CAL STATE EAST BAY

ENGR-610 Final Project Analysis Report

Forecasting Ice Consumption and suggested safety stock

Submitted to Submitted to:

**Dr. Farnaz Ganjeizadeh**

By

**Tanmay Tuscano (hs1657)**

**Siddhesh Kadam (vz36642)**

**Rishikesh Reddy Dinnemeeda (vd5853)**

**Nikhil Khairnar (tz7533)**

**Lakshman Theja (Hj2793)**

## Abstract

This project is Analyzing and Forecasting Ice Consumption for cold drinks and calculating suggested safety stock based on raw data collected from Einstein bagel bro at the CSU EB campus to ensure they don't run out of ice for their Cold Drinks.

## Introduction

Nowadays, managing inventory, manpower, and other business resources in the most optimal manner is the prime objective of management. Decision-making is no longer a function of experience and intuitions but on a firm basis of data analysis and with statistical aid. Be it a business entity just starting out into the market or a very well-established one. Accurate capturing of data and statistical analysis ways precedes decision-making.

To analyze and understand the flow pattern of drinks, we have collected real-time **data from** the counters of one of the popular American food chains -**The Einstein bros bagels at CSUEB**. We had observed that this particular restaurant at CSUEB had been facing difficulties to cater pending orders in acceptable times during peak hours.

In order to find out the optimal stock quantity of ice we have forecasted the quantity of ice per day, and then used inventory model to suggest suitable safety stock.

## Methodology:

1.) Collect real-time data for sales of iced drinks for two weeks from Einstein bros bagels at CSU east bay campus.
2.) Using the collected data, identify the behavior of data with respect to week day and time of the day using regression model.
3.) Select best forecasting technique using MAD (Mean Absolute difference) as the decision parameter.
4.) Forecast the sales of iced drinks for the forthcoming period using the selected forecasting method.
5.) Use the safety stock technique from the inventory control method to calculate safety stock for the forecasted data.
6.) Develop a summary for storage quantity of ice with respect to each weekday to implement at the said store.

## Team Responsibility Matrix: -

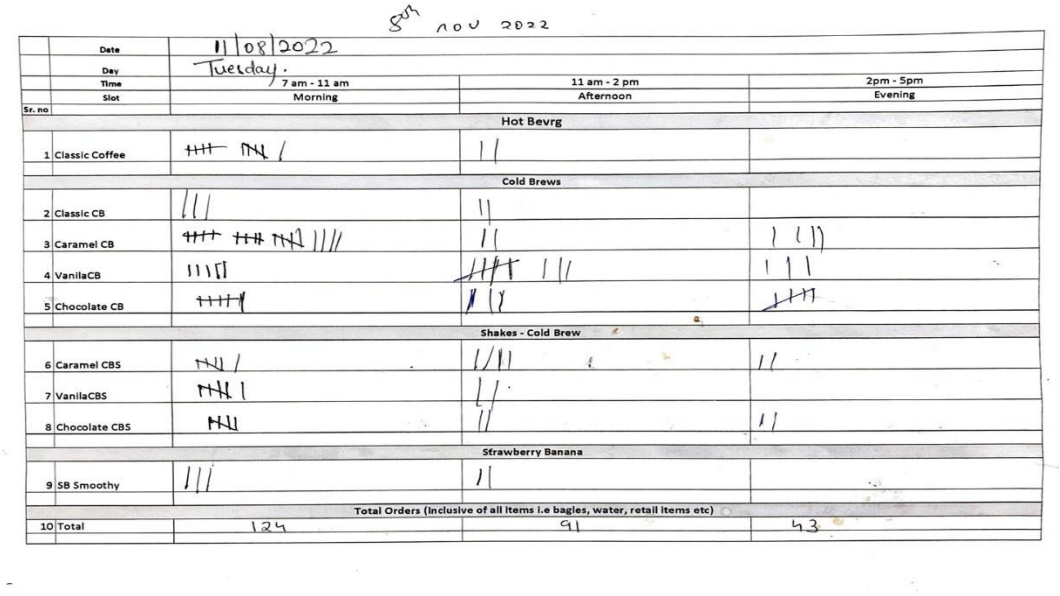
We used the following responsibility matrix to define the roles and responsibilities everyone must hold during our project process. This helped us in dividing the work and saving the time.

| Team Member | | Contribution | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Net Id | Brainstorming | Data Collection | Quantitative Analysis | Qualitative analysis | Report | Presentation |
| Laxman Theja | hj2793 | Yes | | | | Yes | |
| Nikhil Khairnar | **tz7533** | Yes | | | | | Yes |
| Rishikesh Reddy | vd5853 | Yes | | | | Yes | |
| Siddesh Kadam | vz36642 | Yes | Yes | | Yes | | |
| Tanmay Tuscano | hd1657 | yes | Yes | Yes | | Yes | |

## Collection of data:

We collected the data from Einstein bro bagels for 2 weeks from 3rd Nov 2022 to 18th Nov 2022 for sales of drinks.

Reference data collection sheet:



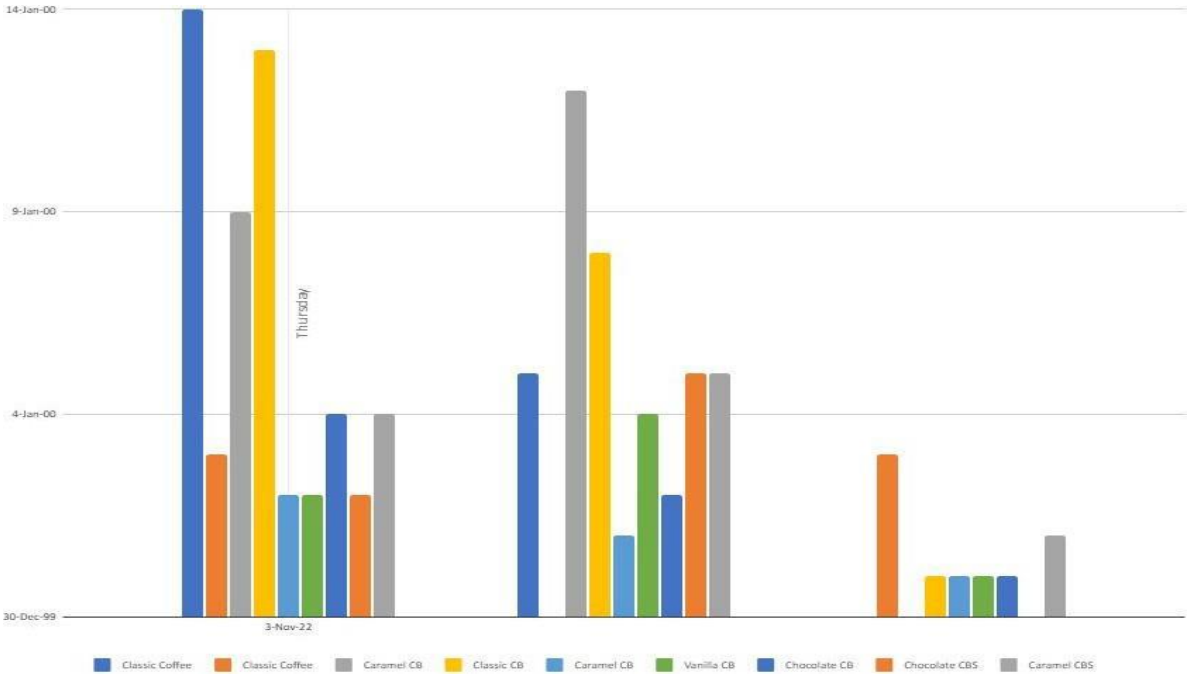
5th NOV 2022

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | 11/08/2022 | | |
| | Day | Tuesday. | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 𝍸 / | // | |
| | **Cold Brews** | | | |
| 2 | Classic CB | /// | // | |
| 3 | Caramel CB | 𝍸 𝍸 𝍸 //// | // | /// |
| 4 | VanilaCB | //// | 𝍸 /// | /// |
| 5 | Chocolate CB | 𝍸 / | // | 𝍸 |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | 𝍸 / | /// | // |
| 7 | VanilaCBS | 𝍸 / | // | |
| 8 | Chocolate CBS | 𝍸 | // | // |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | /// | // | |
| | **Total Orders (inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 124 | 91 | 43 |

Structured data:

| Sales Record of Beverages at Eienstien bagels at CSU East Bay | | | | | |
|---|---|---|---|---|---|
| | Date | 3-Nov-22 | | | |
| | Day | Thursday | | | |
| | Time | 7 AM - 11 AM | 11 AM - 2 PM | 2 PM - 5 PM | Total beverage sales in a day |
| Hot Beverage | Classic Coffee | 15 | 6 | 0 | 21 |
| Cold Brews | Classic CB | 4 | 0 | 4 | 8 |
| | Caramel CB | 10 | 13 | 0 | 23 |
| | Vanilla CB | 14 | 9 | 1 | 24 |
| | Chocolate CB | 3 | 2 | 1 | 6 |
| Shakes - Cold Brews | Caramel CBS | 3 | 5 | 1 | 9 |
| | Vanilla CBS | 5 | 3 | 1 | 9 |
| | Chocolate CBS | 3 | 6 | 0 | 9 |
| Strawberry Banana | SB Smoothy | 5 | 6 | 2 | 13 |
| Total | Total Beverages | 62 | 50 | 10 | 122 |
| | Total Orders (Inc. of all Items - Bagles, Water, Retail Iems | 115 | 80 | 27 | |

Graphical Representation of Data:




Summarized data:

| Date | Day | Cold Brew | Cold Brew Shakes | Smoothie | Sum |
|---|---|---|---|---|---|
| 3-Nov | Thursday - 1 | 61 | 27 | 13 | 101 |
| 4-Nov | Friday - 1 | 36 | 9 | 2 | 47 |
| 7-Nov | Monday - 1 | 38 | 21 | 5 | 64 |
| 8-Nov | Tuesday - 1 | 60 | 29 | 5 | 94 |
| 9-Nov | Wednesday - 1 | 52 | 17 | 6 | 75 |
| 10-Nov | Thursday - 2 | 43 | 19 | 8 | 70 |
| 14-Nov | Monday - 2 | 39 | 17 | 10 | 66 |
| 15-Nov | Tuesday - 2 | 48 | 19 | 16 | 83 |
| 16-Nov | Wednesday - 2 | 62 | 22 | 8 | 92 |
| 17-Nov | Thursday - 3 | 59 | 28 | 5 | 92 |
| 18-Nov | Friday - 3 | 19 | 10 | 1 | 30 |

| | |
|---|---|
| Mean | 74 |
| SD | 22 |

## Methods employed: -

**Quantitative Methods:**

- Regression Analysis.
- Forecasting
- Safety Stock – Inventory management

**Moving Avg** (MAD): -can find deviations and errors by this method. (We do not think Weighted MA is that necessary at this point)

**Regression analysis** In statistical modeling, regression analysis is a set of statistical processes for estimating the relationships between a dependent variable (often called the 'outcome' or 'response' variable, or a 'label' in machine learning parlance) and one or more independent variables (often called 'predictors', 'covariates', 'explanatory variables' or 'features'). The most common form of regression analysis is linear regression, in which one finds the line (or a more complex linear combination) that most closely fits the data according to a specific mathematical criterion. For example, the method of ordinary least squares computes the unique line (or hyperplane) that minimizes the sum of squared differences between the true data and that line (or hyperplane). For specific mathematical reasons (see linear regression), this allows the researcher to estimate the conditional expectation (or population average value) of the dependent variable when the independent variables take on a given set of values.

**Forecasting**: Forecasting using a macro trend (moving average) and seasonality (seasonal index) is a common way to forecast data into the future. The two components, seasonal index and moving average, are based on prior historical trends. They come together to form a model that can be projected out for the near future.

**Seasonal Index Forecasting**: Seasonal indexing is the process of calculating the highs and lows of each time period into an index. This is done by finding an average for an entire set of data that includes the same number of matching periods, then dividing the individual period average into that total average. This gives us an index whose total is the number of periods in a full cycle.

**Decomposition forecasting:** The decomposition approach to forecasting recognizes that a forecast cannot be completed unless you include all components of historical data. Although the components may vary, depending on what variable you are forecasting, you might include a long-term underlying trend line, a cyclical variation such as a business cycle, which would fluctuate around the trend, and a seasonal variable, which could be based on weather or holiday consumer activity. Depending on the variable you are attempting to forecast, you could even include a weekly variable.

**Safety Stock**: Safety stock is an extra quantity of a product which is stored in the warehouse to prevent an out-of-stock situation. It serves as insurance against fluctuations in demand.

1. Demand is variable but lead time is constant:

$$\text{ROP} = \bar{d}L + Z(\sigma_d\sqrt{L})$$

where

$\bar{d}$ = average daily demand
$\sigma_d$ = standard deviation of daily demand
$L$ = lead time in days

Safety stock -> $Z(\sigma_d\sqrt{L})$

**Qualitative Methods:**

Qualitative data analysis (QDA) is the process of organizing, analyzing and interpreting qualitative data—non-numeric, conceptual information and user feedback—to capture themes and patterns, answer research questions, and identify actions to take to improve your product or website.

**Content Analysis: -** Content analysis is a research method that examines and quantifies the presence of certain words, subjects, and concepts in a text, image, video, or audio message. The

method transforms qualitative input into quantitative data to help you make reliable conclusions about what customers think of your brand and how you
can improve their experience and opinion.

**Narrative Analysis: - Narrative** analysis is a method used to interpret research participants' stories – things like testimonials, case studies, interviews, and other text or visual data. The narrative analysis provides product teams with valuable insight into the complexity of customers' lives, feelings, and behaviors.

## Analysis:

### consumption of Ice and suggest Safety stock:

To forecast the consumption of Ice and control the stocking quantity of ice at Einstein Bros bagels, we first identify the best forecasting method for the data on hand and forecast the flow using the best-identified forecasting technique. Using the forecasted quantity, we calculate the buffer quantity (safety stock) using the inventory control method.

**Data for Cold drinks (Iced):**

| Date | Day | CB | CBS | SB | Sum |
|---|---|---|---|---|---|
| 3-Nov | Thursday | 61 | 27 | 13 | 101 |
| 4-Nov | Friday | 36 | 9 | 2 | 47 |
| 7-Nov | Monday | 38 | 21 | 5 | 64 |
| 8-Nov | Tuesday | 60 | 29 | 5 | 94 |
| 9-Nov | Wednesday | 52 | 17 | 6 | 75 |
| 10-Nov | Thursday | 43 | 19 | 8 | 70 |
| 14-Nov | Monday | 39 | 17 | 10 | 66 |
| 15-Nov | Tuesday | 48 | 19 | 16 | 83 |
| 16-Nov | Wednesday | 62 | 22 | 8 | 92 |
| 17-Nov | Thursday | 59 | 28 | 5 | 92 |
| 18-Nov | Friday | 19 | 10 | 1 | 30 |

| | |
|---|---|
| Mean | 74 |
| SD | 22 |

As we do not have the values of 11th November, which was a Friday, data will not follow the cyclic pattern of 5 days of the week while calculating CMA. Hence, we input adjusted dummy data from the previous Friday – 4th November. *We are not considering the Friday of 18th Nov as it was half working day and off day for students.*

## Adjusted Data:

| **Date** | **Day** | CB | CBS | SB | Sum |
|---|---|---|---|---|---|
| 3-Nov | Thursday | 61 | 27 | 13 | 101 |
| 4-Nov | Friday | 36 | 9 | 2 | 47 |
| 7-Nov | Monday | 38 | 21 | 5 | 64 |
| 8-Nov | Tuesday | 60 | 29 | 5 | 94 |
| 9-Nov | Wednesday | 52 | 17 | 6 | 75 |
| 10-Nov | Thursday | 43 | 19 | 8 | 70 |
| 4-Nov | Friday | 36 | 9 | 2 | 47 |
| 14-Nov | Monday | 39 | 17 | 10 | 66 |
| 15-Nov | Tuesday | 48 | 19 | 16 | 83 |
| 16-Nov | Wednesday | 62 | 22 | 8 | 92 |
| 17-Nov | Thursday | 59 | 28 | 5 | 92 |
| 18-Nov | Friday | 19 | 10 | 1 | 30 |

| | |
|---|---|
| Mean | 71.75 |
| SD | 22 |

## 1.) We first check the regression of the data:

Method: Simple Linear Regression/Least Squares

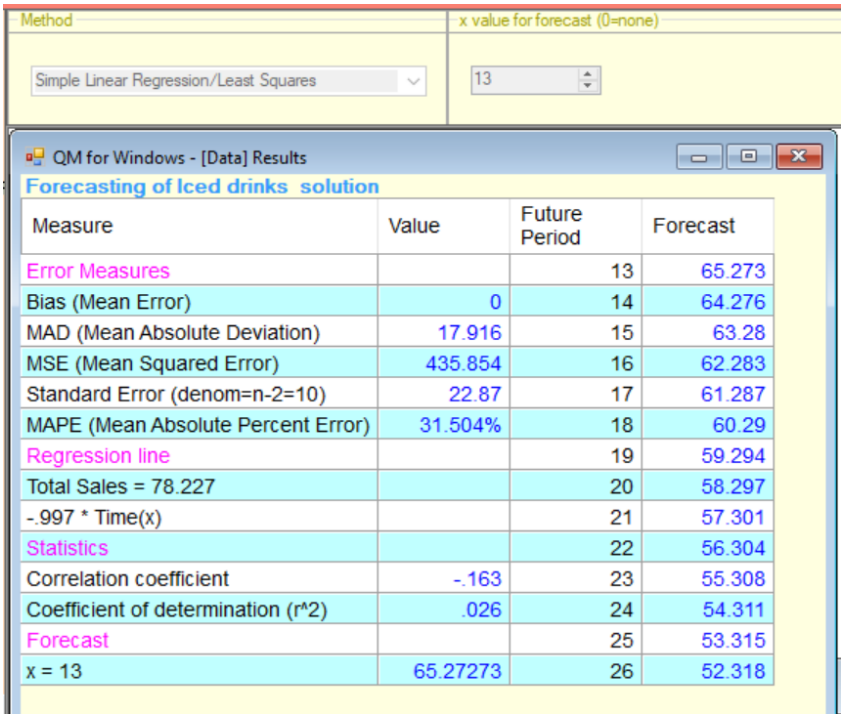
x value for forecast (0=none): 13

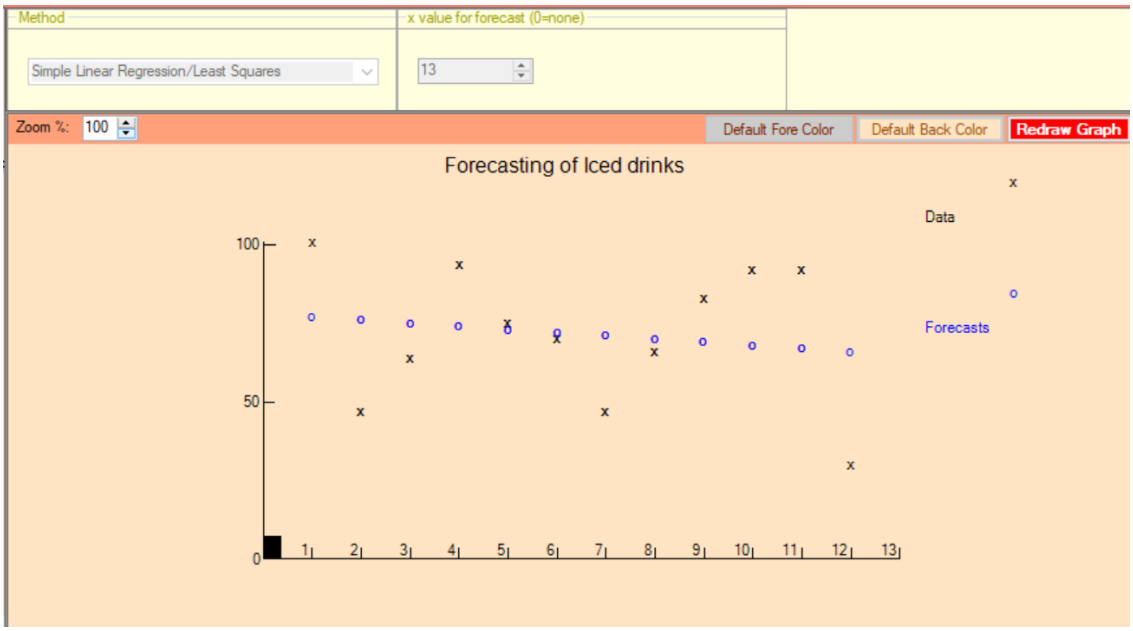
**Forecasting of Iced drinks**

| Day of week in sequence | Total Sales | Time(x) |
|---|---|---|
| Thursday - 1 | 101 | 1 |
| Friday - 1 | 47 | 2 |
| Monday - 1 | 64 | 3 |
| Tuesday - 1 | 94 | 4 |
| Wednesday - 1 | 75 | 5 |
| Thursday - 2 | 70 | 6 |
| Friday - 2 | 47 | 7 |
| Monday - 2 | 66 | 8 |
| Tuesday - 2 | 83 | 9 |
| Wednesday - 2 | 92 | 10 |
| Thursday - 3 | 92 | 11 |
| Friday - 3 | 30 | 12 |

Above is the input data for regression model.

The results from regression model are as follows:



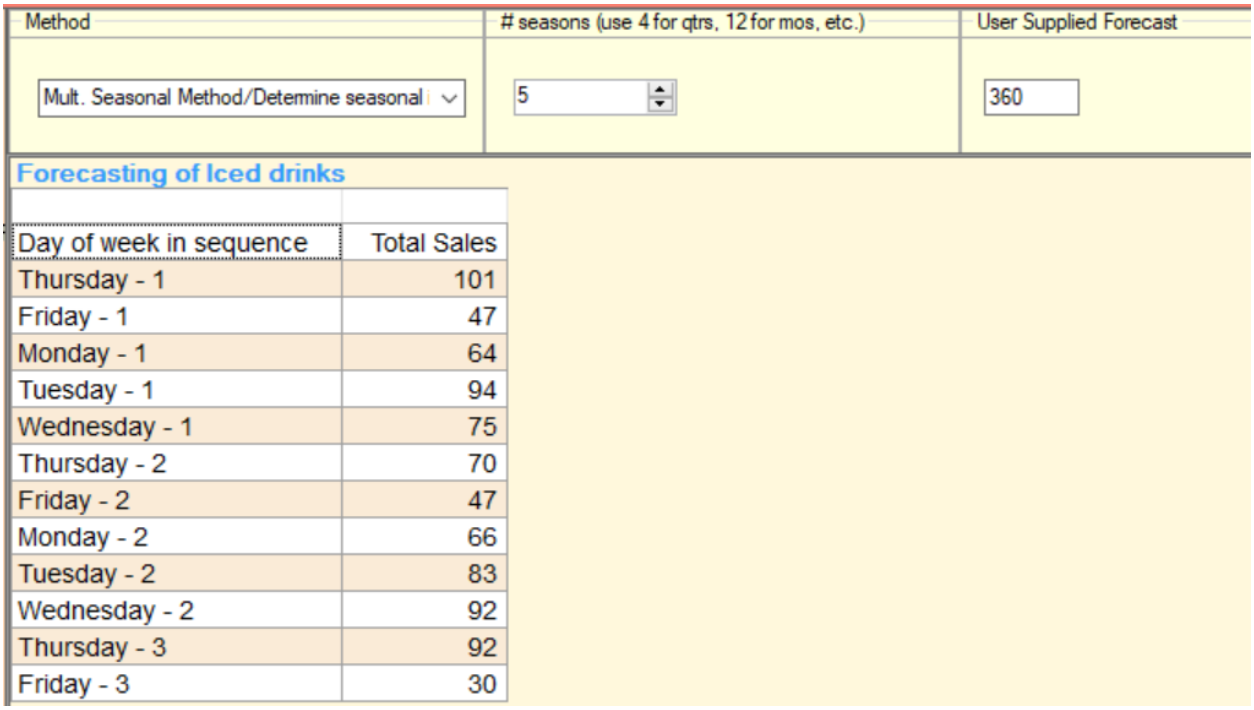



- **Inference from the regression results:**

1. Coefficient of determination $r^2 = 0.026$, which says that the regression line describes just 2.6% of the data. This is unacceptable for this model to be selected for forecasting.
2. The correlation coefficient r is negative 0.163 (-0.163), which shows a declining regression line.
3. Moreover, the Correlation coefficient and the graph make it quite evident that there is a minuscule decreasing trend in the data.
4. The above points and graphical outcomes are sufficient to conclude that the data follows a significant cyclic/season trend as well, which can be modeled with accuracy with other forecasting methods, such as seasonal indices. An even more effective method with respect to this data would be the multiplicative decompression method, as the data displays both trends as well as seasonal components.

## 2.) Forecasting using the Seasonal indices method:

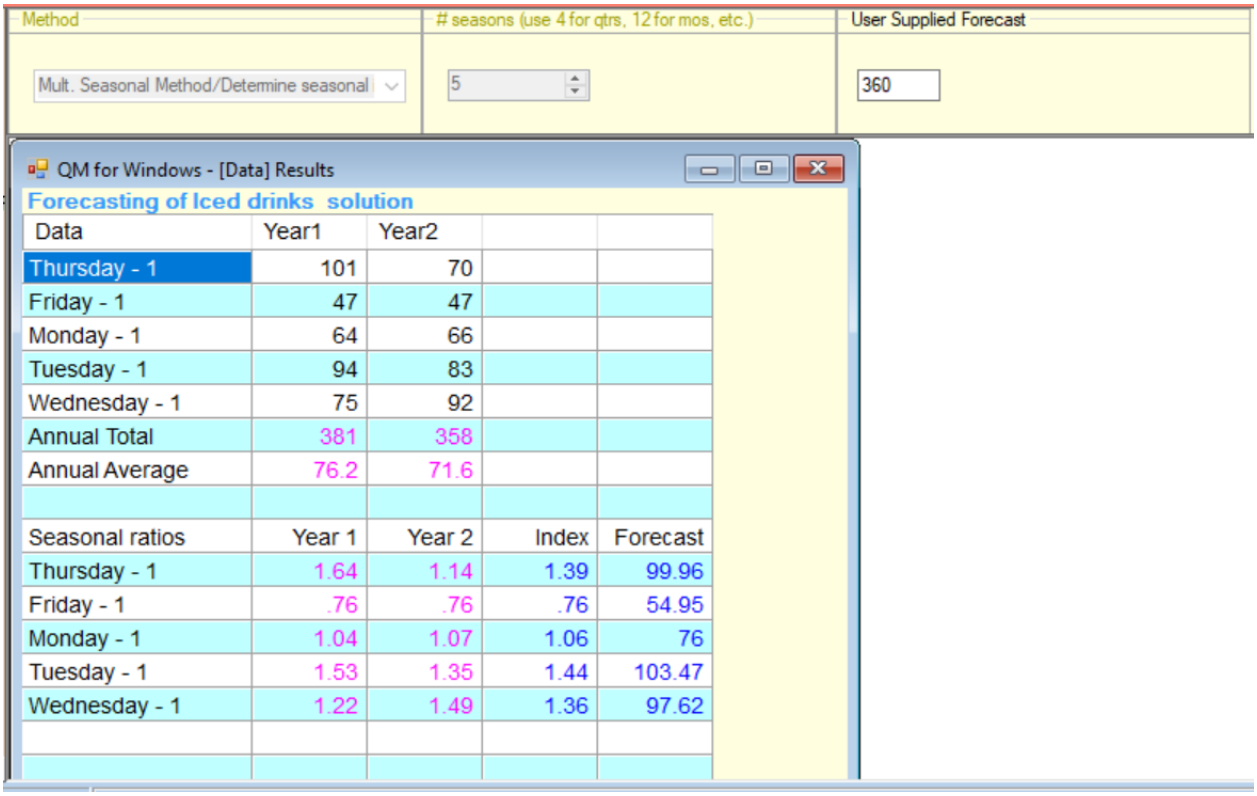
1. The Cycle time (Seasons) would be 5 days as the store operates for 5 days of the week.
2. The mean daily sales are 72 iced drinks, so we take weekly average sales as 72 times 5 equals 360 drinks.



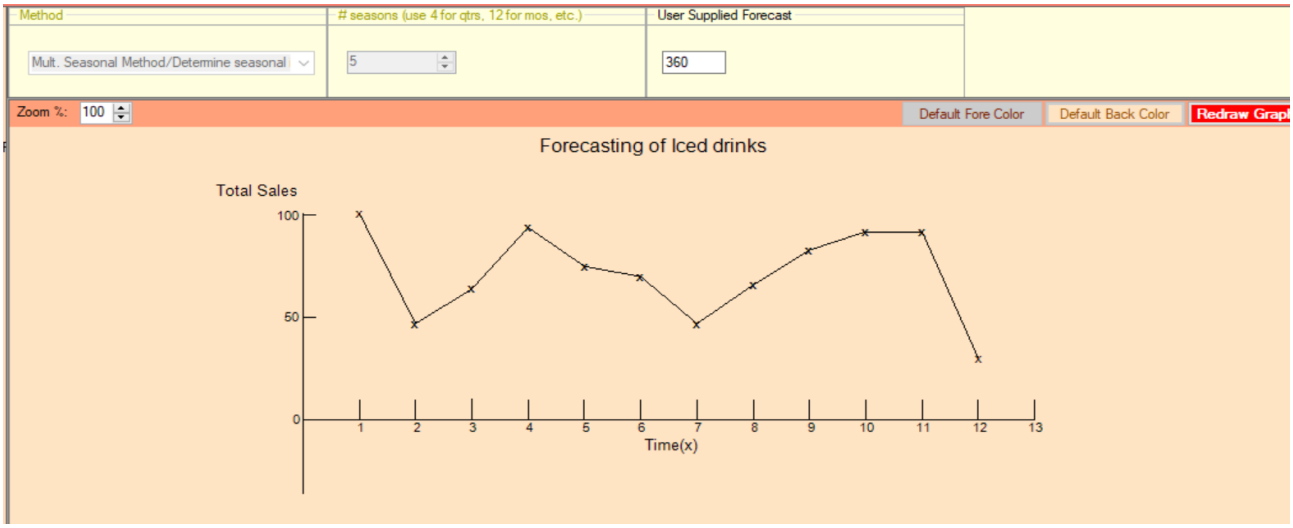

| Day of week in sequence | Total Sales |
|---|---|
| Thursday - 1 | 101 |
| Friday - 1 | 47 |
| Monday - 1 | 64 |
| Tuesday - 1 | 94 |
| Wednesday - 1 | 75 |
| Thursday - 2 | 70 |
| Friday - 2 | 47 |
| Monday - 2 | 66 |
| Tuesday - 2 | 83 |
| Wednesday - 2 | 92 |
| Thursday - 3 | 92 |
| Friday - 3 | 30 |

Above is the input in QM for the seasonal indices' method forecasting.

The results from the seasonal indices model are as follows:

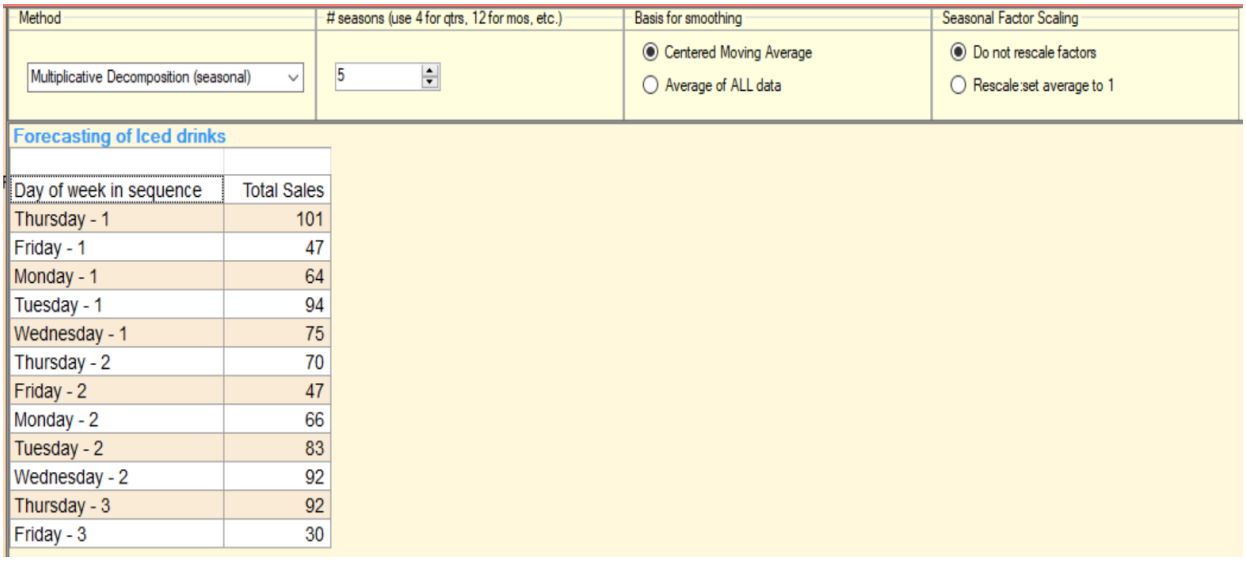



| Data | Year1 | Year2 | | |
|---|---|---|---|---|
| Thursday - 1 | 101 | 70 | | |
| Friday - 1 | 47 | 47 | | |
| Monday - 1 | 64 | 66 | | |
| Tuesday - 1 | 94 | 83 | | |
| Wednesday - 1 | 75 | 92 | | |
| Annual Total | 381 | 358 | | |
| Annual Average | 76.2 | 71.6 | | |
| | | | | |
| Seasonal ratios | Year 1 | Year 2 | Index | Forecast |
| Thursday - 1 | 1.64 | 1.14 | 1.39 | 99.96 |
| Friday - 1 | .76 | .76 | .76 | 54.95 |
| Monday - 1 | 1.04 | 1.07 | 1.06 | 76 |
| Tuesday - 1 | 1.53 | 1.35 | 1.44 | 103.47 |
| Wednesday - 1 | 1.22 | 1.49 | 1.36 | 97.62 |



## 3.) Forecasting using the multiplicative decomposition (Seasonal) method:

The Cycle time (Seasons) would be 5 days as the store operates for 5 days of the week.



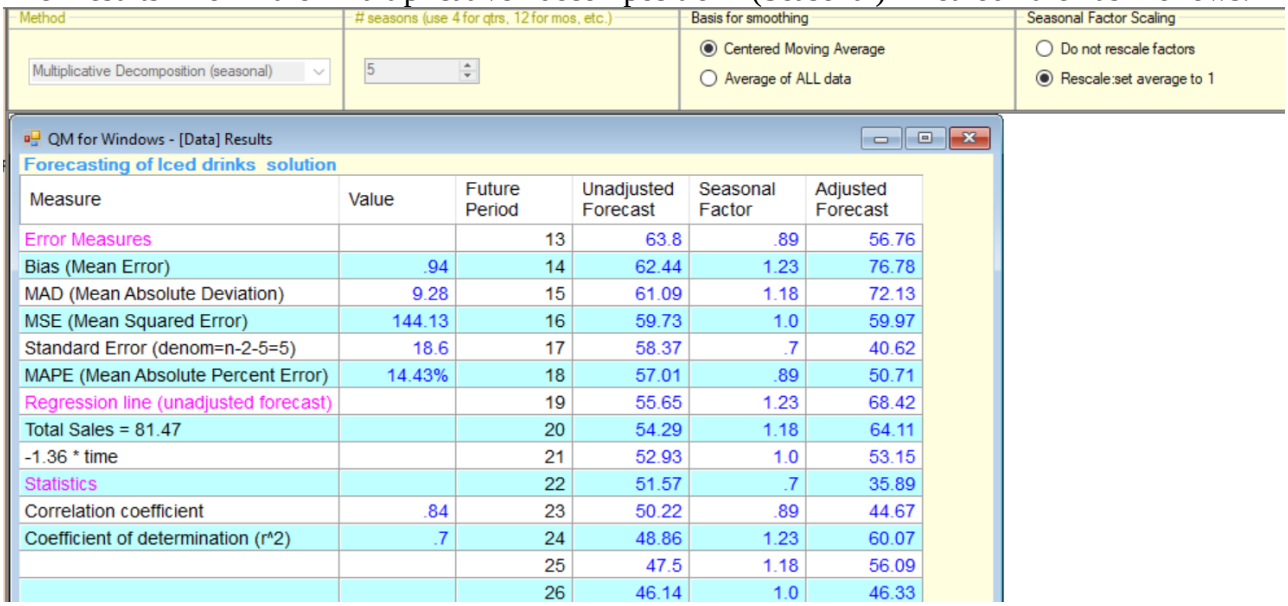
| Method | # seasons (use 4 for qtrs, 12 for mos, etc.) | Basis for smoothing | Seasonal Factor Scaling |
|---|---|---|---|
| Multiplicative Decomposition (seasonal) | 5 | Centered Moving Average / Average of ALL data | Do not rescale factors / Rescale:set average to 1 |

Forecasting of Iced drinks

| Day of week in sequence | Total Sales |
|---|---|
| Thursday - 1 | 101 |
| Friday - 1 | 47 |
| Monday - 1 | 64 |
| Tuesday - 1 | 94 |
| Wednesday - 1 | 75 |
| Thursday - 2 | 70 |
| Friday - 2 | 47 |
| Monday - 2 | 66 |
| Tuesday - 2 | 83 |
| Wednesday - 2 | 92 |
| Thursday - 3 | 92 |
| Friday - 3 | 30 |

Above is the input in QM for the multiplicative decomposition (Seasonal) method forecasting.

The results from the multiplicative decomposition (Seasonal) method are as follows:

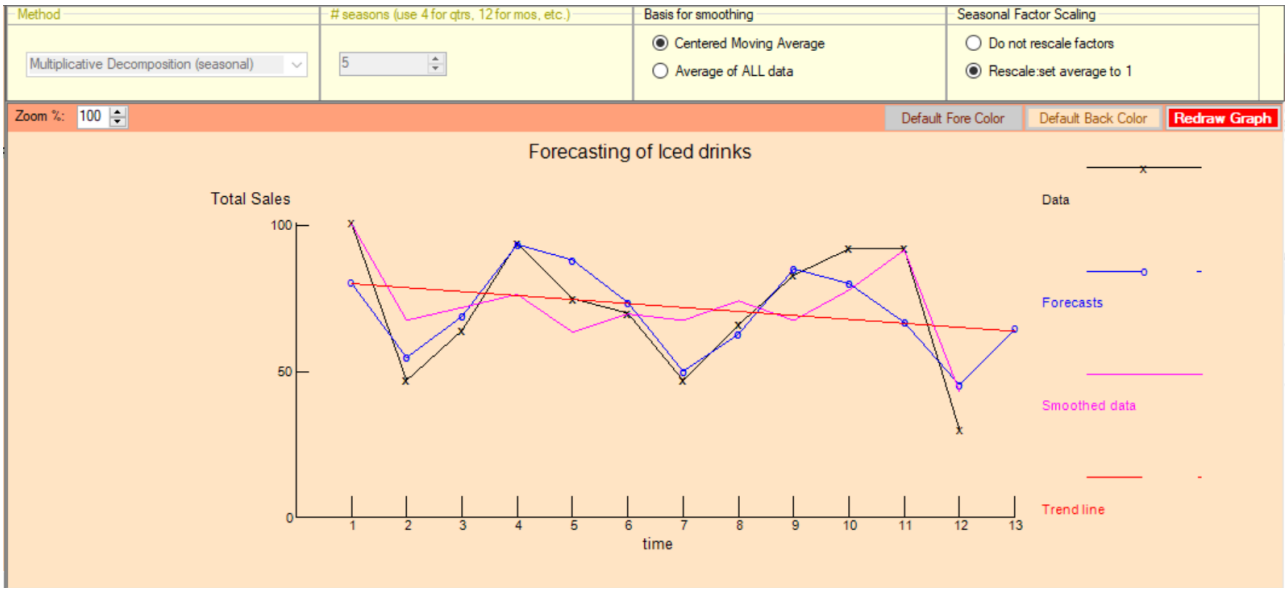


| Method | # seasons (use 4 for qtrs, 12 for mos, etc.) | Basis for smoothing | Seasonal Factor Scaling |
|---|---|---|---|
| Multiplicative Decomposition (seasonal) | 5 | Centered Moving Average / Average of ALL data | Do not rescale factors / Rescale:set average to 1 |

QM for Windows - [Data] Results

Forecasting of Iced drinks solution

| Measure | Value | Future Period | Unadjusted Forecast | Seasonal Factor | Adjusted Forecast |
|---|---|---|---|---|---|
| Error Measures | | 13 | 63.8 | .89 | 56.76 |
| Bias (Mean Error) | .94 | 14 | 62.44 | 1.23 | 76.78 |
| MAD (Mean Absolute Deviation) | 9.28 | 15 | 61.09 | 1.18 | 72.13 |
| MSE (Mean Squared Error) | 144.13 | 16 | 59.73 | 1.0 | 59.97 |
| Standard Error (denom=n-2-5=5) | 18.6 | 17 | 58.37 | .7 | 40.62 |
| MAPE (Mean Absolute Percent Error) | 14.43% | 18 | 57.01 | .89 | 50.71 |
| Regression line (unadjusted forecast) | | 19 | 55.65 | 1.23 | 68.42 |
| Total Sales = 81.47 | | 20 | 54.29 | 1.18 | 64.11 |
| -1.36 * time | | 21 | 52.93 | 1.0 | 53.15 |
| Statistics | | 22 | 51.57 | .7 | 35.89 |
| Correlation coefficient | .84 | 23 | 50.22 | .89 | 44.67 |
| Coefficient of determination (r^2) | .7 | 24 | 48.86 | 1.23 | 60.07 |
| | | 25 | 47.5 | 1.18 | 56.09 |
| | | 26 | 46.14 | 1.0 | 46.33 |




Below is the forecast from both models:

| Date | Forecast period | Day of week | Forecast Seasonal Indices |
|---|---|---|---|
| 21-Nov | 13 | Monday - 3 | 99.96 |
| 22-Nov | 14 | Tuesday - 3 | 54.95 |
| 23-Nov | 15 | Wednesday - 3 | 76 |
| 24-Nov | 16 | Thursday - 4 | 103.47 |
| 25-Nov | 17 | Friday - 4 | 97.62 |

| Date | Forecast period | Day of week | Forecast Decomposition |
|---|---|---|---|
| 21-Nov | 13 | Monday - 3 | 56.76 |
| 22-Nov | 14 | Tuesday - 3 | 76.78 |
| 23-Nov | 15 | Wednesday - 3 | 72.13 |
| 24-Nov | 16 | Thursday - 4 | 59.97 |
| 25-Nov | 17 | Friday - 4 | 40.62 |
| 28-Nov | 18 | Monday - 4 | 50.71 |
| 29-Nov | 19 | Tuesday - 4 | 68.42 |
| 30-Nov | 20 | Wednesday - 4 | 64.11 |
| 1-Dec | 21 | Thursday - 5 | 53.15 |
| 2-Dec | 22 | Friday - 5 | 35.89 |
| 5-Nov | 23 | Monday - 5 | 44.67 |
| 6-Nov | 24 | Tuesday - 5 | 60.07 |
| 7-Nov | 25 | Wednesday - 5 | 56.09 |
| 8-Nov | 26 | Thursday - 6 | 46.33 |

From the decomposition model, we consider the forecast of only the first week. This is because, the data is in a declining trend, and so is the forecast, so if we take the average of forecasted per weekday, the value of the average will be decreased due to the declining values of future forecasts.
Comparing the two seasonal forecasting models:
As we do not have MAD in the seasonal indices method to compare with the MAD of the Decomposition method. We make a comparison based on Weekly assumed average sales.

Comparing both forecasts

| Date | Forecast period | Day of week | Forecast Seasonal Indices | Forecast Decomposition |
|---|---|---|---|---|
| 21-Nov | 13 | Monday - 3 | 99.96 | 56.76 |
| 22-Nov | 14 | Tuesday - 3 | 54.95 | 76.78 |
| 23-Nov | 15 | Wednesday - 3 | 76 | 72.13 |
| 24-Nov | 16 | Thursday - 4 | 103.47 | 59.97 |
| 25-Nov | 17 | Friday - 4 | 97.62 | 40.62 |

| | | |
|---|---|---|
| Avg sales (Forecast) | 86.4 | 61.252 |
| Forecasted Total sales (weekly) | 432 | 306.26 |
| | | |
| Avg Sales (Recorded) | 72 | 72 |
| **Avg Weekly sales** | **360** | **360** |
| | | |
| r (Correlation coefficient) | -16.30% | -16.30% |
| | | |
| Trend factor | 83.70% | 83.70% |
| | | |
| **Forecasted Total sales (weekly) / Trend Factor** | **516** | **366** |

We will proceed with the forecast from decomposition method as the values show more aligning results.

| Date | Forecast period | Day of week | Forecast Seasonal Indices | Forecast Decomposition | value |
|---|---|---|---|---|---|
| 21-Nov | 13 | Monday - 3 | 99.96 | 56.76 | 57 |
| 22-Nov | 14 | Tuesday - 3 | 54.95 | 76.78 | 77 |
| 23-Nov | 15 | Wednesday - 3 | 76 | 72.13 | 73 |
| 24-Nov | 16 | Thursday - 4 | 103.47 | 59.97 | 60 |
| 25-Nov | 17 | Friday - 4 | 97.62 | 40.62 | 41 |

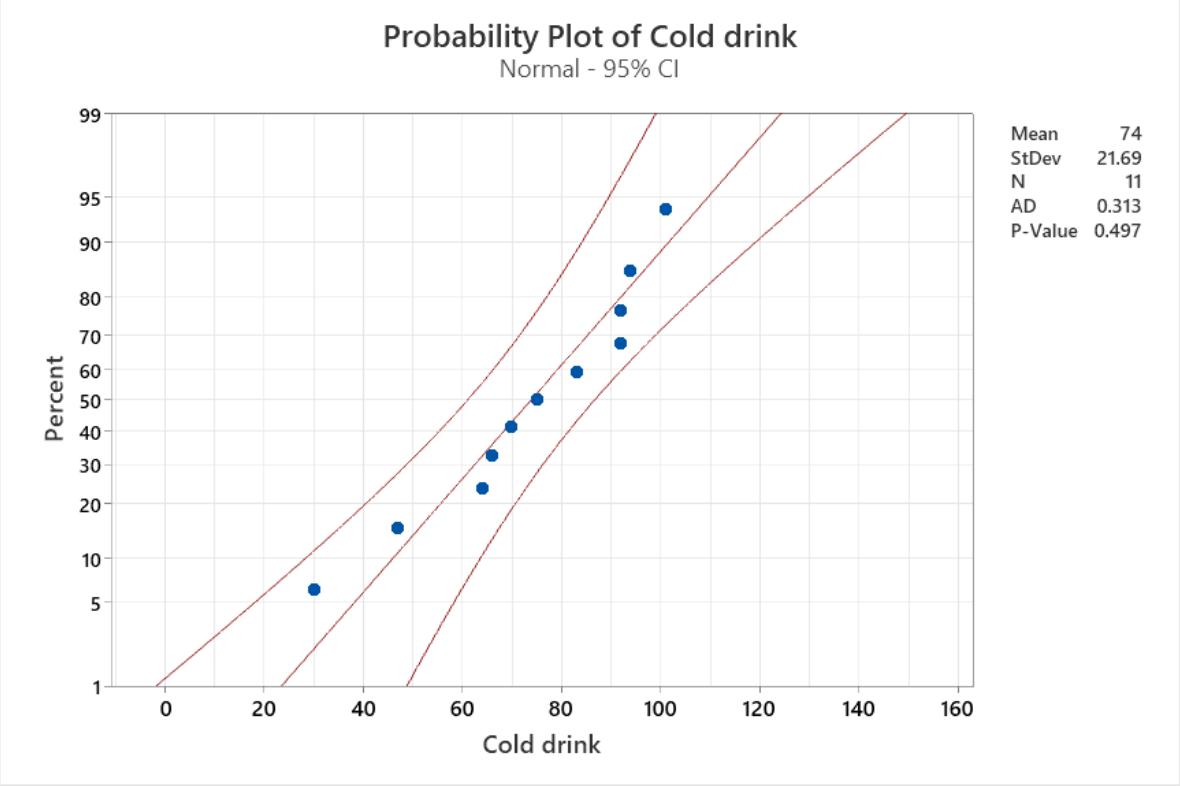
## 4.) For Safety Stock, we will employ the following methodology:

1.) Check if the data is normally distributed.

2.) If the data is normally distributed, then use safety stock for the normal data model.

3.) Find the ROP and safety stock for each day of the week.

## 1.) Check for normality:




The data is normally distributed within a 95% confidence interval. As per the above probability chart.

Since the data is normally distributed, we use the safety stock model for normal data.

- **Assumptions:**

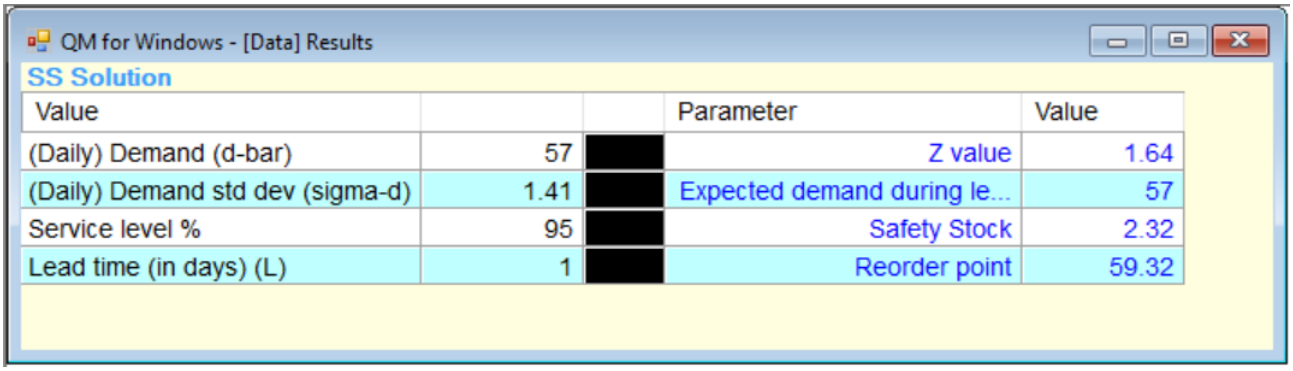
1.) Daily demand for the respective day of the week is the Forecasted quantity required for that particular day.
2.) The standard deviation of each day of the week is the standard deviation of the data recorded for each day.
3.) The Leadtime for ice is one day with a standard deviation of 0 days. As ice is collected overnight in the giant ice maker.
4.) Assuming a service level of 95% percent. (This is as per the store manager)

Below is the input table for QM:

| Date | Forecast period | Day of week | Forecast Decomposition | Daily demand (d) | Sigma d (SD) |
|---|---|---|---|---|---|
| 21-Nov | 13 | Monday - 3 | 56.76 | 57 | 1.414214 |
| 22-Nov | 14 | Tuesday - 3 | 76.78 | 77 | 7.778175 |
| 23-Nov | 15 | Wednesday - 3 | 72.13 | 73 | 12.02082 |
| 24-Nov | 16 | Thursday - 4 | 59.97 | 60 | 15.94783 |
| 25-Nov | 17 | Friday - 4 | 40.62 | 41 | 9.814955 |

## Following is the result for safety stock for each day:

1.) Monday (21-Nov)




- Safety Stock – 3 cups.

2.) Tuesday (22-nov)

QM for Windows - [Data] Results

SS Solution

| Value | | | Parameter | Value |
|---|---|---|---|---|
| (Daily) Demand (d-bar) | 77 | | Z value | 1.64 |
| (Daily) Demand std dev (sigma-d) | 7.78 | | Expected demand during le... | 77 |
| Service level % | 95 | | Safety Stock | 12.76 |
| Lead time (in days) (L) | 1 | | Reorder point | 89.76 |

- Safety stock – 13 cups.

3.) Wednesday (23-nov)

QM for Windows - [Data] Results

SS Solution

| Value | | | Parameter | Value |
|---|---|---|---|---|
| (Daily) Demand (d-bar) | 73 | | Z value | 1.64 |
| (Daily) Demand std dev (sigma-d) | 12.02 | | Expected demand during le... | 73 |
| Service level % | 95 | | Safety Stock | 19.71 |
| Lead time (in days) (L) | 1 | | Reorder point | 92.71 |

- Safety stock – 20 cups.

4.) Thursday (24-Nov)

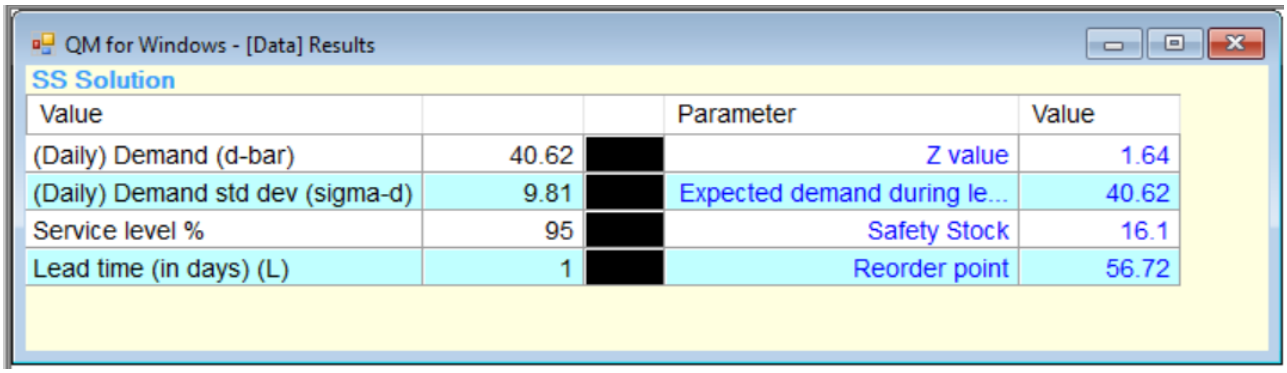
QM for Windows - [Data] Results

SS Solution

| Value | | | Parameter | Value |
|---|---|---|---|---|
| (Daily) Demand (d-bar) | 59.97 | | Z value | 1.64 |
| (Daily) Demand std dev (sigma-d) | 15.95 | | Expected demand during le... | 59.97 |
| Service level % | 95 | | Safety Stock | 26.15 |
| Lead time (in days) (L) | 1 | | Reorder point | 86.12 |

- Safety stock – 27 cups.

5.) Friday (25-Nov)




- Safety stock – 17 cups.

## Summary of Forecast and safety stock:

| Date | Forecast period | Day of week | Forecast Decomposition | Daily demand (d) | Safety Stock | **Day Starting Stock** |
|---|---|---|---|---|---|---|
| 21-Nov | 13 | Monday - 3 | 56.76 | 57 | 3 | **60** |
| 22-Nov | 14 | Tuesday - 3 | 76.78 | 77 | 13 | **90** |
| 23-Nov | 15 | Wednesday - 3 | 72.13 | 73 | 20 | **93** |
| 24-Nov | 16 | Thursday - 4 | 59.97 | 60 | 27 | **87** |
| 25-Nov | 17 | Friday - 4 | 40.62 | 41 | 17 | **58** |

## Content Analysis: -

## 3rd Nov Transcript:

*"On 3rd November (Thursday) at CSU East Bay in Einstein Bagels, there was a total beverage sale of 122 drinks and total orders (Inc. bagels, water, retail items) sale of 222. We can see there was a sale of 21 classic coffees in total that day. In the Cold brew section (CBS), there was a sale of a total 8 Classic CB and 23 Caramel CB, with a total of 24 vanilla CB and 6 chocolate CB. There were also three varieties in Shakes – Cold Brews (CBS), which goes as follows, there were*

*the total sales of 9 Caramel CBS with total vanilla CBS sales of 9 and total chocolate CBS sales of 9. In the end, we can see the total strawberry banana smoothy sales of 13, which completes the total sales of the day at Einstein Bagels on the 3rd of November."*

## For example

## Coding on 3rd Nov Transcripts

- a Large number of total sales.
- Same amount of sales in all CBS

***By using this coding system of content analysis, we got the overall summary of what happened at the 3rd of Nov.***

Similarly, we can use this system for other transcripts as well.

## 4th November Transcripts:

"On 4th November (Friday) at CSU East Bay in Einstein Bagels, there was a total beverage sale of 62 drinks and total orders (Inc. bagels, water, retail items) sale of 118. We can see there was a sale of 15 classic coffees in total that day. In the Cold brew section (CBS), there was a sale of a total 7 Classic CB and 9 Caramel CB, with total 13 vanilla CB and 7 chocolate CB. There were also three varieties in Shakes – Cold Brews (CBS), which goes as follows, there was the total sales of 5 Caramel CBS with tota1 vanilla CBS sales of 1 and total chocolate CBS sales of 3. In the end, we can see the total strawberry banana smoothy sales of 2, which completes the total sales of the day at Einstein Bagels on the 4th of November."

For example

## Coding on 4th Nov Transcripts

5.) **Vast deference in total beverage sales and total orders**

**6.) Very low amount of CBS sales**

**Result –** Here, we can see how useful this tool is to keep a record of what happened in the data and use it for further use if needed by keeping the coding system integrated into it.

## Narrative analysis: -

In a marketing research context, narrative analysis involves capturing and reviewing customers' stories – on social media, for example—to get more insight into their lives, priorities, and challenges.

**Here, we took the interview of Einstein bagels manager Veronica and tried to get some insights into how things work inside the shop.**

The 3 main motive of the interview was to know:

1. To know about manpower allotment at the counter
2. To know about the amount of ice used in a single shake.
3. To know about the classic coffee sales based on the season.

*Here, I am attaching the link to the video of the interview as proof and reference: Manager Interview.*

The transcript of the interview goes like this:

## Question 1

• *Interviewer – Hello, I would like to know about the manpower allotment of the employees at the counter on a working day.*

• *Manager – So as per our previous record of sales, we get more influx of customers in mid-week, like Wednesday and Thursday, so we keep at least 3 people on the counter to complete the orders received and comparatively allot fewer employees at the counter on week start like Monday and weekend like Friday as there is a smaller number of orders here.*

**Our Analysis – Einstein bagels get a smaller number of orders on week start and weekend compared to mid-week. Because of that, the manager allows more employees on Wednesday and Thursday.**

## Question 2

• *Interviewer – My next question will be, as I have heard from the employees of the shop that they use the same tumbler of Ice for every drink they make, does this affect on the taste of the drinks?*
• *Manager – Yes, it is true that we use the same tumbler of ice for every Drink, but we also change the ratios of other ingredients as per the size of the order. (More milk for a large cup and vice versa). By this, the taste of drinks remains the same no matter the size of the order.*

**Our Analysis – Even if they use the same tumbler of ice for measurements, they change the ratios of other ingredients to keep the taste constant for every order.**

## Question 3

• *Interviewer – My last question is what the Classic coffee sales is based on the seasons (Summer/ winter).*

• *Manager – From the sales, we have found out that in summers there are comparatively fewer sales of classic coffee and more sales in winter as there is colder in winters and people usually prefers hot beverages in this season.*

*Our Analysis – There are comparatively more sales in winter for classic coffee and fewer sales in summer.*

**Result –** Here, we can see that we got three insights from the interview we took with the shop's manager, which shows how effective the Narrative analysis method is in Qualitative data analysis.

## Successful link between Quantitative and Qualitative Analysis

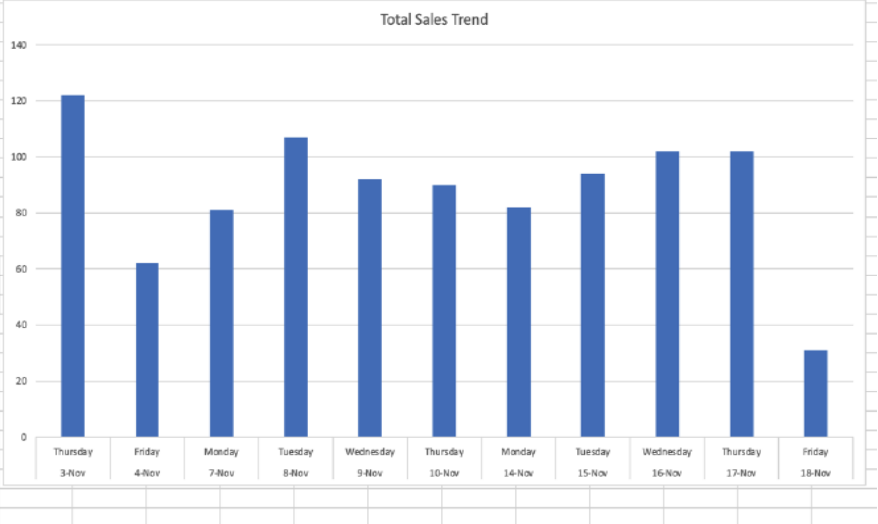
Our last take will be the proving of Narrative analysis by comparing it to the calculated data.

Here we have the total number of sales of beverages on each day from 3rd Nov to 18 Nov, as we analyze it by converting it into the histogram model, we can see that there is a repeated pattern in the total sales of beverages which shows that there are **"Higher number of sales on Tuesday, Wednesday and Thursday compared to the weekend like Friday" –**

Here is the histogram model of the data:

| Date | Day | Beverages Total | Total Orders |
|---|---|---|---|
| 3-Nov | Thursday | 122 | 222 |
| 4-Nov | Friday | 62 | 118 |
| 7-Nov | Monday | 81 | 268 |
| 8-Nov | Tuesday | 107 | 258 |
| 9-Nov | Wednesday | 92 | 247 |
| 10-Nov | Thursday | 90 | 257 |
| 14-Nov | Monday | 82 | 285 |
| 15-Nov | Tuesday | 94 | 242 |
| 16-Nov | Wednesday | 102 | 261 |
| 17-Nov | Thursday | 102 | 288 |
| 18-Nov | Friday | 31 | 95 |

| | Trend Observations |
|---|---|
| 1) | Trend shows the sales Increases from the start of the week, reaches its maximum and decreases as it reaches the weekend. |



*If you remember from analysis of Question 2 of narrative analysis, the store manager also mentioned, "So as per our previous record of sales, we get more influx of customers in mid-week like Wednesday and Thursday, so we keep at least 3 people on the counter to complete the orders received and comparatively allot fewer employees at the counter on week start like Monday and weekend like Friday as there are a smaller number of orders here."*

Here, we can see the successful linkup between our qualitative and quantitate analysis of the data as it gives the same insight in the end.

## Conclusion:

- There is a visible declining trend in consumption with correlation coefficient of negative 0.16.
- The data shows seasonal consumption with respect to the weekdays.
- Forecasting for next week as per the data:

| Date | Day of week | Forecast |
|---|---|---|
| 21-Nov | Monday | 57 |
| 22-Nov | Tuesday | 77 |
| 23-Nov | Wednesday | 73 |
| 24-Nov | Thursday | 60 |
| 25-Nov | Friday | 41 |

- Safety stock for next week as per the data:

| Date | Day of week | Safety Stock |
|---|---|---|
| 21-Nov | Monday | 3 |
| 22-Nov | Tuesday | 13 |
| 23-Nov | Wednesday | 20 |
| 24-Nov | Thursday | 27 |
| 25-Nov | Friday | 17 |

2. From the Narrative analysis, we can see that we got three insights from the interview we took with the shop's manager, which shows how effective the Narrative analysis method is in Qualitative data analysis.

3. In the end, we can also see that there is a visible connection between our qualitative method (narrative analysis interview insights) and quantitative calculation, which proves our analysis was successful.

**Shortcomings and Suggested improvements:**

1.) The data collected is only for 2 weeks, giving the average of only 2 samples for each week day. To perform the same calculation for Ice consumption with respect to respective week day with more accuracy we need data for at least few more weeks.

2.) The Optimal quantity for ice is calculated by taking 2 weeks data and the regression shows a trend in consumption. Hence the forecast for only the subsequent week can be considered suitable. For the forecast of further weeks, continuous input of data is required of current week to forecast for next week. Hence this is a perpetual system.

3.) The data collect was for drinks and in the season of winter, drink consumption ratio is bound to change subjected to change in seasons and weather. This is as per the experience of the store manager. Hence, the model should be followed with diligence and in continuation to capture the trend when the season changes.

4.) Ice stocking per day is suggested as per the proposed model, and required quantity should be conveyed to delivering department a day prior. This means there are 3 critical tasks and nodes in this system.

   I. The Order quantity for next day should be calculated, captured and conveyed without fail to the ice storage.

   II. The person at Ice storage should record the order and forward it to the logistics without any margin of error.

   III. Logistics have to ensure timely and correct delivery else there will be a loss of sales until ice is delivered in the start of the day.

5.) The value of development, process implementation and resources required for this model to work will surpass the monetary gain, ice being a class – C resource. However, these being single time costs, once the introduction curve of system is over, the business will recover the cost by avoiding loss of sales in the long run.

**References used:**


https://www.investopedia.com/terms/n/normaldistribution.asp

https://www.sciencedirect.com/science/article/pii/S2352484720316644

Quantitative Analysis for Management THIRTEENTH EDITION by Barry Render • Ralph M. Stair, Jr. • Michael E. Hanna • Trevor S. Hale


**REFERENCES TO RELATE**

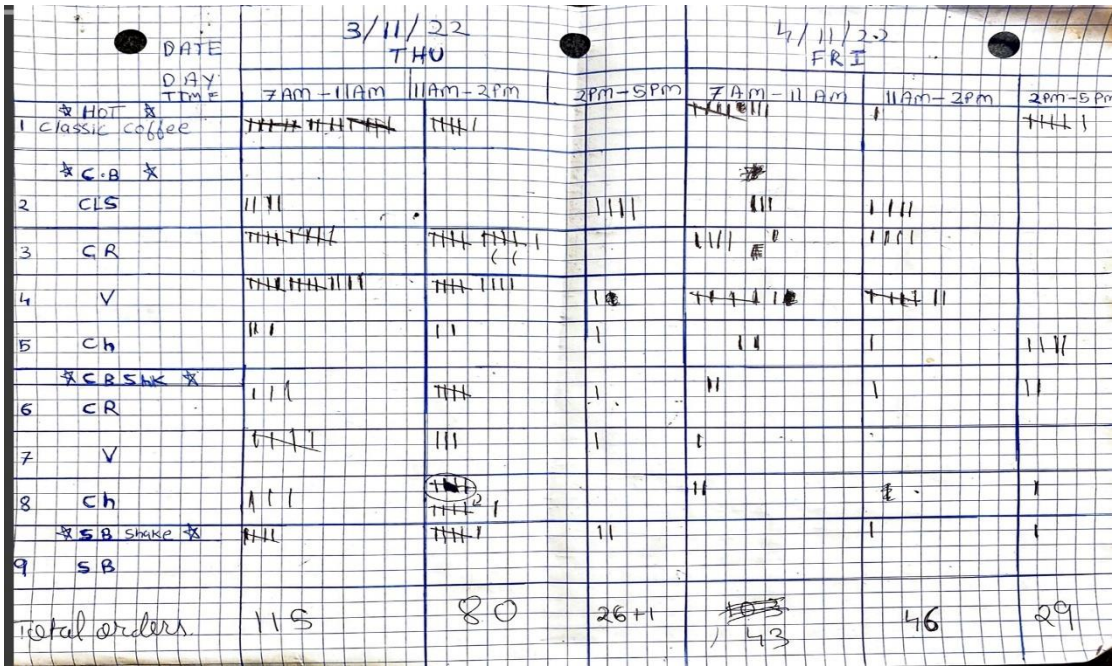
**TUMBLER USED FOR ICE -16(oz).**

**SIZE OF THE ICE FOR REFERENCE**


**The two sizes of cups being used by the business entity**

- **Small size cup - 532 ml**
- **Large size cup - 710 ml**

# RAW DATA



| DATE | 3/11/22 THU | | | 4/11/22 FRI | | |
|---|---|---|---|---|---|---|
| DAY TIME | 7AM–11AM | 11AM–2PM | 2PM–5PM | 7AM–11AM | 11AM–2PM | 2PM–5PM |
| ☆HOT☆ | | | | | | |
| 1 Classic coffee | 𝍸 𝍸 𝍸 | 𝍸 | | 𝍸 | 1 | 𝍸 1 |
| ☆C.B☆ | | | | | | |
| 2 CLS | 11 11 | | 1111 | 1111 | 1 111 | |
| 3 CR | 𝍸 𝍸 𝍸 | 𝍸 𝍸 1 | | 1111 | 1111 | |
| 4 V | 𝍸 𝍸 𝍸 | 𝍸 1111 | 1 | 𝍸 𝍸 | 𝍸 11 | |
| 5 Ch | 11 1 | 11 | 1 | 11 | 1 | 111 |
| ☆CBSbK☆ | | | | | | |
| 6 CR | 111 | 𝍸 | 1 | 11 | 1 | 11 |
| 7 V | 𝍸 1 | 111 | 1 | 1 | | |
| 8 Ch | 111 | 𝍸 1 | | 11 | 1 | 1 |
| ☆SB Shake☆ | | | | | | |
| 9 SB | 𝍸 | 𝍸 1 | 11 | | 1 | 1 |
| Total orders | 115 | 80 | 26+1 | ~~103~~ 43 | 46 | 29 |

| Sr. no | | Date: 7 NOV 2022<br>Day: Monday<br>Time Slot: 7 am - 11 am Morning | 11 am - 2 pm Afternoon | 2pm - 5pm Evening |
|---|---|---|---|---|
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 111 | 11 | 1 |
| | **Cold Brews** | | | |
| 2 | Classic CB | 1111 | 1111 | |
| 3 | Caramel CB | 𝍸 11 | 𝍸 𝍸 1 1 | |
| 4 | VanillaCB | 111 | 𝍸 𝍸 | |
| 5 | Chocolate CB | 111 | 11 | |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | 111 | 1 | 11 |
| 7 | VanillaCBS | 111 | 𝍸 | 1 |
| 8 | Chocolate CBS | | 𝍸 1 | |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | 1 | 111 | 1 |
| | **Total Orders (Inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 109 | 128 | 31 |

8th nov 2022

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | 11/08/2022 | | |
| | Day | Tuesday. | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 𝍸 \| | \|\| | |
| | **Cold Brews** | | | |
| 2 | Classic CB | \|\|\| | \|\| | |
| 3 | Caramel CB | 𝍸 𝍸 𝍸 \|\|\|\| | \|\| | \|\|\| |
| 4 | VanillaCB | \|\|\|\| | 𝍸 \|\|\| | \|\|\| |
| 5 | Chocolate CB | 𝍸 | \|\|\| | 𝍸 |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | 𝍸 \| | \|\|\| | \|\| |
| 7 | VanillaCBS | 𝍸 \| | \|\| | |
| 8 | Chocolate CBS | 𝍸 | \|\| | \|\| |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | \|\|\| | \|\| | |
| | **Total Orders (Inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 124 | 91 | 43 |

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | 9 nov 2022 | | |
| | Day | wed | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 𝍸 \| | \|\|\|\| | \|\| |
| | **Cold Brews** | | | |
| 2 | Classic CB | \|\|\| | 𝍸 | \|\| |
| 3 | Caramel CB | 𝍸 | \|\|\| | \| |
| 4 | VanillaCB | 𝍸 \|\|\|\| | \|\|\|-\|\| | \| |
| 5 | Chocolate CB | 𝍸 𝍸 | \|\|\| | \|\| |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | \|\| | \|\|\| | \| |
| 7 | VanillaCBS | | \|\| | |
| 8 | Chocolate CBS | \|\|\| | 𝍸 | \| |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | \|\|\| | \|\|\| | |
| | **Total Orders (Inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 108 | ~~108~~ 107 | 32 |

9 nov
8 nov
7 nov

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | 10 nov | | |
| | Day | Thu | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 𝍸 \|\|\| | \|\|\|\| | \|\| |
| | **Cold Brews** | | | |
| 2 | Classic CB | \| | 𝍸 𝍸 | \| |
| 3 | Caramel CB | 𝍸 \|\| | \|\|\| | \| |
| 4 | VanillaCB | 𝍸 \| | 𝍸 \|\| | \|\| |
| 5 | Chocolate CB | \|\|\| | \| | |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | \| | \|\| | \|\| |
| 7 | VanillaCBS | \|\| | \| | |
| 8 | Chocolate CBS | \|\| | \|\|\| | \|\|\| |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | \|\|\| | \|\|\|\| | |
| | **Total Orders (inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 114 | 104 | 35 / 3:31pm \| +4 = 39 |

9th nov → 32

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | ~~13~~ 14 Nov | | |
| | Day | | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 𝍸 \|\| | \|\| | \|\| |
| | **Cold Brews** | | | |
| 2 | Classic CB | \| | \|\|\| | \| |
| 3 | Caramel CB | 𝍸 \| | 𝍸 \|\| | \|\|\| |
| 4 | VanillaCB | \|\|\| | 𝍸 \| | \|\|\| |
| 5 | Chocolate CB | \|\|\| | \| | |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | \|\|\| | \|\|\| | \| |
| 7 | VanillaCBS | \| | | \| |
| 8 | Chocolate CBS | ( ) \| | \|\| | \|\| |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | 𝍸 | 𝍸 | |
| | **Total Orders (inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | ~~37~~ 102 | ~~30~~ 131 | 15 52 |

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | 16 Nov | | |
| | Day | | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 | 11 | 111 |
| | **Cold Brews** | | | |
| 2 | Classic CB | 𝍸 | 11 | 1 |
| 3 | Caramel CB | 𝍸 𝍸 111 | 1111 | 𝍸 1 |
| 4 | VanillaCB | 𝍸 𝍸 1 | 𝍸 𝍸 | 11 |
| 5 | Chocolate CB | VIC | | 𝍸 1 |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | 1111 | 𝍸 | |
| 7 | VanillaCBS | 1 | 111 | |
| 8 | Chocolate CBS | 111 | 𝍸 | 1 |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | 𝍸 | 111 | |
| | **Total Orders (inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 131 | 99 | 31 |

| Sr. no | | | | |
|---|---|---|---|---|
| | Date | 17th NOV 22 | | |
| | Day | | | |
| | Time | 7 am - 11 am | 11 am - 2 pm | 2pm - 5pm |
| | Slot | Morning | Afternoon | Evening |
| | **Hot Bevrg** | | | |
| 1 | Classic Coffee | 𝍸 111 | 1 | |
| | **Cold Brews** | | | |
| 2 | Classic CB | 1111 | 11 | 11 |
| 3 | Caramel CB | 𝍸 𝍸 11 | 𝍸 𝍸 𝍸 1 | 1 |
| 4 | VanillaCB | 𝍸 1111 | 𝍸 1 | 1 |
| 5 | Chocolate CB | 111 | 111 | |
| | **Shakes - Cold Brew** | | | |
| 6 | Caramel CBS | 𝍸 | 1 | 1 |
| 7 | VanillaCBS | 1 | 11 | 11 |
| 8 | Chocolate CBS | 𝍸 11 | 𝍸 11 | 11 |
| | **Strawberry Banana** | | | |
| 9 | SB Smoothy | 111 | | 1 |
| | **Total Orders (inclusive of all items i.e bagles, water, retail items etc)** | | | |
| 10 | Total | 132 | 112 | 32 + 11 = 43 + 1 (3:33pm) |

+1 44

**Personal Paragraph of Inference, Takeaways, experience and suggested improvements**.

Name: Tanmay Tuscano
Net Id: HS1657

**Project: Forecasting Ice Consumption and suggested safety stocks at Einstein Bros bagel ®.**

## Inference:

**1.) Regression:**

- Coefficient of determination $r^2$ = 0.026, which says that the regression line describes just the 2.6% of the data. This is unacceptable for this model to be selected for forecasting.
- Correlation coefficient r is negative 0.163 (-0.163) which shows a declining regression line.
- Moreover, the Correlation coefficient and the graph makes it quite evident that there is a miniscule decreasing trend to the data.
- The above points and graphical outcomes are sufficient to conclude that the data follows a significant cyclic/season trend as well, which can be model with accuracy with other forecasting method such as seasonal indices, and even more effective method with respect to this data would be the multiplicative decompression method, as the data displays both trend as well as seasonal component.

**2.) Decomposition forecast:**

- From decomposition model we take into consideration forecast of only first week. This is because, the data is in declining trend and so is the forecast, so if we take average of forecasted per week day, the value of average will be decreased due to the declining values of future forecasts.
- When there is a trend along with seasonality in data, decompositions model gives more accurate output as compared to seasonal indices model.

## Takeaways:

1.) Thorough understanding of concepts of Forecasting, Regression, Inventory control and safety stock under normal distribution.
2.) Practical application of these concepts.
3.) Use of POM QM application for practical problems.

## Suggestions and improvement:

1.) The Optimal quantity for ice is calculated by taking 2 weeks data and the regression shows a trend in consumption. Hence the forecast for only the subsequent week can

be considered suitable. For the forecast of further weeks, continuous input of data is required of current week to forecast for next week. Hence this is a perpetual system.

**2.)** The data collect was for drinks and in the season of winter, drink consumption ratio is bound to change subjected to change in seasons and weather. This is as per the experience of the store manager. Hence, the model should be followed with diligence and in continuation so that the model can capture the trend when the season changes