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# Inventory Management model

Executive & Technical Summaries

Inventory Management Model for Hyper city Mumbai for the Perishable  
Product Classes of Dahi and Milk

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## Executive Summary

The consumer products sector faces volatility in demand on a high scale and level of complexity, thereby posing challenges in the area of inventory management. Economic volatility and demand variability present challenges that simple models of demand forecasts are not equipped to handle. An important method of tackling demand variability is an effective way to improve the inventory control policy, which should be designed to smoothen stocking response to demand variation arising from the customers. The problem gets compounded when we are dealing with perishable goods as shelf life is very small.

The business goal is to arrive at an inventory planning policy for two such perishable classes of goods: dahi/ yogurt and fresh milk. The inventory policy will attempt to balance the costs of under-stocking vs. the cost of over-stocking these goods.

The demand data when plotted showed a linear trend with additive seasonality and some noise. There is one cycle per month with each month having 4-5 weeks. We see some peaks in Aug 2011 and Dec 2011 which is due to high demand during festivals like Janamashtmi.

This inventory policy will be used by store managers to :

1. Determine the near optimal order quantity for different seasons, days of the week etc
2. Determine the reorder point at which the order should be placed

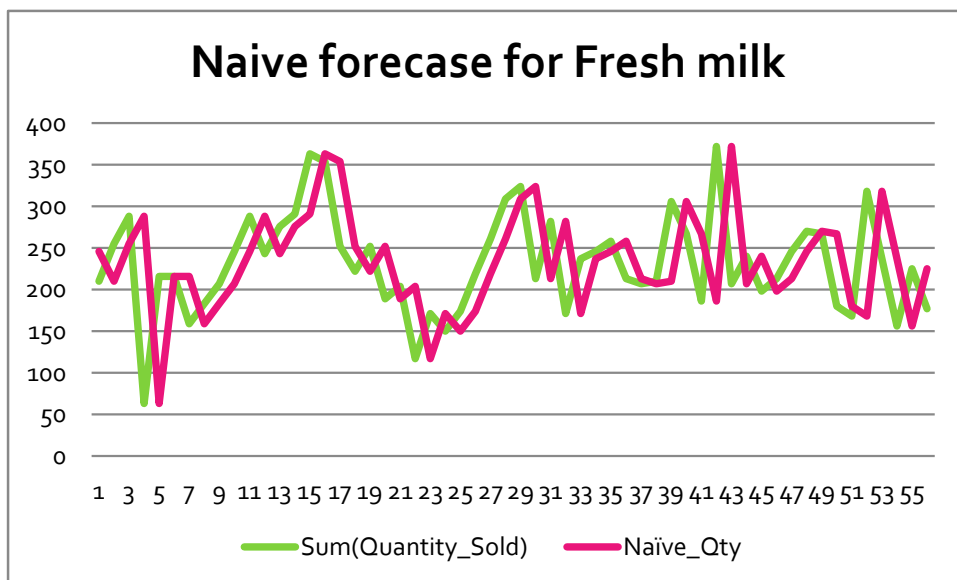
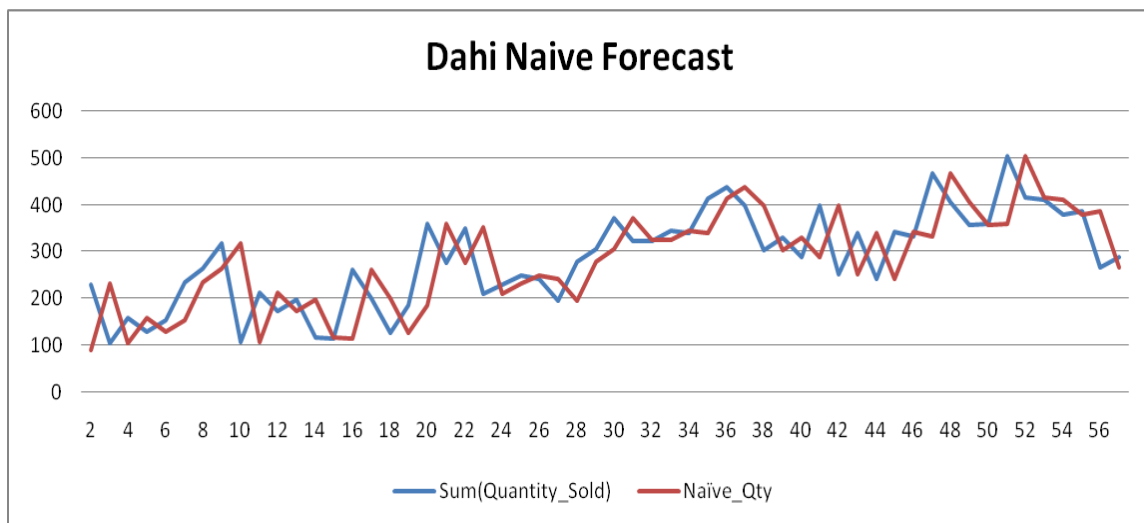
This will be achieved by forecasting the demand for two classes of products: dahi/yogurt and milk. The lead time for the supplier is two weeks and therefore we are forecasting for two weeks! As and when actual data is available for the next week, we roll forward our forecast to include the last week data and forecast for future two weeks.

We used a metric called 'Mean Revenue Impact' which measures the average impact on revenue taking into consideration costs of under and over-forecasting. We found that the method of using Multiple Linear Regression with Auto-Regression on residuals to be superior for forecasting the demand for fresh milk; and Naive forecast to be more accurate for forecasting the demand for dahi/yogurt. Lag-1 Naive forecast was considered as our benchmark.

The plot below details the Naive forecast which serves as our benchmark. We have 57 weeks of data which is divided into 49 weeks of training data and 8 weeks of validation data.

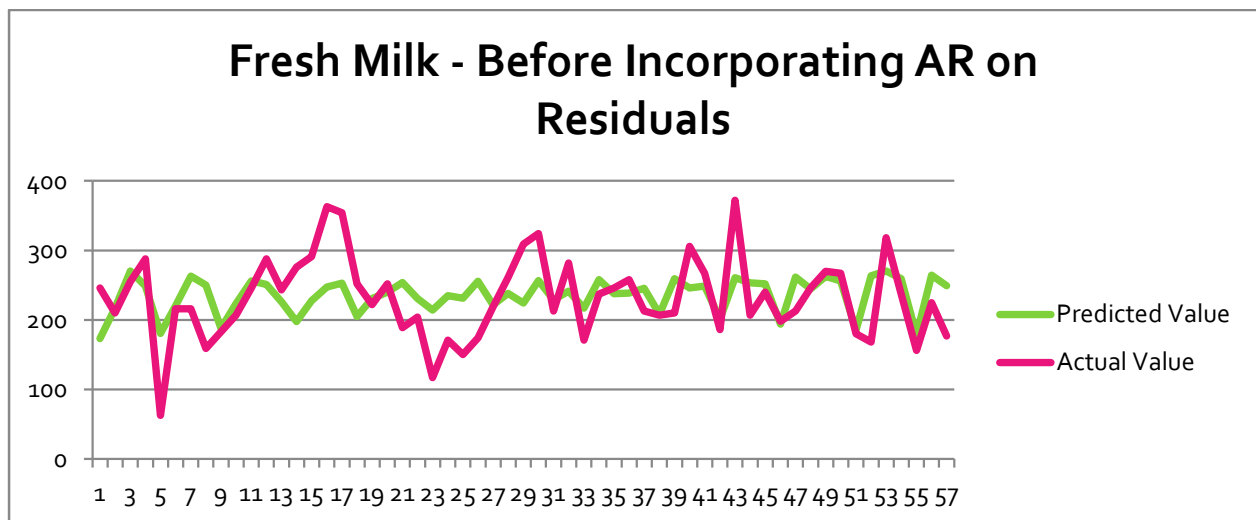
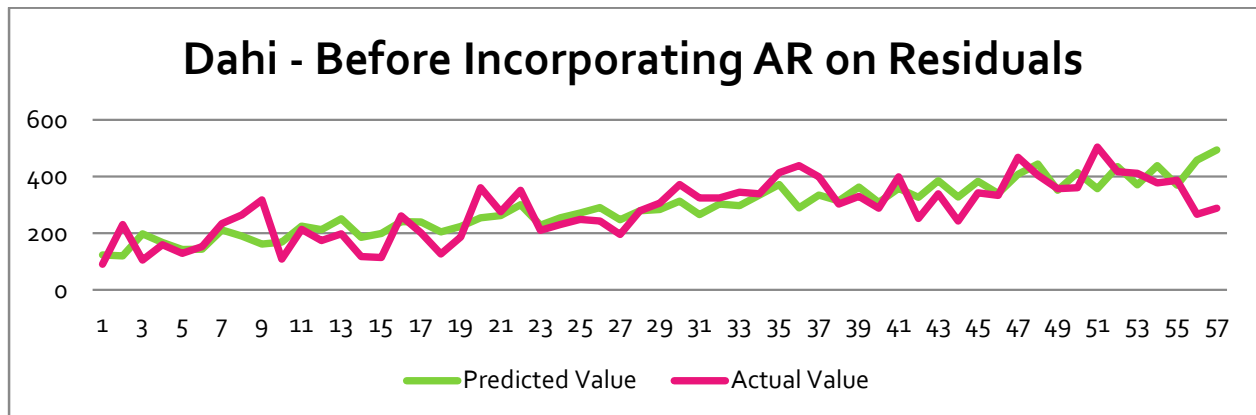
We have found the number of weeks in a month to constitute one cycle. Hence, we assigned week of month numbers # to each week to create dummy and interaction variables which could account for the variations at the weekly level.

## Naïve Forecast



## Multiple-Linear Regression

(training and validation set included in the same chart for representation purposes)



### Multiple Linear Regression with auto-regression on errors

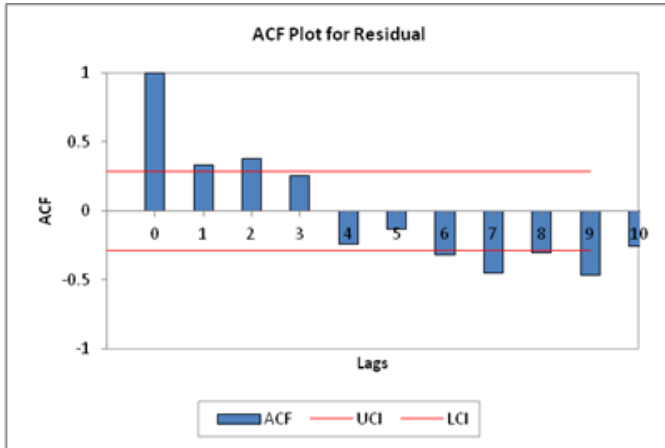
We carried out ACF plots on the residuals of the MLR output and found the residual series to be positively correlated with the corresponding Lag-1 and Lag-2 series. This was a clear indication that the forecast can be further improved by using auto-correlation on the residual series.

We have used Multiple linear regression to get the predicted values and ran auto-regression on residuals to create forecast of errors. Now, we use a new predicted value by adding the error forecasts to MLR predicted values. We calculate the metric of Mean Revenue Impact using the difference between the new predicted value and actual sales data.

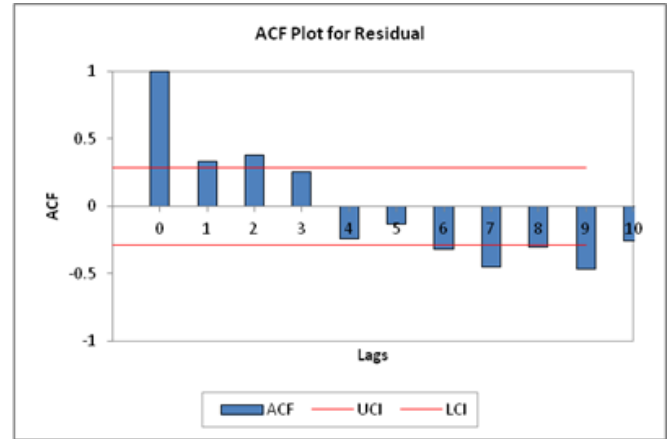
*For Holt-Winter method - refer to the appendix-1*

## ACF plots

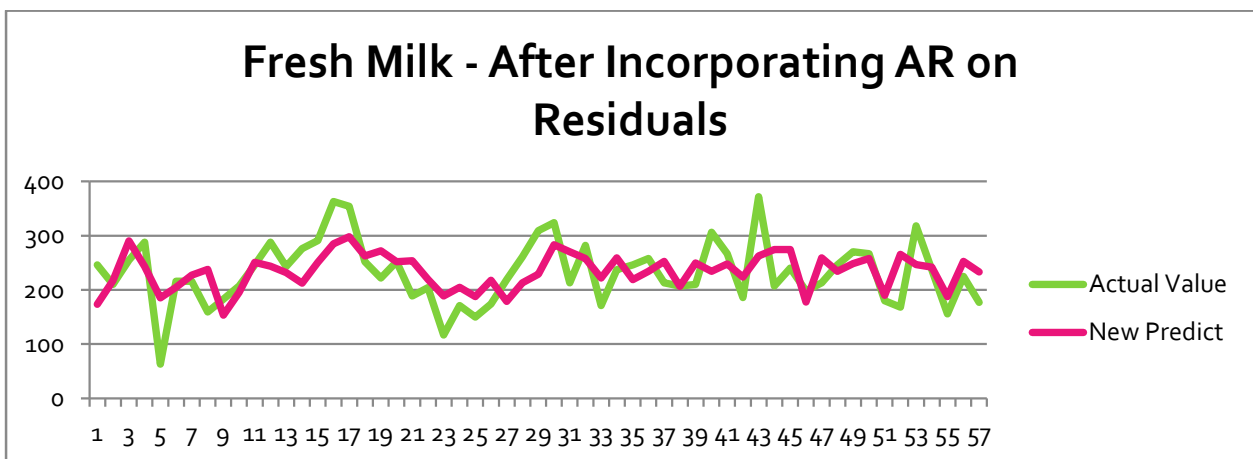
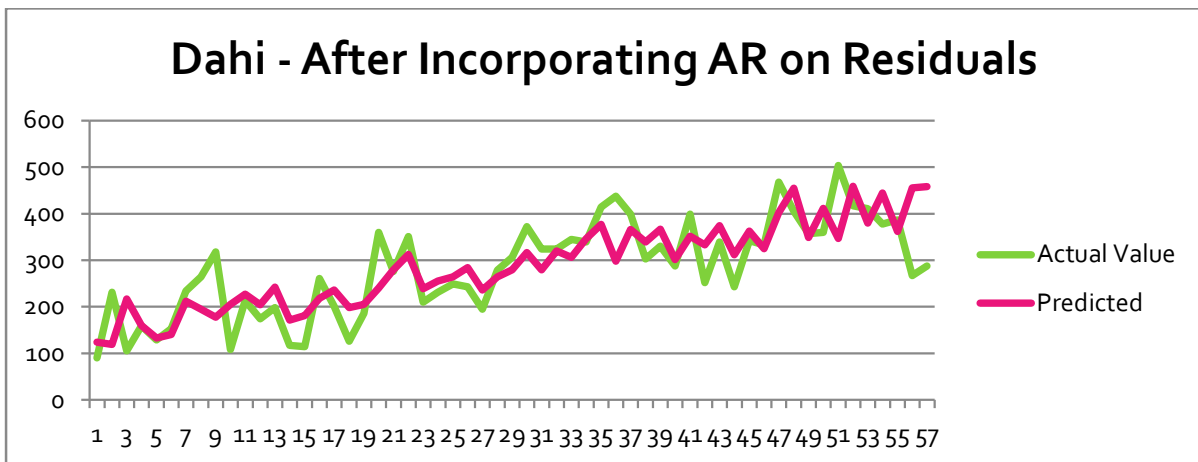
ACF for Dahi



ACF for Fresh milk

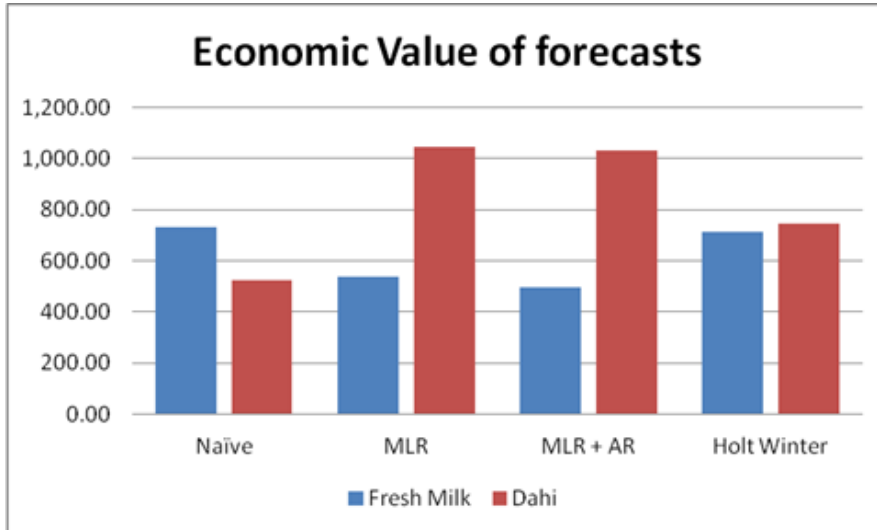


**Multiple-Linear Regression with AR** (training and validation set included in the same chart for representation purposes)



## Appendix - 1

Mean Revenue Impact comparison (metric used to compare all methods against the Naive)



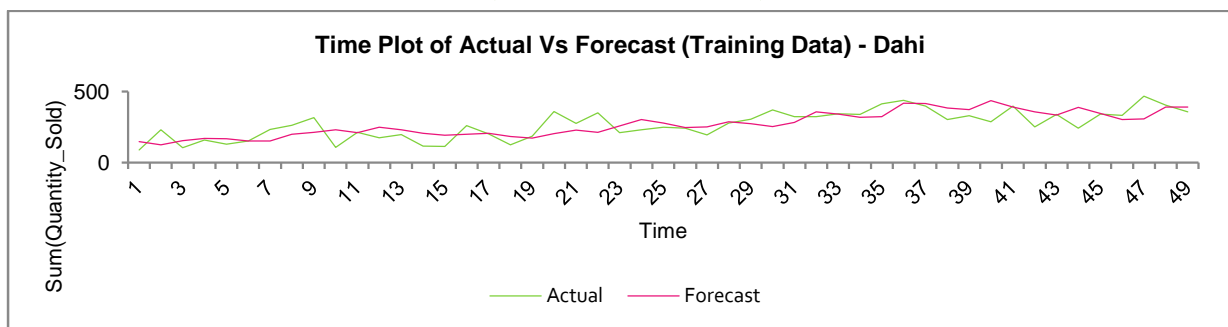
	Fresh Milk	Dahi
Naive	733.50	523.24
MLR	536.92	1,044.95
MLR + AR	495.47	1,030.74
Holt Winter	714.87	747.14

Sample MRI calculation logic using Dahi

Over forecasting	
Cost/Unit	14.4
Predicted	445.85
Actual	342
Error	-103.85
Revenue Impact	-1495.44

Under forecasting	
Margin/Unit	3.6
Predicted	362.82
Actual	434
Error	71.18
Revenue Impact	-256.25

## Holt Winter method (Period = 4)



**Time Plot of Actual Vs Forecast (Training Data) - Fresh milk**

