Forecasting Student Numbers at USF's Feed-A-Bull Pantry

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***Abstract*—We have gathered survey data of the students coming into the USF Feed-a-Bull pantry over the last 4 years (2018-2022). Our objective is to estimate the number of students who might visit the pantry in the future as well as draw some insights from the collected data. In this paper, we utilize time-series forecasting models in addition to data visualization tools to present the findings of our analysis. We present results of trends over the last 4 years, forecast future numbers using prediction models, and ideate on what could potentially be done to make the system more efficient.**

Introduction

A university food pantry is located inside or close to a university, for both students and staff, free food is available in a university pantry. These pantries work along with local nonprofit organizations, national food banks like Feeding Tampa, and university authorities to help students who require extra assistance paying for groceries. However, they don't merely apply to employees and students- many pantries offer their services to anyone who needs it.

Under Student Health Services (SHS) at USF, there exists a similar food pantry for students on the Tampa campus. Feed-A-Bull, an initiative spearheaded by Student Health Services and Feeding America Tampa Bay, strives to alleviate food hardship and hunger among all enrolled USF students by providing supplemental food, nutrition education, and resources to **any student in need -- whatever their situation** -- to ensure their academic success at USF. The confidential pantry was created as a response to the knowledge that approximately 30 percent of students face food insecurity while attending university for a variety of reasons, and supplemental food assistance may allow these students to focus on their studies. There are two ways in which students can avail these services, either by ordering it online and scheduling a pick-up date or a drop in option where the students can hand-pick the items.

Motivation

COVID-19 was declared a global pandemic by the World Health Organization on March 11, 2020. As the world enters the third year of a crisis that has claimed so many lives and livelihoods, one of the most difficult challenges has been dealing with food security.

Thirty-five million Americans, or 10.5% of US families, experienced food insecurity the year before the current COVID-19 pandemic. Since March 2020, this number has increased dramatically; some experts believe the rate has doubled. Before the pandemic, a staggering 30 percent of all college students experienced insecurity at some point in their college careers. Based on the most recent Hope Survey from the fall of 2020, 38% of two-year college students and 29% of four-year college students reported food insecurity.

College students' academic performance and health can suffer because of food insecurity. Students who are food insecure are more likely to report stress and depression symptoms. The impetus for this paper is to try to find significant factors that cause of food insecurity among college students. We also want to scout the most correlated factors, causing this food insecurity, and compare them to pre-pandemic data.

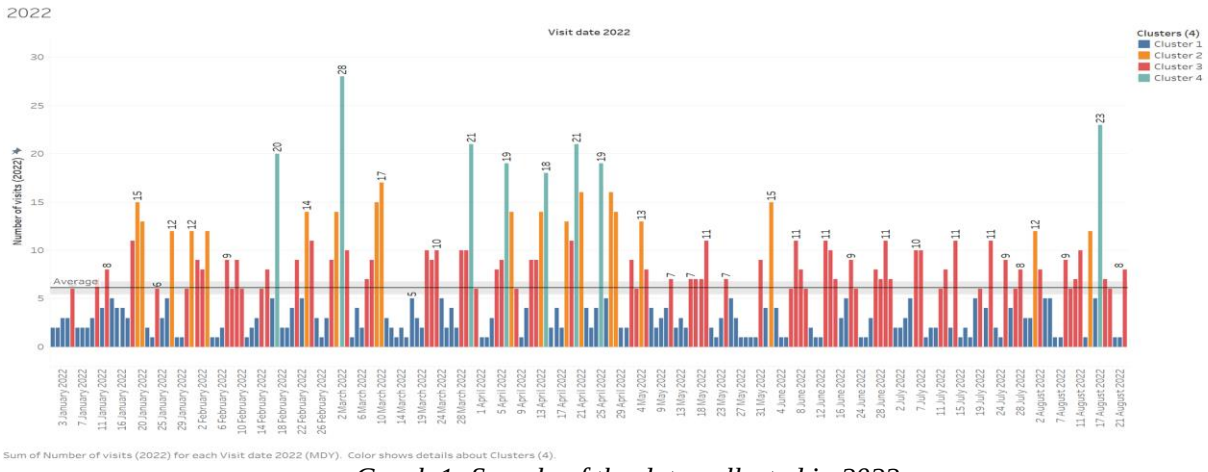
Business Objective

- To predict the number of students who will be visiting weekly to Feed-A-Bull.
- To provide data-driven insights by comparing the statistics pre-pandemic and post-pandemic data.
- To summarize the category of students who will be most vulnerable to experiencing food insecurity.

Data

During operating hours, students have two options for collecting supplies. They can walk in or place a private online order for customized foods. Either way, a student is given a survey form to be filled out before he/she can place an order. We have gathered the survey data from the Fall to Summer semesters from the year 2018 to August 2022. The variables considered for the analysis are shown in the below table, and a sample bar graph of the data collected in the year 2022 is shown in Graph 1.

Variable	**Description**
Date	The date on which the student visited the pantry. Values range from 22-Aug-2018 to 22-Aug-2022.
UID	Student ids (Anonymized)
is.first.time	Whether it is a student's first time visiting the pantry
is.employed	A student's employment status
is.food.bought.insufficient	Whether food bought in the last 30 days was insufficient
is.affordable.balanced.meal	Whether the meals a student could afford were nutritiously balanced
inadequate.meal.size.due.to.funds	Whether a student could afford adequate meal portions
insufficient.money.for.food	Whether a student had sufficient funds for food
cut.or.skip.meal	Whether a student had to cut or skip meals
frequency.cut.or.skip.meal	Frequency of the meals skipped



Graph 1: Sample of the data collected in 2022

Methodology

Exploratory Data Analysis

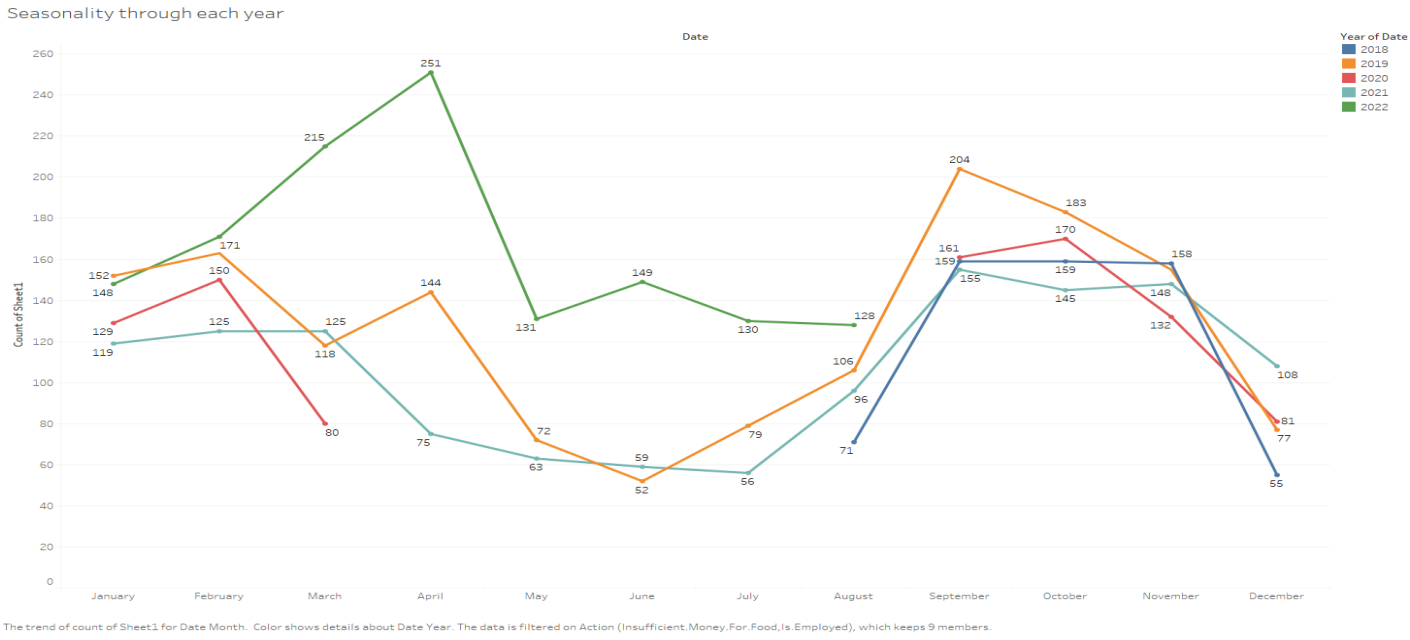
We were provided with 4 flat files of survey data from the Fall to Summer semesters from 2018 through 2022 of the students visiting the pantry. The survey consisted of some basic questionnaires regarding the food insecurity of the students. We cleaned the data and considered a few key variables that were common across all the files for this analysis.

- **Seasonality**

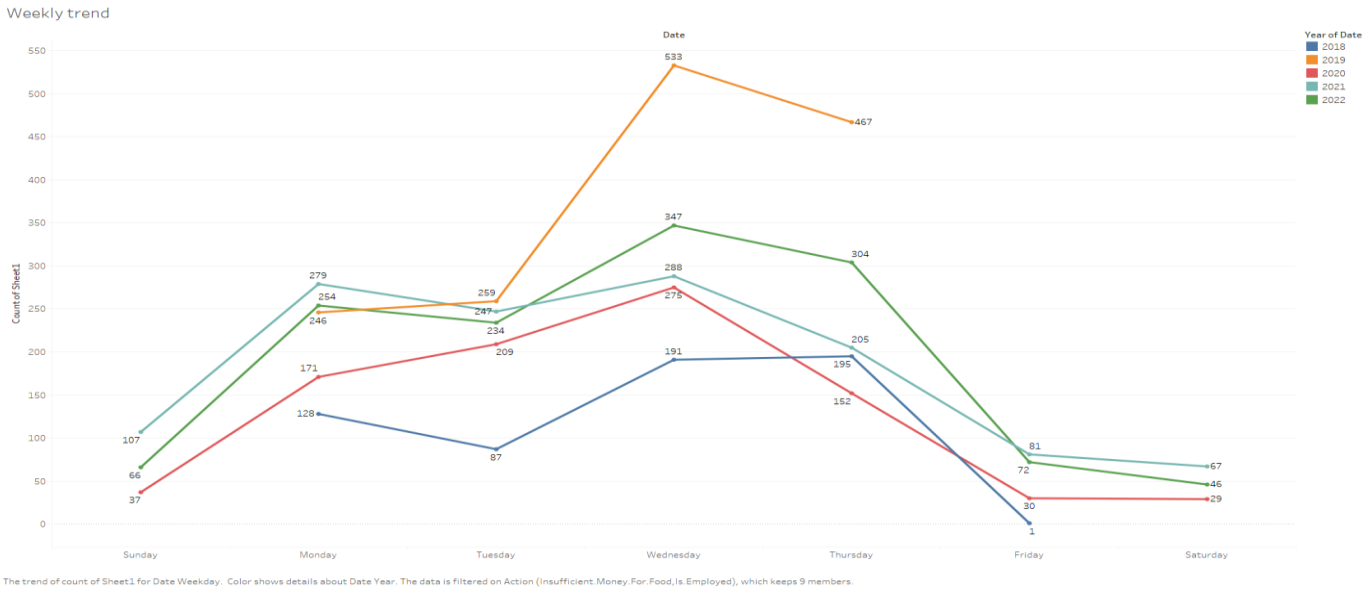
We observed fairly consistent trends during certain months, the following line graph (Graph 2) depicts the seasonality of the number of visitors to the pantry. While there is no significant long-term trend throughout these years, we observe that the months of March and April experience a spike in the number of visitors, followed by a gradual decline towards summer. August and September were the busiest months until 2022, with a significant increase in the numbers as compared to other months. There was no data collected from March 2020 to September 2020 due to Covid-19 closures.

- **Weekly Trends**

Graph 3 depicts the weekly trends associated with the number of students visiting the pantry. We observe definite peaks during Wednesdays, followed by a slight decline during Thursdays, which seem to be the busiest days of the pantry. After a slight fluctuation, these graphs level off after Fridays, with Saturdays having the least number of visitors.



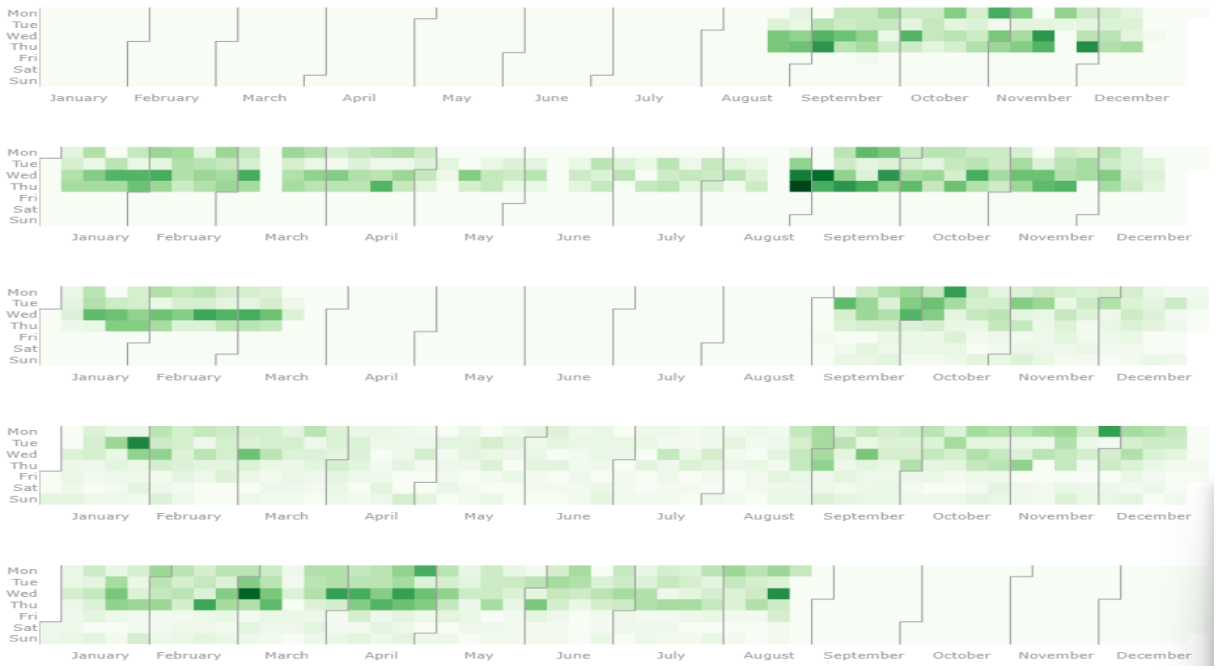
Graph 2: Long term trend in the number of visits.



Graph 3: Seasonality week-wise in the number of visits

- **Calendar Heatmap**

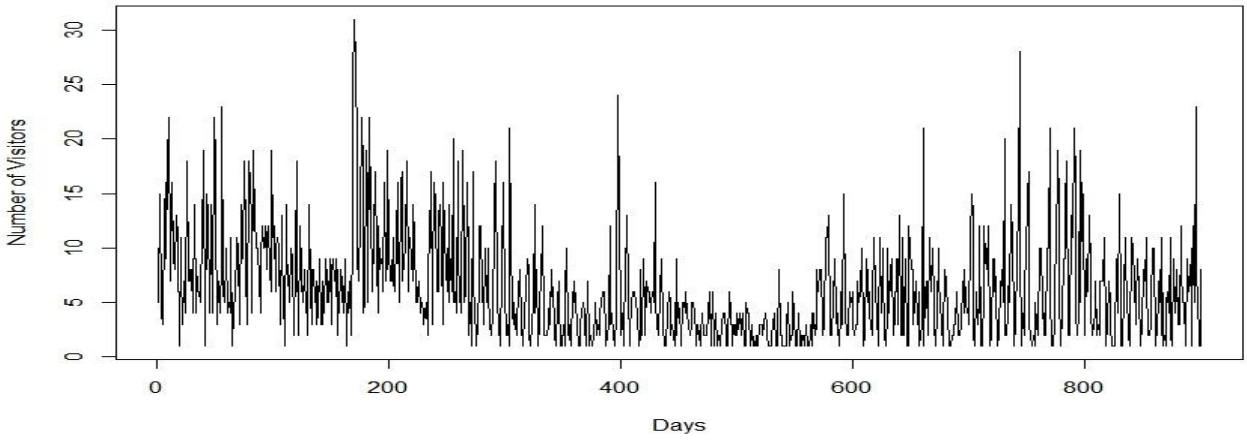
The following calendar heatmap shows daily and weekly trends as the relative number of visitors every day in a calendar view. Individual cells use color gradients to represent the data.



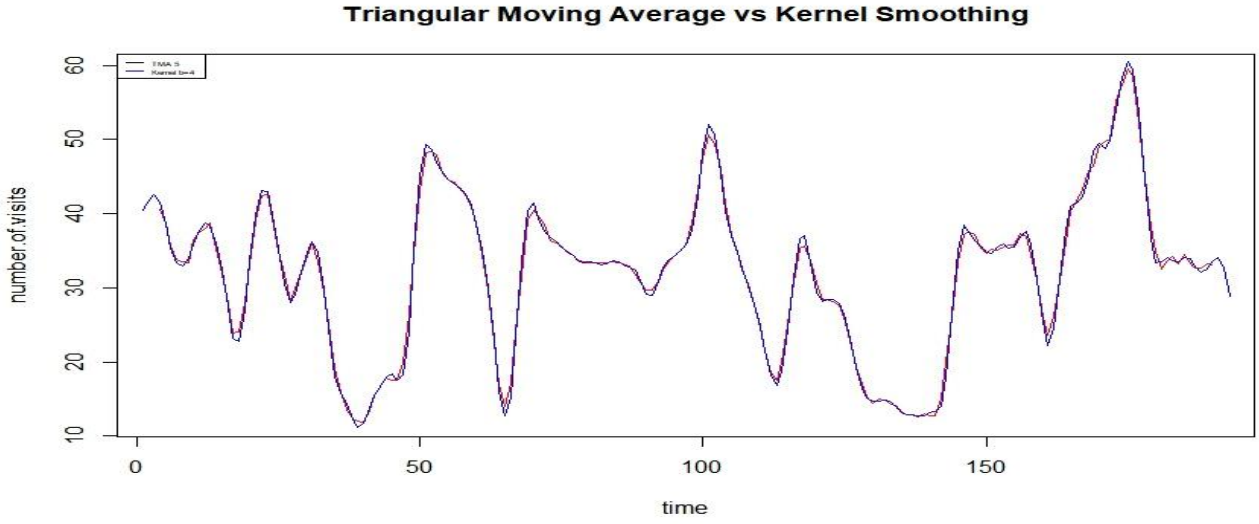
Graph 4: Calendar heatmap for visitor numbers from 2018-2022.

- **Data Smoothing**

Graph 5 depicts the daily trends in the number of visitors to the pantry, however, the data is too noisy to interpret the seasonality. To fix that, we explored two different techniques of data smoothing, namely Triangular Moving Average and Kernel Smoothing. As observed in Graph 6, Kernel smoothing, which takes weighted averages regulated based on a kernel function, performed slightly better with a smoother curve at a bandwidth of 4.



Graph 5: Seasonality for each day from 2018-2022



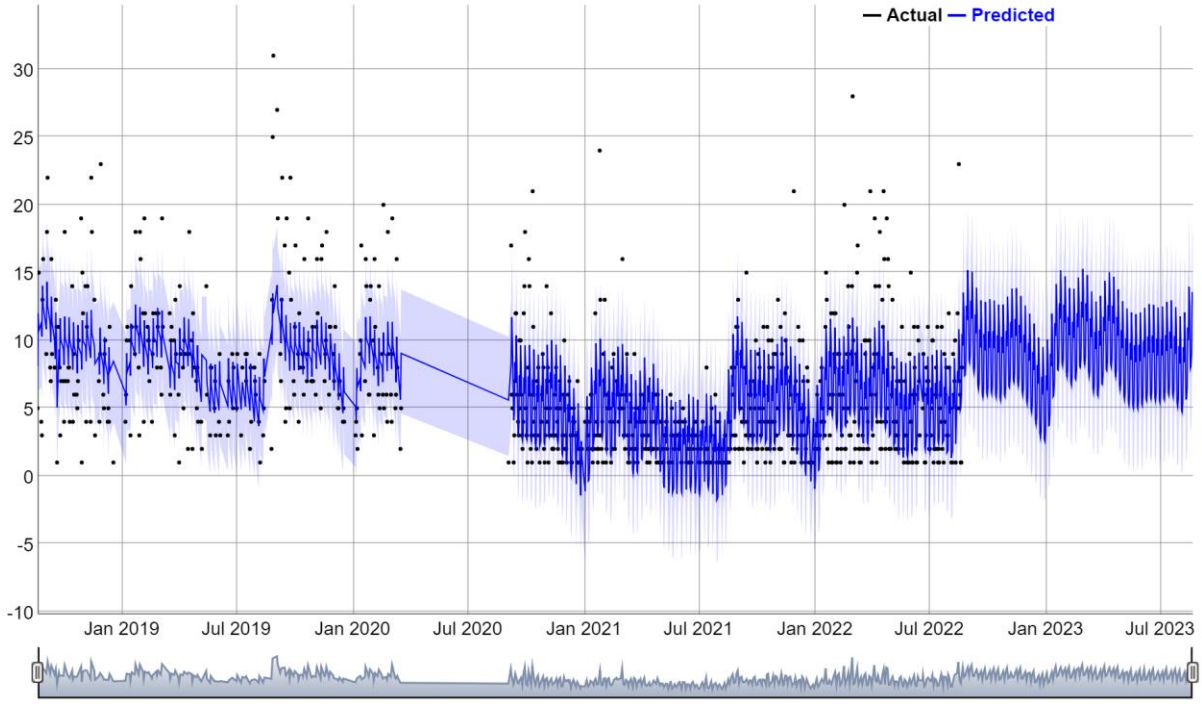
Graph 6: TMA vs Kernel Smoothing Technique

Results

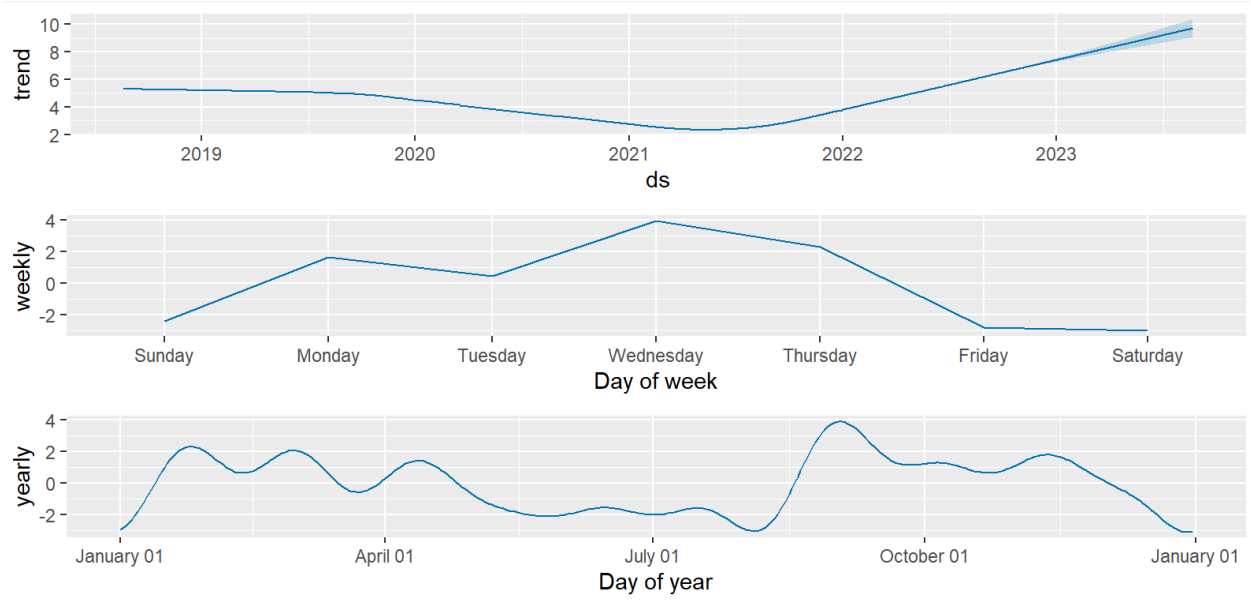
Time Series Analysis using Prophet

The key objective of this study was to predict the number of students visiting the Feed-A-Bull pantry during the next few months. To perform a time series analysis, we used the Prophet package released by Facebook's data science team to forecast the number of visitors. Since the results from exploratory data analysis containing several seasons of historical data showed seasonal effects, prophet was the ideal tool for predicting changes in trends of this data.

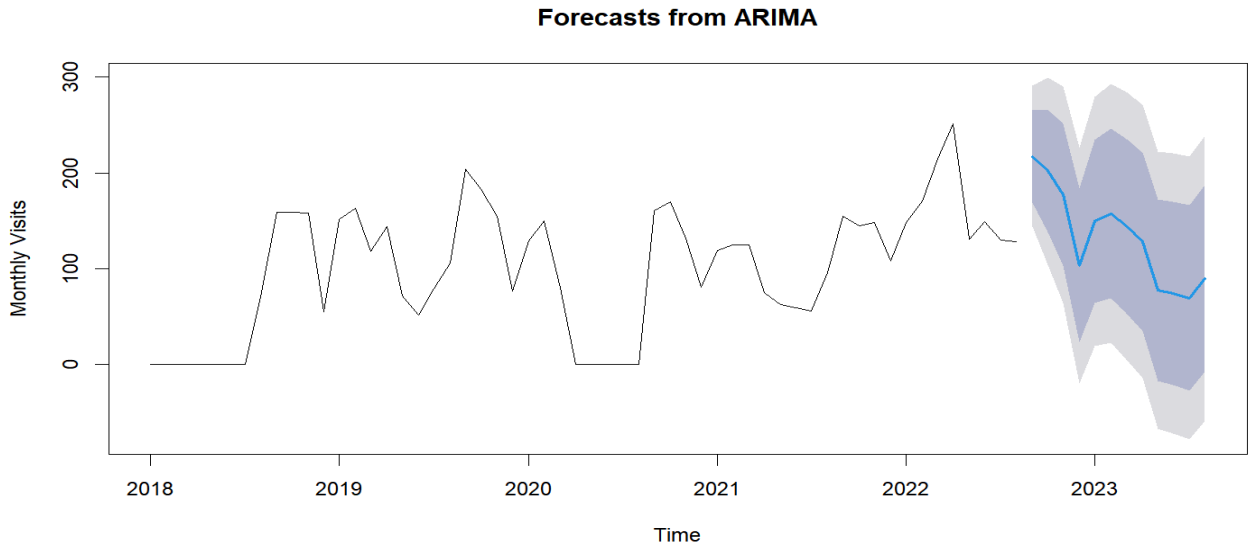
Graph 7 shows the model fit using Prophet. We can observe that the trend has been fairly stationary throughout the five-year period. However, we observe that the numbers have increased steeply in 2022, beginning from the fall semester. The weekly component shows that the numbers peak on Wednesdays and Thursdays and the graph goes on through June 2023 indicating the future likely trend.



Graph 7- Actual vs. Prophet predicted values and a forecast for 365 days in Prophet.



Graph 8- Model components



Model Evaluation Results

Diagnostics

- **Cross validation**

Prophet includes functionality for time series cross validation to measure forecast error using historical data. This is done by selecting cutoff points in the history, and fitting the model for each of them using data only up to that cutoff point. We can then compare the forecasted values to the actual values.

The initial model will be trained on the first 600 days of data. It will forecast the next 60 days of data (because horizon is set to 60). The model will then train on the initial period + the period (1,825 + 30 days in this case) and forecast the next 60 days. It will continue like this, adding another 30 days to the training data and then forecasting for the next 60 until there is no longer enough data to go on.

In summary, period is how much data to add to the training data set in every iteration of cross-validation, and horizon is how far out it will forecast.

```
cv_results = cross_validation(mod, initial = '600 days', horizon = '60 days', period = '30 days')
```

```
evaluate(cv_results['y'], cv_results['yhat'])
```

```
{'MAE': 2.974089164511313,
 'MSE': 16.349755124138355,
 'RMSE': 4.043483043631858}
```

RMSE tells you how many units your model is wrong on average. In our data, the RMSE will tell you how many students you can expect the model to miss in every forecast.

In a nutshell — on an average day, the predictions are off by 4.

Conclusions and Implications

- The model seems to predict a sharp rise in the numbers compared to the previous semesters.
- The model needs to be tuned by having an additive trend with a multiplicative seasonality into it.
- Change points where there is a sharp rise (During August and January) identify these seasonal change points and provide it to the model.
- The data currently collected by the pantry is weak and of itself not too reliable with its predictions since no other factors are being recorded. However, there is plenty of scope of improvement and building better models with deeper, richer data and helping Feed-A-Bull in the months to come.