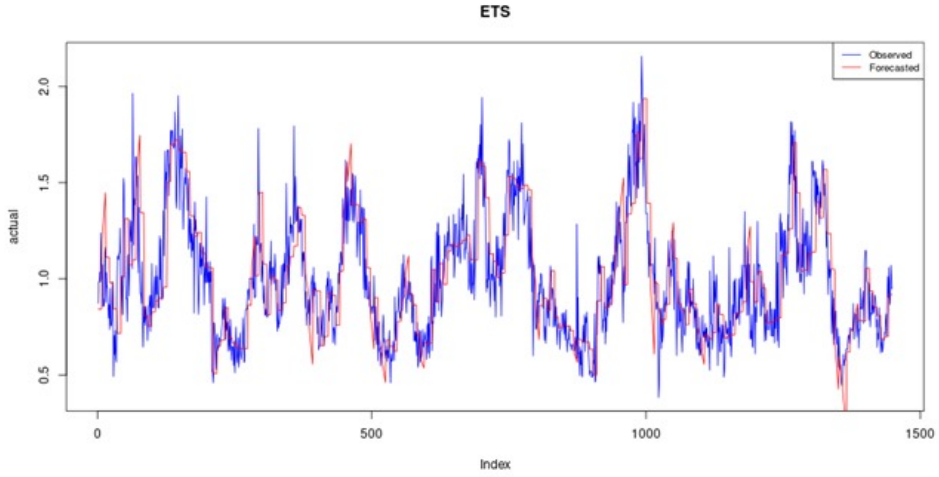

Figure 5.16: Forecasting on Spinach prices using the ETS model

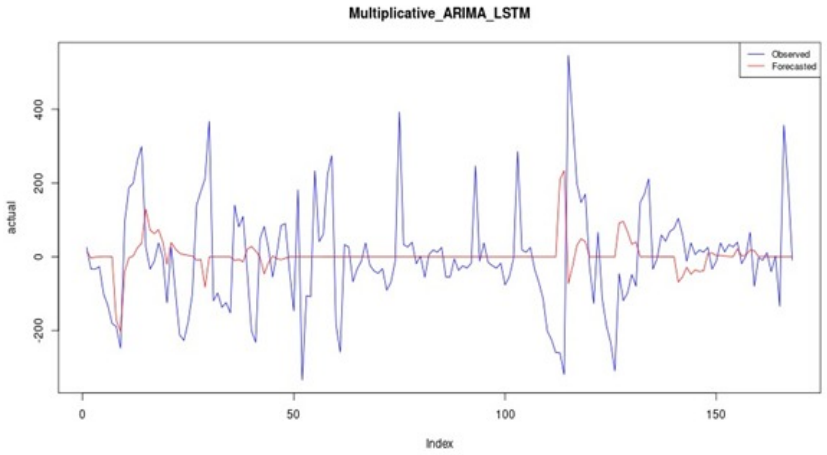

Figure 5.17: Forecasting on Banana prices using the ETS model

5.0.9 Contagion Effect

Financial contagion is the spread of financial market disturbances, crises, or shocks from one market to another or from one institution to another, resulting in the amplification of financial stress and instability. The contagion effect can occur in different ways, such as through direct financial linkages, indirect economic linkages, investor behavior, or psychological factors.

Here, in order to check whether there exists if the nearby markets have a contagion effect on the Pune market, we have considered the Ahmednagar market and the COVID period has been considered as the crisis period.

Here, we perform the test for financial contagion by means of the local Gaussian correlation developed by Støve, Tjøstheim, and Hufthammer (2013). They test whether the local correlations between two financial time series are different before and during crisis times.

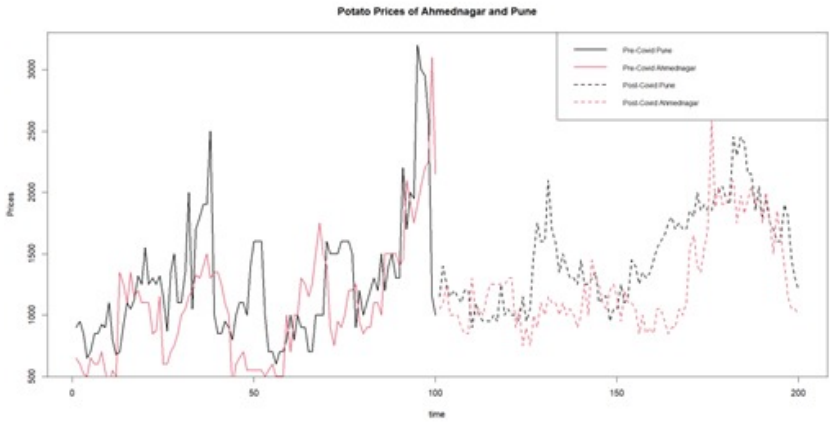

Figure 5.18: Comparison of Potato Prices of Ahmednagar and Pune markets before and during COVID-19.

5.0.10 Ranking of markets for all months based on the Spatio-FLAP Index

The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets across different months.

Table 5.7: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of January

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	926.0240964	450	2000	1.799125406
Aurangabad	932.300885	450	1868.75	2.560295727
Bhivandi	1518.846154	1061.5	1953.75	5.015043655
Jalgaon	951.9962121	450	1700	2.754457536
Junnar	965.8730159	373.5	2000	2.267769657
Junnar(Otur)	1049.489796	105	2000	2.042275683

Continued on next page

Table 5.7 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Kalyan	843.4782609	527.5	1100	4.761844265
Karad	1195.454545	505	1800	3.718619883
Khed(Chakan)	1042.696629	510	1800	2.814532301
Kolhapur	1000	700	1400	4.188010527
Kolhapur(Malkapur)	755	512.75	997.25	2.093590666
Maanachar	986.2962963	500	2052.5	2.167433878
Mumbai	1093.894737	700	1466.25	4.479085232
Nagpur	1050.148148	375	1925	1.354050151
Nasik	972.4201681	500	1900	2.55480426
Osmanabad	1098.894737	142	1782.5	2.846132374
Palghar	956.5666667	500	1800	2.700504614
Pandharpur	827.7777778	360	1450	1.985475738
Parbhani	975	527.5	1500	2.92466767
Pen	1570.588235	770	3320	1.409531648
Pune	1134.234694	600	2200	2.726822984
Pune(Khadiki)	1003.449198	450	1635	2.734868393
Pune(Pimpri)	1379.204545	550	4000	1.282041917
Satara	1213.590604	550	2180	2.653266154
Shrirampur	1052.140288	546.25	1853.75	2.994368424
Solapur	1044.022388	500	2200	2.448618931
Ulhasnagar	1070.689655	655	1250	5.759672475
Vasai	1402.745098	1000	1875	5.578923887
Vashi New Mumbai	1138	600	2070	2.555287937
Koregaon	1070	901.875	1272.125	5.718029303
Chandrapur(Ganjwad)	1177.575758	600	2200	2.288130117
Junnar(Alephata)	550	402.5	782.5	2.523573073

Continued on next page

Table 5.7 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Sangli(Phale, Bhajipura Market)	1161.581921	650	2000	2.345458178
Navapur	1200	622.5	1777.5	2.19089023
Pune(Hadapsar)	916.6666667	562.5	1000	4.490731195
Rahuri	1322.975207	625	2200	2.72970523
Mangal Wedha	1366.666667	1305	1400	23.67136104
Rahata	1196.638655	645	2000	2.981455503
Kamthi	1397.391304	800	2800	2.710980764
Vai	1720	1350	2291.25	5.208082437
Vadgaonpeth	1560	1120	2140	3.750606887
Amarawati	1035.185185	766.25	1517.5	4.323659743
Islampur	1505.666667	800	2480	2.599594858
Akluj	1351.4	700	2000	3.68880649
Ramtek	1036.923077	550	1900	2.502132617
Amrawati(Frui & Veg. Market)	959.9673203	450	1900	2.183294174
Rahuri(Songaon)	2050	2002.5	2097.5	28.99137803
Palthan	743.8596491	700	860	11.3543469
Vita	1000	680	2150	2.745054065
Murbad	1500	1500	1500	Inf
Morshi	1512.4	1072	1870	5.802534722
Pune(Moshi)	938.0597015	700	1367.5	5.309109014
Bhusaval	1624	1045	2000	5.259807304
Pune(Manjri)	1651.515152	1500	1920	8.979637323
Junnar(Narayangaon)	1181.818182	800	1500	5.304576151

Table 5.8: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of February

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	922.1818182	600	1750	2.855667446
Aurangabad	883.1725888	500	1500	3.552803643
Bhivandi	1335.810811	1050	1827.5	5.927713993
Jalgaon	934.9793388	500	1324.375	3.843943924
Junnar	970.7692308	400	1500	3.34528637
Junnar(Otur)	896.6666667	423.75	1500	2.721573497
Kalyan	786.5	634.5	1216.25	3.707585113
Karad	1141.549296	550	1600	3.730244856
Khed(Chakan)	1070.666667	500	1500	2.737398195
Kolhapur	994.6564885	700	1400	4.251272139
Maanachar	883.52	492.5	1350	4.090913848
Mumbai	1008.529412	655	1200	6.522674159
Nagpur	929.5420168	437	1425	2.846903366
Nasik	932.8414097	543	1635	3.338612906
Osmanabad	927.3295455	550	1373.75	4.359825207
Palghar	910.1351351	517.325	1310.15	4.665911243
Pandharpur	761.9047619	500	1200	3.34193859
Parbhani	810	522.5	1355	2.637256847
Pen	1731.25	750	2600	2.346124697
Pune	1043.549618	600	1700	3.824967114
Pune(Khadiki)	943.6	450	1400	3.334328235
Pune(Pimpri)	943.0188679	565	1535	3.409956128
Sangola	728.3333333	500	1562.5	1.525270569
Satara	1061.896552	600	1500	4.00711649

Continued on next page

Table 5.8 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Shrirampur	976.8647541	600	1296.25	4.239843733
Solapur	902.687747	450	1400	3.890046007
Ulhasnagar	971.0526316	507.5	1485	3.646323388
Vasai	1328.787879	1000	1700	5.906906289
Vashi New Mumbai	1049.492386	600	1605	3.791484121
Koregaon	858.3333333	663.75	1108.75	5.996633141
Chandrapur(Ganjwad)	1080.3125	750	1700	4.028289562
Junnar(Alephata)	687.5	453.75	985	2.650281836
Sangli(Phale, Bhajipura Market)	1111.5625	600	1800	3.706845902
Navapur	1325	1200	1492.5	8.833333333
Pune(Hadapsar)	1135	947.5	1762.5	4.297172581
Rahuri	1096.787037	600	1908.125	3.179332886
Mangal Wedha	1430	1222.5	1887.5	6.460081506
Rahata	1113.596491	641.25	1617.5	3.969916572
Kamthi	1215.384615	800	2200	3.209551158
Vai	1390.384615	1181.25	1668.75	10.30512764
Vadgaonpeth	1925	1515	2462.5	4.425969617
Amarawati	820	703.75	978.625	11.39558777
Chandrapur	1000	905	1095	10
Islampur	1525.862069	525	1930	3.666978416
Akluj	1198.540146	640	1800	3.915996567
Ramtek	888.3333333	550	1352.5	4.210034988
Amrawati(Frui & Veg. Market)	921.9594595	633.75	1400	4.422054402
Palthan	790	685	1000	9.051418968
Vita	1008.064516	675	2350	2.241899959

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Table 5.8 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Murbad	2750	1562.5	3937.5	1.555634919
Morshi	1332.03125	1177.5	1461.25	15.89180887
Pune(Moshi)	777.1186441	572.5	1055	5.638808645
Bhusaval	1601.785714	1200	2000	6.086021058
Pune(Manjri)	1529.411765	1500	1717.5	20.12488244
Junnar(Narayangaon)	927.2727273	800	1200	5.730698831

Table 5.9: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of March

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	789.5061728	500	1100	3.688526048
Aurangabad	873.7149533	500	1500	3.229351509
Bhivandi	1153.75	823.25	1725	3.506170748
Jalgan	901.0121457	500	1500	3.460866535
Junnar	1005.769231	500	1500	3.116036397
Junnar(Otur)	938.4615385	492.5	1500	3.341508826
Kalyan	841.6666667	706.25	1043.75	5.751275728
Karad	1257.006369	600	1750	3.211965424
Khed(Chakan)	1092.716049	550	1500	3.765244458
Kolhapur	1020.921986	700	1500	4.034247439
Maanachar	899.0384615	650	1488.125	4.270702775
Mumbai	1074.411765	800	1272.5	7.181825865
Nagpur	890.8391304	437	1477.5	3.302734592
Nasik	954.75	500	1500	3.425102004
Osmanabad	979.1666667	623.75	1426.25	4.322156695

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Table 5.9 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Palghar	987.5774648	697.5	1400.25	5.259658265
Pandharpur	720.8333333	427.5	1131.25	3.373286416
Parbhani	615	500	855	5.112196098
Pen	2050	1800	2372.5	10.86677399
Pune	1072.057762	659	1700	3.670131553
Pune(Khadiki)	954.3715847	461	1445	3.334290308
Pune(Pimpri)	1042.857143	533.75	1811.25	2.848643667
Sangola	743.3333333	538.5	985	3.123543412
Satara	1131.25	650	1650	3.874481798
Shrirampur	976.4652015	600	1400	3.92022315
Solapur	888.3908046	480	1325	3.466929743
Ulhasnagar	1019.047619	850	1150	10.97652418
Vasai	1245.384615	1089	1525	9.766519051
Vashi New Mumbai	1097.29798	746.25	1700	4.060395648
Koregaon	831.6666667	635.5	1058.75	6.101556078
Aatpadi	1025	1025	1025	Inf
Chandrapur(Ganjwad)	1064.567901	700	1400	4.081086111
Sangli(Phale, Bhajipura Market)	1174.666667	800	1700	4.257256085
Pune(Hadapsar)	985.1851852	800	1000	18.45743853
Rahuri	990.2857143	600	1500	4.202122791
Barshi	1150	1012.5	1200	13.74512901
Chalisgaon	865	827.25	898.5	22.91440978
Mangal Wedha	1200	1000	1300	10.81665383
Rahata	1076.448	600	1690	3.353530153
Kamthi	1228.04878	800	2385	2.902463864
Vai	1350	1200	1650	8.475598293

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Table 5.9 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Amarawati	915.1315789	650	1050	8.257595604
Islampur	1095.212766	775	1685	3.531866829
Akluj	1165.384615	755	1500	5.08065392
Ramtek	1374.813559	700	2500	0.848390183
Amrawati(Frui & Veg. Market)	978.7878788	650	1800	3.377659948
Dhule	975	856.25	1093.75	5.515432893
Sinner	908.8888889	484	1180	3.908120232
Palthan	842.7083333	700	1100	6.399724678
Vita	1093.333333	700	2050	3.175093717
Murbad	2500	2025	2975	3.535533906
Morshi	1242.886364	635.25	1890.025	3.656481555
Pune(Moshi)	858.8888889	600	1190	4.873795842
Bhusaval	1414.285714	1000	1575	7.852663416
Pune(Manjri)	1362.5	1000	1566.25	8.413242934

Table 5.10: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of April

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	851.75	498.75	1552.5	3.056404008
Aurangabad	955.8908046	500	1500	3.106205283
Bhivandi	1221.388889	893.75	1556.25	5.475640245
Jalgaon	959.4324324	476.25	1511.875	3.245132346
Junnar	1085.121951	400	1800	2.468734025
Junnar(Otur)	1067.5	647.5	2287.5	2.132448201

Continued on next page

Table 5.10 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Kalyan	1120.588235	725	1410	4.945276795
Karad	1359.202454	650	2200	3.534169776
Khed(Chakan)	1266.768293	650	1600	3.999073369
Kolhapur	1192.281879	700	1800	3.979710779
Maanachar	1057	500	1725.625	3.634597205
Mumbai	1255.479452	870	1620	5.763435598
Nagpur	1010.004237	458.875	1636.875	2.671397672
Nasik	1070.428571	550	1700	3.630938391
Osmanabad	757.6086957	108.25	1467.5	1.55356318
Palghar	998.255814	578.125	1500	3.390053843
Parbhani	863.6363636	600	1175	4.003061683
Pen	1970.37037	1800	2200	12.04030531
Pune	1225.433884	800	1700	4.300624432
Pune(Khadiki)	1008.163265	300	1457.5	3.012537513
Pune(Pimpri)	1095	700	1732.5	2.835428286
Sangola	691.4705882	468	860	5.840236799
Satara	1351.953125	650	2300	1.980597164
Shrirampur	1095.917969	600	1600	3.817219929
Solapur	1047.560976	462.5	1693.75	3.260300082
Ulhasnagar	972.2222222	742.5	1100	9.552050849
Vasai	1154.166667	927.5	1445	7.204698993
Vashi New Mumbai	1201.17801	625	1712.5	3.95885214
Koregaon	881.25	758.75	1073.75	7.785422588
Chandrapur(Ganjwad)	1252.651515	700	1972.5	3.864141409
Sangli(Phale, Bhajipura Market)	1306.769231	800	2000	4.099692962
Pune(Hadapsar)	1545	1000	3000	2.422309227

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Table 5.10 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Rahuri	1098.211009	800	1660.5	4.489693313
Chalisgaon	812.5	387.5	1046.25	2.540406658
Mangal Wedha	1400	1300	1575	12.78019301
Rahata	1249.019608	652.5	1900	3.462192948
Kamthi	1335.443038	800	2210	3.053866048
Vai	1523.333333	1250	1650	10.92654271
Amarawati	1149.264706	806.25	1517.5	4.947582538
Islampur	1628.947368	822.5	2555	3.619099262
Akluj	1301.369863	762.5	2200	3.87196506
Ramtek	1357.758621	900	1900	4.303432557
Amrawati(Fruit & Veg. Market)	1104.166667	600	1650	2.898900977
Sinner	999.6153846	411.5	1270	3.731781083
Palthan	1040	761.25	1477.5	4.805516075
Vita	1237.878788	900	2150	3.243792696
Murbad	1787.5	1213.75	2417.5	4.323060272
Morshi	1388	976.5	2000	4.038732134
Pune(Moshi)	1035.520833	708.75	1304.125	5.744107583
Bhusaval	1539.473684	1170	2000	6.507364851
Pune(Manjri)	1372.413793	1000	1660	7.197885141

Table 5.11: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of May

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	1207.758621	671.25	2100	2.724757047
Aurangabad	1058.006135	526.25	1600	3.061348425
Bhivandi	1205.853659	850	1600	5.510555903
Jalgaon	1012.28	500	1625	2.92916913
Junnar	1493.478261	777.5	2000	3.012667962
Junnar(Otur)	983.3333333	370	1500	2.286203562
Kalyan	1240.909091	1162.5	1350	17.71085098
Karad	1502.554745	770	2200	3.810928253
Khed(Chakan)	1425	742.5	1850	4.348601507
Kolhapur	1292.682927	800	1800	2.675698621
Maanachar	1274.027778	731.25	2059.375	2.705036971
Mumbai	1366.791045	982.5	1658.75	5.786924615
Nagpur	1157.600985	437	1750	2.390469904
Nasik	1130.964286	650	1800	3.692995132
Osmanabad	651.4285714	101.5	1000	1.65991672
Palghar	945.973913	500	1551.65	3.700122129
Parbhani	1015	700	1377.5	4.348890731
Pen	2000	1800	2200	14.49137675
Pune	1332.581967	800	1850	4.094485613
Pune(Khadiki)	1252.016129	652.5	1600	4.999630951
Pune(Pimpri)	1150	853.75	1658.75	2.952927398
Sangola	784.7222222	692.5	850	16.39962244
Satara	1468.548387	750	2250	3.547060112
Shrirampur	1169.880952	681.875	1800	3.491344091

Continued on next page

Table 5.11 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Solapur	1171.201493	550	1766.25	3.321290357
Ulhasnagar	1012.068966	625	1310	5.181403517
Vasai	1253.416667	957.5	1490	6.372213005
Vashi New Mumbai	1277.866972	760.625	1750	4.494529282
Koregaon	650	650	650	Inf
Aatpadi	1050	1050	1050	Inf
Chandrapur(Ganjwad)	1378.83871	800	1900	4.780414069
Ratnagiri (Nachane)	2566.666667	2505	2600	44.45597073
Sangli(Phale, Bhajipura Market)	1311.655405	800	2000	3.225880711
Pune(Hadapsar)	1319.047619	1000	1500	5.98214934
Rahuri	1308.70339	694.725	1753.75	3.834917662
Mangal Wedha	1556.25	1500	1700	19.11993551
Rahata	1421.717172	822.5	1927.5	3.872233653
Kamthi	1328.099174	700	2200	3.052264041
Vai	1730	1497.5	2000	11.2164051
Vadgaonpeth	1700	1605	1795	12.02081528
Amarawati	1298.958333	804.375	1500	7.263376987
Islampur	2164.583333	1500	2500	6.103927471
Akluj	1383.72093	900	1800	4.442893438
Ramtek	1422.330097	900	1900	5.231834065
Amrawati(Frui & Veg. Market)	1219.491525	600	1503.75	1.974280246
Palthan	1181.372549	800	1500	3.684670027
Vita	1223.542857	12	2050	2.381013522
Murbad	1666.666667	1500	1960	10.54092553
Morshi	1600.714286	1276.5	1957.5	5.800783477

Continued on next page

Table 5.11 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Pune(Moshi)	1216.949153	800	1705	4.326854768
Bhusaval	1691.428571	1000	2000	5.423103387
Pune(Manjri)	1711.764706	1500	2000	10.89040129

Table 5.12: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of June

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	1290.229358	570	1900	3.548413067
Aurangabad	1221.568627	600	1750	3.19600209
Bhivandi	1290.714286	992.5	1650	4.946340712
Jalgaon	1067.430657	500	1700	2.841011622
Junnar	1373.076923	930	1900	3.37765829
Junnar(Otur)	674	138	1180	1.474726442
Kalyan	1148	680	1700	3.910245277
Karad	1546.013793	712	2300	3.346352163
Khed(Chakan)	1328.392857	700	1796.25	3.431369342
Kolhapur	1249.127907	700	1800	3.764524665
Maanachar	1243.75	963.75	1916.125	3.617970889
Mumbai	1414.5	1000	1825	4.7216361
Nagpur	1218.016807	622.15	1725	3.589576593
Nasik	1182.409091	600	1850	2.508795915
Osmanabad	765	541.75	988.25	2.301858245
Palghar	1052.852174	600	1706.6	3.295059127
Parbhani	1025	627.5	1345	3.999459306
Pen	2288.888889	2040	2760	9.259011444

Continued on next page

Table 5.12 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Pune	1359.107807	800	1965	3.674775266
Pune(Khadiki)	1395.918367	1100	1960	6.797601195
Pune(Pimpri)	1080	750	1445	3.191692273
Sangola	720.5882353	650	800	15.34249513
Satara	1493.181818	781.875	2050	3.60925303
Shrirampur	1200.37037	650	1763.75	3.776651634
Solapur	1179.105263	550	1800	3.250678679
Ulhasnagar	1214.705882	765	1600	4.789489334
Vasai	1286.530612	910	1690	5.055342958
Vashi New Mumbai	1338.065844	702.5	1900	4.234474166
Aatpadi	1212.5	1050	1608.75	4.14363464
Chandrapur(Ganjwad)	1330.582524	700	2100	2.812369316
Sangli(Phale, Bhajipura Market)	1412.650602	900	2100	4.097189736
Pune(Hadapsar)	1454.545455	1050	2000	4.332242889
Rahuri	1262.40146	11	1903	2.718047686
Chalisgaon	1100	1100	1100	Inf
Mangal Wedha	1411.111111	1342.5	1500	29.93418707
Rahata	1397.222222	800	2138.75	3.449508403
Kamthi	1541.791045	800	2200	3.867130988
Vai	1811.290323	1587.5	2025	11.54407706
Vadgaonpeth	1601.777778	312.8	1980	2.620488742
Amarawati	1465.625	1028.75	1585.625	9.057174693
Chandrapur	925	700	1532.5	2.055555556
Islampur	2394.117647	2000	2560	12.91982115
Akluj	1480.606061	1000	2100	4.015402467
Ramtek	1566.483516	1100	1900	5.385230494

Continued on next page

Table 5.12 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Amrawati(Frui & Veg. Market)	1182.991803	650	1650	3.345416369
Rahuri(Songaon)	1350	1250	1492.5	11.02270384
Palthan	1144.897959	800	1500	3.916793081
Vita	1350	778.75	2235	2.64425353
Murbad	1553.846154	1255	1770	9.87178225
Morshi	1495.8	1100	1982.5	4.01099262
Pune(Moshi)	1309.722222	788.75	1700	4.815003781
Bhusaval	1967.647059	1747.5	2000	19.54624764
Pune(Manjri)	1637.755102	1500	1800	11.03311041
Junnar(Narayangaon)	1675	1508.75	1841.25	6.768022048

Table 5.13: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of July

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	1257.302632	550	2100	2.843996565
Aurangabad	1262.729469	478.75	2100	2.525791656
Bhivandi	1438.392857	1050	2297.5	3.87158044
Jalgaon	1100.415162	425	1800	2.578978429
Junnar	1135.714286	1000	1807.5	3.162965853
Junnar(Otur)	883.3333333	802.5	992.5	8.486792152
Kalyan	1255.714286	592.5	2015	2.950096081
Karad	1540.495868	700	2200	3.66009026
Khed(Chakan)	1358.139535	600	1943.75	3.148184609
Kolhapur	1144.594595	800	1800	3.362748741

Continued on next page

Table 5.13 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Maanachar	1827.777778	800	2600	2.481751369
Mumbai	1347.807018	770	1950	2.999049871
Nagpur	1263.114504	687	2111.875	2.995800144
Nasik	1216.842742	600	2220.625	2.625741242
Osmanabad	1733.333333	685	2300	1.766012588
Palghar	1098.527778	600	2000	2.669020576
Parbhani	1053.846154	700	1540	3.628370016
Pen	2707.692308	2530	2940	19.59085897
Pune	1400.357143	700	2250	2.945863857
Pune(Khadiki)	1347.321429	1118.75	1500	12.51841567
Pune(Pimpri)	1175	866.25	1483.75	2.556462978
Sangola	725	650	786.25	16.03035315
Satara	1442.857143	700	2325	2.947513479
Shrirampur	1194.498069	611.25	2000	2.908946793
Solapur	1237.216117	550	2100	2.615786439
Ulhasnagar	1622.580645	1225	1800	8.065345163
Vasai	1199.565217	955	1800	4.513322136
Vashi New Mumbai	1341.061224	750	2000	3.446261303
Aatpadi	1283.333333	1050	1715	3.175426481
Chandrapur(Ganjwad)	1320.535714	700	2142.5	3.167230623
Sangli(Phale, Bhajipura Market)	1377.819549	800	2200	3.390337369
Pune(Hadapsar)	1400	1215	1500	9.899494937
Rahuri	1395.496774	800	2311.75	3.179720932
Chalisgaon	1242.857143	822.5	1500	4.134661572
Mangal Wedha	1409.090909	1250	1500	16.95229727
Rahata	1360.869565	700	2200	2.957373244

Continued on next page

Table 5.13 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Kamthi	1743.697479	895	2800	3.246859337
Vai	1981.818182	1453.75	2500	5.879569763
Vadgaonpeth	1750	1355	2145	6.79317748
Amarawati	1465	725	1650	4.270816376
Chandrapur	1350	1100	1600	4.67653718
Islampur	2541.176471	2000	2920	7.045963079
Akluj	1531.034483	900	2400	3.353828495
Ramtek	1551.359551	900	2100	3.604051993
Amrawati(Frui & Veg. Market)	1387.5	450	1900	0.891344496
Palthan	1225.423729	800	2000	2.84880481
Vita	1182.833333	18.3	2150	1.572786963
Murbad	1385.294118	1070	2160	4.026541943
Morshi	1357.619048	900	2289.15	3.226507727
Pune(Moshi)	1402.054795	800	2210	3.190726633
Bhusaval	1940.47619	1500	2000	10.14103651
Pune(Manjri)	1682.352941	1500	1875	3.962237491
Junnar(Narayangaon)	1779.166667	1137.5	2100	5.76605993

Table 5.14: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of August

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	1235.714286	550	2393.75	2.16616951
Aurangabad	1301.535088	450	2216.25	2.283438814
Bhivandi	1902.586207	1035	3240	2.981528163

Continued on next page

Table 5.14 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Jalgaon	1122.44898	450	2095	2.430005384
Junnar(Otur)	1475	1451.25	1498.75	41.71930009
Kalyan	1136.363636	664.375	2123.75	2.286177096
Karad	1660	700	2300	3.637184084
Khed(Chakan)	1506.25	600	2365	2.17462983
Kolhapur	1179.856115	800	1800	3.211282524
Mumbai	1429	811.25	2150	2.689386644
Nagpur	1332.596244	575	2450	2.675194576
Nasik	1268.090517	569.375	2300	2.283187086
Osmanabad	1050	1002.5	1097.5	14.8492424
Palghar	1128.333333	575	1800	2.688498325
Parbhani	993.75	658.75	1300	3.538204057
Pen	3000	2800	3400	11.12429773
Pune	1467.811321	700	2600	2.667096368
Pune(Khadiki)	1308.62069	1000	1578.75	6.768479401
Pune(Pimpri)	2930	512.5	4000	1.912632965
Sangola	655	501.25	782.5	8.273356819
Satara	1576.206897	700	2650	2.49827252
Shrirampur	1199.665428	642.5	1950	2.834534358
Solapur	1286.666667	550	2200	2.521180385
Ulhasnagar	1890.333333	1072.5	2400	4.451596078
Vasai	1436.666667	1086.25	2555	3.351235829
Vashi New Mumbai	1336.374408	625	2250	3.029106097
Chandrapur(Ganjwad)	1443.274854	600	2500	2.654381086
Sangli(Phale, Bhajipura Market)	1431.818182	700	2500	2.598808027
Pune(Hadapsar)	1400	1300	1670	7

Continued on next page

Table 5.14 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Rahuri	1477.798611	700	2410.625	2.780684846
Barshi	2052.222222	137	2800	2.161360422
Chalisgaon	1476.388889	1085	2000	4.948719161
Mangal Wedha	1366.666667	1300	1490	11.83568052
Rahata	1268.681319	700	2100	2.964057514
Kamthi	1769.166667	997.5	2800	3.397057798
Vai	2239.130435	1350	2650	4.694019525
Vadgaonpeth	1711.538462	1400	2720	3.875234483
Amarawati	1582.5	1450	1650	22.3652205
Islampur	2793.75	2000	3062.5	7.485571673
Akluj	1582.285714	900	2700	2.552656081
Ramtek	1572.941176	900	2190	3.734381667
Amrawati(Frui & Veg. Market)	1171.053571	500	1912.5	1.90710632
Rahuri(Songaon)	2137.5	2103.75	2150	85.5
Palthan	1289.583333	700	1900	3.028379082
Vita	743.275	17.95	2350	0.846679212
Murbad	1728.571429	1265	2233.75	5.386891534
Morshi	1571.268657	900	2900	2.176242485
Pune(Moshi)	1426	750	2122.5	3.240863848
Bhusaval	1907.894737	1292.5	2000	8.933393213
Pune(Manjri)	1682.978723	1500	2000	8.267086191
Junnar(Narayangaon)	1779.166667	1210	2100	6.062770342

Table 5.15: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of September

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	985	500	1697.5	2.607770978
Aurangabad	1320.581395	450	2600	2.033299795
Bhivandi	2263.636364	1500	4875	1.786257112
Jalgaon	1139.718615	400	2306.25	2.10620108
Junnar	1400	450	2875	1.702764894
Junnar(Otur)	1564.285714	897.5	3012.5	2.433402662
Kalyan	1340.833333	720.625	2306.25	1.862261035
Karad	1562.291667	748.75	2201.25	4.092711347
Khed(Chakan)	1388.125	797.5	2000	3.718128767
Kolhapur	1078.571429	750	1700	3.26172221
Maanachar	945.7857143	492.5	1703.9	3.348630557
Mumbai	1455.654545	900	2150	2.837375857
Nagpur	1327.613636	612	2750	2.27935751
Nasik	1194.262295	522	2417.5	2.079132044
Osmanabad	975	833.75	1095	7.004606779
Palghar	1046.654545	600	1765	2.820259163
Pandharpur	1273.333333	944	1495	4.106814697
Parbhani	1145.454545	762.5	1600	3.636321992
Pen	3508.333333	3400	3600	38.96690624
Pune	1491.948819	766.25	2750	2.553209457
Pune(Khadiki)	1379.375	897.5	2305	4.291000141
Pune(Pimpri)	3790	2015.5	4000	4.82342908
Sangola	633.3333333	600	693.75	15.51343504
Satara	1614.230769	611.25	2750	1.595653844

Continued on next page

Table 5.15 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Shrirampur	1172.547893	600	2000	2.750188452
Solapur	1330.583658	550	2460	2.033485202
Ulhasnagar	1664.285714	600	2332.5	3.10755686
Vasai	1237.878788	1040	1640	7.300009703
Vashi New Mumbai	1368.844221	648.75	2600	2.581016978
Koregaon	701.6666667	607.5	754.75	7.966116033
Chandrapur(Ganjwad)	1413.372093	700	3000	2.291131418
Chopada	650	602.5	697.5	9.192388155
Sangli(Phale, Bhajipura Market)	1423.404255	700	2550	2.371452098
Rahuri	1353.657407	650	2517.875	2.773775341
Barshi	804.2857143	100	2585	0.674199282
Chalisgaon	1200	1000	1842.5	4.076197323
Rahata	1393.367347	750	2200	2.762732618
Kamthi	1698.425197	800	2970	2.859869464
Vai	2186.666667	1300	2900	3.667438013
Vadgaonpeth	1710	1400	2477.5	4.291422271
Amarawati	1391.176471	1100	1515	11.02134883
Islampur	2860.714286	2032.5	3467.5	5.431749734
Akluj	1535.25641	900	3100	2.731207614
Ramtek	1606.097561	900	2600	2.707079203
Amrawati(Frui & Veg. Market)	1202.148438	650	3000	1.838865234
Palthan	1188.333333	700	1652.5	3.341500366
Vita	1740.027027	16.7	2770	2.472243969
Murbad	1305	822.5	1600	3.950215126
Morshi	1726.349206	950	3100	1.989978242

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Table 5.15 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Pune(Moshi)	1526.119403	800	2250	2.824592412
Bhusaval	1645.454545	1280	2000	4.890998803
Pune(Manjri)	1634.693878	1500	1980	9.337867469
Junnar(Narayangaon)	1933.333333	1900	2000	37.43883901

Table 5.16: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of October

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Ahmednagar	1200.722222	500	3037.5	1.17827173
Aurangabad	1324.017467	485	2650	2.197373717
Bhivandi	1495.833333	1106.25	1828.75	6.728019718
Jalgaon	1161.482143	400	2500	2.153415078
Junnar	1366.25	696.25	2600	2.602676057
Junnar(Otur)	1213.378378	90	2150	1.865399471
Kalyan	1767.857143	663.75	5006.25	1.266787705
Karad	1402.205882	550	2125	3.037482139
Khed(Chakan)	1543.125	696.25	2402.5	1.974771136
Kolhapur	1006.140351	700	1400	3.951601772
Maanachar	1053.28125	512	1925	2.654038182
Mumbai	1463.839286	918.75	2162.5	3.133089987
Nagpur	1273.460526	575	2488.75	2.342286986
Nasik	1141.22905	500	2455	2.03042559
Osmanabad	514.8947368	126.15	2405	0.637282248
Palghar	1084.597403	546	1800	2.859425467
Pandharpur	780	500	1270	2.18873278

Continued on next page

Table 5.16 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Parbhani	1075	668.75	1575	2.815815418
Pen	3566.666667	3260	3760	22.55758064
Pune	1529.757463	841.875	2700	2.655317644
Pune(Khadiki)	1364.210526	935	1830	4.921268067
Pune(Pimpri)	3462.631579	1178	4000	3.28231853
Satara	1508.206107	600	2500	2.664578381
Shrirampur	1239.148551	500	2100	2.720134917
Solapur	1288.2749	500	2500	2.337448476
Ulhasnagar	1389.407407	524.9	1700	3.871914252
Vasai	1273.461538	1000	2137.5	3.921192762
Vashi New Mumbai	1422.189055	650	2700	2.640697781
Koregaon	795.8333333	568.75	984.375	5.125970055
Aatpadi	1045	1027.5	1050	93.46764146
Chandrapur(Ganjwad)	1506.030151	700	2800	2.557720382
Sangli(Phale, Bhajipura Market)	1293.246269	700	2600	2.457057618
Rahuri	1340.807339	650	2741	2.504208789
Barshi	100	100	100	Inf
Mangal Wedha	1285.714286	1200	1385	18.6317701
Washi(Thane Market)	1005	971.75	1038.25	20.30406615
Rahata	1520.652174	700	2300	2.774755508
Kamthi	1723.577236	1000	3380	2.733021145
Vai	2052.631579	1346.25	2757.5	4.250236454
Vadgaonpeth	1520	1410	1600	18.16747486
Amarawati	1282.317073	950	1800	5.08966709
Jalana	1000	815	1185	6.123724357
Islampur	2749	1400	4282.5	2.68095951

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Table 5.16 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Akluj	1636.792453	995	3200	2.621236434
Ramtek	1521.118421	900	2700	2.548916784
Amrawati(Frui & Veg. Market)	1252.142857	550	2928.75	2.12409407
Rahuri(Songaon)	2162.5	2100	2246.25	28.83333333
Palthan	1086.206897	600	1500	3.362244238
Vita	1250	750	1830	3.986205026
Murbad	1400	1400	1400	Inf
Morshi	1828.150943	1100	3370	2.0432557
Pune(Moshi)	1550	850	2300	3.379902086
Bhusaval	1812.121212	1460	2500	5.630027837
Pune(Manjri)	1615.384615	1355	1900	8.827875901
Junnar(Narayangaon)	2008.333333	1927.5	2100	39.00216722

Table 5.17: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of November

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Ahmednagar	1334.214286	500	3250	1.978488254
Aurangabad	1489.222222	440	3300	1.847989191
Bhivandi	1305.652174	944	1917.5	4.399177142
Jalgaon	1297.869198	347.5	2805	1.929729688
Junnar	1600	650	3355	2.199887764
Junnar(Otur)	1467.5	697.5	2025	3.849506618
Kalyan	981.5789474	575	1630	2.694598602
Karad	1468.095238	600	2250	3.165424056

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Table 5.17 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Khed(Chakan)	1809.139785	700	3335	2.385040082
Kolhapur	1053.571429	700	1300	1.704305537
Maanachar	1342.823529	880	2480.625	2.664029397
Mumbai	1661.458333	650	2311.25	3.400688153
Nagpur	1595.752336	541.25	3875	2.041653631
Nasik	1456.968085	500	3465.75	1.799668559
Osmanabad	300	140	980	0.765465545
Palghar	1107.708333	600	1800	3.139545749
Parbhani	1388.888889	700	2180	2.369375558
Pen	3500	3412.5	3587.5	55.33985905
Pune	1573.212996	700	3300	2.224018133
Pune(Khadiki)	1409.876543	1000	2500	3.924071511
Pune(Pimpri)	3840.625	2406.25	4000	6.024509804
Satara	1682.459677	600	2946.25	2.33028487
Shrirampur	1384.562738	500	2600	2.467083641
Solapur	1470.851852	450	3300	2.040323777
Ulhasnagar	1446.428571	767.5	2315	2.720988895
Vasai	1195.714286	1132.5	1227	40.47975385
Vashi New Mumbai	1531.603774	575	3300	2.049679561
Koregaon	881.6666667	700	1210	4.833318221
Chandrapur(Ganjwad)	1611.375661	600	3530	2.094078434
Sangli(Phale, Bhajipura Market)	1554.4	700	2800	2.161943522
Rahuri	1643.875	700	3400.125	2.172664187
Mangal Wedha	1400	1400	1400	Inf
Washi(Thane Market)	1136.666667	973.5	1382	4.926531835
Rahata	1607.142857	750	2700	2.725816189

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Table 5.17 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Kamthi	1936.734694	842.5	3800	2.337538716
Vai	2317.44186	1500	3395	3.834679246
Vadgaonpeth	1700	1515	1800	12.02081528
Amarawati	1608.62069	900	2220	4.446059257
Chandrapur	1766.666667	1605	1985	8.486792152
Islampur	2853.703704	1365	4300	2.660441647
Akluj	1853.939394	900	3700	2.344268799
Ramtek	1632.394366	700	3100	2.603667118
Amrawati(Frui & Veg. Market)	1350.728477	500	3500	1.709501961
Rahuri(Songaon)	1900	1710	2215	9.083737431
Palthan	1051.666667	700	1400	3.566584247
Vita	1584.615385	825	3250	2.21380247
Murbad	1500	1165	1955	4.888129019
Morshi	2873.965517	1570	3965	2.829151577
Pune(Moshi)	1747.142857	936.25	2955	2.604720495
Bhusaval	1922.222222	1130	2675	4.933726194
Pune(Manjri)	1727.906977	1500	2200	6.158287729
Junnar(Narayangaon)	1675	1427.5	1945	8.982462943

Table 5.18: The tables below show the average prices, the 95 percent confidence interval, and the Spatio-FLAP Index for the markets for the month of December

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Ahmednagar	1119.59596	400	2705	1.916305383
Aurangabad	1123.839662	350	2650	1.736618012

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Table 5.18 Continues

Location	**Mean**	**Lower_CI**	**Upper_CI**	**Spatio_FLAP**
Bhivandi	1382.4	930	2322	3.183524325
Jalgaon	1099.375494	325	2500	1.744743895
Junnar	1348.148148	566.25	2370	2.57083398
Junnar(Otur)	1307.142857	500	2825	1.918525235
Kalyan	986.9047619	450	2175	1.599049668
Karad	1319.655172	530	2440	3.073824867
Khed(Chakan)	1319.607843	426.25	2395	2.195702476
Kolhapur	926.25	600	1400	3.464729469
Maanachar	1208.490566	586	2200	3.034609071
Mumbai	1522.666667	942.5	2300	3.174842688
Nagpur	1224.875	437	3250	1.809118092
Nasik	1129.974576	450	2706.25	1.615584056
Osmanabad	1481.428571	150	2596.25	2.235366692
Palghar	1066.208333	580.5	1522.5	3.773352427
Pandharpur	830.5555556	200	2810	0.990388855
Parbhani	1514.285714	875	2185	3.103362232
Pen	3350	2740	3500	10.90992737
Pune	1455.716783	650	2687.5	2.317016788
Pune(Khadiki)	1259.756098	452.5	2200	2.674953208
Pune(Pimpri)	3474	1380	4000	3.722683018
Satara	1465.27027	500	2832.5	2.256031854
Shrirampur	1301.020408	450	2795	1.916321656
Solapur	1312.226027	420	2800	1.913044629
Ulhasnagar	1361.66667	800	1713.75	5.266792852
Vasai	1230.588235	1120	1406	14.61120633
Vashi New Mumbai	1277.95045	500	2773.75	2.042867282
Koregaon	1116.666667	900	1393.75	5.061832289

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Table 5.18 Continues

Location	Mean	Lower_CI	Upper_CI	Spatio_FLAP
Aatpadi	1050	1050	1050	Inf
Chandrapur(Ganjwad)	1409.808612	400	3580	1.744737605
Junnar(Alephata)	1233.333333	497.5	1827.5	1.725602873
Sangli(Phale, Bhajipura Market)	1343.583333	573.75	2826.25	2.092592559
Navapur	1160	820	1900	2.429352668
Rahuri	1320.357143	600	2945.375	2.035022323
Mangal Wedha	1500	1310	1770	8.017837257
Washi(Thane Market)	720	677.25	762.75	11.3137085
Rahata	1503.658537	455	3285	1.973203698
Kamthi	1742.741935	800	3585	2.267085074
Vai	2121.111111	1550	3395	3.969654232
Vadgaonpeth	1600	1600	1600	Inf
Amarawati	1181.395349	700	1990	3.370875918
Islampur	2376.666667	1400	4070	2.620401449
Akluj	1740.935673	625	3800	2.02272403
Ramtek	1454.794521	700	3100	2.308227697
Amrawati(Frui & Veg. Market)	1149.350649	500	2878.75	1.755816005
Rahuri(Songaon)	1925	1452.5	2100	5.5
Palthan	905.7142857	700	1300	1.040536856
Vita	1359.090909	780	2430	2.597999476
Morshi	2309.354839	1207.5	3887.5	2.565549336
Pune(Moshi)	1357.894737	787.5	2512.5	2.617456838
Bhusaval	1720.512821	1200	2000	6.000987434
Pune(Manjri)	1661.764706	1500	2000	8.812433218
Junnar(Narayangaon)	1516.666667	1200	1800	7.909965585

Table 5.19: Top three markets to sell potatoes in Maharashtra for each month according to Spatio-FLAP index

Month	**Rank 1**	**Rank 2**	**Rank 3**
January	Murbad	Rahuri (Songaon)	Mangal Wedha
February	Pune (Manjri)	Morshi	Amarawati
March	Aatpadi	Chalisgaon	Pune (Hadapsar)
April	Mangal Wedha	Pen	Vai
May	Koregaon	Aatpadi	Ratnagiri (Nachane)
June	Chalisgaon	Mangal Wedha	Bhusaval
July	Pen	Mangal Wedha	Sangola
August	Rahuri (Songaon)	Junnar (Otur)	Amarawati
September	Pen	Junnar (Narayangaon)	Sangola
October	Barshi	Murbad	Aatpadi
November	Mangal Wedha	Pen	Vasai
December	Aatpadi	Vadgaonpeth	Vasai

The table above shows the best 3 markets in Maharashtra for each month based on the Spatio-FLAP Index.

- The farmers may develop a monthly contract with the suppliers in the suggested markets for the different months according to the Spatio-Temporal FLAP Index.

- Those markets which consistently show higher ranking like Pen, Vasai, and Mangal Wedha and are close to the farm, a farmer can decide to sell the production to these markets throughout the season if he/she is restricted in the resources.

- Developing a proper supply chain considering the Spatio-Temporal FLAP Index will help the farmers in increasing their sale prices and decrease the uncertainty in their income as well.

- We have provided the top three markets instead of just the best one so that, the farmers can figure out which markets to target in which month considering the expenses for logistics as well.

■

Chapter 6

Conclusion

1. By observing the FLAP Index, the lower confidence interval of the prices, and the mean of the prices, farmers can decide when to sell the products so as to maximize profits.

2. Forecasting lets the farmer select the day on which he/ she can sell the crop.

3. Forecasting is specifically helpful for crops like spinach which is perishable.

4. For spinach and potato, the optimum model turned out to be ETS.

5. There exists no significant contagion effect among the markets of Pune and Ahmednagar.

6. We have ranked the best 3 markets in Maharashtra for each month as a suggestion to the farmer where to sell the crop in which month to gain maximum profit with more consistency.

■

Chapter 7

Scope

1. The Spatio-FLAP Index work is only based on a single crop. We can construct the Spatio-FLAP index for different crops which would be helpful for farmers who produce multiple crops.

2. Construct an index that includes, the FLAP index, the lower confidence interval, and the mean of the prices. And then we can make a more robust suggestion to the farmer.

3. Repeat contagion effect for different crops for different markets.

■

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