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RESEARCH ARTICLE

A Study on Transport Cost Optimization in Several Sectors: A Case Study of Operation Research

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ABSTRACT

The main objective is to formulate and computational study of transportation problem to maximize the profit in food transportation in rail logistics. The transportation of food products within rail logistics are in demand nowadays as the tourism is increasing day by day and also it presents a critical operational challenge for railway operators and food distributors to earn and to provide food in optimal cost. Through case studies, examples and by using some computational techniques, this research highlights the best practices and innovative approaches adopted by industry leaders to achieve significant cost savings and operational excellence in the transportation of food products via rail. Also, after maximizing the profit, Microsoft excel is used to achieve the optimal solution and the solution is verified by solving manually.

INTRODUCTION

Operation research is a systematic and analytic approach that helps in solving problem and in decision making.

It is a branch of mathematics that applies statistics and unique techniques to get optimal solution for the most complex problems. The optimal solution is mainly obtained with maximizing the profit and minimizing the loss and risk.

A classic optimization problem that is an exceptional subclass of (LPP) linear programming problem that gives out the most effective and efficient way to transport goods from multiple sources to various destinations along with minimizing transportation cost such a problem is defined as transportation problem.

In transportation problem it is assumed that the supply and demand values are deterministic and known in advance.

Travelling in train going on long distance family trips, having fun with family or even sometimes going somewhere in train in emergency but unable to carry foods and eating stuffs with oneself.

As we known that railway is major part of common means life and so is food.

Minister of state railway stated that in 2014 − 15 the railway catering services earned a revenue of Rs.13,255 but the expenses were Rs.2.3 Lakh. While in 2015 − 16 total amount earned was Rs.14.83 Lakh and expenses were Rs.1.29 Crore and in year 2016 − 17 total earning was Rs.1.38 Crore and expenses were Rs.2.89 Crore [see, 1].

In 2017 − 18 generated revenue was Rs.1.8 Crore and expenses were of Rs.2.89 Crore. The onboard catering marketing is expected to exhibita growth rate of more than 5% during period on 2020 − 2025 [see, 2].

In 2013, Deepak Baindur et.al gave a theory of transportation problem in food delivery systemby taking Mumbai dabbas system into consideration. This paper was based on the case study of the lunch box delivery system organized by the Mumbai dabbawallas. This paper suggests the facts that motivates to adapt logistics solutions to urban landscape and public policy in such a way that it meets the consumers as well as producers' satisfaction. By taking both qualitative and quantitative data into consideration a case study on Mumbai dabbawallas or Mumbai lunch box carriers was conducted and inferences were made on that basis [see, 3].

In 2013 paper titled as Effect of distance of transportation on willingness to pay for food waspublished by Grebitus in which the main aim was to discuss the issue of distance of transporting and its impact on consumer preference. According to the researcher, the price of the food varies with the amount of distance the food travelled which also depend on the type of the food ordered and varies accordingly. Consumers increasingly show interests in food which is locally grown and also some food is consistently marketed as locally grown. This paper mainly aims to get the answer to the question that how the price and the driver preference for delivery of the food varies on the basis of number of miles travelled by the food [see, 4].

In 2014, Shilpa Parkhi et.al proposed a paper that optimizes the logistic cost at secondary distribution of retail supply chain. The main aim of this paper was to optimize the logistics cost at secondary distribution network. The crucial part of the logistics is the transportation as it determines the efficiency of the moving products. Along with optimizing the transportation cost this paper also discusses the importance of transportation and also provide the solution to reduce the transportation cost by considering various factors affecting the cost. But the limitation of this study is that it is limited to retail distribution network [see, 5].

In 2016, Nakandala, D., Lau, H., & Zhang, J., published a paper on topic, Cost-optimization modelling for fresh food quality and transportation. In this paper, researcher main aim was to manage both product quality and cost. During research they considered a case of multiple fresh food products collected from various farms to be transported to warehouses to the retailers. In this study the researchers developed a total cost model in which they included cost and the quality of product while transportation. They used the GA, FGA and SA with repair mechanism to demonstrate the total cost model [see, 6].

In 2018, paper titled as Operation research in food delivery was proposed by Gera, M., Nawander, N., Tharwani, N., & Bhatia, P. The main aim of this research paper was to explore the use of operation research in food delivery companies explaining the mechanism restaurants use to choose between these food delivering companies using the transportation problem. They focused on giving the overview of how can transportation modelling can be used in deciding the food delivery companies and restaurants [see, 7].

In 2019, Wu, X., Nie, L., Xu, M., & Zhao, L., proposed a theory with title, Distribution planning problem for a high-speed rail catering service considering time-varying demands and pedestrian congestion: A lot-sizing-based model and decomposition algorithm. In this paper, the main finding was to determine the locations for producing different types of food products and controlling the inventory levels of trains during their trips, considering the storage capacities and time-varying demands. A Lagrangian substitution-based solution approach was applied to decompose the model into a mixed integer linear programming model and a sequence of univariate concave models [see, 8].

In 2023, Chunling Luo and Lei Xu designed a theory to optimize the meal ordering procedureand proposed some optimized policies and improved systems for meal ordering on high-speedrailway. Considering the ambiguity in demand distributions and uncertainty in delivery time, the researchers developed distributionally robust stochastic optimization models for both the existing and the pre-ordering procedures. Cutting-plane algorithms are developed to solve the proposed models. Computational studies on a real-world high-speed railway line in China show that our proposed new policy could simultaneously increase service availability, improve the profit, and reduce delay rate [see,9].

FORMULATION OF PROBLEM

Transportation problem general formulation

Let it be assumed that there are m origins and n destinations.

a_i be the total product available at origin i where $i = 1,2,3 \ldots ..m$

b_j be the quantity of products required at destinations j where $j = 1,2,3, \ldots ..n$

c_{ij} be the one-unit production cost of product form origin to destination and

x_{ij} be the amount transported from origin i to destination j

Mathematically we can define the problem as:

$Mini\ Z = \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} c_{ij}$

Subject to constraints,

$\sum_{j=1}^{n} x_{ij} = a_i, i = 1,2,3, \ldots .m$

$$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2,3 \ldots ..n$$

and, $x_{ij} \geq 0;\ i = 1,2,3 \ldots .m\ and\ j = 1,2,3, \ldots ..,n$

assuming that, $\sum_{i=1}^{m} x_{ij} = \sum_{j=1}^{n} x_{ij}$, i.e., (Total supply = Total demand)

Problem formulation

In this study, I have tried to maximize the profit of rail catering services by taking into consideration a station and taking data on the basis of record provided.

After solving the problem using excel to make complex problems solution easier, I havesolved it manually.

To understand the problem completely first we need to understand how the food is distributedand arranged.

Platform	**Thali**	**Chinese**	**Biriyani**	**South Indian**	**Supply**
1	73	120	63	85	625
2	76	125	70	90	730
3	85	135	85	105	895
4	90	150	90	120	750
Demand	550	750	900	800	

So basically, four main platters served are: Veg. Thali consisting of 2 sabjis, 1 dal, 1 sweet,amount of rice and 3 — 4 chapattis depending on different services.

Second option is the Chinese platter, where customers have the flexibility to optimize theirselection, whether it's Manchurian, noodles or any other choice.

The third option is Biriyani, a fundamental and highly preferred meal by customers, especially for its light dinner appeal.

The last option is the South Indian platter, allowing passengers to choose from various itemslike of masala dosa, idli sambar, menduvada or any other option available.

In this problem, we are considering the scenario of a station with 4 platforms where the costof each platter for each station varies based on the of delivery charges incurred to offset theexpenses of delivery personnel.

Let x_{ij} be no. of plates transported from source to platforms.Objective function:

$$\text{Maximize } Z = 73x_{11} + 120x_{12} + 63x_{13} + 85x_{14} + 76x_{21} + 125x_{22} + 70x_{23} + 90x_{24} + 85x_{31} + 135x_{32} + 85x_{33} + 105x_{34} + 90x_{41} + 150x_{42} + 90x_{43} + 120x_{44}$$

Subject to constraints,

$$x_{11} + x_{12} + x_{13} + x_{14} \leq 625$$
$$x_{21} + x_{22} + x_{23} + x_{24} \leq 730$$
$$x_{31} + x_{32} + x_{33} + x_{34} \leq 895$$
$$x_{41} + x_{42} + x_{43} + x_{44} \leq 750$$
$$x_{11} + x_{21} + x_{31} + x_{41} = 550$$
$$x_{12} + x_{22} + x_{32} + x_{42} = 750$$
$$x_{13} + x_{23} + x_{33} + x_{43} = 900$$
$$x_{14} + x_{24} + x_{34} + x_{44} = 800$$

Non negative constraints,

$$x_{ij} \geq 0, \; i = 1,2,3,4 \text{ and } j = 1,2,3,4$$

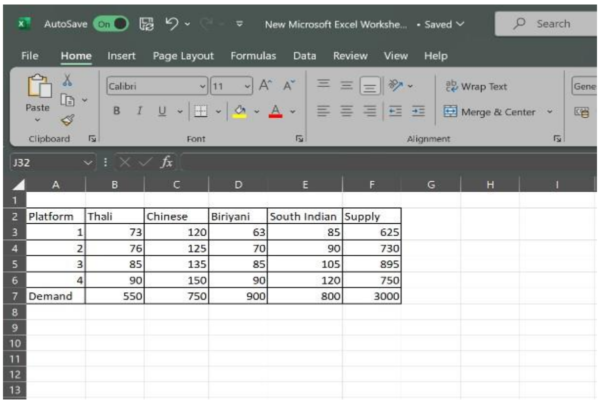
Also

$\sum_{i=1}^{4} a_i = \sum_{j=1}^{4} b_j$ i.e. supply= demand= 3000

SOLUTION

The transportation problem can also be solved by using Microsoft excel so let us now checkour optimal solution by solving it in excel.

To solve the transportation problem in excel sheet lets understand it step wise:Step 1: First step is to generate a problem table in excel



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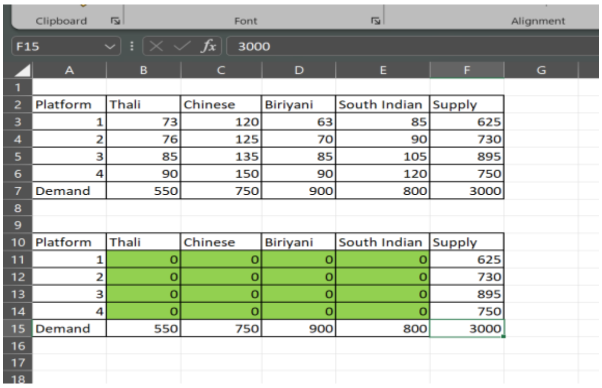
4	90	150	90	120	750
Demand	550	750	900	800	3000

Step 2: In next step we copy the generated matrix and paste it below the existing one by deletingall the objective co-efficient and highlighting that part in green and allotting them value zero. These values are deleted to zero as these cells will contain the value of decision variable at optimalsolution.



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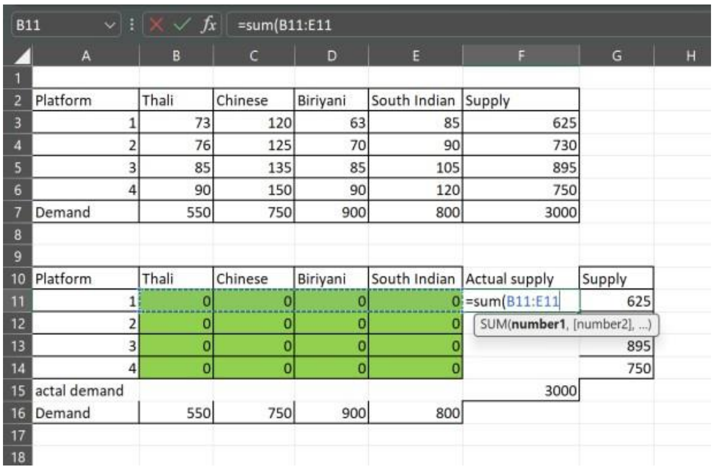
3	85	135	85	105	895
4	90	150	90	120	750
Demand	550	750	900	800	3000

Platform	Thali	Chinese	Biriyani	South Indian	Supply
1	0	0	0	0	625
2	0	0	0	0	730
3	0	0	0	0	895
4	0	0	0	0	750
Demand	550	750	900	800	3000

Step 3: Next, we will shift the demand and origin one column and on row apart respectively toget the space for actual supply and demand on the basis of optimal solution matrix formed. The actual demand and supply will be the sum of the original values in the optimal matrix formed.



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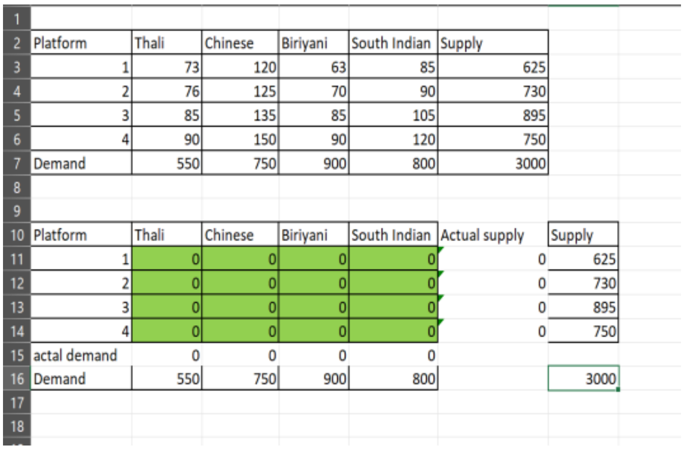
2	76	125	70	90	730
3	85	135	85	105	895
4	90	150	90	120	750
Demand	550	750	900	800	3000

Platform	Thali	Chinese	Biriyani	South Indian	Actual supply	Supply
1	0	0	0	0	=sum(B11:E11	625
2	0	0	0	0	SUM(number1, [number2], ...)	
3	0	0	0	0		895
4	0	0	0	0		750
actal demand					3000	
Demand	550	750	900	800		



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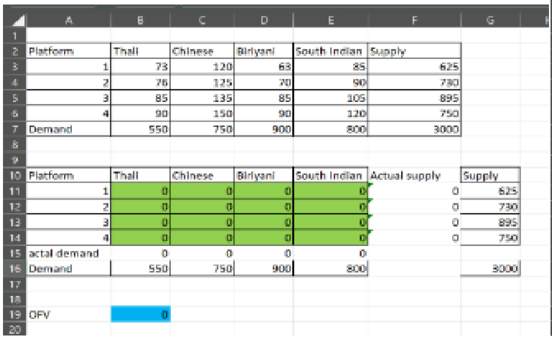
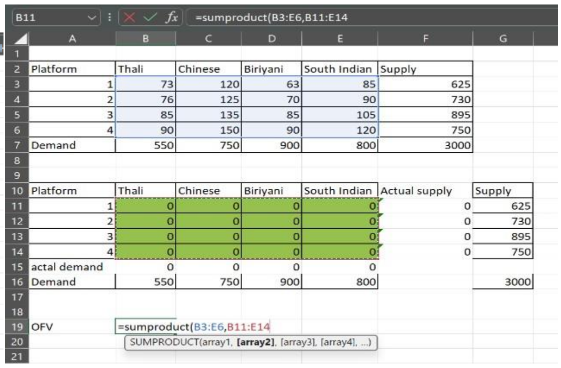
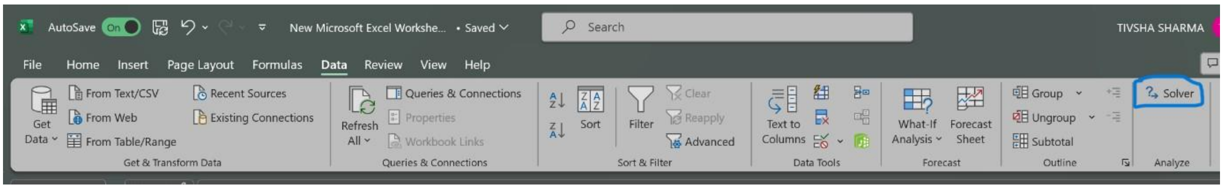
3	0	0	0	0	0	895
4	0	0	0	0	0	750
actal demand	0	0	0	0		
Demand	550	750	900	800		3000

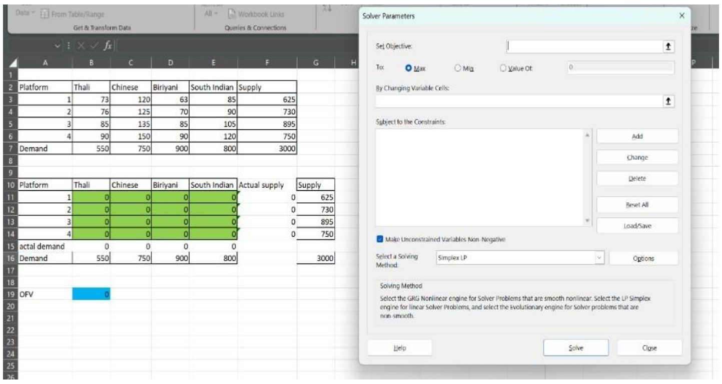
Step 4: Next step involves finding the objective function value, where we will multiply the objective co-efficient by decision value, and then add the results together.



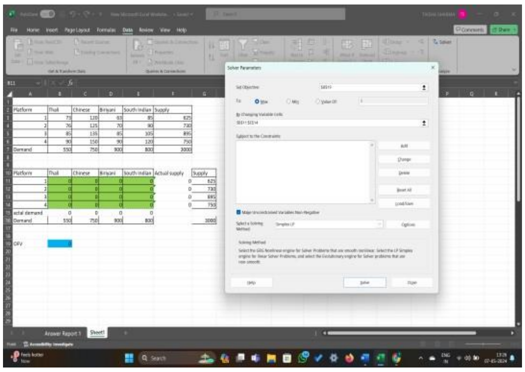


Step 5: Now the setup is complete and we can use the solver to get the solution. The green shaded portion will contain the value of decision variable at optimal solution. The blue shaded portion will contain the actual value of objective function variable at optimal solution. So, now selecting solver from data tab.

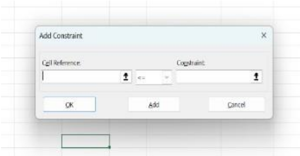




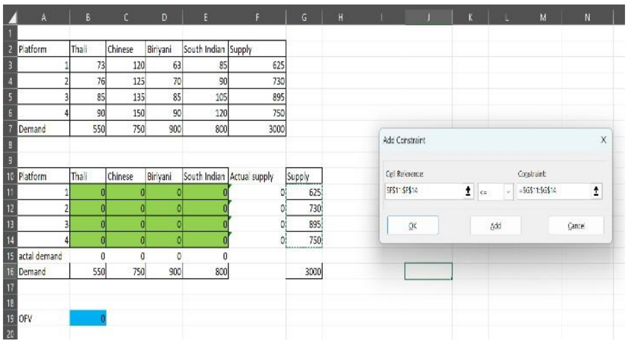
Step 6: Now allotting the parameters in the solver our objective is to determine objective function so in setting objective we will select blue highlighted cell and our aim is to maximize the profit so we will select maximum function and the changing variable cells will be the green high-lighted cells.



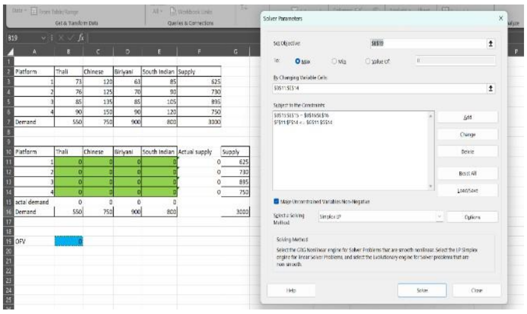
Step 7: To add constraints, click on add on the right side and the supply constraints will be theactual supply and the sign will be less than equal to as at most the given no. of amount is to be supplied. And for demand constraints it will be actual demand and sign will be equal to as this much of amount is to be transported.



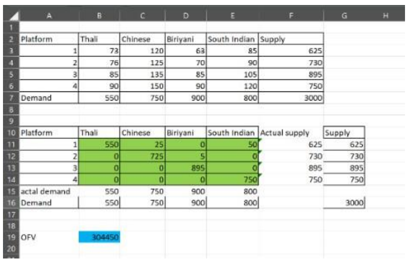
Adding supply constraints:



Adding demand constraints:



Clicking on solve to get the optimal solution:



After solving we get the optimal solution that is the maximum profit as Rs. 3,04,450.

CONCLUSION

This study suggests a rough plan for maximizing profits for rail catering services. Basically, rail catering services are the sector which has helped most of the passengers mainly who need to travelin trains for long distance but are not able to carry their own food. In this study, I have tried to maximize the profit for rail catering services providers. Here, the data considered is not primary;the data I have considered is secondary. The data considered may vary according to the changing situations but the methodology used here can be considered in each case to calculate and maximize the profit.

The optimal solution that is the maximized profit for a day for catering service provider organization will be Rs. 3,04,450 and this profit may vary according to the changing situations andplaces. The future aspect of this study is that currently rail catering service is under growing sectorand according to a study in next five years this sector will grow up to 5% and even more in upcoming years.

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