Optimization Project

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SUMMARY

GoChatzz is an Indian vegetarian restaurant located in Fremont, California. At reasonable costs, they deliver authentic and excellent Indian cuisine produced from locally available ingredients. They are, however, up against severe competition from other well-known restaurants in the region, such as Idli Express and Dosa Hut.

GoChatzz sought assistance from our analytics team to enhance their operations in order to remain competitive and generate profitability. Our team determined that their raw materials, including ingredient supply and storage, preparation and cooking time, and labour hours, have the greatest potential for optimization.

We created a product mix/profit maximisation linear optimization model that includes decision factors for the top-selling food items: Panipuri, Samosa, Momos, Manchurian, and Jalebi. The goal is to maximise revenue while maintaining sustainability, and we set limitations based on the restaurant's resource capability.

We intended to process the model using Excel solver and get the optimal solution, then examine the solver-sensitivity report to see how changes in objective coefficients affect the optimal solution. We also performed one-way and two-way sensitivity analysis to determine how changes in input parameters affect the optimal solution of the model. Our goal was to assist GoChat in optimising their operations and competing more successfully in the competitive Indian Food Market. We intend to assist GoChat establish itself as a strong player in the local restaurant industry by increasing revenue and maintaining sustainability.

Problem

GoChatzz in Fremont, California confronts stiff competition from several well-known Indian restaurants. The proprietors seek to maximize profits in order to stand out and build a sustainable firm. During a conversation with the owners, we discovered that the number of employees and labour costs are already at a bare minimum, but there is still significant room for improvement in the areas of raw materials, ingredient supply and storage, preparation and cooking time, and total labour hours. To increase profitability, the owners have requested us to recommend the number of units per food item category that must be produced weekly. GoChatzz may reduce waste, limit costs, and increase income by finding the appropriate number of units to generate. To determine the most popular menu items and estimate customer demand, we want to undertake market research and analyze sales data. Furthermore, we will evaluate the restaurant's existing ingredient sourcing and storage processes to find potential areas for improvement. Our goal is to assist GoChatzz in developing a viable business strategy that can prosper in a competitive market. We believe

that by optimizing their manufacturing and ingredient procurement, they will be able to boost profitability while still providing tasty and genuine Indian food to their customers.

We intend to recommend the optimal number of units per food item category that must be produced weekly in order to maximize profitability. Market research and sales data analysis will assist us in determining the most popular menu items and forecasting customer demand. In addition, we will assess the restaurant's current ingredient sourcing and storage processes in order to find potential areas for improvement. Our ultimate goal is to assist GoChat in developing a profitable business model that can thrive in a competitive market by optimizing manufacturing and ingredient procurement.

Proposed Solution

The use of linear programming optimization is suggested as a way to help the GoChatzz make the most money possible. Analysing the numerous limitations and creating decision variables and an objective function that will maximise profit are steps in this strategy.

They can increase their profitability by optimizing their staffing, prices, and inventories. The first stage in the suggested method is to identify the decision variables, or the number of units of each item in the GoChatzz that should be made each week. As a result, GoChatzz will be able to produce the optimal mix of goods based on their likelihood of selling. The target function is then created to maximize profit, taking into account the selling price of each good as well as any connected expenses.

To achieve the objective function, the GoChatzz must consider a variety of constraints, such as ingredient availability based on the restaurant's storage capacity and the associated supplier, total labor hours, and total number of food items provided. These constraints will be built into the model to ensure that the best alternative is feasible and workable. Following the creation of the model, sensitivity analysis will be performed to assess how changing the various constraints will affect the profit. The suggested strategy of using linear programming optimization to optimize revenues is a powerful instrument that can help the restaurant meet its financial goals. This plan will assist in optimizing its product mix, reducing expenses, and increasing income, all of which will raise profitability and sustainability.

Data Collection

Our team has received data from GoChatzz and highlighted five items Panipuri,Samosa,Momos,Manchurian and Jalebi. Each of these food items require specific quantity of Flour, Spices, Vegetables, Potatoes, Sugar, Cooking oil, sweet chutney, hot chutney, GoChatzz special blend.
Weekly, the restaurant imports from a select group of vendors a preset amount of these basic supplies. Additionally, the business is required to prepare a minimum number of each item based on historical demand data for each item. The corporation is faced with a number of limitations, such as the maximum preparation and cooking times depending on the total work hours, the restaurant's weekly capacity for food production, and the limited storage space for raw materials. When creating a solution for their issue, these limitations must be taken into account.

Food Items	Variables	Preparation Time	Cook Time	Profit Per unit
Pani puri	P1	4	8	4.29
Samosa	P2	5	7	6.45
Momos	P3	7	10	7.41
Manchurian	P4	5	10	7.26
Jalebi	P5	8	10	5.61
		5670	6930	

Table 1: Illustrates information on food items, preparation time, cooking time and profit per food item for each type of food.

Food Item Type	Flour	Spices	Vegetables	Potatoes	Sugar	Cooking Oil	Sweet Chutney	Hot Chutney	GoChatzz Special Blend Sauce
Panipuri Plate	2	3	3	1	2	1	2	3	2
Samosa	4	4	6	4	0	3	2	4	2
Momo	3	4	4	0	0	3	3	4	2
Manchurian	0	3	3	1	0	1	2	2	2
Jalebi	3	6	0	0	8	4	0	1	0
Raw Material Availability (ounces per week)	4800	4000	3840	1600	2240	1600	1800	3200	1450

Table 2: Illustrates information on the ingredients required per food item type to prepare each food type.

Data Analysis

The team has conducted an analysis of the data collected from the owners of GoChatzz. One of the constraints identified was the raw material quantities (per week), which were given in pounds. To make it easier to use per item, the team has decided to convert the measurements to ounces. This will allow for more precise calculations and better decision-making when determining the optimal production levels of each food item. To calculate the weekly profit on each type of food item, the team will multiply the individual profit by the number of items prepared weekly. This information will provide a baseline for further analysis and allow the team to understand the profitability of each food item. Using this data, the team can proceed with formulating the model for the Linear Programming optimization. The model will take into account the various constraints, including raw material quantities, labor hours, and overall food items expected to be sold on a weekly basis. These constraints will be incorporated into the model to ensure that the optimal solution is feasible and can be implemented by the restaurant.

Optimization model

We started developing a linear optimization model under the product-mix/profit maximization category. The model includes decision variables, such as the number of units to be produced per food item type, which mainly focused on the five food items with the highest selling capability namely Panipuri, Samosa,Momos,Manchurian, and Jalebi, the objective function is to maximize the restaurant's profitability while ensuring its sustainability, and other inputs like the preparation time, total cooking staff hours & raw materials supply needed on weekly basis. We also formulated constraints pertaining to the inputs such as capacity of resources, ingredient supply, labor hours for preparation, cooking and decision variables that are considered crucial in this particular optimization model.

Decision Variables

Decision variables:	
Number of Panipuri Plates sold weekly, units	**P1**
Number of Samosa Plate sold weekly, units	**P2**
Number of Momo plates sold weekly, units	**P3**
Number of manchurian plates sold weekly, units	**P4**
Number of jalebis sold weekly, units	**P5**

Time requirements

Decisions			Preparation Time, min. per unit	Cooking Time, min. per unit
Number of panipuri Plates sold weekly, units	P1=	140.0	4	8
Number of samosa chat sold weekly, units	P2=	70.0	5	7
Number of momo's plates sold weekly, units	P3=	140.0	7	10
Number of manchuria sold weekly, units	P4=	246.0	5	10
Number of jalebi sold weekly, units	P5=	146.0	8	10
Total cooking staff hours (minutes per week)			5670	6930
	Total	742.0		

Ingredients

Food Item Type	Flour	Spices	Vegetables	Potatoes	Sugar	Cooking Oil	Sweet Chutney	Hot Chutney	GoChatzz Special Blend Sauce
Panipuri Plate	2	3	3	1	2	1	2	3	2
Samosa	4	4	6	4	0	3	2	4	2
Momo	3	4	4	0	0	3	3	4	2
Manchurian	0	3	3	1	0	1	2	2	2
Jalebi	3	6	0	0	8	4	0	1	0
Raw Material Availability (ounces per week)	4800	4000	3840	1600	2240	1600	1800	3200	1450

Objective Function

Objective Function:	
Maximize weekly profit ($)	Max 4.14*P1 + 3.10*P2 + 3.36*P3 + 3.86*P4 + 5.61*P5

Constraints

Constraints:	
Preparation time, min. <= 5670	4*P1 + 5*P2 + 7*P3 + 5*P4+ 8*P5<= 5670
Cooking time, min. <= 6930	8*P1 + 7*P2 +10*P3+ 10*P4 + 10*P5<= 6930
Weekly availability of Flour, ounces <= 4800	2*P1 + 4*P2 + 3*P3 + 0*P4 + 3*P5<= 4800
Weekly availability of spices, ounces <= 4000	3*P1 + 4*P2 + 4*P3 + 3*P4+ 6*P5<= 4000
Weekly availability of vegetables, ounces <= 3840	3*P1 + 6*P2 + 4*P3+ 3*P4+ 0*P5<= 3840
Weekly availability of potatoes, ounces <= 1600	1*P1 + 4*P2 + 0*P3 + 1*P4 + 0*P5<= 1600
Weekly availability of sugar, ounces <= 2240	2*P1 + 0*P2 + 0*P3 + 0*P4 + 8*P5<= 2240
Weekly availability of cooking oil, ounces <= 1600	1*P1 + 3*P2 + 3*P3 + 1*P4 + 4*P5<= 1600
Weekly availability of sweet chutney, ounces <= 960	2*P1 + 2*P2 + 3*P3 + 2*P4 + 0*P5<= 960
Weekly availability of hot chutney, ounces <= 1280	3*P1 + 4*P2 + 4*P3 + 2*P4+ 1*P5<= 1280
Weekly availability of GoChatzz Special Blend, ounces <= 800	2*P1 + 2*P2 + 2*P3 + 2*P4+ 0*P5<= 800
Minimum Panipuri plates sold weekly >= 140	P1 >= 140
Number of Samosa plates sold weekly >= 70	P2 >= 70
Number of Momo plates sold weekly >= 140	P3 >= 140
Number of Manchuriuan plates sold weekly >= 70	P4 >= 70
Number of jalebi sold weekly >= 70	P5 >= 70
Total food items sold weekly <= 1000	P1 + P2 + P3+ P4 +P5 <= 1000
Non-negativity: P1, P2, P3, P4, P5 >=0	

Decision Variables, Input and Constraints using Index Notation Decision Variables:

Table 3

Notation	Description
Pi	Number of types of food items sold, weekly(i=1,2,…,5)

3 illustrates decision variables used

Inputs: The following inputs are used in the model formulation.

Table 4

Notation	Description
i	Food item type, i = 1,2,..,6 (1=PaniPuri, 2=Samosa, 3=Momo, 4= Manchurian, 5= Jalebi
Ci	Profit per item for each food item type i, i = 1, ...,5
Xi	Preparation time for each food item i, i = 1, ...,5
Yi	Cooking time for each food item type i, i = 1, ...,5

Ai	Quantity of Flour required for each item i, i = 1, ...,5
Bi	Quantity of Spices required for each item i, i = 1, ...,5
Di	Quantity of vegetables required for each item i, i = 1, ...,5
Ei	Quantity of Potatoes required for each item i, i = 1, ...,5

Fi	Quantity of Sugar required for each item i, i = 1, ...,5
Gi	Quantity of Cooking Oil required for each item i, i = 1, ...,5
Hi	Quantity of Sweet Chutney required for each item i, i = 1, ...,5
Ii	Quantity of Hot Chutney required for each item i, i = 1, ...,5
Ji	Quantity of GoChatzz Special Blend Sauce required for each item i, i = 1, ...,5
TP	Maximum preparation time available weekly (TP =5670)
Tc	Maximum preparation time available weekly (Tc =6930)
Amax	Maximum quantity of Flour available every week (Amax =4800)
Bmax	Maximum quantity of Spices available every week (Bmax =4000)

Dmax	Maximum quantity of vegetables available every week (Dmax =3840)
Emax	Maximum quantity of Potatoes available every week (Emax =1600)
Fmax	Maximum quantity of Sugar available every week (Fmax =2240)
Gmax	Maximum quantity of Cooking Oil available every week (Gmax =1600)
Hmax	Maximum quantity of Sweet Chutney available every week (Hmax =1800)
Imax	Maximum quantity of Hot Chutney available every week (Imax =3200)
Jmax	Maximum quantity of GoChatzz Special blend sauce available every week (Jmax =1450)
P1min	Minimum no of PaniPuri plates to be sold weekly (P1min =140)
P2min	Minimum no of Samosa be sold weekly (P2min =70)
P3min	Minimum no of Momo’s to be sold weekly (P3min =140)
P4min	Minimum no of Manchuria to be sold weekly (P4min =246)

P5min	Minimum no of Jalebi to be made sold (P5min =146)
Pmax	Maximum no of food items to be sold weekly (Pmax <= 1000)

4 illustrates the input parameters for LP

Objective to maximize weekly total profit: Max Pi

Constraints:

Maximum preparation time available weekly: Pi ≤ TP

Maximum cooking time available weekly: Pi ≤ TC

Minimum number of Pani Puri to be sold weekly: P1 ≥ P1min

Minimum number of Samosa to be sold weekly: P2 ≥ P2min

Minimum number of Momos to be sold weekly: P3 ≥ P3min

Minimum number of manchurian to be sold weekly: P4 ≥ P4min

Minimum number of Jalebi to be sold weekly: P5 ≥ P5min

Maximum quantity of Spices available every week: Pi ≤ Amax

Maximum quantity of Vegetables available every week: Pi ≤ Bmax

Maximum quantity of Potato available every week: Pi ≤ Dmax

Maximum quantity of sugar available every week: Pi ≤ Emax

Maximum quantity of cooking oil available every week: Pi ≤ Fmax

Maximum quantity of sweet chutney available every week: Pi ≤ Gmax

Maximum quantity of hot chutney available every week: Pi ≤ Hmax

Maximum quantity of GoChatzz Special blend available every week: Pi ≤ Imax

Maximum quantity of food items to be sold weekly: ≤ Pmax

Nonnegativity: Pi ≥ 0 where i =1, ...,4

Solution Results and Analysis

We computed the highest profit by minimising the amount of food items that must be sold while adhering to all constraints. The table below displays the quantity of different Food items - Pani Puri, Samosa Chaat, Momo's, Manchuria, Jalebi - that must be sold weekly in order to achieve the maximum profit of $4695.52 USD each week.

Decisions		
Number of panipuri Plates sold weekly, units	P1=	140.0
Number of samosa chat sold weekly, units	P2=	70.0
Number of momo's plates sold weekly, units	P3=	140.0
Number of manchuria sold weekly, units	P4=	246.0
Number of jalebi sold weekly, units	P5=	146.0
Total cooking staff hours (minutes per week)		
	Total	742.0

We calculated the profit split for each food item type based on the percentage of different types of food items sold by Go Chaats to achieve the greatest weekly profit. As shown on the graph below, Manchuria contributes the biggest profit share of around **$1785.96,** followed by Momo's, which contributes **$999.6** of our maximum weekly earnings of **$4694.52 USD.**

Sensitivity Analysis

Sensitivity Analysis is the inquiry that deals with variations in the optimal solution as a result of parameter modifications. Sensitivity Analysis is used to determine the impact of a group of independent factors on a dependent variable under specified conditions. A LP model can be subjected to many sorts of sensitivity analysis. We performed three different forms of Sensitivity Analysis in this case.

- Solver Sensitivity Report
- Solver Table Two Way Analysis

Solver Sensitivity Report

SolverSensitivity Report in Excel allows you to build a sensitivity report with any solved LP model. The report includes two tables, one dealing with variables and the other with restrictions. To further analyse the model solution, the solver-sensitivity report shown below

was prepared for this model.

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficien	Allowable Increase	Allowable Decrease
C4	P1=	140	0	4.29	1.636956522	1E+30
C5	P2=	169.1304348	0	6.45	15.33	1.1955
C6	P3=	140	0	7.41	1.039565217	1E+30
C7	P4=	252.6086957	0	7.26	1.954285714	2.214705882
C8	P5=	70	0	5.61	3.434347826	1E+30

This section deals with the sensitivity of the coefficients to modifications. Each row in this section shows how changing one of these coefficients affects the optimal solution. In general, a lowered cost in the second column indicates how much the objective coefficient of a choice variable that is now 0 must change before the variable changes. We don't have any reduced costs estimated because there are no food items with a 0 value.

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
B23	Preparation time, min. <= 5670 LHS	4208.695652	0	5670	1E+30	1461.304348
B24	Cooking time, min. <= 6930 LHS	6930	0.666521739	6930	267.5	1400
B25	Weekly availability of Flour, ounces <= 4800 LHS	1586.521739	0	4800	1E+30	3213.478261
B26	Weekly availability of spices, ounces <= 4000 LHS	2834.347826	0	4000	1E+30	1165.652174
B27	Weekly availability of vegetables, ounces <= 3840 LHS	2752.608696	0	3840	1E+30	1087.391304
B28	Weekly availability of potatoes, ounces <= 1600 LHS	1069.130435	0	1600	1E+30	530.8695652
B29	Weekly availability of sugar, ounces <= 2240 LHS	840	0	2240	1E+30	1400
B30	Weekly availability of cooking oil, ounces <= 1600 LHS	1600	0.594782609	1600	178.3333333	228
B31	Weekly availability of sweet chutney, ounces <= 1800 LHS	1543.478261	0	1800	1E+30	256.5217391
B32	Weekly availability of hot chutney, ounces <= 3200 LHS	2231.73913	0	3200	1E+30	968.2608696
B33	Weekly availability of GoChatzz Special Blend, ounces <= 1450 LH	1403.478261	0	1450	1E+30	46.52173913
B34	Minimum Panipuri plates sold weekly >= 140 LHS	140	-1.636956522	140	133.75	140
B35	Number of Samosa plates sold weekly >= 70 LHS	169.1304348	0	70	99.13043478	1E+30
B36	Number of Momo plates sold weekly >= 140 LHS	140	-1.039565217	140	114	89.16666667
B37	Number of Manchuriuan plates sold weekly >= 70 LHS	252.6086957	0	70	182.6086957	1E+30
B38	Number of jalebi sold weekly >= 70 LHS	70	-3.434347826	70	76	16.71875
B39	Total food items sold weekly <= 1000 LHS	771.7391304	0	1000	1E+30	228.2608696

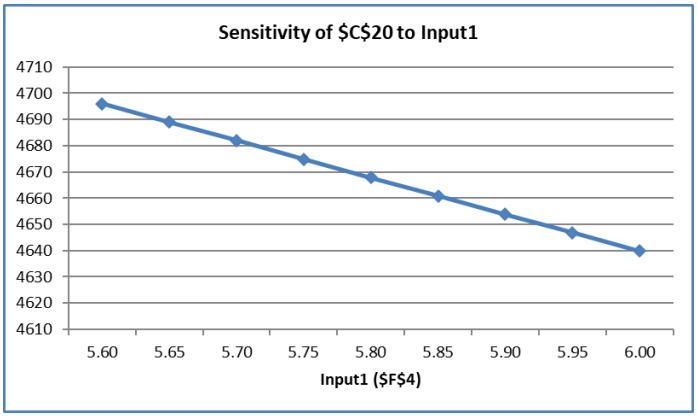
This section is for sensitivity to changes in the right-hand side (RHS). Each row in this section indicates how the optimal solution changes if one of these availabilities' changes. A shadow price indicates the change in the optimal value of the objective when the right-hand side of some constraint changes by one unit. For number of Samosa's sold weekly allowable increase is 15.33, allowable decrease is 1.19 and shadow price is 0 which implies that in case the number of Samosa's sold weekly decrease below 140 for example 139, the total profit will go down. We have a similar analysis for rest of the items

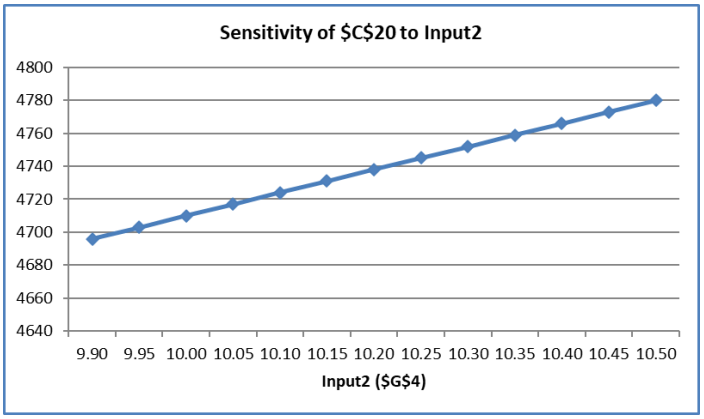
Two-Way Sensitivity Analysis For two-way sensitivity analysis there can be one or maximum two input cells and multiple output cells.

Two-way analysis for Solver model in food item_mix_Solution worksheet

Input1 (cell F4) values along side, Input2 (cell G4) values along top, output cell in corner

C$20	9.90	9.95	10.00	10.05	10.10	10.15	10.20	10.25	10.30	10.35	10.40	10.45	10.50
5.60	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92	4744.92	4751.92	4758.92	4765.92	4772.92	4779.92
5.65	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92	4744.92	4751.92	4758.92	4765.92	4772.92
5.70	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92	4744.92	4751.92	4758.92	4765.92
5.75	4674.92	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92	4744.92	4751.92	4758.92
5.80	4667.92	4674.92	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92	4744.92	4751.92
5.85	4660.92	4667.92	4674.92	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92	4744.92
5.90	4653.92	4660.92	4667.92	4674.92	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92	4737.92
5.95	4646.92	4653.92	4660.92	4667.92	4674.92	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92	4730.92
6.00	4639.92	4646.92	4653.92	4660.92	4667.92	4674.92	4681.92	4688.92	4695.92	4702.92	4709.92	4716.92	4723.92





Conclusion

Based on the data collected and the output of the optimization model, the following conclusions can be gathered:

● For the restaurant's product-mix-based profit maximization model, the linear programming (LP) method is applied. After accounting for all constraints such as raw material availability, the minimum/maximum quantity of food items to be produced (due to storage capacity and supplier production capability), and maximum preparation and cooking time, the maximum weekly profit value is $4694.52.

● This corresponds to the owners' annual profit forecasts. Given that this is a relatively new enterprise, the owners anticipate a profit of roughly $244,115.04 per annum. According to our calculations, the restaurant will make $244,115.0 every year.

●Furthermore, according to industry norms, the expected number of orders (number of food items) for a restaurant on a daily basis is normally in the range of 100-300, depending on the vintage and popularity of the facility. In this scenario, the decision variables, namely the number of food items sold each week, total 742.0 (Pani Puri Plates - 140, Samosa Chaat - 70, Momo's plate - 140, Manchuria plate - 246.0, jalebi - 146.0), indicating that it meets the norms.

● The decision factors consist of five food products (vegan/veggies), as specified by the owners based on majority sales over the previous month and basic awareness of the business. The proprietors' initial assumption was that Pani Puri and Samosa Chaat would be the most popular in terms of sales. However, according to the model, Manchuria and Momo's sales contribute the most to optimal profit value. The proprietors may now concentrate on increasing the popularity of Momo's and Manchuria, hence increasing profitability.

● Two-way sensitivity analysis involving profit per unit of te items is also included, This is intended for the owners to have a better understanding of this particular variation and make changes to the product's pricing, if necessary**.**

References (Bibliography) : https://www.gochaatzzfremont.com/

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