

# Operations Research in Hospitality Industry

Harshil Mehta<sup>1</sup>, Harshvardhan Mishra<sup>2</sup>, Jay Shah<sup>3</sup>, Jyotsna Singh<sup>4</sup>, Khushi Fadia<sup>5</sup>  
<sup>1,2,3,4,5</sup>Students of NMIMS, Anil Surendra Modi School of Commerce, Mumbai Campus

**Abstract-** This paper presents a methodology to determine the benefits hospitality industry can get by using various methods of Operations Research. The assignment problems, transportation problems, linear programming problems and replacement theory are generally used for benefits of various service sectors. These theories have been used to determine the benefits that hospitality industry can receive by using these theories. The economic gains have been found. The economic gains are flexible and it is directly proportional to the services that one provides. These theories can also be applied to find out ways which can help expertise in the hospitality industry by competing with competitors by effectively using these strategies.

**Index terms-** Revenue Management, Linear Programming, Simulation, Assignment Problems, Replacement Theory

## INTRODUCTION

Management Sciences are the interdisciplinary study of problem solving and decision making in organizations using management studies, economics, business studies, engineering, and management consulting among other topics. It helps achieve goals using scientific tools like mathematical modeling, statistics and numerical algorithms. Applications of management sciences include, Market analysis, Linear Programming (LP), Assignment and transportation models, Goal Programming, Inventory models, Network models, Dynamic programming, Decision theory, Game theory, Simulation, Waiting line models (queues).

The issues of hospitality industry include job allocation, food wastages, efficient use of revenue and substitution of resources for greater productivity and efficiency. The various models discussed in this paper help form models that strive to reach the greatest level of efficiency possible.

## OVERVIEW

Hospitality Industry has been in some form or other around the world as people have always found themselves moving from one place to another, and often finding a need for a place to stay during their journey. The earliest instance of hospitality has been recorded in 15,000 BCE at the Lascaux caves in France, which is the first shelter in history that provably accommodated people of a different tribe. In the Middle Ages, Japan had the first two hotels in history called ryokans, built in the early 700s. In the Middle East, caravanserais were a resting place for caravans along the Silk Road, and refuges served pilgrims and crusaders on their way to the Holy Land. In China and Mongolia, staging posts provided shelter for couriers and allowed horses to be changed more easily. Whereas in Europe, cloisters and abbeys provided free accommodation to travelers. Gradually, inns and guesthouses began to open on popular trade routes to provide lodging for traveling merchants and their horses. In the Early 1700s, Masonic Lodges began to appear in North America. In 1927, Hot Shoppes was founded in Washington, D.C., a hospitality company that later became Marriott Corp. In 2015, The First World Hotel in Pahang, Malaysia, became the world's largest hotel by expanding to 7351 rooms.

Hospitality industry is a subset of the service industry and comprises of four major segments, that is, of Food and beverages, Travel and Tourism, Lodging, and Recreation. It is dependent mainly on leisure time and disposable income of its potential customers as the quality and quantity of the four segments is directly proportional to how much time and income they wish to invest. It consists of infrastructure (buildings, IT structure) and operations (management, human resources).

## RESEARCH OBJECTIVES

Through this paper, we aim to understand

- cost minimization

- profit maximization
- reducing food wastage
- efficient job allocation

## RESEARCH METHODOLOGY

This research paper is qualitative in nature and uses secondary data found from various research papers, and websites on Operations Research on different fields. The aim is to try and understand whether methods from other sources can be used to make the Hospitality Industry more efficient.

## LITERATURE REVIEW

**Simulation:** Simulation means imitation of reality. Simulation techniques are widely used in industry for the purpose of capacity & resource planning. Based on the well developed statistical theories, simulation effectively deals with the unforeseen uncertainties in any business. When used proficiently, it enables to determine the fluctuations in many business parameters (like, demand, service time, waiting time, downtime, repair time, etc..) to the desired level of accuracy with specified degree of confidence level.

**Linear Programming:** Revenue management not only ensures better performance for the firm but also provides greater benefit to the customers. Revenue Management encompasses the activities that concentrate on proper allocation of resources, minimization of costs and thereby ensuring better profits are achieved. (Barth, 2002) Revenue Management techniques have been most efficient when applied to firms that have fixed capacity, demand that can be segmented into clearly identified segments and that is variable, perishable inventory, varying customer price sensitivity, advanced product or service selling, low marginal sales costs but high marginal production costs. (Hwang, 2009)

The hospitality industry uses revenue management techniques extensively. Hotel industry is among the major areas of revenue management and operations research applications because the products are perishable, fixed costs are much higher than the variable costs and demand variations over time. Maximizing profits is also vital for the hotels because of fixed costs arising from the fixed capacity. Revenue Management plays crucial role in success of

the hotel's as its helps in pricing, forecasting capacity control and overbooking. (Hwang, 2009)

A manager has to consider all human, economic and political aspects of the decision while designing solutions. Operations Research techniques like linear programming help in systematic problem solving and decision making. Linear Programming helps in finding rational bases for decision making by seeking to understand and considering structural constraints, to forecast system behaviour and improve performance.

Linear Programming is widely used model that helps formulating feasible solutions by considering various variables, constraints and the objective functions. Linear Programming can be used to identify solutions which are optimal and satisfy the objective constraints. Hotels can use linear programming:

- To maximize profits subject constraints
- To minimize costs subject to constraints
- To find optimal combinations of variables

One of the characteristics of the hospitality industry is that the products under review are perishable. If hotel rooms are not rented on the target day, the hotel does not earn any revenue and rather incur losses because of the fixed costs. So, the rooms should be reserved in advance and, especially when supply is more than the demand, the decision maker should determine the right number of rooms to be booked in advance, so as to maximise the revenue. The manager needs to decide whether or not to rent the room in advance to the potential customer. When making this decision, the manager does not know how many additional potential customers will turn up on a particular day, paying higher rent. Therefore, the decision that the hotel room manager faces is whether to accept a reservation request or not depending upon the profitability. (Kimes, 2010)

**Replacement Theory:** Machine replacement problem has been studied by many researchers and is also an important topic in operation research and management science. (Bhadra, 2012) But as for hospitality sector there is much more to do with replacement theory than just machines and other fixed assets. Cleanliness is one of the first things guests notice about a hotel - making housekeeping a top priority for both hoteliers and their guests. That being said, housekeeping is about more than maintaining clean rooms - it's about ensuring guests

have everything they need during their stay. This can include everything from hygiene products, to a selection of teas, and up-to-date room service menus. So now it is important to focus on these things and not only on replacement of fixed assets. United States Bureau of Labour Statistics reported over 4.5 million employee separations in 2014 because of resignations, layoffs, or terminations. Hospitality managers face some of the lowest employee retention rates of any industry, which leads to poor customer satisfaction and decreased profitability. (Scott, 2016) Thus replacement theory can help in a ways and should be applied.

Assignment problems: In the course of this research we observed that the use of operations research in the hospitality industry is minimal. Even at places where OR can easily be used to optimise tasks and increase efficiency using simple tools tasks are done on a trial and error basis also called heuristics. We have explored various ways in which an assignment problem can be used to optimise process for example timetabling. The paper talks about how an assignment problem is defined and identifies the objective and constraint applicable for the hospitality industry

#### FINDINGS

Simulation: With the advent of many simulation software, simulation is gaining ever increasing importance in industry to plan & control processes effectively. Service industries are different than manufacturing industries in the sense that the former works with more flexibility in the processes. Standardized processes may vary from time to time depending on the customer's requirement. Service industries, in general, employ comparatively less automation, which is one of the causes for the variations. Hence, it would be interesting to study the process deviations under changing customer's requirements and to develop a master plan that could compensate for the expected deviation without hampering the resource availability.

In this case we are going to know how the use of simulation methods in baking sector can be adopted by the hospitality industry for more efficient work. In this case a Discrete- event system simulation model is used, Discrete-event system simulation is the modeling of system in which the state variable changes only at discrete set of point in time. The

simulation models are analyzed by numerical method rather than by analytical method. Analytical methods employ the deductive reasoning of mathematics to solve the model. Numerical methods employ computational procedure to solve mathematical models. System can be categorized as discrete or continuous. Few systems in practice are wholly discrete or continuous, but one type change predominates for most system, it will usually be possible to classify a system as discrete or continuous system. The bank is an example of a discrete system, the state variable that is the number of customers in the bank, changes only when a customer arrives or when the service provided to a customer is completed. There are various software packages available for discrete event simulation. Few of them are ARENA, AUTOMAD, EXTEND, FLEXSIM, MICRO SAINT, PROMODEL, QUEST, SIMUL8. This project makes use of highly effective and user friendly software package ARENA

The service industry selected for simulation was a bank. The bank was suffering from some problems like ineffective utilization of various resources, long waiting line of customer, completion of some transaction taking more time than the standard time for these transactions, etc. A simulation study was needed in this bank to improve various processes of the bank. A simulation model of this service industry will help in analyzing various problems and finding proper solutions of these problems. The bank considered for study opens at 10:30 am every morning and remains open up to 4 pm evening. Sunday is holiday and on Saturday it remains open up to 1 pm. The bank mainly deals with transaction like saving fund account open, Current fund account open, fixed fund account open, Draft issue, Income tax challan, Cash savings, Cash withdrawal, loans, pension etc. The bank has five various counters for various transactions. Customers come randomly for various transactions and form queues in these counters. Various data regarding to the customer arrival, their waiting time, their service start time, service end time are recorded. These observations were done from 02.02.2010 to 27.03.2010 for a period of 51 days. These data were analyzed and tested for various probability distribution functions. They were made ready for use as input to the simulation model.

1. Data is collected at the savings counter and a table is prepared using columns of arrival time, service start, service end, service time, waiting time, purpose and inter arrival time.
2. A simulation model is prepared for 10350 minutes using the analytical data with the help of a software
3. And then the model was simulated for total replication time if 10350 minutes

This model helps us to find out:

1. Resource utilization
2. Arrival of various customers in future for various transactions
3. Actual time required for various transactions
4. Opening of current account takes more time than standard time

The simulated model gives some important results for improvement of the processes and reduced waiting time. It reduces current account opening time. After changing the layout of the bank it will reduce further. Proper resource utilization is possible. The model can also predict no of customers in future. It will help for future planning of the bank

We can therefore use this model in the hospitality industry for the efficient working of hotels. This may help in improved room allocation, room service, organizing fun activities for guests and an overall joyous stay of guests with spending less time on reception counter or calling room service for getting some work done.

Linear Programming: Linear Programming can be used for optimization in a food and beverage department of a hotel industry. The food and beverages department offer two different types of donuts chocolate and double trouble.

- Constraints
- Labour hours

Making one batch of chocolate donut requires 1 hr and making one batch of double trouble donut requires 2 hrs. There are only 24 labour hours available in day

- Demand Variations
- Everyday there is minimum demand for 4 batches of chocolate and 6 batches of double trouble.

- Raw Material

Everyday the hotel has raw materials (dough, sugar and chocolate) that can make total of 20 batches

- Objective function
- To maximize profits by considering the best combinations of the two donuts to made per day. Chocolate earns a profit of Rs 35 and double trouble earns a profit of Rs 40.

- Formulation
- Let  $x_1$  be the quantity of Chocolate donut made &  $x_2$  be the quantity of Double Trouble Donut made  
To Maximize  $Z=35x_1 + 40x_2$

Subject to constraints:

1.  $x_1+2x_2 \leq 24$
2.  $x_1 \geq 4$
3.  $x_2 \geq 6$
4.  $x_1+x_2 \leq 20$

- Solution
- To maximize the profits and find the optimal combination of the two variables (Chocolate and Double Trouble donuts) the manager needs to consider constraints and the objective function. The optimal solution is 12 units of Chocolate donuts and 6 units of trouble donuts will result in the maximum profits of Rs.660.

Replacement Theory: The items which follow the sudden failure mechanism may fail any time, thus precipitating the cost of failure. The cost of failure of an item may be quite high as compared to the value of the item itself. Sudden failure may cause loss of customer's faith and may also cause loss of goodwill. This type of failure may cause the worker's satisfaction to work go down. The item should be replaced before it actually fails.

1. Replacement of employees- This does not mean to remove them from the job but this replacement can be done in two ways:- a) shifting them to another type of work and at other time of the day b)shifting them to another branch nearby where they would not mind going because of distance or any other issue and is feasible to them. This will help them work in various environments and they will not get bored. Job satisfaction will be high which will automatically increase the services provided by them.

2. Replacement of furniture- By allocating more cost to the infrastructure, they can earn a greater advantage of competitors. So they can replace furniture annually and not necessary they have to change the whole thing. Maybe they can change little bit of room structure, reception, theme of hotel, etc. this will attract many people and can also motivate workers as they might get a feeling of new working space annually.
3. Replacement of electric products- From time to time they should replace these as less of lighting, air conditioners not working and all of that a customer should not be receiving after paying huge amount of money.

Assignment Problem: In this part of the paper we will try and explore the uses of ASSIGNMENT PROBLEM in the hospitality industry. The tool of assignment problems in itself has a wide scope of application and if we include the different variations of the tool the area of usage becomes boundless.

Not only that, by using different types of problems you can aim to maximise profits, minimise losses, increase efficiency of workers, allocate jobs in an unbiased and fair manner etc.

An assignment problem as the name suggests is used to allocate resources to demand points in the most optimal way possible given that both the demand point and the resource are of equal no.

It can be noted that an assignment problem is a type of transportation problem with two variations

- a. the cost matrix is a square matrix
- b. The optimal solution is contained such that there is only one assignment per row or column of the cost matrix

The problem can mathematically be depicted as follows

$$\sum_{i=1}^n \sum_{j=1}^n c_{ij}x_{ij} \quad (1)$$

$$\sum_{j=1}^n x_{ij} = 1, \quad i = 1, \dots, n \quad (2)$$

$$\sum_{i=1}^n x_{ij} = 1, \quad j = 1, \dots, n \quad (3)$$

$$x_{ij} = 0 \text{ or } 1, \quad i = 1, \dots, n, \quad j = 1, \dots, n \quad (4)$$

where  $C_{ij}$  is the cost or effectiveness of assigning  $I$ 'th resource to  $j$ 'th demand,  $x_{ij}$  is 0 or 1 (as presented in (4)), and  $n$  is the number of resources or demands. The

constraints of the problem are defined as (2) and (3). Equation (2) indicates that each resource needs to be assigned to only one demand, while (3) shows that each demand needs to be assigned to only one resource.

In relation to every assignment problem, there is a matrix named cost or effectiveness matrix, where is the assigning cost of  $I$ 'th resource to  $j$ 'th demand. In this paper, it is called an assignment matrix, where every resource can be assigned to only one demand and signify it. (Faudzi, Abdul-Rahman, & Rahman, 2018)

The use of AP in the hospitality industry can be used to optimise different processes such as:

1. Timetabling: this according to Syakinah (2018) can be efficiently used in the education industry to create time tables, similarly it can be used in the hospitality industry to create job time tables where you allocate daily jobs and departments to workers for ex: front office duties, kitchen duties etc
2. Assign contracts to bidders through evaluation of bids from competing suppliers for supply of resources such as groceries, cleaning supplies, linen, gas and diesel etc
3. When these tools are used it would lead to cost minimization, better room allocation and profit maximization.

The same problems can be solved without using the techniques of operations research but according to Martí et al (2012) "exact methods assure to provide an optimum solution, while heuristic methods simply try to produce a good but not certainly optimum solution. Nevertheless, the duration to find an optimum solution of a complex problem of exact method is more complicated than that of the heuristic (due to the incorporation of many irrelevant cases)"

In case of a time table problem, the resources are workers and jobs. In school timetabling, students are normally preassigned, while only teachers and rooms need to be assigned in the timetabling problem. As such, Cerdeira-Pena (2008) stated that STP is aimed at assigning period for certain subject in a specified group by considering groups of students and teachers in a fixed period scheduling. According to Pillay (2014), STP is considered as NP-complete or NP-hard problem that depends on the intricacy of the problem in relation to various constraints.

In the scenario of hotel industry, the variables are workers and jobs rather than teachers and rooms however other variables are much similar and thus the same tool can efficiently be used to solve the given problem.

The hard and soft constraints related to STP adopted from Cerdeira-Pena adapted for the hospitality industry (Cerdeira-Pena, Carpenente, Fariña, & D. Seco, 2008)

#### HARD CONSTRAINTS

1. Overlaps: avoid the possibility of a job being allocated to more than one employee on the same day and avoid sharing resources (i.e. two housekeeping employees being allocated to the same room etc.)
2. Consecutiveness: this constraint checks whether a distribution of hours/days for a pair employee-job is followed. For example, some employees should not have two days of kitchen or front office.

#### SOFT CONSTRAINTS

1. Overuse: it refers to the number of hours per day in which an employee undertakes his shifts, over its specified hours per day.
2. Underuse: when employees have preferences on their minimum number of hours per day, it indicates the number of hours under such minimum.
3. Holes: consider the number of empty periods between two consecutive periods where a teacher is assigned a class. Breaks and free-time periods are not considered holes.
- 4.

#### CONCLUSION

A manager is required to be aware of what and how the organization is working. Not only should they be aware, but also help the organization reach the highest productivity levels possible. Operations Research provides models that help managers reach optimal level of efficiency and productivity. In any organization, job allocation of human resources is one of the most common and important roles in any industry. Hospitality industry being a service industry, human resource is one of the most important resources. Simulating various cases helps

in predicting unfavorable situations. One of the most important aspects of any business is to minimize costs and maximise profits, which is understood by linear programming. Any business that uses equipment has to keep a check on when to replace with a substitute. In the hospitality industry, the equipment becomes human resources and having the knowledge of making necessary replacements from time to time.

#### LIMITATIONS

1. Often the softwares used are expensive and are not accessible to everyone
2. Even with highest accuracies and precisions, software may not be able to predict accurately.
3. In real life, the objective function and constraints are not linear.
4. Only a single objective function is generally dealt with while solving, however, in real life situations, problems have multiple objectives.

#### REFERENCES

- [1] Cerdeira-Pena, A., Carpenente, L., Fariña, A., & D. Seco. (2008). New approaches for the school timetabling problem. *MICAI*, 261-267.
- [2] Faudzi, S., Abdul-Rahman, S., & Rahman, R. A. (2018). An Assignment Problem and Its Application in Education Domain: A Review and Potential Path. *Hindawi*.
- [3] Martí, R., Reinelt, G., & Duarte, A. (2012). A benchmark library and a comparison of heuristic methods for the linear ordering problem. *Computational Optimization and Applications*, 1297-1317.
- [4] Pillay, N. (2014). A survey of school timetabling research. *Annals of operations research*, 261-293. (Partha Protim Borthakur, 2013)
- [5] <https://www.kendall.edu/blog/history-of-the-hospitality-industry/>
- [6] Barth, J. (2002). Yield management opportunities for private club managers. *International Journal of Contemporary Hospitality Management*, 136-141.
- [7] Hwang, J. W. (2009). The Effect of Perceived Fairness toward Hotel Overbooking. *International Journal of Contemporary Hospitality Management*, 659-675.

- [8] Kimes. (2010). The Future Of Hotel Revenue Management. Cornell Hospitality Report.
- [9] Bhadra, S. K. (2012). Application of Replacement Theory in Determination of Pavement Design Life. Jordan Journal of Civil Engineering.
- [10] Scott, M. E. (2016). Strategies for Retaining Employees in the Hospitality Industry. Walden University ScholarWorks .