# BPJ 420
# Final Project Report

Sugo
Bryanpark

A operations research approach to work scheduling aimed at identifying and assigning the minimum staffing qualities to meet Sugo Bryanpark's client satisfaction requirements in an uncertain dynamic demand.


Name: Emile Garrett Van Den Berg
Student Number: 29262314
Project Leader: Tanja Olckers

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# Declaration of originality

I, Emile Garrett Van Den Berg, student number 29262314 hereby declare that this report is my own original work, and that the references listed provides a comprehensive list of all sources cited or quoted in this report.

# Executive Report

Work scheduling in the restaurant industry is an often neglected task due to the abnormal complexities of having to allocate multi-skilled staff over multiple overlapping shifts to meet dynamic demand. Client satisfaction is a significant aspect of the industry, in which the time to produce is almost as important as the quality of the food. Thus it is vital for a restaurant to be able to anticipate and meet demand.

It is found that the use of quantitative (formula driven) methods does not ensure higher accuracy in both the forecasting and work-scheduling, but rather when used in combination with qualitative (experience input) is the accuracy majorly increased.

The forecast model operates on data gathered from the point of sale system, and is then reworked into 100 different time intervals over the course of each day in a week. The output is then validated and adjusted before it is imported into the work-schedule function. The work-schedule function is able to output the ideal work schedule per staff member while also illustrating the shortages and surplus staff per time interval.

This then allows the manager to ensure that service delivery is met as efficiently as possible.

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# 1 Introduction and Background

## 1.1 Problem Background

Sugo Bryanpark is a unique restaurant situated in Bryanston, Johannesburg. It is unique on the basis that it has received the Rosetta Award for Excellence, in the Best Coffee Shop category, for five years running by the Restaurant Association of South Africa. However, Sugo Bryanpark is not just a simple cafe. It is a fully-fledged restaurant boasting over 370 different menu ordering options. Sugo operates seven days a week, weekday times from 6:00 am to 9:00 pm. The restaurant can seat 96 patrons, has 24 staff members, six different departments and produces over 11 000 orders a month. (*www.sugobryanpark.co.za*, 2017)

The restaurant industry is a highly competitive and complex industry. This is due to the extreme requirements of quality, and the turn-around time required on every item produced. Demand fluctuates on a constant basis. The competitive nature of the industry and the customers expectations results in a higher emphasis on turn-around, quality and price. Thus it is more important than ever to be able to have an ability to forecast demand, and create a methodology that enables the restaurant to have the necessary skill-sets ready to meet the demand. However, having the necessary staff/skill-set requires some basic considerations:

1. All staff are full-time employees, thus staffing levels cannot simply be adjusted.
2. Sustainability needs to be considered; therefore staff need to have sufficient rest periods between shifts
3. The hiring of additional staff is not feasible due to the need of avoiding additional overhead costs.

Work Scheduling is a tedious and arduous task to perform, therefore the task is not focused on resulting in no qualitative planning being conducted. At present the work roster is primarily focused on balancing staff working hours to ensure that everyone meets their minimum obligated time. Little to no consideration is given to demand or skill-set balancing.

## 1.2 Rational of Research

Work scheduling is a common industry problem that is not unique to just Sugo Bryanpark. It is a tedious, unrewarding task because there are so many considerations that need to be regarded. Namely:

1. Balancing work hours for all staff so that paid over-time hours are kept to a minimum, while also ensuring that all other staff work their contracted hours.
2. Balancing the shift allocation to accommodate the staff that are unable to work certain shifts.

3. Attempting to forecast demand for the whole month ahead, and balance the staffing requirements.

4. Ensuring that the Basic Conditions of Employment Act for rest and maximum work hours are adhered to.

The ability to forecast demand is another momentous task. This is due to:

1. Seasonality: Each seasons demand characteristics are fundamentally different.

2. Day of the week trends: Each day in the week has its own unique characteristics in terms of demand patterns and customer ordering preferences.

3. Different departments: Each department has their individual demand trends, with their own characterises of staffing skills and turnaround times.

4. Time to serve: A major consideration is the fallacy of averages. On average it may appear that the demand can be met easily, however the focus needs to be placed on having to meet demand over each and every short period of time This is because clients are only willing to wait a few minutes for their orders.

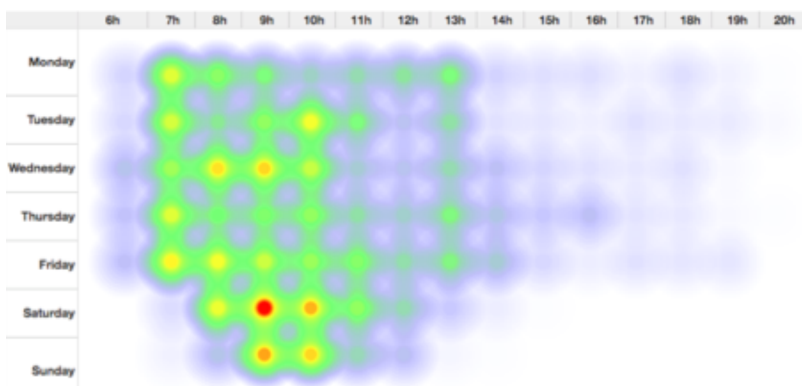


Figure 1: A heat map showing the times in the day that a Cappuccino Grande is ordered


Figure 2: A heat map showing times in the day that a Margherita is ordered

A good example to illustrate this is the difference between the ordering pattern of a *Cappuccino Grande Sit Down Coffee* versus a *Margherita Pizza* order. The heat map illustration, as seen in **Figure 1** shows the cumulative orders for a cappuccino from the 01/01/2017 to 26/03/2017. It is evident that considerable planning needs to be in place to ensure that demand is met in the red periods. The less demanding times are illustrated in the blue and purple periods where it would be acceptable to have a lesser skilled staff member during those shift times. In comparison **Figure A** indicated when Margherita Pizzas are ordered; this is a clear illustration of how demand dramatically differs per department and day of the week.

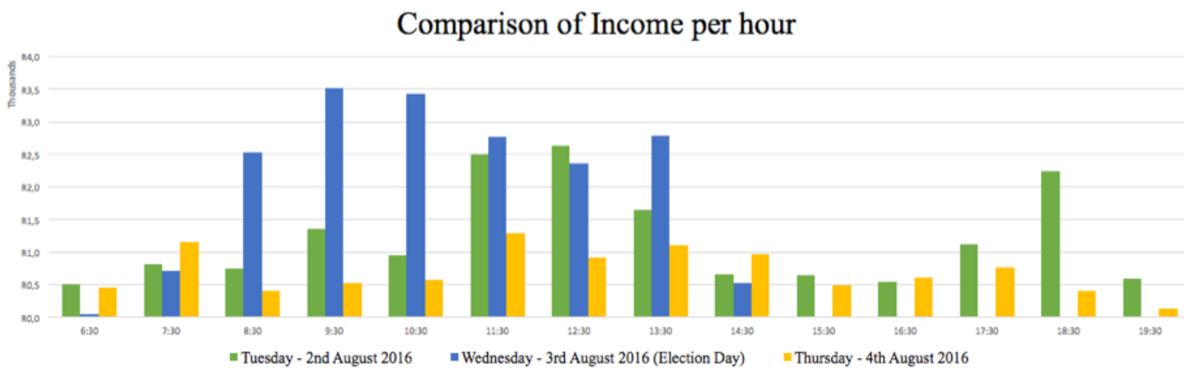


Figure 3: Income per hour comparison for Municipal Election Day 3rd August 2016

Another worthwhile example is shown in the result of incorrect planning that occurred on Wednesday the 3rd August 2016. It was the South African Municipal Elections resulting in the day being a South African Public Holiday. Common practice was followed with skeleton staff operating (around five staff members in total, a normal operating day can have around 12-15 staff members during the course of the day). However, no consideration was given the effect of demand. **Figure 3** illustrates how intense the demand was during the day of the 3rd (Blue bars), by comparing it to normal operating days prior (2nd August - Green Bar) and after (4th August - Yellow Bar). The result was that customers were dissatisfied and complained because orders took too long to be prepared.

Attempting to create a staff work schedule that balances dynamic demand efficiently is beyond that capacity of an untrained manager let alone a well skilled individual.

# 2 Problem Statement and Project Approach

## 2.1 Problem Statement

There is complexity involved in balancing the relevant staffing levels to meet the constant demand fluctuations where the relevant skill set is present to ensure that the customer and Sugo Bryanpark are both satisfied with customer service level. Therefore, the question that will be addressed is:

> *"What is the required work schedule per staff member that ensures the Sugo Bryanpark meets the Basic Conditions of Employment Act relating to Rest and Work periods, whilst enabling Sugo Bryanpark to meet the dynamic shifting levels of demand and ensuring overtime is kept to a minimum"*

## 2.2 Research Methodology

To find a possible solution, the creation of a multi-objective optimisation model via operations research mathematical modelling is proposed. This model needs to optimise multiple different constraints and requirements, namely:

1. Staff work Scheduling
2. Labour Law Regulations
3. Cost minimisation.

For the optimisation model to create a solution, the demand requirements will need to be identified. Also a forecast of demand will need to be reworked, this flow can be seen in **Figure 4**. The forecast will need to output the required staffing level required to meet demand in a minimum time allocation. The minimum time allocation is based on the Customer Expectations and the companies Service Level Plans.

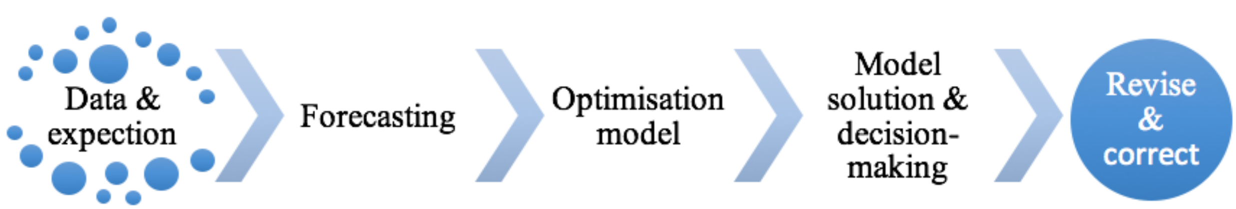


Figure 4: The proposed indication of the project components

### 2.2.1 Literature Review

A literature review has been completed to identify and understand the required background knowledge with regards to work scheduling, shift planning, demand fluctuations and the basic conditions of labour law rest and work periods. By reviewing the work performed in previous journals and articles, it has been possible to find an array of possible recommendations that can be used to solve the project problems.

### 2.2.2 Identification of Customer Expectations and Company Service Level Plan

The success of not just this project but of Sugo Bryanpark is based on the ability to understand and meet the client's expectations. An analysis needs to be performed to identify and find the expectations of how long a client is willing to wait for a product to be produced. By merging this information with the demand forecast analysis, it will then be possible to identify how many staff are required to be present and operational to satisfy the demand. By then comparing this data to the company's service level plan, it will be possible to identify what the company is willing/able to meet.

### 2.2.3 Identification of Demand Trends

A major component of the success of the project is based on the accuracy of the forecast analysis in identifying the demand trends. A considerable amount of research and vetting has been allocated to the research of understanding the effects of demand at Sugo Bryanpark. Some major tasks of this component are based on:

1. Identifying the optimal time periods. If the period is too large, the accuracy will be lost; if it is too small, the completion of the solution will take too long.
2. Understanding the effect of seasonality on demand.
3. Understanding the effect of weather on demand.
4. Understanding the effect of the day of the week on demand.

### 2.2.4 Identification of Basic Conditions of Employment Act

The optimal solution for the work schedule will be meaningless if it does not comply with legal and company policies. It is imperative that these considerations and requirements are understood and built into the optimisation function at the foundation phase. A basic analysis of the legal requirements has been researched. However, these requirements will need to be vetted and approved by the company's labour lawyer.

### 2.2.5 Formulation of Optimisation Model

The formulation of the optimisation model is the main aim of the project; the model has multiple constraints and requirements that it needs to solve. The model is the amalgamation of all the prior components. It will need to consider and optimise the following:

1. Demand level fluctuations

2. Multiple different skill sets of staff members
3. Staff work time preferences
4. Multiple different departments
5. Multiple work shift environments
6. Labour Law regulations
7. Minimisation of overtime costs

### 2.2.6 Model Solution and Decision-making

The model solution needs to be in a format for the manager to create an informed decision. Thus it must be able to run with multiple different service level parameters, and the output should be in an intuitive, but in a flexible format so that the manager can vet and confirm. The main functions of the model solution should answer the research questions, while also answer the question:

> *"Will we satisfy the demand and customers expectation?"*

The solution will need to be run on a monthly basis to meet the forecasted demand.

# 3 Literature Review

Extensive research and work has been done on staff work scheduling and demand forecasting, as these are major problems for any organisation. However, it is important not to neglect the human factor of managing the algorithms.

## 3.1 Managing Algorithms

Luca and Kleinberg (2016) wrote a relevant article in the Harvard Business Review on how "Algorithms need managers too". They go on to quote Shakespeare's Julius Caesar, in which a soothsayer warns Caesar *"beware of the Ides of March"*. This quote is vague; it warns of something but gives no indication of what it could be. This is on the same basis as building an algorithm to manage and optimise, without taking into consideration the legal requirements. Ensuring that not only algorithms should be used, but also allowing the managers to add in components of heuristic experience.

In Love and Hoey (1990), Baines (1992) and Asgeirsson (2012) emphasis is placed on having the output of work schedules reviewed and not blindly following the output.

## 3.2 Demand Forecasting

Forecasting can best be described as a method to predict the future based on past events. A forecast model will always be incorrect, but the aim is to get a model that's the least incorrect as possible.

### 3.2.1 Quantitative Forecasting Analysis

Quantitative forecasting is primarily based on mathematical relationships, using either time-series models or econometric-models. Song and Li (2008) describe the time-series models as a variable with regards to its own past, with a particular focus on the historic trends and patterns. Whereas econometric models lie in the casual relationship in finding correlation between depended and independence variables.

Song and Li (2008) performed an in-depth analysis of different forecasting models, what they found is that forecasting is most often performed over an annual. As a result, the following should be considered:

- Cycles: In the context of tourism, these are seen as the turning points in a model, it is therefore important to also note the directional change demand trend.
- Seasonality Analysis: This is an important and complex component of analysis, the model can either have deterministic (no randomness) or stochastic (having random probabilities) components in a time-series.

- Event impact: In the tourism context these are seen as man crises or natural disasters that can have a considerable effect on the forecast. In the restaurant industry, this could be seen as effects of extreme weather.

Martin and Witt (1989) dive into the accuracy of different quantitative forecasting methods. What they found is that no model is better for all scenarios, but a combination of multiple models needs to be used and compared to find the most appropriate model. They go on to mention that accuracy is lost the longer the period is forecasted. This conclusion reiterates the findings of Song and Li (2008).

Rajopadgye and Eister (2001) used the winter-holt forecasting model to attempt to forecast uncertain hotel room demand. They used different weighting models of short term and long term forecasts in an attempt to create a model that didn't require management expertise, but found that the accuracy will only increase by incorporating expert knowledge.

### 3.2.2 Qualitative Forecasting Analysis

Baines (1992) discusses incorporation of both qualitative and quantitative forecasting. Baines found that most managers use forecasting without being even being aware of it. He goes on to discuss the Delphi method (often referred to as "think tank") in which experts give their opinions. The opinions are then shared amongst the team to create a general idea or in this case a forecasting approach.
A clear trend is seen on both sides of the qualitative and quantitative forecasting methods, where no model works best in isolation. A reiterative approach is required for the forecasting between the qualitative and quantitative methods.

## 3.3 Work Scheduling

### 3.3.1 Labour Law Requirements

The Basic Conditions of Employment Act, 1997 and the Labour Relations Act, 1995 apply to the restaurant industry and the staff schedules that need to be modeled. These acts stipulate that a staff member may only work 45 hours per week, nine hours on any given day if the worker works five or fewer days and eight hours per day if the worker works five or more days a week. Overtime may accumulate to ten hours per week, but these are at a higher rate per hour. A daily rest period of 12 consecutive hours is required between ending work and starting the next day, with a weekly rest period of 36 consecutive hours.

### 3.3.2 Restaurant Work Scheduling

Love and Hoey (1990) created a work scheduling algorithm for the McDonald's fast food chain. This model worked on some key vital concepts such as a multi-shift operation, multi-skill set staff and fluctuating demand. However, it worked by having a high portion of temporary workers, some working three hours a day, which is against Sugo Bryanpark's company policy. The objective function meets a large basis of the project requirements as it is based on the minimisation of surplus hours per shift while balancing the skill sets.

Burns and Carter (1985) created an algorithm based on optimising the environment of having minimum staff to meet demand. However, it purely revolved around operating on a single-shift schedule, unlike the multi-shift requirements of Sugo Bryanpark. The model operates on assigning which staff can't work on a particular day, and then balancing the demand evenly.

Asgeirsson (2012) created a heuristics based algorithm, working on soft and hard variables. They created an optimal schedule and leave roster based on the desired working hours that staff directly request. The proposed solution is not viable due to the models operating on a single shift environment, and due to the extensive dependence on heuristic rules. However, the notion of having staff submit a desired work-schedule was noted to having a positive impact on the workforce moral.

The Love and Hoey (1990)) algorithm based on a multi-shift environment with different skill- sets gives a foundation to operate on. A plausible work schedule solution may be possible by adapting this algorithm's shift times and incorporating rest periods to become compliant according to the Basic Conditions of Employment Act.

# 4 Data Analysis

## 4.1 Pareto Analysis

Pareto analysis can assist in identifying the key topic points in a wide range of data that has been captured on the point of sale system. This form of graphical illustration emphasises the components of the company that need to be given specific focus. **Figure 5** illustrates the analysis for the product order quantity(as a percentage of orders and the number of orders) over the period of January 2017 to April 2017; showing that the 80/20 principle can be applied. Meaning that 80% of the orders are as a result of 20% of sold products. The key milestones in the data are captured in **Table 1** showing this relationship in a table format, the 10,1% (blue line) and 20,1% 9 (green line) product percentage milestones are overlaid in the graph to further illustrate the need to focus on the core products.

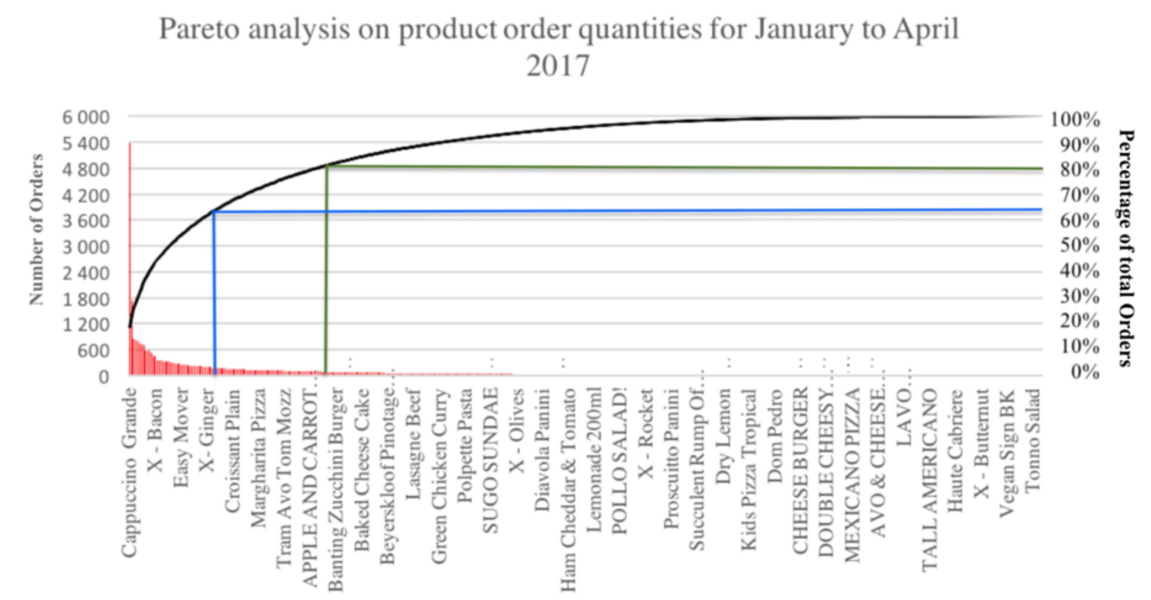


Figure 5: Pareto analysis on product order quantities for January to April 2017

Table 1: Key points comparing percentage of top products against percentage of order quantity

| **Product Percentage (%)** | **Order Percentage (%)** |
|---|---|
| 10.1 | 63,2 |
| 14,1 | 70,2 |
| 15,1 | 71,9 |
| 20,1 | 78,3 |
| 21,8 | 80,0 |
| 30,0 | 86,8 |

An annual comparison (**Table 2**) was performed on the top three ordered products over the course of 2015 to 2017. This table shows that there is a reasonable level of consistency over the years.

Table 2: The top products as a percentage of sales per year

| **Product** | **2015 (%)** | **2016 (%)** | **2017* (%)** |
|---|---|---|---|
| Cappuccino Grande | 15,11 | 14,29 | 14,77 |
| Americano Grande | 4,57 | 4,27 | 4,79 |
| Latte Single | 1,62 | 2,05 | 2,34 |

*2017 is based on year to date data available from January to April.

## 4.2 Time Study

Time study is required under the component of forecasting, it is used to determine how many staff will be required to meet demand. A time study was performed by placing a video camera at each of the respective workstation and then analysing the film to identify how long it takes to produce an item. In addition, principles of the lean manufacturing technique 'single minute exchange of dies' was used. The time to produce a product were broken into two categories:

- Internal time: In the event of producing multiple of the same item, the time needed is unique to a single unit of production. The time is not affected if multiple unites are produced.
- External time: This is a section of time in the production of a unit. If multiple items were being produced simultaneously, then the time would be shared across the items.

Thus if two identical items were to be produced simultaneously, then the total time for production would be the sum of the internal times and only one external time amount. **Table 3** contains the summary time studies that were performed, each product has it production time, as well as the internal time component as a ratio of the production time.

Table 3: The production time and internal time ratio per 10 of the top ordered product

| Product Name | Production Time (min) | Internal Time Ratio |
|---|---|---|
| Cappuccino Grande | 1:50 | 0,5 |
| Americano Grande | 2:32 | 0,2 |
| Cappuccino Grande take away | 1:52 | 0,5 |
| Fresh fruit juice | 0:30 | 0,9 |
| Skinny Grande cappuccino | 1:43 | 0,5 |
| Cappuccino piccolo | 1:55 | 0,4 |
| On the Go | 3:53 | 0,6 |
| Coke 330ml | 0:30 | 0,9 |
| Water Still 500ml | 0:30 | 0,9 |
| Latte single | 2:20 | 0,5 |

## 4.3 Demand Trends

Demand at the restaurant is extremely volatile, the demand can be majorly affected by:

- Weather: Unpleasant weather such as rain or abnormal cold conditions can dramatically reduce demand.
- Construction: Construction in the shopping centre can have a huge effect on demand, this is due to noise and the unaesthetic appearance of the shopping centre.
- Public Holidays: Public holidays have one of the biggest impacts on decreased demand.
- School Holidays: During this period the arrival time of regular patrons is affected.

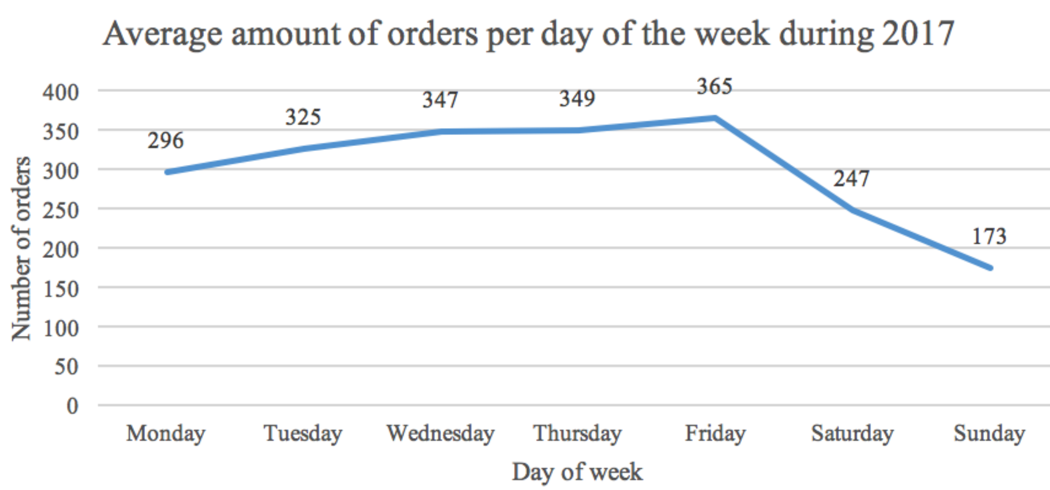


Figure 6: The average number of orders per day of the week in 2017

However, there are general trends that have been identified such as:

- Demand distribution over a week: The common trend that occurs per week can be seen in **Figure 6**, which shows the average number of orders per day of each week. In addition, it illustrates the increase in demand as the week progresses from Monday to the peak on Friday. Demand then rapidly decreases till the low of the week on a Sunday.
- Seasonality: There is a general increase in demand over the summer months, with a low trade in the winter months.
- Distribution per day: There are general trends that can be seen over the course of each day of the week. **Table 4** visually portrayed the calculated distribution of new tables per hour of each day of the week.

As much as there is volatility in the demand, there are the general trends that can be further calculated. Combining these quantitative calculations with the qualitative experience of the manager, it will be possible to create versatile forecasts.

Table 4: Calculated number of new tables per hour of each day of the week

| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|---|
| 6:00 AM | 0 | 5 | 6 | 7 | 7 | 6 | 0 |
| 7:00 AM | 1 | 15 | 18 | 19 | 20 | 18 | 5 |
| 8:00 AM | 7 | 12 | 14 | 18 | 16 | 15 | 17 |
| 9:00 AM | 12 | 13 | 12 | 14 | 13 | 13 | 17 |
| 10:00 AM | 12 | 11 | 11 | 12 | 12 | 13 | 19 |
| 11:00 AM | 11 | 10 | 11 | 11 | 12 | 12 | 15 |
| 12:00 PM | 7 | 14 | 14 | 15 | 14 | 14 | 12 |
| 1:00 PM | 3 | 12 | 13 | 13 | 12 | 14 | 8 |
| 2:00 PM | 1 | 8 | 8 | 10 | 9 | 9 | 5 |
| 3:00 PM | 0 | 7 | 9 | 10 | 9 | 7 | 0 |
| 4:00 PM | 0 | 6 | 6 | 7 | 8 | 6 | 0 |
| 5:00 PM | 0 | 5 | 6 | 6 | 7 | 6 | 0 |
| 6:00 PM | 0 | 5 | 6 | 7 | 7 | 6 | 0 |
| 7:00 PM | 0 | 3 | 3 | 4 | 4 | 4 | 0 |
| 8:00 PM | 0 | 1 | 1 | 2 | 2 | 2 | 0 |
| 9:00 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.4 Findings

The data analysis has shown that as much as there is chaos and disorder in the orders, there are trends and patterns that can be used to create forecast models that can be used to both assist in creating a forecast model and in vetting the accuracy of the model.

# 5 Forecast Conceptual Design

Using a combination of quantitative (formula driven) and qualitative (experience input) a conceptual forecast model is required.

## 5.1 Quantitative Method Requirements

The output of this component is the import data for the Work-schedule component. Thus it is imperative that the data is organised in a logical manner that will ease with the import stage.

### 5.1.1 Input and Parameters

Using the *Transactions* export excel from the Point of Sale software the data fields as seen in **Table 5**, can be used to determine the number of transactions that have occurred per time interval across all weeks.

Table 5: Transactions excel export data fields and possible usage for demand forecastingt

| Data Field | Purpose |
|---|---|
| *Date and time* | This field has the date and time of the order; this represents the moment that the client has placed the order. |
| *SKU* | This field is a unique code assigned to each product, from this code it is possible to identify the product name. This code will be correlated to the time study data. |
| *Quantity* | The number of the same products ordered in a single transaction. |
| *Account group* | This field is used to determine the department that the order is being placed in. |

### 5.1.2 Sets

$\bar{S}$ Denotes the different items available for order (SKU Number)

$\bar{D}$ Denotes the day of the week

$\bar{T}$ Denotes the time period during a day

$\bar{K}$ Donates the department that products can be ordered from

### 5.1.3 Variables

$a_{std} \triangleq$ The given number of products $s \in \bar{S}$ ordered during time interval $t \in \bar{T}$ on day of the week $d \in \bar{D}$

$p_s \triangleq$ The given time to produce product $s \in \bar{S}$

$b_{sk} \triangleq$ 1, if product $s \in \bar{S}$ is produced in department $k \in \bar{K}$.
0, otherwise

### 5.1.4 Equation

By analysing the existing data is it evident the trends that occur per day of the week are repetitive and be mapped via simple averages. In order to avoid the *'Fallacy of averages'* a high number of data points are used. Data is collected over every 10 minutes.

$$f_{tdk} = \frac{\sum_s a_{std} \cdot p_s \cdot b_{sk}}{Weeks} \qquad \forall t, d, k$$

The same process is then run for $f^{15}_{tdk}, f^{16}_{tdk}, f^{17}_{tdk}$ but with only 2015, 2016 and 2017 respective records.

### 5.1.5 Output

The output of the forecast model will need to follow be in the following format:

$f_{tdk} \triangleq$ The forecasted number of total production minutes needed during time interval $t \in \bar{T}$ on day of the week $d \in \bar{D}$ in department $k \in \bar{K}$

$f^{15}_{tdk} \triangleq$ The forecasted number of total production minutes needed during time interval $t \in \bar{T}$ on day of the week $d \in \bar{D}$ in department $k \in \bar{K}$ for the year 2015

$f^{16}_{tdk} \triangleq$ The forecasted number of total production minutes needed during time interval $t \in \bar{T}$ on day of the week $d \in \bar{D}$ in department $k \in \bar{K}$ for the year 2016

$f_{tdk}^{17} \triangleq$ The forecasted number of total production minutes needed during time interval $t \in \bar{T}$ on day of the week $d \in \bar{D}$ in department $k \in \bar{K}$ for the year 2017

This output is then exported to Excel so that it can be viewed by the manager.

## 5.2 Qualitative Method

The output of the Quantitative Methods is now vetted by the manager and the values are then updated in the excel document to either accommodate for a higher/lower level of anticipated demand.
The following are some considerations that the manager will use for reason to adjust:

- Abnormalities: Any data that is easily observed to be extremely unlikely.
- Public holidays: In the event of public holidays, the manager can then reduce the forecast to reflect the normal public holiday demand
- Extreme weather: In the event of extreme weather conditions the manager can then reduce the forecast to reflect a more appropriate demand
- Functions: The manager can alter the forecast to reflect a more appropriate demand fora set function.

A high level of attention to detail is required at the stage due to this being the import for the work-schedule equations.

## 5.3 Alternative Method

The Winter-holt forecasting model was identified as an alternative method. The model presented major faults in attempting to forecast the production in different time periods in different days as it was designed more for season cycles over large periods of time, often into the months. As a result this model would have not been able to meet the requirements and would result in further problems in the next sections.

# 6 Work-schedule Concept Design

## 6.1 Input and Parameters

The current concept of design operates on a weekly computational basis, where the required staff members (the forecast output) needed to work on are inputted along with the skills and viability matrix.
This linear integer program is an adaptation of the model defined in Love and Hoey (1990), where the base concepts have been updated to reflect labour legislation requirements and alterations for different demands per the day of week. The algorithm will be coded into Lindo to process an optimal solution.

## 6.2 Sets

$\bar{I}$ Denotes the staff member working at Sugo Bryanpark

$\bar{H}$ Denotes the time period during a day

$\bar{K}$ Denotes a day in the week

$\bar{L}$ Denotes a department that a staff member can work in

## 6.3 Variables

$x_{hkl} \triangleq$ The given number of staffing requirement needed to be met for time period $h \in \bar{H}$ on day $k \in \bar{K}$ in department $l \in \bar{L}$

$r_{hkl} \triangleq$ The calculated shortage in the number of staff members needed to work in time zone $H \in \bar{H}$ on day $k \in \bar{K}$ in department $l \in \bar{L}$

$s_{hkl} \triangleq$ The calculated surplus of staff members for time period $h \in \bar{H}$ on day $k \in \bar{K}$ in department $l \in \bar{L}$

$z_i \triangleq$ The calculated number of days that staff member $i \in \bar{I}$ is scheduled to work.

$w_{ihkl} \triangleq$ 1, if staff member $i \in \bar{I}$ is to work in time zone $H \in \bar{H}$ on day $k \in \bar{K}$ in department $l \in \bar{L}$ .
0, otherwise

$y_{ik} \triangleq$ 1, if staff member $i \in \bar{I}$ is scheduled to work on day $k \in \bar{K}$
0, otherwise

$M^1_{hl} \triangleq$ A big m value appropriately chosen to limit surplus employees for time period $h \in \bar{H}$ in department $l \in \bar{L}$

$M^2_{hkl} \triangleq$ A big m value appropriately chosen to limit shortage of staff members needed to work in time zone $H \in \bar{H}$ on day $k \in \bar{K}$ in department $l \in \bar{L}$

## 6.4 Objective Function

$$\min \text{Z} = \sum_{hl} M^1_{hl} s_{hl} + \sum_{ihkl} w_{ihkl} + \sum_{hkl} M^2_{hkl} r_{hkl} \tag{1}$$

## 6.5 Constraints

$$\sum_{i} w_{ihkl} + s_{hkl} = x_{hkl} + r_{hkl} \quad \forall h, k, l \tag{2}$$
$$\sum_{hl} w_{ihkl} \leq (1 - Y^1_{ik}) \quad \forall i, k \tag{3}$$
$$- y_{ik} + 1 \leq Y^1_{ik} \quad \forall i, k \tag{4}$$
$$\sum_{k} y_{ik} = z_i \quad \forall i \tag{5}$$
$$8 - \sum_{n=1}^{8} w_{inkl} \leq M(Y^n_{ikl}) \quad \forall i, k, l \tag{6}$$
$$w_{i1kl} \leq M(1 - Y^n_{ikl}) \quad \forall i, k, l \tag{7}$$
$$z_i \leq 5 \quad \forall i \tag{8}$$
$$\sum_{hl} w_{ihkl} \leq 40 \quad \forall i, k \tag{9}$$
$$\sum_{hkl} w_{ihkl} \leq 200 \quad \forall i \tag{10}$$
$$y_{ik} \in (0, 1) \quad \forall i, k \tag{11}$$
$$w_{ihkl} \in (0, 1) \quad \forall i, h, k, l \tag{12}$$
$$z_i \geq 0 \quad \forall i \tag{13}$$
$$s_{hkl}, r_{hkl} \geq 0 \quad \forall h, k, l \tag{14}$$

The objective function in **Equation 1** is designed to minimise surplus number of staff as well as the control shortage levels of staff.

**Equation 2** balanced the manning demand requirements per time zone while allocating the surplus staff and recording shortages. **Equations 3 - 4** are if-then functions built to record if a staff member is set to work on a particular day, while **Equation 5** records the number of days a staff member works in a week. **Equations 6 - 7** simply represent the shift allocation procedure to ensure that a staff member works eight hours over an eight hour period. **Equations 8 - 10** are used to regulated the max amount of hours and days that a staff member works in order to be compliant with the *Basic Conditions of Employment Act, 1997.* **Equations 10 - 14** are used to set non-negative and binary to variables.

## 6.6 Output

The output of the linear program contains three components:

- Schedule: This is the proposed work schedule that a staff member will work for a calculated week.
- Shortage: This is the calculated shortages of staff per time-period that the manager needs to assess and use expert knowledge to find a solution, such as assign overtime staff.
- Excess: This is the calculated excess of staff per time period that the manager needs to assess using expert knowledge to utilise the staff (such as assigning tea breaks or preparations for later demand).

## 6.7 Alternative Methods

### 6.7.1 Burns and Carter(1985) Method

The model designed by Burns and Carter(1985) was not feasible due to operating on a single shift environment, Sugo operates on a multi-shifts system. This would have major problems for the organisation as it would not be complaint in accordance with the Labour Law requirements. This would be a viable solution in the event that Sugo was to change it labour agreements with the staff and move to a 12 hour shifts with the ability to overtime.

### 6.7.2 Asgeirsson (2012) Method

The Heuristics model presented by Asgeirsson (2012) worked on a high level of staff engagement, where the staff nominated the preferred hours that they wanted to work. Sugo doesn't have an a full time Human Resource manager; as a result this would put additional unnecessary levels of work on the manager to have to engage with the staff on their preferences. Additional problems can arise in the event of which staff get preference over the other staff.
The model also doesn't have a mathematical method to distributing the staff number according to demand, as it works on the premises on fixed levels of demand.
As a result of the above points, the model would not be able to meet the objectives of the project.

# 7 Solution Validation

## 7.1 Forecasting

There is always validation of the forecast model due to the vetting of the output by the manager. However, the accuracy of the forecast can be validated by the following comparisons:

### 7.1.1 Bar Department

The departmental forecasts of the bar have been compared to the yearly averages for 2015, 2016 and 2017 for each day of the week as seen in **Figure 7 to Figure 13**. The forecasts operate on a 10 minute internal period from 6:00am till 10:30pm, with the blue, orange and gray line representing the 2017, 2016 and 2015 average trends respectively. The yellow line represents the forecasted demand.

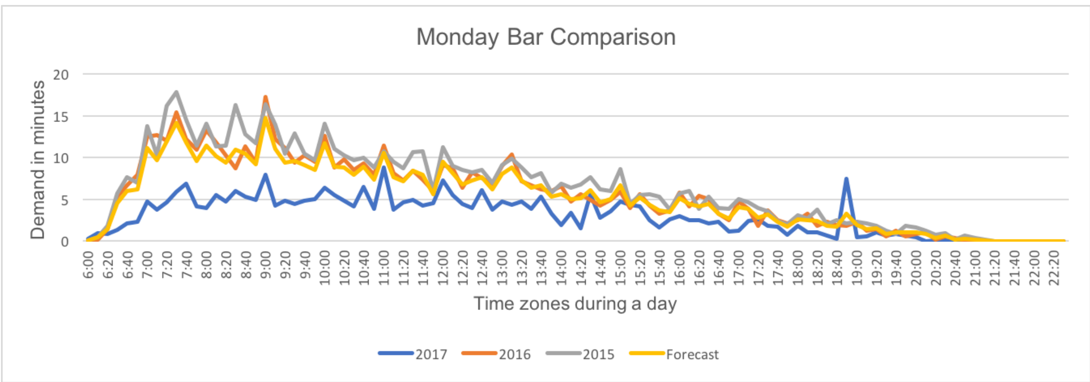


Figure 7: The trends versus the forecasted of demand in the Bar for a Monday

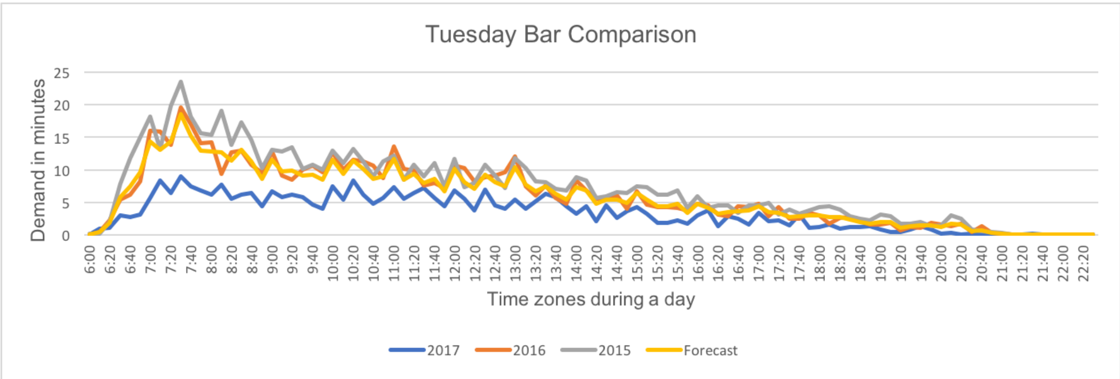


Figure 8: The trends versus the forecasted of demand in the Bar for a Tuesday

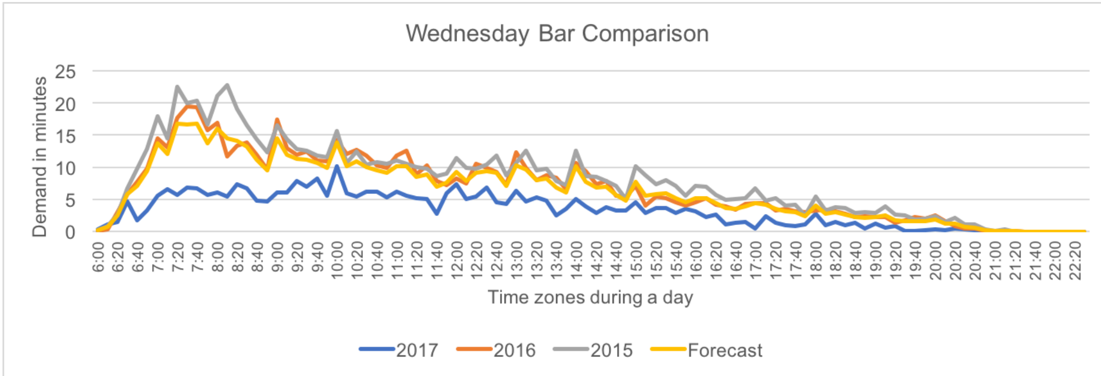


Figure 9: The trends versus the forecasted of demand in the Bar for a Wednesday

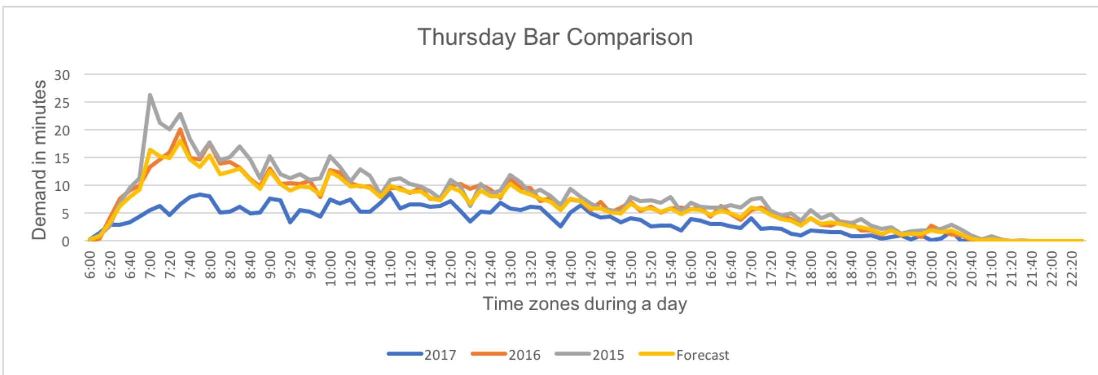


Figure 10: The trends versus the forecasted of demand in the Bar for a Thursday

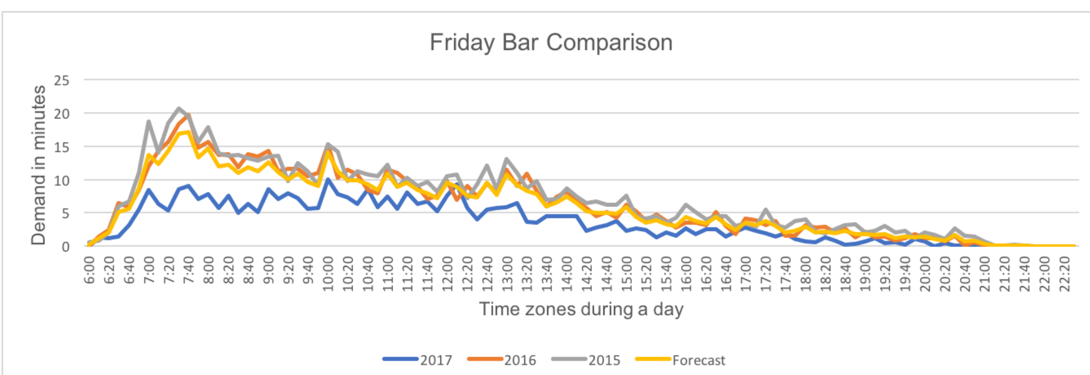


Figure 11: The trends versus the forecasted of demand in the Bar for a Friday

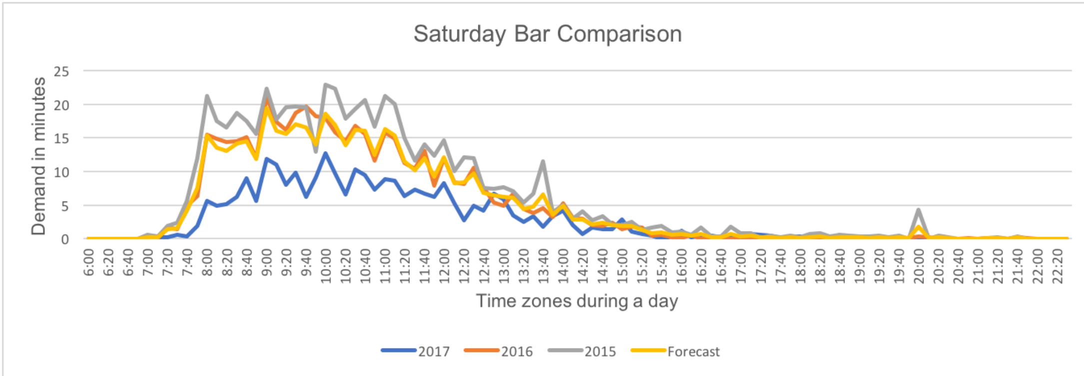


Figure 12: The trends versus the forecasted of demand in the Bar for a Saturday

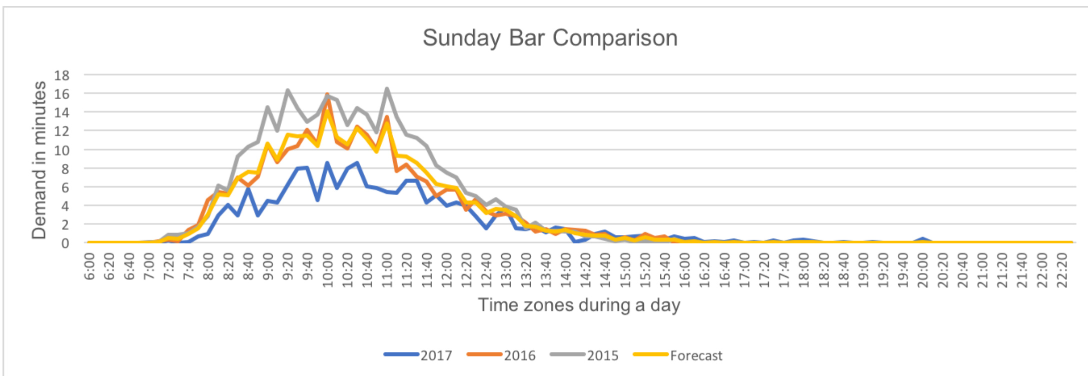


Figure 13: The trends versus the forecasted of demand in the Bar for a Sunday

The 2017 demand tend is on average 70% to 75% of the forecasted demand, this is due to construction in the shopping centre that occurred for the first several months of the year. However, the accuracy is emphasised in the correlation in all the yearly trends compared to the forecast can be seen in **Table 6**.

Table 6: The correlation accuracy of each years trend in the Bar compared to the forecast

| **Weekday** | **2017** | **2016** | **2015** | **Daily Average** |
|---|---|---|---|---|
| Monday | 88,7% | 98,7% | 99,0% | 95,5% |
| Tuesday | 93,9% | 98,4% | 98,4% | 96,9% |
| Wednesday | 91,6% | 98,8% | 98,7% | 96,4% |
| Thursday | 89,3% | 98,8% | 98,5% | 95,5% |
| Friday | 93,9% | 98,9% | 99,0% | 97,3% |
| Saturday | 95,9% | 99,3% | 99,3% | 98,2% |
| Sunday | 96,4% | 99,3% | 99,5% | 98,4% |
| **Yearly Average** | 92,8% | 98,9% | 98,9% | 96,9% |

### 7.1.2 Kitchen Department

As with the bar department, the departmental forecasts of the kitchen have been compared to the yearly averages for 2015, 2016 and 2017 for each day of the week as seen in **Figure 14 to Figure 20**. The forecasts operate on a 10 minute internal period from 6:00am till 10:30pm, with the blue, orange and gray line representing the 2017, 2016 and 2015 average trends respectively. The yellow line represents the forecasted demand.

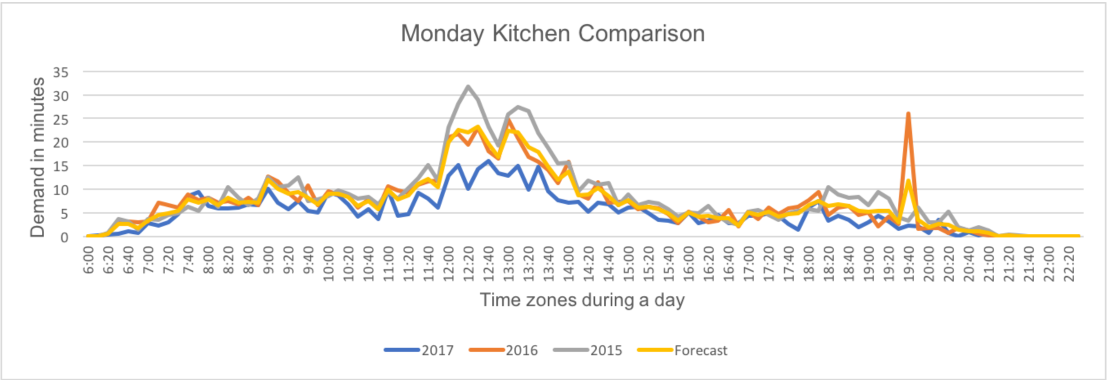


Figure 14: The trends versus the forecasted of demand in the Kitchen for a Monday

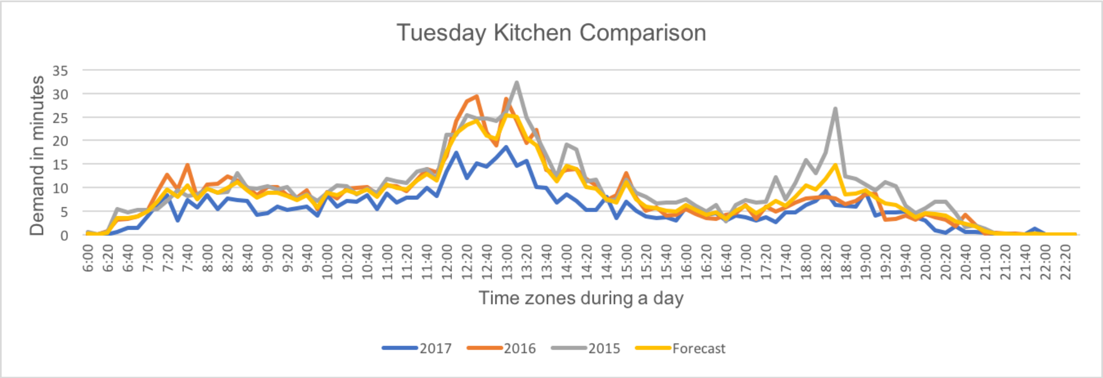


Figure 15: The trends versus the forecasted of demand in the Kitchen for a Tuesday

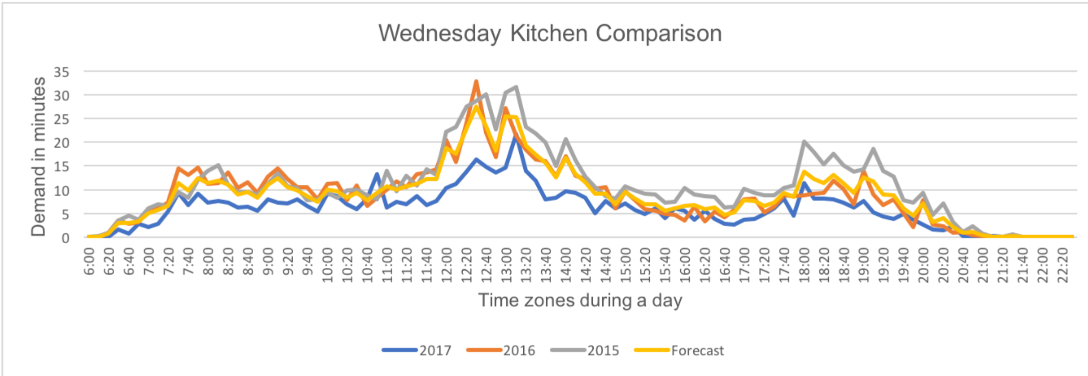


Figure 16: The trends versus the forecasted of demand in the Kitchen for a Wednesday

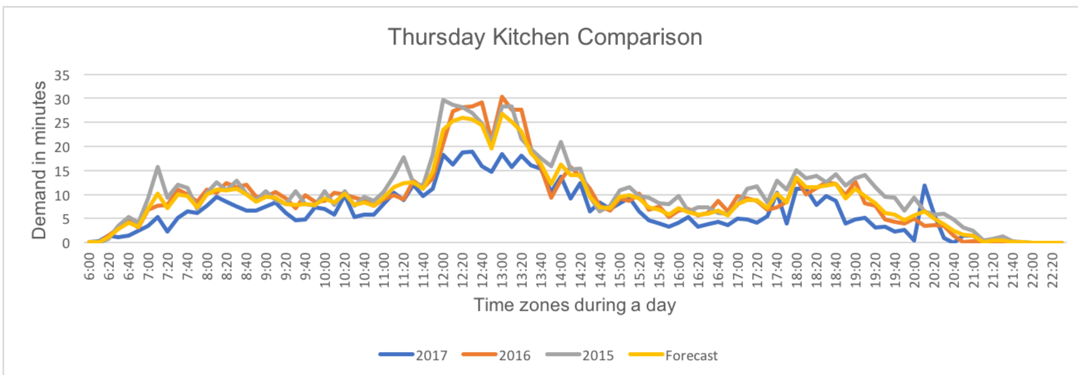


Figure 17: The trends versus the forecasted of demand in the Kitchen for a Thursday

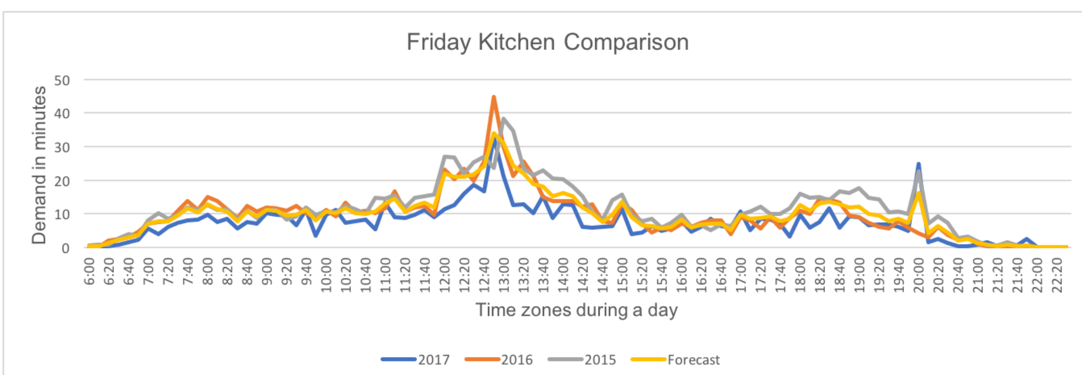


Figure 18: The trends versus the forecasted of demand in the Kitchen for a Friday

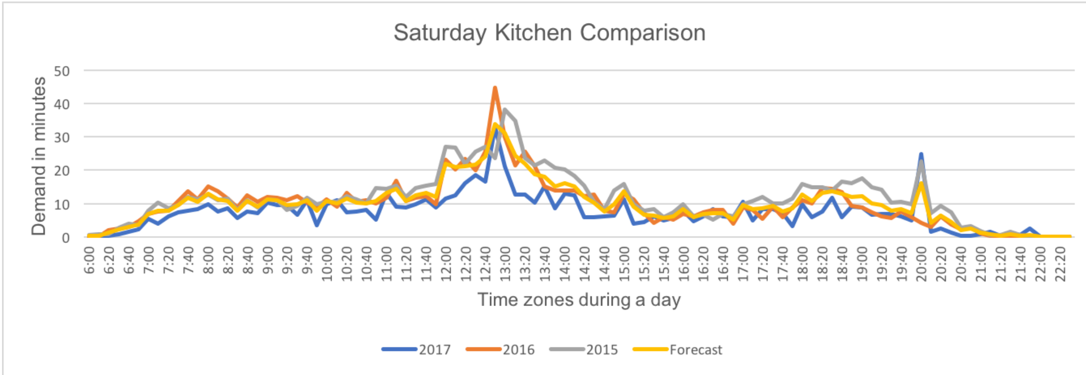


Figure 19: The trends versus the forecasted of demand in the Kitchen for a Saturday

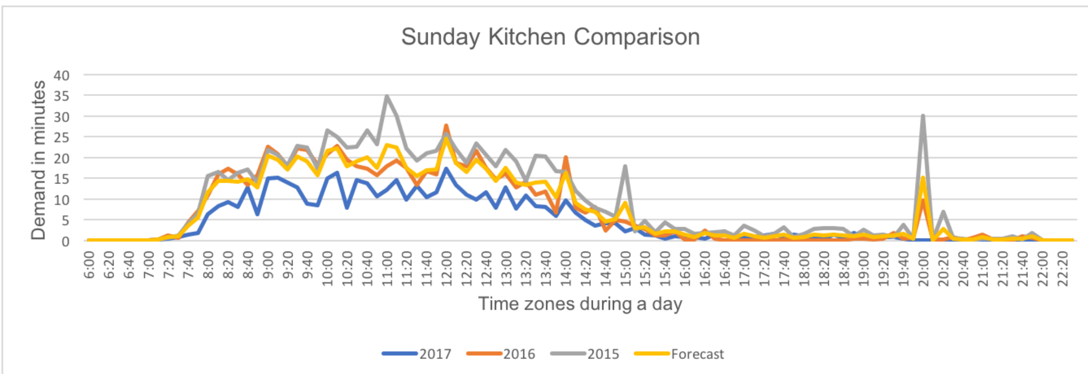


Figure 20: The trends versus the forecasted of demand in the Kitchen for a Sunday

The 2017 demand kitchen tend is a lot more similar to the forecasted demand when compared to that of the bar, but with lower demand during the peak lunch time periods. The correlation accuracy (**Table 7**) is also incredibly high.

Table 7: The correlation accuracy of each years trend in the Kitchen compared to the forecast

| **Weekday** | **2017** | **2016** | **2015** | **Daily Average** |
|---|---|---|---|---|
| Monday | 92,6% | 95,4% | 96,9% | 95,0% |
| Tuesday | 94,8% | 96,8% | 96,5% | 96,0% |
| Wednesday | 94,1% | 97,0% | 97,6% | 96,2% |
| Thursday | 94,3% | 98,1% | 97,9% | 96,8% |
| Friday | 90,2% | 95,4% | 95,4% | 93,7% |
| Saturday | 90,2% | 95,4% | 95,4% | 93,7% |
| Sunday | 95,5% | 98,1% | 97,9% | 97,2% |
| **Yearly Average** | 93,1% | 96,6% | 96,8% | 95,5% |

The accuracy in the correlation of the trends shows that the manager can simply multiply the forecasted demand by a ratio to either increase or decrease the output that will be used

in the work-scheduling component.
For any events that will negatively effect the demand; the ratio should be less than 1. While any positive events would be greater 1.

### 7.1.3 Objective Criteria Overview

The forecasting component of the project has met the following requirements for the project.

Table 8: Project requirements met in Forecasting Model

| **Objective Requirement** | **Met** | **Not Met** |
|---|---|---|
| Service Level Plans | The service levels were identified and used successfully in the forecasting model. Using a combination of time study and uniqueness values | |
| Optimal time periods | The optimal time periods were calculated to be 5 min, in this period there is little loss of accuracy due to averaging | |
| Seasonality and Weather | A factor function was built in to allow the manager to adjust the overall forecast to adapt for variations | |
| Ease of adaption | The output of this model is easily edited in excel | |

As expressed in **Table 8** the model has met the all the required objectives of the project and is able to output the required demand per time period for each department over each day of the week. The output is also in a scalable format allowing the manager to vet and adjust as required.
In addition the model has produced the trends for each of the past years, allowing for an in-depth analysis and testing of the accuracy.

## 7.2 Work-schedule

As per the Forecasting, validation always occurs before an implementation can occur due to the manager vetting the outputs of the system.
From a restaurant manager perspective, the most important aspect to consider is the shortage and surplus of staff per hour. A shortage will result in a low service offering, while a high surplus can be seen as a wasted investment.

### 7.2.1 Shortage and Surplus levels

When running the model on the forecasted values, it was found that there is no major shortages that occur in any of the departments when compared to as is real life situation at the restaurant.
**Figure 21** and **Figure 22** shows the distribution of the bar and kitchen surplus staff respectively per hour in the form of all positive values, while the shortage of staff can be seen as the negative values.

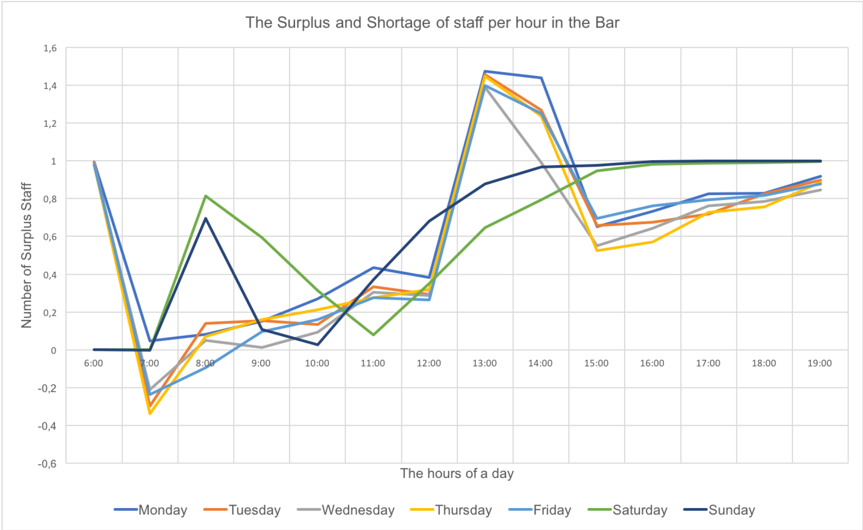


Figure 21: The Surplus and Shortage of Staff in the Bar per day of the week

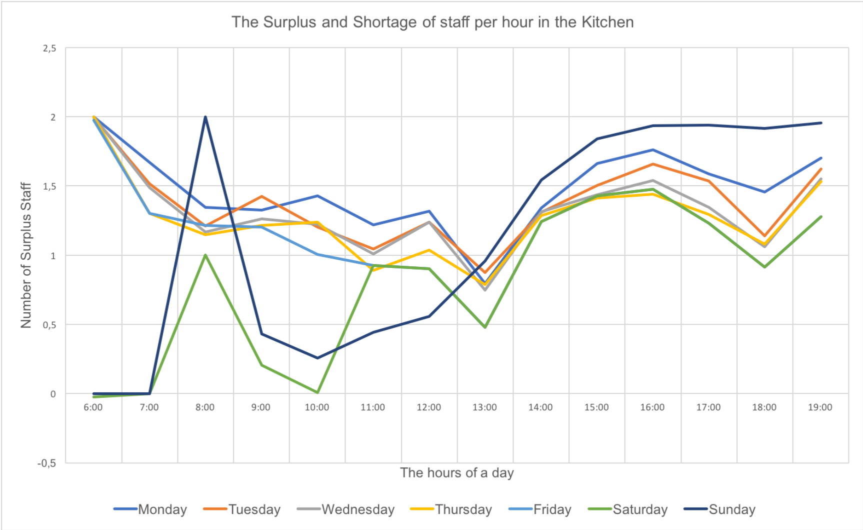


Figure 22: The Surplus and Shortage of Staff in the Kitchen per day of the week

### 7.2.2 High Demand Test

As a precaution the model was run with high levels of demand , where the forecast was inflated by 30% per time interval. In such an event the surplus and shortages of staff can been seen in **Figure 23** and **Figure 24** for the Bar and Kitchen respectively. As expected, the bar Work-schedule remained the same where as the kitchen reallocated shifts from Monday to Sunday.

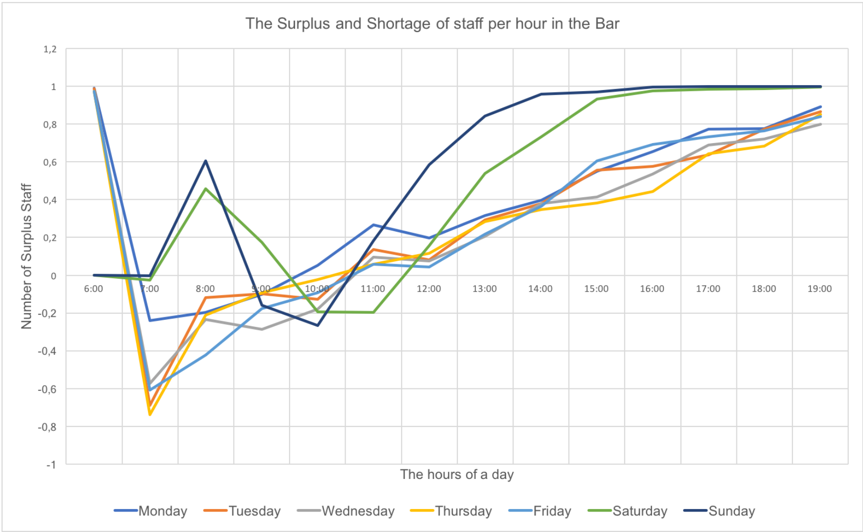


Figure 23: The Surplus and Shortage of Staff in the Bar per day of the week with high Demand

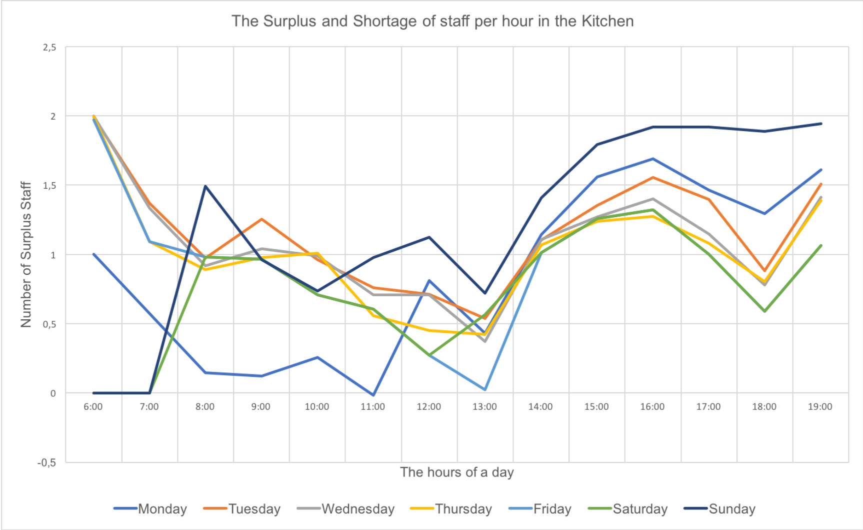


Figure 24: The Surplus and Shortage of Staff in the Kitchen per day of the week with high Demand

#### 7.2.3 Objective Criteria Overview

The Work-scheduling model has met the following requirements that were defined in the project scope.

Table 9: Project requirements met in Work-schedule Model

| **Objective Requirement** | **Met** | **Not Met** |
|---|---|---|
| Adapt to demand fluctuations | The model is built to adjust to the demand fluctuations. Using shortage and surplus staff variables, it is even able to output an optimal solution when demand is above possible limits | |
| Staff time preferences | | Sugo nominated not to use this function, as there is no HR department that can consult and plan these times accordingly. However, in the event that the shift is not possible, a staff member has a weeks notice to consult with management |
| Multiple departments | The system is able to adapt to any number of departments | |
| Multiple Work shift | The model has eight different starting shift during a day to ensure the staff members meet demand levels and work the required hours | |
| Labour Law | The model has the labour law requirements built in | |
| Minimisation of overtime costs | The model assigns to staffing to meet demand with out overtime required. However, the model then records a shortage requirement per time slot that allows the manager to decide if he needs addition staffing in that time period. | |

As seen in **Table 9** the model is able to allocate staff according to both normal and adjusted forecasted levels. Whilst creating a output that allows managers to observe the

expected shortages and surplus staff per time zone.
This then allows the manager to adjust and reallocate according to his expert knowledge.
The function of having the staff nominated preferred hours was not incorporated due to the burden this task would add to the Manager.
In addition, the model is able to compute the model with in a few seconds, making the model easy to rerun with in a short notice period.

# 8 Proposed Implementation

The implementation of the project is relatively simply due to this work-schedule being a replacement of an existing process.

## 8.1 Implementation

The rollout will occur during the first week of October 2017, while the notices to work will be issued during a team meeting in the last week of September.
The advantages of issuing the work-schedules a week early is that additional verification can occur by the staff themselves during this meeting to comment on any potential problems.
During the meeting, the following checks will occur with each staff member:

- They work adequate hours.
- They don't work more than the required number of day.
- They don't work more than the required number of hours per day.

The week before implementation the forecast will be adjusted the to expected demand ratio.

## 8.2 Risk Mitigation

In the event that a major problem occurs resulting in either the project not being able to be implement or being delayed; there is no risk to the company, as the current work-schedule can be used and reimplemented with almost immediate effect.

# 9 Conclusion

There is a reduction in the risk of major errors being forecast and actioned due to the reiterative checks and validations used by a combining quantitative and qualitative methods for both the forecast model and then the work scheduling model.
The current concept design for the work schedule is based on a proven concept in a similar industry, the flexibility in the model allows for the manager to adjust and alter as required to meet the needs of the company, while having the ability to see the levels of surplus and shortages of staff.
The largest risk of inaccuracy would be as a result of the forecasting. However, the correlation indexes are extremely high, mixing with the manager being able to adjust either individual value or the forecast as a whole.
Even when the demand forecast was significantly inflated, the work-schedule was able to allocate and reduce the shortage of staff.

# 10 Recommendation

The forecast is able to match the trends of the 2015 and 2016 orders with extreme accuracy, however the 2017 demand isn't as accurate; thus an alternative weighting method could be used to bring a larger emphasis to more recent orders.
In addition some investigation should performed on what are ideal ratios to use when adjusting the forecasts to compensate for event impact.

The work-schedule can be built on further to have an attribute field that allows for the capture of different number of days a staff member can work. This will help in the event that some staff might work fewer day or when a staff has time off due.

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# A Signed Industry Sponsorship Form

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| Company: | Syntegrica 7 (Pty) Ltd (T.A. Sugo Bryanpark) |
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| Student Name: | Emile Garrett Van Den Berg |
| Student number: | 29262314 |
| Student Signature: | |
| Sponsor Name: | Mandy Van Den Berg |
| Designation: | Owner |
| E-mail: | owner@sugobryanpark.co.za |
| Tel No: | 011 463 1233 |
| Cell No: | 082 55 19382 |
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