# LINEAR PROGRAMMING FOR REVENUE MANAGEMENT IN HOTEL INDUSTRY

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**ABSTRACT**

*Linear Programming (LP) is the mathematical technique for optimum allocation of 'scarce' of 'limited' resources, such as labour, material, machine, capital, energy and so on, to several competing activities, such as products, services, jobs, new equipment, projects, and so on, on the basis of a given criterion of optimality. This paper is an insight into how LP can be made use of in the hotel industry too, where the use has been limited in India. A simple optimisation case has been tried to solve graphically and arrive at an optimal solution in an F&B Production department of a hotel.*

***Keywords:*** *Revenue Management, linear programming.*

## Introduction

Companies throughout the entire hospitality industry focus on implementing successful operational techniques in order to optimize their efficiency and increase profitability. Revenue Management is seen as an important technique in the hotels' operation and therefore to maximize their revenues, hotels are increasingly implementing Revenue Management practices (Hwang and Wen, 2009).

"Yield" or Revenue Management is an important tool for matching supply and demand by segmenting customers into different segments based on their willingness to pay and allocating limited capacity to the different segments in a way that maximizes company's revenues (Haddat, Ropper and Jones, 2008). It is also defined as "the application of information systems and pricing strategies to allocate the right capacity to the right customer at the right price at the right time" (Kimes and Wirtz, 2003). Firstly developed by the airline industry, Revenue Management has grown from its origins in airlines, to its status today as a common business practice in a wide range of industries (Talluri, Ryzin, Karaesmen and Vulcano, 2009).

## Literature Review

There are multiple sources of literature that outline the positive impacts of Revenue Management on a company level (Barth, 2002; Cross, 1997). In addition, Esse (2003) suggests that Revenue Management provides more benefits to customers and this leads to greater performance results. In its essence, other scholars conclude that Revenue

Management encompasses activities that concentrate on proper allocation of resources by virtue of which better profits can be achieved (Kimes, Chase, and Choi, 1998). In addition, the application of Revenue Management techniques has been most effective 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 (Kimes, 1989; Kimes and Wirtz, 2003, Wirtz and Kimes, 2007).

The hospitality industry is one of the business fields which witnesses extensive utilization of Revenue Management techniques (Kimes and Wirtz, 2003). Hotel industry is among the major areas of Revenue Management application as hotels' products are perishable, hotel's fixed costs are higher than the variable costs, and the demand varies over time (Chiang, Chen and Xu, 2007). O'Connor and Murphy (2008) also add that "maximizing revenue is important for hotels because of their high fixed costs and their fixed capacity". In this regard Revenue Management is accepted as one of the most vital areas of consideration for the hotel's success. Chiang et al (2007) distinguish several different areas of the Revenue Management - pricing, capacity control, overbooking, and forecasting but they state that all of them "are highly correlated and need to be considered jointly".

Operations Research (OR) is a scientific approach to analysing problems and making decisions. OR professionals aim to provide rati onal bases for decision-making by seeking to understand and structure complex situations, and to use this understanding to predict system behaviour and improve system performance. Operations Research is a branch of mathematics used to provide a scientific base for management to take timely and effective decisions. It possibly avoids the dangers arising from decisions based on guesswork. The concept of management has basically two characteristics:

***Multidimensional***

Because managerial problems and their probable solutions have repercussions in several fields such as human, economic, social and political fields.

***Dynamic***

A manager will never remain static while prevailing in the business. Hence, any manager, while taking decisions, considers all aspects in addition to economic aspect, to make his solutions useful in every respect. Management problems can also be solved using quantitative approach. This approach requires the problem to be properly defined and thoroughly analysed. This includes collecting data, facts and information and then solving the problem ina rational and systematic way, based on analysis rather on mere guess work, or using trial and error methods. Operations research is primarily concerned with helping managers and executives to arrive at better decisions.

In the world of business, where systematic problem-solving and decision-making are the norm, the use of algorithms provides a wealth of advantages for hotel owners when it comes to managing revenue and increasing profits. The use of algorithms - which are defined as a precise rule, or set of rules, specifying how to solve a problem - can be a very effective way for business owners to accurately conduct calculations,

process data and gather important information about the buying habits of consumers. ( Jean Francois Mourier,2010).

A survey of nearly 500 revenue management professionals in the hotel and related industries and they forecasted that the application of revenue management (RM) will become more strategic and will be supported by increasingly sophisticated technology as it includes more of hotel's income streams. (Prof. Shreyl E Kimes , 2010) .Using a 5 point scale , respondents were asked to indicate the future likelihood of RM being applied to eight different possible functions. The Food & Beverage had high likelihood with 3.9 where 1= not likely and 5 = very likely.

Particularly in the field of hotel revenue management, which heavily involves the application of different tactics to predict consumer behaviour and optimize product availability, using algorithms allows revenue managers to solve problems with a sequenced, scientific decision that encourages the examination of wide ranging factors. With algorithms, coming to conclusions becomes more of a rational process, producing better and more profitable results for the business. However, the scope of the current paper is to focus how Revenue Management can be used for optimisation in an F&B Department of a hotel. The optimum solution is arrived at graphically in the present paper.

## Mathematical Formulation

- A typical mathematical problem consists of a single objective function, representing either profits to be maximised or costs to be minimised, and a set of constraints that circumscribe the decision variables. In the case of a linear program (LP), the objective function and constraints are all linear functions of the decision variables.
- Linear programming is a widely used model type that can solve decision problems with thousands of variables. Generally, the feasible values of the decision variables are limited by a set of constraints that are described by mathematical functions of the decision variables. The feasible decisions are compared using an objective function that depends on the decision variables. For a linear program, the objective function and constraints are required to be linearly related to the variables of the problem.
- A linear programming problem (LPP) is a special case of a mathematical programming problem wherein a mathematical program tries to identify an extreme (i.e. minimum or maximum) point of a function f(x1, x2, ….. , xn) , which furthermore satisfies a set of constraints, e.g. g(x1, x2, …. Xn) $\geq$ b. Linear programming is the specialisation of mathematical programming to the case where both function f, to be called objective function, and the problem constraints are linear.
- A case: Assume that you are a manager of a donut store that sells two types of donuts: regular and chocolate. Making one batch of regular donuts takes 1 hour of an employee A's time and 2 hours of employee B's time. Making one

batch of chocolate donuts takes 2 hours of employee A's time and 1 hour of employee B's time. One batch of regular and chocolate donuts sells at $35 and $55 respectively. It costs $30 and $45to make a batch of regular and chocolate donuts respectively. Employee A works 8 hours a day and employee B works only 7 hours a day. Your donuts are so good that there is unlimited amount of demand for them. Everyday, you want to produce at least one batch of regular donuts. You always have enough to make only 4 batches of chocolate donuts every day.

- Now you need to decide how many batches of regular and chocolate donuts to be made so that your objective of maximising profit is met. You have the constraints A's and B's time, ingredients of chocolate donuts, production rule of 1 batch of regular donuts, no negative number of donuts and no partial batches.
- Let us denote batches of regular donuts to produce as R and batches of chocolate donuts to produce as C. By writing the objective function in terms of the above , we have Maximise 5R + 10C.
- {Regular donuts profits are 35 – 30 = 5$ and chocolate donuts profits are 55-45 = 10$}
- Let us now express all constraints using decision codes:
- Employee A's time = 8 hours. Hence, $1R + 2C \leq 8$
- Employee B's time = 7hours. Hence $2R + 1C \leq 7$
- Ingredients for chocolate donuts= 4, Hence $C \leq 4$
- Atleast one batch of regular donuts; $R \geq 1$
- No negative number of donuts of either type: Hence $R \geq 0$, $C \geq 0$
- No partial batches allowed R & C are integers.

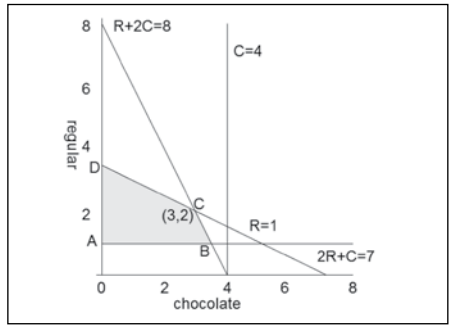


**Figure 1 : Graphical presentation of LP problem**

## Solution

The shaded area is where the inequalities of four equations are satisfied. The objective function to maximise 5R + 10C is attained at the point C(3,2). Hence the optimal solution is to prepare 3 batches of Chocolate and 2 batches of Regular donuts

## Conclusion

In this paper we studied that linear programming , which is very successfully used in many industries can also be used in food & beverage department of a hotel. We have discussed here how we could use LP to maximise the objective function and obtain an optimal solution. Though only two variables have been used here, the same could be extended for more variables and solution could be attained by using Excel solver.

## References


- *Barth, J.E. (2002). Yield management: opportunities for private club managers. International Journal of Contemporary Hospitality Management, 14, 136–141.*
- *Chiang, W.C. , Chen, J. C.H&Xu, X. (2007), An overview of research on revenue management: current issues and future research. International Journal of Revenue Management, 1(1), 2007, 97-127*
- *Cross, R. G. (1997). Revenue Management: Hard- Core Tactics for Market Domination, Broadway Books, Bantam Doubleday, Dell.*
- *El Haddad, R., Roper, A. & Jones, P. (2008). The impact of Revenue Management Decisions on Customers Attitudes and behaviours: A case study of a leading UK Budget Hotel Chain. EuroCHRIE 2008 Congress, Emirates Hotel School, Dubai, UAE, October 11-14.*
- *Esse, T. (2003). Securing the Value of Customer Value Management. Journal of Revenue and Pricing Management.*
- *Hwang, J.& Wen, L.(2009). The Effect of Perceived Fairness toward Hotel Overbooking and Compensation Practices on Customer Loyalty. International Journal of Contemporary Hospitality Management, 21(6) , 659-675*
- *Mourier J F ,(2010). All Science, No Guesswork : The Benefits of Algorithms in Hotel Revenue Management. ehotelier.com ,Dec 1, 2010*
- *Kimes, S.E. et al. (1998). Restaurant revenue management: applying yield management to the restaurant industry. Cornell Hotel and Restaurant Administration Quarterly. (39), 32–39.*
- *Kimes, E. Sh&Wirtz, J (2003). Has Revenue Management Become Acceptable? Findings from an International Study on the Perceived Fairness of Rate Fences. Journal of Service Research, 6(2), 125-135*
- *Shah N H et.al. (2010) - Operations Research*
- *O'Connor, P. & Murphy, J. (2008). Hotel Yield Management Practices across multiple electronic distribution channels. Information Technology & Tourism, 10(2) , 161-172.*
- *Kimes, E. Sh, (2010) .The Future of Hotel Revenue Management. Cornell Hospitality Report, 10(14),*
- *Todorov, Andrey and Zhechev, Vladimir, (2010). The impact of overbooking on hotels' operation management. http://ssrn.com/abstract=1698103*
- *Talluri, K.et al. (2009). Revenue management: Models and Methods. Proceedings of the 2009 Winter Simulation Conference M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin, and R. G. Ingalls, eds.*