Computational Study on Optimizing Transportation Cost in Railway Logistics

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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.

1 INTRODUCTION

1.1 *Transportation problem*

Operation research is a systematic and analytic approach that helps in solving problem and in decision making. It is a branch of math's 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.

1.2 *Rail Catering Services*

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 one self. 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. 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 exhibit a growth rate of more than 5% during period on $2020 - 2025$.

2 LITERATURE REVIEW

- In 2013, Deepak Baindur et.al gave a theory of transportation problem in food delivery system by taking Mumbai dabbas system into consideration.
- In 2013 paper titled as Effect of distance of transportation on willingness to pay for food was published by Grebitus whose main aim was to discuss the issue of distance of transporting and its impact on consumer preference.
- In 2014, Shilpa Parkhi et.al proposed a paper that optimizes the logistic cost at secondary distribution of retail supply chain.
- In 2021, worked on transportation theory for food delivery and the design of an android application for food delivery in trains was undertaken by Mosfikur Rahman et.al.
- In 2023, Chunling Luo and Lei Xu designed a theory to optimize the meal ordering procedure and proposed some optimized policies and improved systems for meal ordering on high-speed railway.

3 FORMULATION OF PROBLEM

3.1 *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 $\mathrm{i} = 1,2,3 \ldots\ldots \mathrm{m}$
b_j be the quantity of products required at destinations j where $\mathrm{j} = 1,2,3, \ldots\ldots \mathrm{n}$
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. $\mathrm{Z} = \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij}\, c_{ij}$
Subject to constraints,

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

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

and, $x_{ij} \geq 0$; $\mathrm{i} = 1,2,3 \ldots\ldots m$ and $\mathrm{j} = 1,2,3, \ldots\ldots n$
assuming that $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$ i.e. (Total supply = Total demand)

3.2 *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 have solved it manually.
To understand the problem completely first we need to understand how the food is distributed and arranged.

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 their selection, 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 items like 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 cost of each platter for each station varies based on the of delivery charges incurred to offset the expenses of delivery personnel.

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	

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

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

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,

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

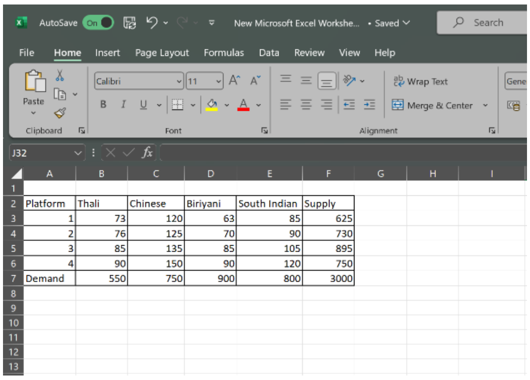
Also
$\sum_{i=1}^{4} a_i = \sum_{j=1}^{4} b_j$ i.e. supply= demand= 3000

4 SOLUTION

The transportation problem can also be solved by using Microsoft excel so let us now check our 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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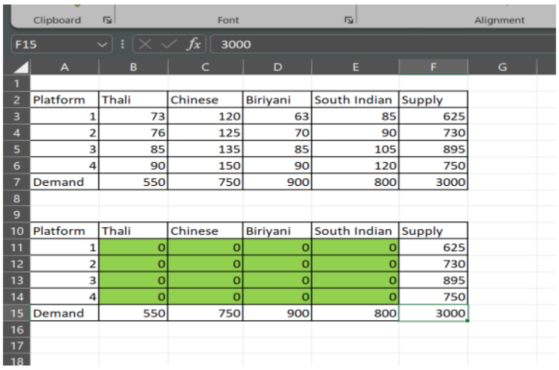
Step 2: In next step we copy the generated matrix and paste it below the existing one by deleting all the objective co-efficient and highlighting that part in green and allotting them value zero. These values are deleted to zero as these cells will contain the value of decision variable at optimal solution.



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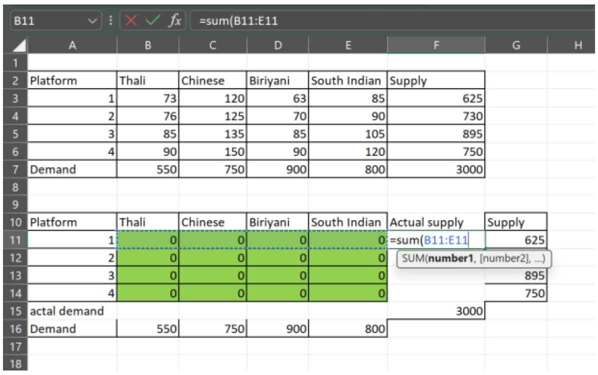
Platform	Thali	Chinese	Biriyani	South Indian	Supply
1	0	0	0	0	625
2	0	0	0	0	730
3	0	0	0	0	895
4	0	0	0	0	750
Demand	550	750	900	800	3000

Step 3: Next we will shift the demand and origin one column and on row apart respectively to get 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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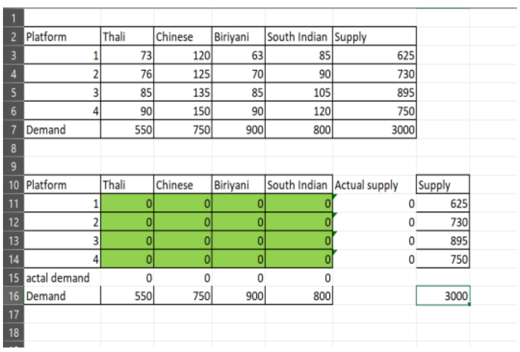
4	90	150	90	120	750
Demand	550	750	900	800	3000

Platform	Thali	Chinese	Biriyani	South Indian	Actual supply	Supply
1	0	0	0	0	=sum(B11:E11	625
2	0	0	0	0		
3	0	0	0	0		895
4	0	0	0	0		750
actal demand					3000	
Demand	550	750	900	800		



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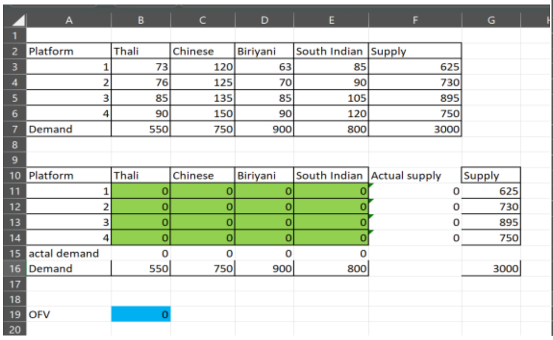
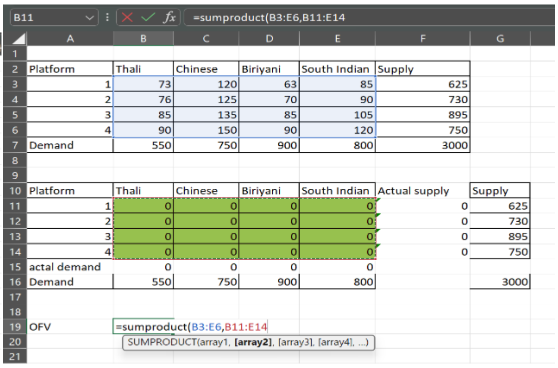
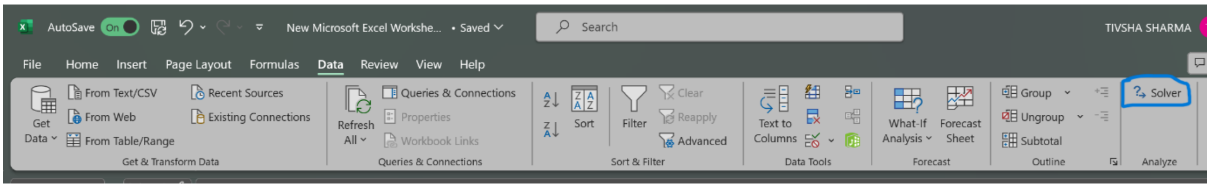
4	0	0	0	0	0	750
actal demand	0	0	0	0		
Demand	550	750	900	800		3000

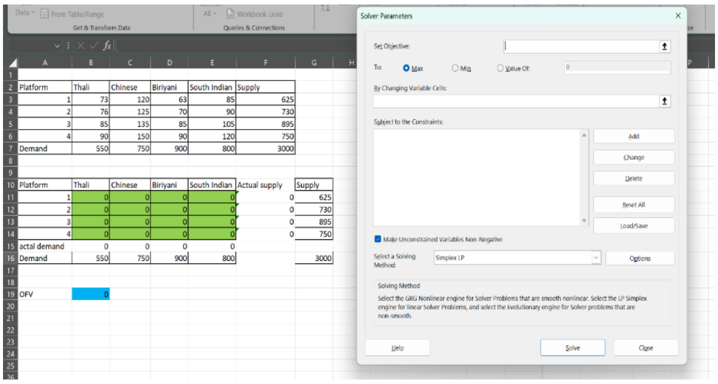
Step 4: Next step involves finding the objective function value, where we will multiply the objective co-efficient by decision value, and then add the results together.



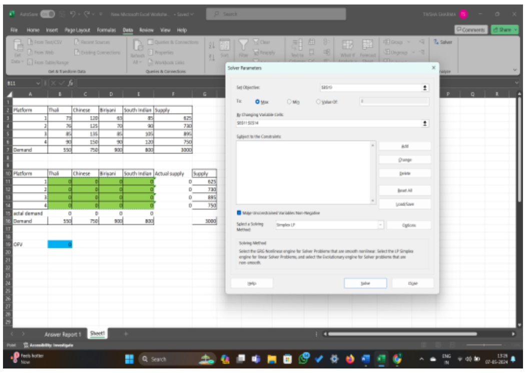


Step 5: Now the setup is complete and we can use the solver to get the solution. The green shaded portion will contain the value of decision variable at optimal solution. The blue shaded portion will contain the actual value of objective function variable at optimal solution. So, now selecting solver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

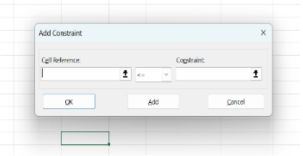




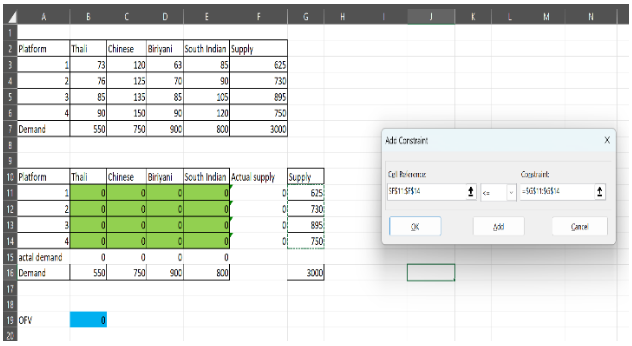
Step 6: Now allotting the parameters in the solver our objective is to determine objective function so in setting objective we will select blue highlighted cell and our aim is to maximize the profit so we will select maximum function and the changing variable cells will be the green highlighted cells.



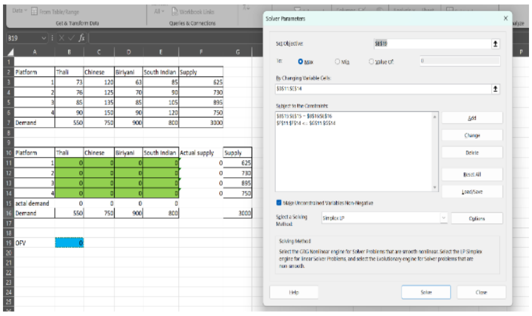
Step 7: To add constraints, click on add on the right side and the supply constraints will be the actual supply and the sign will be less than equal to as at most the given no. of amount is to be supplied. And for demand constraints it will be actual demand and sign will be equal to as this much of amount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



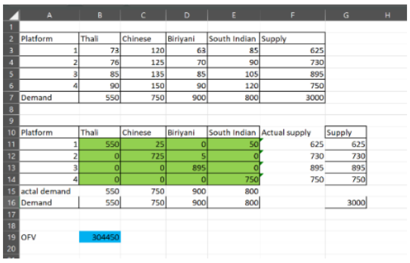
Adding supply constraints:



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.

5 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 travel in 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 and places. The future aspect of this study is that currently rail catering service is under growing sector and according to a study in next five years this sector will grow up to 5% and even more in upcoming years.

REFERENCES:

- Baindur, D., & Macário, R. M. (2013). Mumbai lunch box delivery system: A transferable benchmark in urban logistics. *Research in transportation economics*, *38*(1), 110-121.
- Grebitus, C., Lusk, J. L., & Nayga Jr, R. M. (2013). Effect of distance of transportation on willingness to pay for food. *Ecological economics*, *88*, 67-75.
- Luo, C., & Xu, L. (2023). Online-to-offline on the railway: Optimization of on-demand meal ordering on high-speed railway. *Transportation Research Part C: Emerging Technologies*, *152*, 104143.
- Gera, M., Nawander, N., Tharwani, N., & Bhatia, P. (2018). Operations research in food delivery. *International Journal for Advance Research and Development*, *3*(10), 73-78.
- Nakandala, D., Lau, H., & Zhang, J. (2016). Cost-optimization modelling for fresh food quality and transportation. *Industrial Management & Data Systems*, *116*(3), 564-583.
- Parkhi, S., Jagadeesh, D., & Kumar, R. A. (2014). A study on transport cost optimization in retail distribution. *Journal of Supply Chain Management Systems*, *3*(4), 31-38