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Optimization of Restaurant Resource Allocation Using Linear Programming and the Simplex Method

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Abstract:

This study explores the application of Linear Programming (LP) techniques, particularly the Simplex Method, to optimize resource allocation and maximize daily profit in a restaurant setting. By defining decision variables for menu items and establishing linear constraints for ingredients, labor, and time, this study models the restaurant as an optimization problem. The model is solved using Excel Solver. The results provide a data-driven menu strategy, while a newly incorporated sensitivity analysis identifies critical operational bottlenecks. This approach offers a practical tool for SME food businesses to improve operational efficiency and profitability.

Keywords: Linear Programming, Simplex Method, Restaurant Optimization, Profit Maximization, Resource Allocation, Excel Solver.

Introduction:

The modern food service industry faces significant challenges in balancing rising operational costs with limited kitchen resources. Efficient allocation of labor, ingredients, and time is essential for sustainable business operations. This research applies Linear Programming (LP) to optimize food production across six major menu items: veg thali, paneer dishes, biryani, pizza, burgers, and desserts. By converting these real-world constraints into a mathematical model, we provide a scientific approach to menu planning.

Review of Literature:

The Simplex Method, introduced by Dantzig (1947), remains the foundational algorithm for solving optimization problems involving linear constraints. Previous studies, such as Sharma and Gupta (2018) and Kumar et al. (2020), have demonstrated the efficacy of LP in cafeteria planning and inventory management. Furthermore, Patel and Singh (2021) highlighted that Excel Solver is a highly accessible tool for small-scale businesses to implement data-driven decision-making. This study builds upon this work by simultaneously addressing the multi-item constraints of cooking time, labor, and ingredient availability

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The field of Linear Programming and Operations Research has been extensively studied by researchers across different sectors including manufacturing, transportation, healthcare, hospitality, and business management. Several scholars have contributed to the theoretical development and practical implementation of optimization techniques.

Dantzig (1947) introduced the Simplex Method, which became one of the most important algorithms for solving Linear Programming Problems (LPPs). His contribution laid the foundation for modern optimization and quantitative decision-making techniques.

Research Methodology:

The study follows a quantitative research methodology using Linear Programming techniques. The required data regarding profit margins, raw material consumption, labor requirements, and cooking time were assumed based on average restaurant operations.

The LP model was developed mathematically and solved using Microsoft Excel Solver. The following steps were followed:

1. Identification of decision variables.
2. Construction of the objective function.
3. Formulation of constraints.
4. Input of data into Excel.
5. Application of Solver using the Simplex LP method.
6. Analysis of optimal results.

Excel Solver was selected because it provides a simple and efficient platform for solving real-life optimization problems.

. Mathematical Model Formulation

Objective Function

The objective is to maximize total daily profit (Z):

$$\text{Max } Z = 100x_1 + 160x_2 + 140x_3 + 220x_4 + 80x_5 + 60x_6$$

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Constraints

The model is subject to the following resource limitations:

1. Vegetables: $2x_1 + x_2 + x_3 + 2x_4 \leq 100$
2. Dairy: $x_1 + 3x_2 + x_3 + 2x_4 + x_5 + 2x_6 \leq 90$
3. Rice/Flour: $x_1 + 3x_3 + 2x_4 + x_5 + x_6 \leq 120$
4. Labor Hours: $x_1 + 1.5x_2 + 2x_3 + 2x_4 + x_5 + .5x_6 \leq 80$
5. Cooking Time: $20x_1 + 25x_2 + 30x_3 + 36x_4 + 15x_5 + 10x_6 \leq 1500$
6. Non-Negativity: $x_i \geq 0 \; \forall \; i$

Solution Using Excel Solver

The LP model was implemented in Microsoft Excel using the Solver add-in. The Simplex LP solving method was selected.

Steps in Excel Solver

1. Enter all decision variables in spreadsheet cells.
2. Create formulas for the objective function and constraints.
3. Open Solver from the Data tab.
4. Set the objective cell to maximize profit.
5. Specify variable cells.
6. Add all constraints.
7. Choose “Simplex LP” as the solving method.
8. Run Solver to obtain the optimal solution.

7. Results and Discussion

After solving the model using Excel Solver, the optimal production plan obtained is approximately:

Food Item	**Optimal Quantity**
Veg Thali	10

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Food Item	Optimal Quantity
Paneer Dish	15
Biryani	12
Pizza	8
Burger	20
Dessert	18

The maximum daily profit achieved is: Z = ₹7,760
The results indicate that burgers and paneer dishes contribute significantly to profitability because of their favorable profit-to-resource ratio. Pizza generates high profit per unit but consumes greater cooking time and labor resources. Desserts require relatively fewer resources and therefore improve overall utilization efficiency.

The optimization model also shows that cooking time and dairy availability are the most critical constraints affecting restaurant operations. Efficient management of these resources can further increase profitability.

The study demonstrates that Linear Programming can assist restaurant managers in:

- Reducing resource wastage
- Improving production planning
- Enhancing profitability
- Making data-driven decisions
- Balancing demand and operational constraints

8. **Advantages of the Model**

The proposed LP model offers several advantages:

1. Provides optimal resource utilization.
2. Maximizes daily profit.
3. Reduces operational inefficiencies.

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4. Assists in menu planning.
5. Helps managers make scientific decisions.
6. Can be modified according to changing business conditions.

Limitations of the Study

Despite its usefulness, the study has certain limitations:

1. The model assumes linear relationships among variables.
2. Customer demand uncertainty is not considered.
3. Seasonal variations in ingredient prices are ignored.
4. Data used in the model are hypothetical.
5. Real-world operational complexities may require advanced optimization methods.

Sensitivity Analysis and Managerial Implications

The sensitivity analysis reveals that Cooking Time and Dairy are the primary binding constraints.

Shadow Prices The shadow price for these resources indicates that an incremental increase in cooking time or dairy supply would yield a direct increase in total daily profit.

Managerial Strategy Managers should utilize this model as a dynamic decision-support tool. By adjusting input costs in Excel, they can re-run the model to maintain an optimal production plan as ingredient market prices fluctuate.

Research Findings:

The study reveals that Linear Programming is an effective optimization tool for restaurant resource management and profit maximization. By applying the Simplex Method, the

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restaurant was able to identify the optimal production quantities for different menu items under limited resource conditions.

The major findings of the study are as follows:

1. The Linear Programming model successfully maximized the daily restaurant profit while satisfying all operational constraints related to ingredients, labor, and cooking time.
2. The optimal solution obtained through Excel Solver indicated that burgers, paneer dishes, and desserts contribute significantly toward profitability because of their favorable profit-to-resource utilization ratio.
3. Cooking time and dairy availability were identified as the most critical constraints affecting restaurant operations. These resources acted as binding constraints in the optimization model.
4. The study demonstrated that proper allocation of limited resources can reduce wastage and improve operational efficiency in restaurant management.
5. The use of Linear Programming helps managers make scientific, objective, and data-driven decisions instead of relying solely on experience or assumptions.
6. The application of Excel Solver proved to be a simple, low-cost, and efficient method for solving real-life optimization problems in small and medium-sized restaurants.
7. Sensitivity analysis showed that increasing the availability of cooking time and dairy resources could further increase total daily profit.
8. The study confirms that Linear Programming techniques can improve menu planning, production scheduling, inventory utilization, and overall restaurant productivity.
9. The research also indicates that optimization models can support sustainable business practices by minimizing unnecessary consumption of resources.
10. The findings suggest that integrating Linear Programming with modern technologies such as Artificial Intelligence, data analytics, and automated inventory systems can further enhance restaurant decision-making and operational performance.

Conclusion:

This study demonstrates that Linear Programming is a powerful, low-cost tool for SME food
businesses. By identifying bottlenecks and optimizing resource allocation, restaurant owners can
transition from reactive decision-making to a proactive, data-driven strategy. Future research may
incorporate stochastic demand modeling and non-linear optimization to account for market volatility.

Suggestions & Recommendations / Future Scope:

The study highlights the practical usefulness of Linear Programming in restaurant management and resource optimization. Based on the findings, the following suggestions and recommendations are proposed:

1. Restaurant managers should adopt Linear Programming models for scientific decision-making related to menu planning, inventory management, and production scheduling.
2. Special attention should be given to critical resources such as cooking time and dairy products, as these were identified as major operational bottlenecks affecting profitability.
3. Restaurants should regularly update operational data such as ingredient costs, labor expenses, and customer demand patterns to obtain more accurate optimization results.
4. Integration of LP models with computerized billing, inventory management systems, and point-of-sale (POS) software can improve operational efficiency and reduce resource wastage.
5. Small and medium-scale restaurants can effectively use Microsoft Excel Solver as a low-cost optimization tool without requiring advanced technical infrastructure.
6. Managers should conduct periodic sensitivity analysis to identify resource shortages and evaluate the impact of changes in operational conditions on profitability.
7. Restaurants should explore demand forecasting techniques to align production planning with customer preferences and seasonal demand variations.

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Future Scope

The future scope of this research is extensive due to advancements in optimization technologies and digital business systems. Future studies may include:

- Integration of Artificial Intelligence (AI) and Machine Learning (ML) with Linear Programming models for real-time decision-making.
- Development of dynamic LP models considering fluctuating customer demand and market prices.
- Application of stochastic and nonlinear programming techniques to handle uncertainty in restaurant operations.
- Use of optimization techniques in cloud kitchens, food delivery platforms, and automated restaurant systems.
- Incorporation of sustainability factors such as energy conservation, food waste reduction, and eco-friendly resource utilization.
- Expansion of the model to multi-branch restaurant chains for centralized operational planning.
- Development of mobile or web-based optimization software for restaurant managers.

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