**BANA 6670 Final Report**

**Optimizing Production Quantities for profit Maximization**

**GROUP 3**

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**Introduction, Problem Statement and Project Motivation**

Balaji-Fast-Food restaurant, a popular eatery known for its wide range of fast foods and beverages, faces a critical challenge in optimizing its production quantities to meet customer demand efficiently. The restaurant offers seven types of fast foods and beverages, including Aalopuri, Cold coffee, Frankie, Panipuri, Sandwich, Sugarcane juice, and Vadapav, catering to customers from morning till midnight. Each food item has its own price per quantity, and the restaurant accepts both online and cash payments. The primary objective of this project is to develop an optimization model that maximizes the restaurant's daily revenue by determining the best quantity of each food type to produce at each given time of the day.

This optimization process aims to address the main issue faced by the restaurant: overproduction when demand is low, leading to wastage of resources, and underproduction when demand is high, resulting in lost customers and revenue. The key decision-maker in this project is the Balaji-Fast-Food restaurant owner, while the stakeholders include cashiers and the head chef. The project's success hinges on accurately determining the popularity of food groups at different times of the day, understanding customer preferences for specific food types, and analyzing the impact of each payment method on the restaurant's daily revenue.

**Decision Variables**

The project's constraints revolve around product demand, quality of products produced, and raw material availability. This will ensure that the production quantities meet or exceed the expected demand while adhering to quality standards and resource constraints is crucial for maximizing revenue and maintaining customer satisfaction. The data used for this project was collected from a local restaurant and has been made available for analysis and educational purposes. The decision variables represent the quantities of each food item to be produced.

Xij: Where i= represent the quantities of each food item to be produced.

* 1: Quantity of Aalopuri
* 2: Quantity of Cold coffee
* 3: Quantity of Frankie
* 4: Quantity of Panipuri
* 5: Quantity of Sandwich
* 6: Quantity of Sugarcane juice
* 7: Quantity of Vadapav
* Where j = represent the each given time of the day.
* 1: Morning
* 2: afternoon
* 3: evening
* 4: night
* 5: mid-night

**Objective Function**

**Maximize Z (Profit)**

**4x11+4x12+4x13+4x14+4x15+ 8x21+8x22+8x23+8x24+8x25+ 10x31+10x32+10x33+10x34+10x35+4x41+4x42+4x43+4x44+4x45+**

**12x51+12x52+12x53+12x54+12x55+5x61+5x62+5x63+5x64+5x65+**

**4x71+4x72+4x73+4x74+4x75**

**Constraints**

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**Demand Constraints Supply Constraints**

x11<=150

x12<=300

x13<=200

x14<=250

x15<=200

x21<=250

x22<=180

x11<=215

x12<=287

x13<=204

x14<=233

x15<=234

x21<=260

x22<=200

x23<=226

x23<=150

x24<=300

x25<=200

x31<=250

x32<=150

x33<=300

x34<=180

x35<=100

x41<=200

x42<=150

x43<=200

x44<=150

x45<=200

x51<=150

x52<=200

x53<=150

x54<=250

x55<=200

x61<=250

x62<=200

x63<=250

x64<=180

x65<=100

x71<=150

x72<=150

x73<=200

x74<=150

x75<=200

x24<=337

x25<=238

x31<=230

x32<=164

x33<=325

x34<=194

x35<=136

x41<=235

x42<=240

x43<=241

x44<=206

x45<=180

x51<=230

x52<=244

x53<=299

x54<=270

x55<=244

x61<=292

x62<=290

x63<=190

x64<=223

x65<=203

x71<=198

x72<=278

x73<=201

x74<=223

x75<=192

**Optimal Solution and Value**

**Optimal solution**: Below we can see the Optimal Solution of which type of food should is sold more at which time of the day. These Outcomes include all the supply and demand of the products.

Aalopuri - Morning, Evening, Midnight

Cold Coffee - Morning, Afternoon, Evening, Night, Midnight

Frankie - Afternoon, Evening, Night, Midnight

Panipuri - Morning, Afternoon, Evening, Night

Sandwich - Morning, Afternoon, Evening, Night

Sugarcane\_Juice - Morning, Afternoon, Evening, Night, Midnight

Vadapav - Morning, Afternoon, Evening, Night, Midnight

**Optimal Value:**

Our Optimal Value is 44,984 (profit Maximization). This means by implementing our optimal solution. The restaurant will reach 44,984 profits on daily basis.

**Sensitivity Analysis**

1. Demand Sensitivity

- Evening Demand Impact: Consider the sensitivity of the demand for products like "Frankie," which had an evening unit sale of 180 units. If sensitivity analysis indicates that an allowable increase in price leads to a profit margin improvement without significantly reducing demand, the restaurant could test a price increase during this peak period.

Morning and Midnight Peaks: With "Aalopuri" selling 215 units in the morning and 223 units at midnight, these could be critical times for focusing marketing efforts or special promotions to maximize revenue when the demand is naturally higher.

2. Supply Constraints:

- Binding Supply Constraints: If the constraint on "Evening Units Sold" at 250 units is binding and the shadow price for this constraint is high, this suggests that every additional unit that could be sold in the evening would add significantly to the profit. It implies a need to potentially increase kitchen capacity or streamline operations during these hours.

- Non-binding Constraints: For example, if "Night Units Sold" for sandwiches is 200 and this constraint is not binding, it indicates that there's additional capacity to sell more during these hours without needing extra resources.

3. Profit Maximization:

- Optimal Item Focus: If the shadow prices indicate a high profit impact for "Cold Coffee" and "Sandwiches," which have higher selling prices and possibly higher margins, focusing on boosting these sales during high-demand periods could be particularly profitable.

- Strategic Adjustments: The analysis might show that the "Midnight Units Sold" constraint for "Vadapav" at 150 units has a low shadow price, indicating less profit impact from increasing sales. This might suggest deprioritizing efforts on this item during late hours in favor of more profitable items.

By incorporating these specific values and findings from the sensitivity analysis, the restaurant can more precisely target its operational strategies and pricing decisions to areas where they will have the most significant impact on profitability and efficiency. This practical use of data not only supports better financial outcomes but also aligns resource utilization with market demand dynamics**.**

**A screenshot of a computer

Description automatically generated**

**Model development/Methodology.**

To address the challenges faced by Balaji-Fast-Food restaurant and develop an optimized production model, a comprehensive methodology was employed. The first step involved creating a new sheet in the Excel workbook, named "Decision Variables," to define the decision variables representing the quantities of each food type to be produced at different times of the day. In the "Decision Variables" sheet, a table was constructed with columns representing each food type (Aalopuri, Cold coffee, Frankie, Panipuri, Sandwich, Sugarcane juice, and Vadapav) and rows representing different times of the day (Morning, Afternoon, Evening, Night, and Midnight).

To populate the initial values for the decision variables, a thorough analysis of the historical data was conducted. A new sheet, named "Demand Analysis," was created to estimate the expected demand for each food type at different times of the day. This analysis involved several approaches, including descriptive statistics, frequency analysis, and the use of Excel's built-in functions such as AVERAGEIFS, MAXIFS, and COUNTIFS.

To ensure that the quantity produced (decision variables) met or exceeded the expected demand, constraints were added to the "Decision Variables" sheet. For each cell in the sheet, a constraint formula was included, ensuring that the decision variable value was greater than or equal to the expected demand value from the "Demand Analysis" sheet. Another crucial aspect of the model development was accounting for raw material availability.

Additionally, a separate row or column in the "Raw Materials" sheet was dedicated to entering the available quantity of each raw material. Constraints were then added to the "Decision Variables" sheet to ensure that the total raw materials required for the planned production, based on the decision variables and raw material requirements, did not exceed the available quantities. With the decision variables, expected demand analysis, and raw material constraints in place, the final step involved setting up the Solver parameters in Excel.

**Problem Complexity**

The optimization problem faced by Balaji-Fast-Food restaurant is a complex multi-faceted challenge that requires careful consideration of various factors and constraints. The complexity of the problem arises from the following aspects. The problem involves determining the optimal quantities of seven different food types (Aalopuri, Cold coffee, Frankie, Panipuri, Sandwich, Sugarcane juice, and Vadapav) to be produced at five different times of the day (Morning, Afternoon, Evening, Night, and Midnight). This results in a total of 35 decision variables that need to be optimized simultaneously, making the problem inherently complex.

While the objective function of maximizing daily revenue appears to be a linear function of the decision variables, the underlying relationships between demand, production quantities, and revenue may be non-linear in nature. Customer preferences, substitution effects, and pricing strategies can introduce non-linearities that make the optimization problem more challenging to solve. The problem is subject to various constraints, including product demand constraints, raw material availability constraints, and potentially others related to production capacity, labor availability, or quality standards.

Customer preferences, demand patterns, and market conditions are not static but can change over time due to various factors, such as seasonal variations, marketing campaigns, competitor actions, and changes in economic conditions. This dynamic nature of the problem necessitates continuous monitoring, data updates, and model recalibration, increasing the complexity of maintaining an accurate and up-to-date optimization model. The model assumes independence between the demand for different food types and times of the day.

While the model focuses on optimizing production quantities, it may not consider all the operational constraints and practical limitations faced by the restaurant, such as limited equipment, labor availability, production bottlenecks, or logistical challenges. Incorporating these operational constraints into the optimization model can further increase its complexity. To effectively address the complexity of the optimization problem, it is essential to employ advanced analytical techniques, and continuously refine the model based on updated data and changing requirements.

**Analysis and Results**

The analysis and results of the optimization model developed for Balaji-Fast-Food restaurant provide valuable insights into the restaurant's operations and potential revenue maximization strategies. To begin with, the analysis of the historical data revealed significant variations in customer demand for different food types at different times of the day. The "Demand Analysis" sheet, which calculated the expected demand (average quantity) for each food type and time combination, highlighted these variations.

For instance, the average demand for Aalopuri in the morning was 0.131855309 units, while in the afternoon, it was 0.088311688 units. Similarly, the average demand for Cold coffee was highest in the morning at 0.196616103 units and lowest in the evening at 0.128888889 units. These insights into customer preferences and demand patterns were crucial in determining the initial decision variable values and setting up the constraints to ensure that the production quantities met or exceeded the expected demand.

The constraints added to the "Decision Variables" sheet played a vital role in ensuring that the optimization model adhered to the product demand and raw material availability constraints. Initially, the model showed that the decision variable values (production quantities) violated the constraints, as indicated by the "FALSE" values in the constraint column. For example, the optimal quantity of Aalopuri to be produced in the morning was found to be 215 units, while in the evening, it was 136 units. Similarly, the optimal quantity of Sugarcane juice to be produced at night was 227 units, and the optimal quantity of Vadapav to be produced in the afternoon was 194 units.

Furthermore, the analysis of the historical data revealed interesting patterns in payment methods used by customers. The "Demand Analysis" sheet showed that for beverages (Cold coffee and Sugarcane juice), the total quantity sold was higher in the afternoon (662 units) and evening (518 units) compared to other times of the day. These insights into the payment method preferences and purchasing behaviors of customers can inform the restaurant's pricing strategies, promotional campaigns, and resource allocation decisions.

**Limitations**

While the optimization model developed for Balaji-Fast-Food restaurant provides valuable insights and recommendations, it is essential to acknowledge certain limitations and assumptions inherent in the project. Firstly, the accuracy of the model's output heavily relies on the quality and completeness of the historical data used for analysis. Any errors or inconsistencies in the data could potentially impact the reliability of the expected demand calculations and, consequently, the optimal production quantities suggested by the model.

The model assumes a static demand pattern based on historical data. However, customer preferences and demand patterns can be influenced by various external factors, such as seasonal variations, marketing campaigns, competitor actions, and changes in economic conditions. The model may need to be periodically updated and recalibrated to account for these dynamic changes. Thirdly, the model focuses primarily on maximizing daily revenue and does not explicitly consider factors such as customer satisfaction, brand reputation, or long-term strategic goals.

Additionally, the model assumes that the restaurant has sufficient production capacity and resources to meet the optimal production quantities suggested by the Solver. In reality, there may be operational constraints, such as limited equipment, labor availability, or production bottlenecks, which could impact the feasibility of the recommended production quantities.

Furthermore, the model does not account for potential interdependencies or substitution effects between different food types. For example, if the production of one food type is increased, it may impact the demand for other food types, which could affect the overall revenue maximization objective. Finally, the model relies on certain assumptions and simplifications, such as the linear relationship between production quantities and revenue, constant raw material requirements, and fixed item prices.

**Managerial Recommendations and Insights**

Based on the analysis and results obtained from the optimization model developed for Balaji-Fast-Food restaurant, several managerial recommendations and insights can be derived to support the restaurant's decision-making processes and revenue maximization strategies. The optimal production quantities suggested by the model should be used as a guideline for daily production planning. This will ensure that the restaurant produces the right quantities of each food type at different times of the day, minimizing wastage due to overproduction and lost revenue due to underproduction.

The analysis of customer demand patterns and preferences for different food types at various times of the day can guide the restaurant's pricing strategies. For instance, the restaurant could consider offering discounts or promotions for food items with lower demand during certain time periods to stimulate sales and maximize revenue. The insights gained from analyzing the impact of payment methods (online or cash) on daily revenue can help the restaurant tailor its promotional campaigns and incentives. For example, if online payments contribute significantly to revenue during certain times of the day, the restaurant could consider offering exclusive online discounts or rewards to encourage customer loyalty and drive online sales.

Customer preferences and demand patterns are subject to change over time due to various factors. It is recommended that the restaurant continuously monitor its sales data, update the optimization model with the latest information, and adapt its production and pricing strategies accordingly. Regular data analysis and model recalibration will ensure that the restaurant remains responsive to evolving market conditions. If the optimal production quantities suggested by the model exceed the restaurant's current production capacity, it may be necessary to consider capacity expansion initiatives.

While the primary objective of the model is to maximize revenue, it is crucial for the restaurant to maintain high standards of customer satisfaction. Regularly soliciting customer feedback, addressing quality concerns, and ensuring a positive dining experience will contribute to long-term customer loyalty and sustainable revenue growth.