Performance Improvement of a Restaurant, Through Optimization Applications

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Abstract

This paper studies the menu in a traditional restaurant business. The restaurant in view struggles with pressures related to poor product planning, manual scheduling of employees as well as weak links in the menu. The paper seeks to optimize the profitability of the menu, identify potential monetary leakages and design a rotation-based schedule for employees. Further, we seek to tackle this issue through analyzing our system using a revised simplex method and generating an adjustable model. The paper uses minimization techniques in order to cut costs with scheduling, through linear programming and formulation using Lingo as a tool. Moreover, after implementing recommendations found in this paper, restaurant profitability was found to increase drastically.

Keywords

Optimization, linear programming, scheduling, cost analysis.

1. Introduction

Romana is a traditional middle eastern restaurant based in Riyadh, Saudi Arabia. It opened its doors mid-2021. Due to the impact of covid-19 on the F&B industry as well as the shop-owners' relatively novel experience, the restaurant has struggled with meeting financial expectations set out in the initial plan. Viewing this, the shop-owners sought to find an objective antidote to increase their efficiency as a business. The paper seeks to offer small businesses a simple, customizable and effective model to use as a tool. Further, as a team, the writers are motivated to preserve iconic local initiatives and help them navigate with ease. The methods applied in the paper are applicable to a wide array of small businesses found in the region.

1.1 Objectives

The research seeks to fulfil four main objectives, namely:

1- To provide an optimized business model, complete with an accurate objective function and constraints.
2- Explore scheduling options as to allocate workers in demand relative shift times.

3- Identify monetary leakages and find feasible solutions.
4- Identify products with the most reduced cost on the restaurant.

2. Literature Review

Many studies have sought to address the issue of optimizing restaurant menus with the objective of profit maximization. In this section, we seek to review established literatures related to our topic.

Waheed et al (2012), demonstrates the practical use of linear programming, where it has been stated that linear-programming is used regularly as a tool in operational research. Further, the paper demonstrated the optimization of profits in a soap mixture business. Analysis for this was completed with R-statistical package. Fagoyinbo and Ajibode (2010) report that the success of an organization depends largely on objective decisions regarding business planning. They argue that this stage cannot be left to individual experience since a wrong decision could be very costly. Further they arrive to linear programming as an effective quantitative method to decision making. In their paper titled "use of linear programming for optimal production", Balogun et al (2012) have found that in production sectors, management is often faced with issues regarding the proper allocation of resources. In their study, modelling for the Coca-Cola company, they have found that only 2 out of the 9 products in question were contributing towards the maximization of profit. Additionally, Mula et al (2005) argue that in mathematical modelling, embedding uncertainty is crucial in order to make optimal choices. This takes shape in sensitivity analysis.

Moreover, a number of concepts regarding scheduling were taken into account. Floudas and Lin (2005) report that scheduling involves the determination and allocation of a plant's resources. Manne (1960) suggested a discrete linear programming model to solve typical job-shop scheduling problems. Several earlier reviews for scheduling were found, where Jain (1998) focuses on job-shop scheduling techniques. Graves (1981) focuses on production scheduling. More recently, Çaliş (2015) focuses on generating AI solutions for JSP optimization.

Finally, our paper seeks to address to continue upon previous research with a focus on small business in the region of Saudi Arabia. Few adaptations have taken place in this ecosystem. We seek for our paper to provide an empirical study for this region.

3. Methods

In order to proceed with calculations, a few assumptions were put into place, namely:

i. We assume that total demand is held at an average rate of 14,740 orders per month.
ii. Demand is lower on the weekends.
iii. We assume that labor efficiency gives an efficiency of 50 units per hour, 400 per shift or 12,400 monthly.
iv. We assume that the demand weightage is unequal. Where some products outperform others.
v. We must reach a margin of profit of at least 17,000 monthly to break even.

Given these assumptions we can derive the following two equations as objective functions:

1) Max z=
20.5275X1+ 17.595X2+ 11.73X3+ 5.865X4+ 12.7075X5+ 13.685X6+ 18.5725X7+ 12.7075X8+ 5.474X19+ 10.7525X20+ 5.865X21+ 11.73X22+ 11.73X24+ 11.73X25+ 11.73X26+ 11.73X27+ 12.7075X28+ 12.7075X29+ 10.7525X30+ 10.7525X31+ 5.865X32+ 5.865X33+ 10.7525X34+ 12.7075X35+ 8.7975X36+ 8.7975X37+ 6.8425X38+ 7.82X39+ 7.82X40+ 8.7975X41+ 5.865X42+ 5.865X43+ 6.8425X44+ 6.8425X45+ 6.8425X46+ 6.8425X47+ 6.8425X48+ 5.865X49+ 5.865X50+ 6.8425X51+ 6.8425X52+ 5.865X53+ 8.7975X54
2) Max z=
2.9325X9+2.9325X10+2.9325X11+2.9325X12+2.9325X+132.9325X14+3.91X15+3.91X16+1.955X17+2.9325X18+2.9325X55

Where the first equation signifies the profits made through food products and the latter signifies profits made through beverages.

We also derive the following constraints:

1- Beverage demand constraint: $\sum X_{i \leq}$ 7500 units.
2- Food demand constraint: $\sum Xi$ = 14,750 units / month.
3- Labor efficiency constraint: $\sum X_{i \leq}$ 12400 units / month.
4- Special demand for product 3 constraint: $X3 \geq 70$ units.

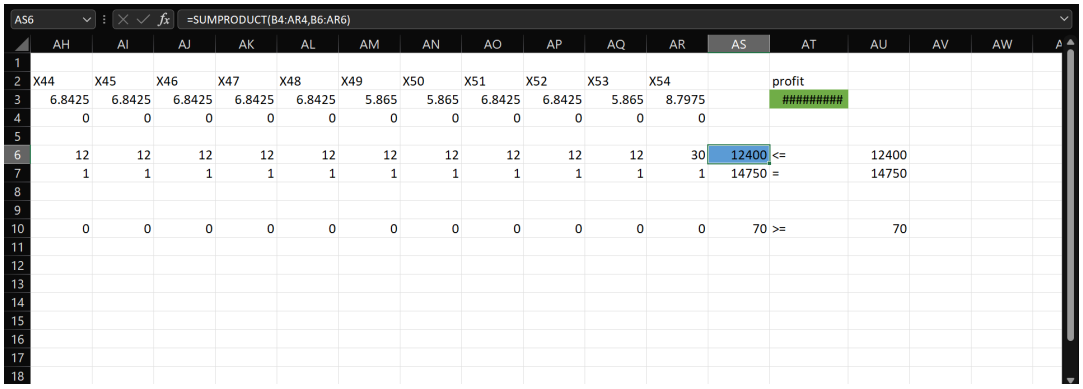
Through plotting the beverage objective function in Excel we get:

TABLE 1: Beverage Product Formulation

VARS	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X55
PROFIT	2.9325	2.9325	2.9325	2.9325	2.9325	2.9325	3.91	3.91	1.955	2.9325	2.9325
QUANTITY	0	0	0	0	0	0	7500	0	0	0	0
Demand Constraint:	1	1	1	1	1	1	1	1	1	1	1

For the food products we also get:

Table 2: Food Products



Scheduling:

Using Lingo to optimize our workers' schedules we derive the following as an objective function:

MIN= X1+X2+X3+X4+X5+X6+X7, where variables Xi represent days Sunday through Saturday.

We also derive the following constraints:

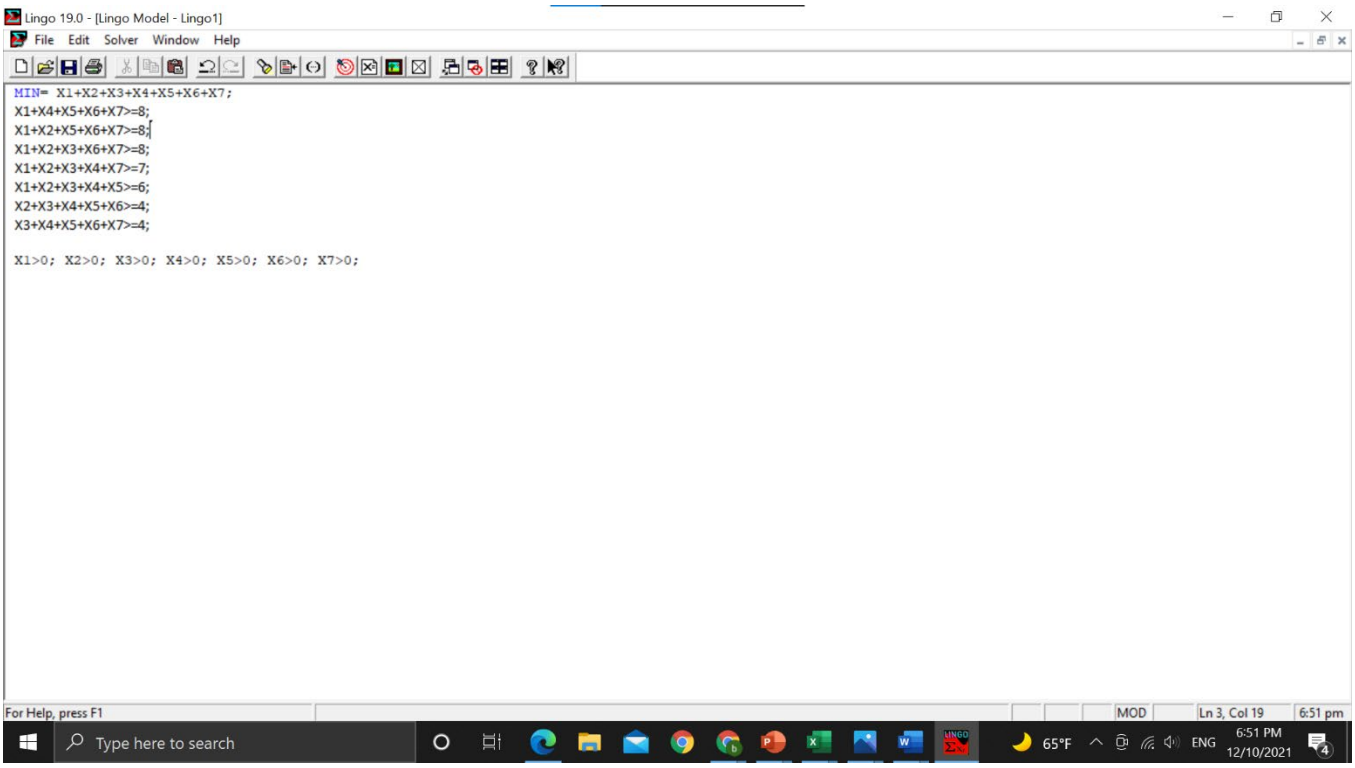
I. X1+X4+X5+X6+X7>=8;
II. X1+X2+X5+X6+X7>=8;
III. X1+X2+X3+X6+X7>=8;
IV. X1+X2+X3+X4+X7>=7;
V. X1+X2+X3+X4+X5>=6;
VI. X2+X3+X4+X5+X6>=4;
VII. X3+X4+X5+X6+X7>=4;

X1>0; X2>0; X3>0; X4>0; X5>0; X6>0; X7>0;

Where constraints I through VII represent the demand on each day, the final row represents positivity constraints placed on our variables.

Viewing this in Lingo:

Table 3: Schedule Formulation



4. Data Collection

Data for our analysis was granted to us by the shop-owners directly. This included the cost of rent, cost of ingredients and utility costs. These costs are reflected in the food constraint found in table 1. Further, prices were obtained through the restaurant's menu directly. Otherwise, formulations and results concerning the scheduling of employees were derived based on forecasts made by the shop-owners directly.

5. Results and Discussion

Table 4: Beverages, Optimal

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$N$3	PROFIT PROFIT	0	29325

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$4	QUANTITY X9	0	0	Contin
$C$4	QUANTITY X10	0	0	Contin
$D$4	QUANTITY X11	0	0	Contin
$E$4	QUANTITY X12	0	0	Contin
$F$4	QUANTITY X13	0	0	Contin
$G$4	QUANTITY X14	0	0	Contin
$H$4	QUANTITY X15	0	7500	Contin
$I$4	QUANTITY X16	0	0	Contin
$J$4	QUANTITY X17	0	0	Contin
$K$4	QUANTITY X18	0	0	Contin
$L$4	QUANTITY X55	0	0	Contin

Table 5: Food, Optimal

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$AT$3	Profit profit	$ 15,882.18	$ 15,882.18

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$4	quantities x1	727.0140594	727.0140594	Contin
$C$4	quantities x2	0	0	Contin
$D$4	quantities x3	70	70	Contin
$E$4	quantities x4	23.40995314	23.40995314	Contin
$F$4	quantities x5	0	0	Contin
$G$4	quantities x6	0	0	Contin
$H$4	quantities x7	0	0	Contin
$I$4	quantities x8	0	0	Contin
$J$4	quantities X19	0	0	Contin
$K$4	quantities X20	0	0	Contin
$L$4	quantities X21	0	0	Contin
$M$4	quantities X22	0	0	Contin
$N$4	quantities X24	0	0	Contin
$O$4	quantities X25	0	0	Contin
$P$4	quantities X26	0	0	Contin
$Q$4	quantities X27	0	0	Contin
$R$4	quantities X28	0	0	Contin
$S$4	quantities X29	0	0	Contin
$T$4	quantities X30	0	0	Contin
$U$4	quantities X31	0	0	Contin
$V$4	quantities X32	0	0	Contin
$W$4	quantities X33	0	0	Contin
$X$4	quantities X34	0	0	Contin
$Y$4	quantities X35	0	0	Contin
$Z$4	quantities X36	0	0	Contin
$AA$4	quantities X37	0	0	Contin
$AB$4	quantities X38	0	0	Contin
$AC$4	quantities X39	0	0	Contin
$AD$4	quantities X40	0	0	Contin
$AE$4	quantities X41	0	0	Contin
$AF$4	quantities X42	0	0	Contin
$AG$4	quantities X43	0	0	Contin
$AH$4	quantities X44	0	0	Contin
$AI$4	quantities X45	0	0	Contin
$AJ$4	quantities X46	0	0	Contin
$AK$4	quantities X47	0	0	Contin
$AL$4	quantities X48	0	0	Contin
$AM$4	quantities X49	0	0	Contin
$AN$4	quantities X50	0	0	Contin
$AO$4	quantities X51	0	0	Contin
$AP$4	quantities X52	0	0	Contin
$AQ$4	quantities X53	0	0	Contin
$AR$4	quantities X54	0	0	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$AS$10	large shawerma	70	$AS$10>=$AU$10	Binding	0
$AS$6	Labor Constraint units produced:	12400	$AS$6<=$AU$6	Binding	0
$AS$7	Demand Constraint:	14750	$AS$7=$AU$7	Binding	0

Table 6: Sensitivity Analysis of Beverage Products

riable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$4	QUANTITY X9	0	-0.9775	2.9325	0.9775	1E+30
$C$4	QUANTITY X10	0	-0.9775	2.9325	0.9775	1E+30
$D$4	QUANTITY X11	0	-0.9775	2.9325	0.9775	1E+30
$E$4	QUANTITY X12	0	-0.9775	2.9325	0.9775	1E+30
$F$4	QUANTITY X13	0	-0.9775	2.9325	0.9775	1E+30
$G$4	QUANTITY X14	0	-0.9775	2.9325	0.9775	1E+30
$H$4	QUANTITY X15	7500	0	3.91	1E+30	0
$I$4	QUANTITY X16	0	0	3.91	0	1E+30
$J$4	QUANTITY X17	0	-1.955	1.955	1.955	1E+30
$K$4	QUANTITY X18	0	-0.9775	2.9325	0.9775	1E+30
$L$4	QUANTITY X55	0	-0.9775	2.9325	0.9775	1E+30

nstraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$M$6	Demand Constraint:	7500	3.91	7500	1E+30	7500

Table 7: Sensitivity Analysis of Food Products

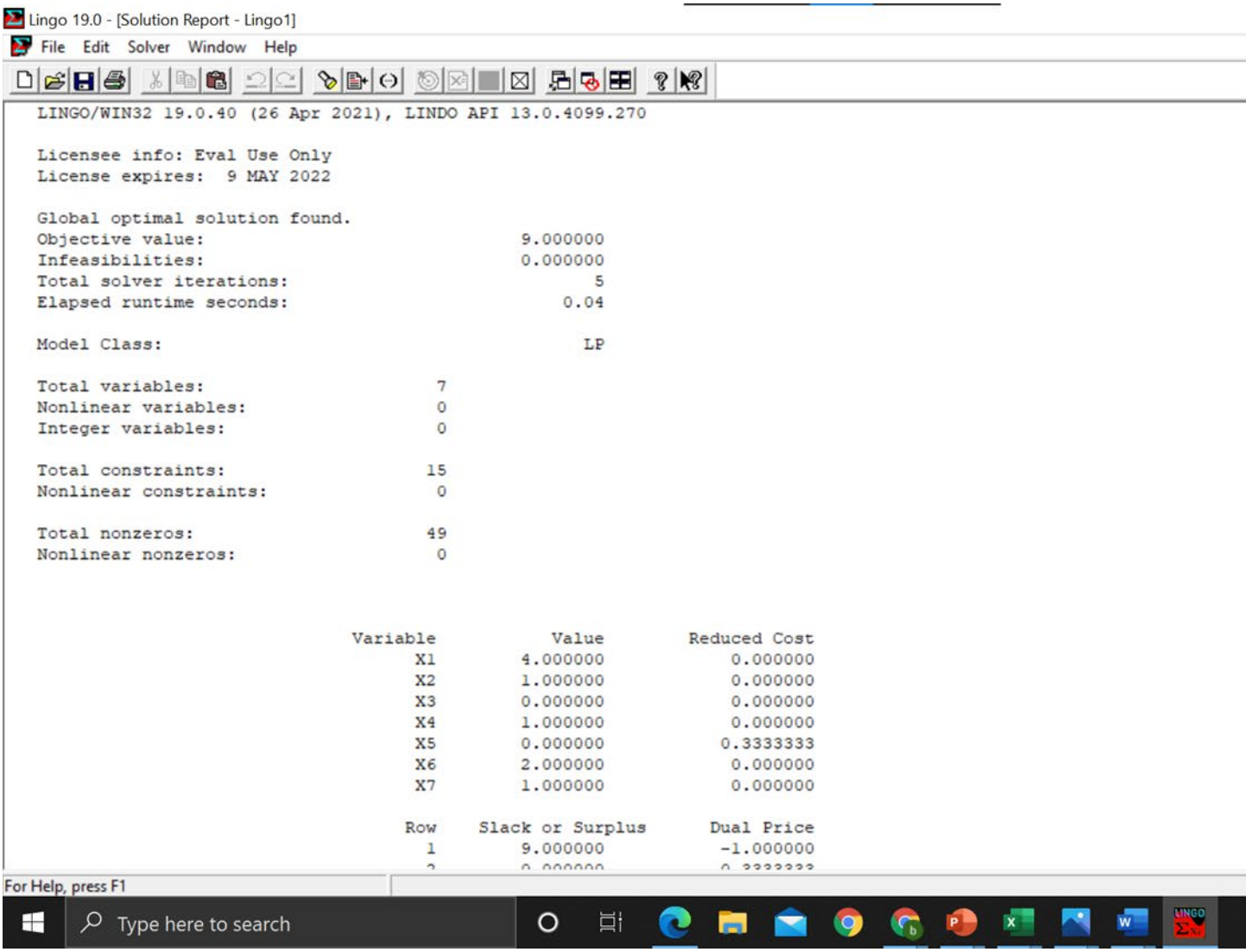
Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$4	quantities x1	727.0140594	0	20.5275	1E+30	3.661113462
$C$4	quantities x2	0	-4.305493751	17.595	4.305493751	1E+30
$D$4	quantities x3	70	0	11.73	2.124279179	1E+30
$E$4	quantities x4	23.40995314	0	5.865	6152.385	6.410030303
$F$4	quantities x5	0	-14.68496876	12.7075	14.68496876	1E+30
$G$4	quantities x6	0	-2.915266682	13.685	2.915266682	1E+30
$H$4	quantities x7	0	-15.68493751	18.5725	15.68493751	1E+30
$I$4	quantities x8	0	-28.41490627	12.7075	28.41490627	1E+30
$J$4	quantities X19	0	-56.24331254	5.474	56.24331254	1E+30
$K$4	quantities X20	0	-33.11589377	10.7525	33.11589377	1E+30
$L$4	quantities X21	0	-43.49536878	5.865	43.49536878	1E+30
$M$4	quantities X22	0	-33.67826713	11.73	33.67826713	1E+30
$N$4	quantities X24	0	-22.52743751	11.73	22.52743751	1E+30
$O$4	quantities X25	0	-15.66246876	11.73	15.66246876	1E+30
$P$4	quantities X26	0	-22.52743751	11.73	22.52743751	1E+30
$Q$4	quantities X27	0	-12.91648125	11.73	12.91648125	1E+30
$R$4	quantities X28	0	-18.80395001	12.7075	18.80395001	1E+30
$S$4	quantities X29	0	-11.93898125	12.7075	11.93898125	1E+30
$T$4	quantities X30	0	-13.89398125	10.7525	13.89398125	1E+30
$U$4	quantities X31	0	-11.14799375	10.7525	11.14799375	1E+30
$V$4	quantities X32	0	-20.15447501	5.865	20.15447501	1E+30
$W$4	quantities X33	0	-10.54351875	5.865	10.54351875	1E+30
$X$4	quantities X34	0	-16.63996876	10.7525	16.63996876	1E+30
$Y$4	quantities X35	0	-14.68496876	12.7075	14.68496876	1E+30
$Z$4	quantities X36	0	-18.59496876	8.7975	18.59496876	1E+30
$AA$4	quantities X37	0	-52.91981254	8.7975	52.91981254	1E+30
$AB$4	quantities X38	0	-54.87481254	6.8425	54.87481254	1E+30
$AC$4	quantities X39	0	-8.588518746	7.82	8.588518746	1E+30
$AD$4	quantities X40	0	-8.588518746	7.82	8.588518746	1E+30
$AE$4	quantities X41	0	-7.611018746	8.7975	7.611018746	1E+30
$AF$4	quantities X42	0	-10.54351875	5.865	10.54351875	1E+30
$AG$4	quantities X43	0	-17.4084875	5.865	17.4084875	1E+30
$AH$4	quantities X44	0	-9.566018746	6.8425	9.566018746	1E+30
$AI$4	quantities X45	0	-9.566018746	6.8425	9.566018746	1E+30
$AJ$4	quantities X46	0	-9.566018746	6.8425	9.566018746	1E+30
$AK$4	quantities X47	0	-9.566018746	6.8425	9.566018746	1E+30
$AL$4	quantities X48	0	-9.566018746	6.8425	9.566018746	1E+30
$AM$4	quantities X49	0	-10.54351875	5.865	10.54351875	1E+30
$AN$4	quantities X50	0	-10.54351875	5.865	10.54351875	1E+30
$AO$4	quantities X51	0	-9.566018746	6.8425	9.566018746	1E+30
$AP$4	quantities X52	0	-9.566018746	6.8425	9.566018746	1E+30
$AQ$4	quantities X53	0	-10.54351875	5.865	10.54351875	1E+30
$AR$4	quantities X54	0	-32.32490627	8.7975	32.32490627	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$AS$10	large shawerma	70	-2.124279179	70	70.63973064	70
$AS$6	Labor Constraint units produced:	12400	1.372993751	12400	104900	10859.16667
$AS$7	Demand Constraint:	14750	-0.067406271	14750	171460.5263	6993.333333

Table 8: Optimized Schedule



Viewing our obtained results, we can infer that only 5 of our original 55 variables proved to be contributing towards the profit. Namely, variables: Shawerma plate(X1) with quantity of 727 plate will reach a profit of 14,923 SR ,70 of Large Shawerma (X3) should be sold to satisfy the demand and it will return 821.1SR as profit, 23 of Small Shawerma(X4) will return 134.9 SR as profit, Pepsi(X15) as it doesn't take no time to serve, it will return the most profit for the restaurant with 8000 Pepsi cans sold 23,460SR will be received as profit ,1600 cans of 7up(X16) will return 5865SR as profit. Moreover, given our variables and constraints we can obtain an optimized profit 45,207 SAR per month.

From our analysis using Lingo we denote that 9 employees would be optimal for our situation. Four employees will be starting their workings day on Sunday, one employee will start on Monday, Wednesday and Saturday, none of the employee will start on Tuesday and Thursday and two employees will start on Friday. This schedule will satisfy both the restaurant owner and the workers. All workers will get two consecutive off-work days per week; 9 employees is the least number of employees to achieve that specific demand per day.

6. Conclusion

In this paper, we have effectively addressed the issue of underperformance at our targeted business. Further, we have explored linear programming and believe firmly in its value as a tool for modeling. We have provided an accessible method for small businesses to analyze and process data. This makes it feasible; we believe for many other practical areas.

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