

CHAPTER 11
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Revenue management

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Introduction

Revenue management (RM) is frequently defined as selling the right room at the right price to the right customer at the right time (see for instance, Kimes 1997). However, Jones (1999) argues that this is what hoteliers have always tried to do, and hence this simply defines the advanced reservations process in general. In this chapter, the definition of RM will be explored and its practice explained.

Revenue management is often confused with yield management (YM).¹ But YM is just one component of RM. Yield is the ratio between actual and potential room revenue.² Actual room revenue is that revenue received from room sales. Potential revenue is what a hotel would have received if their rooms were sold at full price or rack rates. Keep in mind, of course, that for this to be realistic, the full price rates must be realistic. Rack rates that are rarely achieved have little meaning for true yield ratios. Also realize that a hotel will have any number of different rates, including suite rates. All these must be calculated to determine a true yield ratio. Incremental revenue of food and beverages also cannot be ignored. Thus, a hotel can reach the same, better or poorer yield through different combinations of average rates and occupancy.

Revenue management is one of the most researched areas in the field of hospitality (Jones and Lockwood 1998). Research interest is mainly focused on particular issues such as the analysis of the RM concept and its development into implementation models (such as Orkin 1988; Rowe 1989; Jones and Hamilton 1992; Brotherton and Mooney 1992; Donaghy et al. 1995, 1997; Jones 1988), the development of an RM culture (Jones and Hamilton 1992) and adoption, understanding and implementation of RM in the hotel industry (Bradley and Ingold 1993; Bitran and Mondschein 1995; Peters and Riley 1997; Jarvis et al. 1997; Badinelli 2000; Upchurch et al. 2002). Savkina and Yakovlev (1997) research the application of YM in Russia.

Griffin (1995, 1996, 1997) has focused on the critical success factors of an RM system. The contribution and value of information technology (IT) use for RM implementation is also heavily mentioned in the literature. These highlight the need for systems integration (Kimes 1989) and for addressing the

¹Also, the usage of these terms has been different in the United States and the United Kingdom. Revenue management replaced yield management as the common terminology in the late 1990s in the United States, but yield management continued to be used in the United Kingdom until four or five years later (Editor).

²In the airline industry – yield is revenue per passenger and per mile traveled.

development of different modules and information system architecture of computerized YM systems (Gamble 1990; Jauncey et al. 1995). Sigala et al. (2001) identify the strategic role that IT plays in successful YM practices. Schwartz and Cohen (2003) found from a study of 57 experienced revenue managers that the interaction between a human revenue manager and a computer screen offering revenue management data is influenced by certain attributes of the computer interface.

More recently, researchers have turned their attention to two issues. The first is the extension of RM principles and techniques by either using more sophisticated analysis of customer spend (Dunn and Brooks 1990; Noone and Griffin 1997; Choi and Cho 2000) or applying it not only to rooms but also to banqueting and conference centres (Van Westering 1994; Kimes and McGuire 2001). The second area of research is into the issues of concern about the long-term effect of RM on customer satisfaction and loyalty, as considered by Kandampully and Suhartanto (2000) and Kimes (2003). Huyton et al. (1997) were concerned about the ethical and legal issues of applying RM.

Revenue management overview

Revenue management is best suited to environments where the firm's product is perishable and either is sold to the customer within a specific time frame or remains unused and disappears from the firm's inventory without generating revenue. It was originally developed by airlines in the early 1960s and quickly spread to other industries, such as hotels, rental car companies and cruise lines because airplane seats (hotel rooms, rental cars and cruise ship cabins) are perishable products that must be sold for the flight (night, day or cruise) of interest; otherwise they go unused. Before RM, this was largely limited to balancing group with individual demand on the basis of complementary booking times. Today, through computer technology, the attempt is to juggle all bookings and rate quotations so that on any given night the maximum revenue potential is realized.

Revenue management plans the ideal business mix for each day of the upcoming year and prices the rooms accordingly. It then adjusts the mix and prices on an ongoing basis as reservations do or do not develop.

There are several factors that make the use of RM suitable to the hotel industry. First, a hotel room is a perishable product, so it is sometimes better to sell it at a lower price than not to sell it at all because of low marginal production costs and high marginal capacity costs (i.e. contribution margin pricing).

Second, capacity is fixed and cannot be increased to meet more demand. Third, hotel demand is widely fluctuating and uncertain, depending on the days of the week and seasons of the year. Fourth, different market segments have different lead times for purchase. A convention group might reserve hotel rooms three years in advance, a pleasure traveller two months and a businessman a week ahead. Fifth, hotels have great flexibility in varying their prices at any given time.

These factors are very similar to the airline industry and represent the requisite conditions for a successful RM program. Although an operational tool, RM requires hotels to be market oriented. Knowledge of market segments, their buying behaviour and the prices they are willing to pay is essential for maximum success.

The essential rules for successful RM for hotels have been said (Lieberman 1993) to be as follows:

- Set the most effective pricing structure.
- Limit the number of reservations accepted for any given night or room type on the basis of profit potential.
- Negotiate volume discounts with groups.
- Match market segments with room type and price needs.
- Enable reservations agents to be effective sales agents rather than merely order takers.

To these, the following could be added:

- Provide reasons for lower rates, such as advance purchase time, payment in advance, non-refundability and length of stay for a variety of market segments. Marriott has done this deliberately to put the trade-off decision in the hands of the customer. In industry jargon, this is called 'fences'.
- Be consistent across the central reservation system, property reservationists, travel agents and other intermediaries so that quoted rates are the same. This refers to rate parity, discussed earlier in the chapter.

Defining revenue management

There are many definitions of RM. Jauncey et al. (1995: 1111) conducted a literature review of nine RM studies dating back to 1988 and concluded that 'YM (sic) is concerned with the maximization of room revenue through the manipulation of room rates in a structured fashion so as to take into account the forecasted patterns of demand'. Donaghy et al. (1995: 188) suggest that 'RM is a revenue maximization technique which

aims to increase net yield through the predicted allocation of available bedroom capacity to predetermined market segments at optimal price’.

Jones (1999) argues that these definitions describe the *purpose* of RM but fail to differentiate it from reservation practices that existed prior to RM implementation. Hence RM is not *meaningfully* defined by its purpose, since hotels have always tried to make as much money as they could out of their fixed capacity. Jones proposes that RM needs to be defined by its ‘systems structure’, that is, how it enables revenue maximization. Few existing definitions identify this. However, the American Hotel and Motel Association (1994) described RM as ‘a set of demand-forecasting techniques used to determine whether prices should be raised or lowered and a reservation request should be accepted or rejected to maximize revenue’. Jones (1999) goes on to develop a more detailed definition based on soft systems analysis – a research methodology designed to distinguish structure and function. The definition that is proposed from this analysis is as follows: ‘Yield management is a system for hotel owners to maximize profitability through their senior management in hotels identifying the profitability of market segments, establishing value, setting prices, creating discount and displacement rules for application to the advanced reservations process and monitoring the effectiveness of these rules and their implementation’.

This definition emphasizes the strategic role of RM in managing *profitability*. Increasingly, the hotel industry, and the relevant academic literature, is placing greater emphasis on the profitability of each market segment, not just on the sales value of their custom.

Models of revenue management

One of the earliest models of RM was developed by Orkin (1988) on the basis of four main elements: forecasting; systems and procedures; strategic and tactical plans; and feedback system. Another early model was proposed by Jones and Hamilton (1992) as shown in Figure 11.1. The first stage in their model is to develop a yield (sic) culture, followed by a systematic analysis of market demand. However, the technological input and information systems needed to support RM are not addressed.

In contrast, a later work by Jauncey et al. (1995) gives a more specific view of the elements that are essential for the ‘ideal YM applications’, as they call it. They identify eight elements

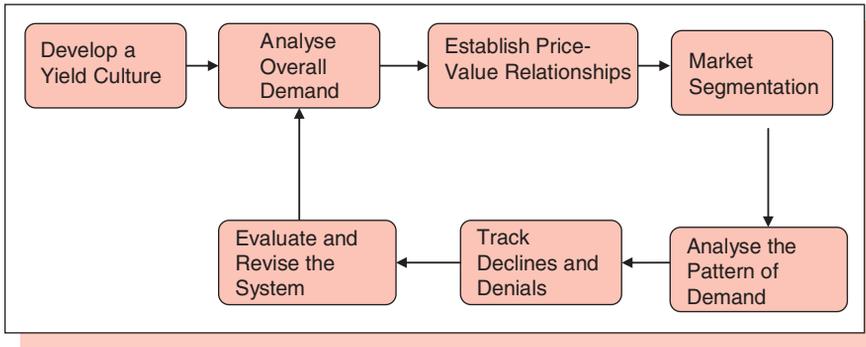


Figure 11.1

The yield management process (*Source: Jones and Hamilton 1992*).

for RM applications and focus on the technological side of the system, as follows:

- Historical demand analysis
- Future demand predictions
- Reservations inventory
- Actual versus forecast sales
- Market composition
- Non-arrival and cancellation analysis
- Analysis and reports
- Advice on rates and restrictions

The model proposed by Donaghy et al. (1995) develops a wide-ranging framework of 10 'key areas' for the effective operation of an RM system in the hotel industry. This framework focuses on identifying both decision-making and information systems (Table 11.1).

Finally, Jones (1999) proposes a systems model³ of RM. It is divided into two main systems: the decision-making system and the decision support system. The decision-making system is again sub-divided into strategic and operational decision making. As Jones (1999: 1115) states, 'one is concerned with making decisions of a long-term nature and drawing up plans in relation to market segmentation, pricing and operational target setting. The other one is concerned with accepting or rejecting advance reservations in response to customer requests, consistent with pricing, discounting and displacement

³See chapter 2 for a discussion of systems theory.

Table 11.1 Key stages in a formal YM system

Stage 1	Personnel	Develop employee understanding/ highlight customer or hotel interface/ appoint forecasting committee/sort available customer and market data
Stage 2	Analyse demand	Identify competitors and source of demand/define hotel's strengths and weakness/predict demand levels and booking patterns/constantly monitor external factors
Stage 3	Market segmentation	Identify market (existing and potential) Segment market (demographic, psychographic and geographic)
Stage 4	Determine optimal guest mix	Based on propensity to spend Based on volume usage
Stage 5	Analyse trade-offs	Extensive calculations of monetary leakages Avoid displacing high-spending guests
Stage 6	Establish capacity levels	Set capacity to meet demand of market segments
Stage 7	Introduce YM system	Groups and consortiums need tailor- made system Small or independent hotels adopt revised version of above to achieve maximum benefits
Stage 8	Customer reorientation	Train comes into practice by (a) realizing hotel YM objectives and (b) meeting customer needs
Stage 9	Operational evaluations	Revise room allocation Evaluate low-demand changes Identify additional factors which determine demand
Stage 10	Actions	Implement any changes required immediately

Source: Donaghy et al. 1995.

rules'. The decision support system includes all the functions that aim to assist and support the core of decision-making system, which are an information system, human resource system and technological support system. An information system

is concerned on one hand with the actual reservations made, declines, cancellations and no-shows and on the other hand with the analysis of demand used in the strategic and operational decision making. The other two are in effect the outline structure model that supports the RM process. The model also indicates how the external environment continually affects the daily routine of the RM system.

Revenue management in practice

Revenue management is often described as consisting of two distinct components: differential pricing and inventory control (Belobaba 1987).

Differential pricing is the practice of differentiating products by offering different amenities and restrictions and hence setting different prices for each combination of product, amenities and restrictions. Different purchasing patterns of business and leisure customers and the offer of differentiated products add to the complexity of the RM problem and have created the need for inventory control and the development of computerized RM systems.

Inventory control determines how many products of each type to make available throughout the selling period. In particular, it sets the amount of low-price products to make available to ensure that later-purchasing, higher-price customers are able to purchase the remaining products at a higher price without turning away needed low-price demand. An alternative way of thinking about this is termed 'duration control' (Weatherford et al. 2001).

Overview of the history of pricing in the hotel business

It is proposed that pricing in the hotel industry will have five phases of development. In the first phase, hospitality firms had basically the same price for their products. Rates only changed by season, not day by day. Any demand forecasting that was undertaken was used by management not to set rates, but to determine the scheduling of employees.

The second phase of pricing occurred with the advent of YM systems to the airline industry. The YM systems designed for the airlines were then adapted to the hotel industry. Hoteliers used the information provided by the YM systems to forecast demand and change prices accordingly. The standard statistic used to measure results was REVPAR, or revenue per available room.

In the third phase, RM and customer relationship management come together. While setting prices and availability, pricing managers consider not only demand but also the lifetime value of the customer buying the service. Harrah's Entertainment recently implemented a customized RM system which merges their traditional YM system with their total rewards program. Other firms have started doing the same. In this phase of pricing, the standard statistic used to measure results is REVPAC, or revenue per available customer.

In these authors' view, the fourth and next phase of pricing focuses on the value delivered to the customer, not necessarily the availability of the inventory. Essentially, pricing managers will move from being controlled by their RM systems to having their systems as just one part of the overall marketing mix. In setting rates, pricing managers will examine the different components of value being delivered and price accordingly. This way of thinking about pricing becomes critical in a down economy where there is a tendency in many firms to lower prices to fill capacity. The problem with lowering prices, of course, is that one destroys the brand image, and it also becomes hard to raise prices when demand improves. The statistic used to measure this will be VALUEPAC, or value generated by and for per available customer. The value *by* the customer is the price paid and the value *for* the customer refers to the costs incurred by the firm supplying the value. The key, of course, is for the firm to supply features that the customer really values but have little cost to the service firm. An upgrade on an airplane is but just one example – last room availability is another.

Pricing will reach the final phase when the consumer is completely incorporated in the pricing decision. In other words, pricing managers will use knowledge of consumer behaviour to determine not only how to price but also how the pricing information is presented to the consumer. The measurement here will also be VALUEPAC. The VALUEPAC statistic will be higher in this phase than in the previous phases.

Alternative pricing strategies

Value-based pricing • • •

This strategy involves choosing a price after developing estimates of market demand on the basis of how potential customers perceive the value of the product or service. It has nothing to do with the cost to produce the item. Perceived value is often defined as what one receives divided by the price one paid. Value-based pricing has the advantage that it forces

managers to review the objectives they have when marketing their product or service and keep in touch with the needs and preferences of customers.

In establishing prices, there are some elements that are particularly pertinent with regard to the customer. The first of these elements is the perceived price value relationship, as it is commonly called. The importance of price value is illustrated by a study of business travellers (Bowen and Shoemaker 1998) who spend more than \$120 per night for a hotel room and make six or more business trips per year. The study revealed that 28% of the 344 who spend more than 75 nights per year in hotels (38% of the total sample) claimed that the feature 'is a good value for the price paid' is important in the decision to stay in the same hotel chain when travelling on business.

The role of the management is to increase the perceptions of price value so that consumers will be willing to spend more money. One way to accomplish this goal is to focus on one or more of the eight components of value, as follows:

- *financial* (e.g. saving money on future transactions, complete reimbursement if service failure, 10% discount at gift shop)
- *temporal* (e.g. saving time by priority check-in)
- *functional* (e.g. availability of check cashing)
- *experiential* (e.g. active participation in the service)
- *emotional* (e.g. more recognition)
- *social* (e.g. interpersonal link with a service provider)
- *trust* (e.g. the organization does what it says)
- *identification with the organization* (e.g. affinity with a sports team)

Prospect pricing ● ● ●

Prospect theory argues that when people make decisions, they do so by examining changes relative to a reference point. That reference point can be established by quoting a high price initially for a premium product, so that subsequent prices for less premium products appear to be good value. Prospect theory is applied in restaurants. In a study on menu pricing (Shoemaker et al. 2006), it was found that menu items with detailed descriptions and high prices were perceived to have the same price value as menu items with modest description and low prices.

Reference pricing ● ● ●

Customers have in mind a price they expect to pay for a given solution. This is called their reference price. Reactions to prices

will vary around this reference or expected price, on the basis of some kind of prior experience or knowledge. In understanding reference pricing, it is important to understand some critical pricing definitions. *Reference price* is the first pricing term firms need to understand. This is the price for which consumers believe the product should sell. The reference price is formed when consumers consider such things as:

- the price last paid
- the price of similar items
- the price considering the brand name
- the real or imagined cost to produce the item
- the perceived cost of product failure

The last item is of considerable importance because it reflects consumers' imaginations. For example, the reference price for a meal where one is celebrating a special occasion is higher than the reference price for a meal with some old college friends, even though the restaurant may be the same. The risk of failure is critical in the first case and less critical in the second.

The second definition one needs to understand is *reservation price*. Reservation price is defined as the maximum price the customer will pay for a product. If the selling price is less than the reservation price, the customer will buy the product. Firms that price exactly to the reservation price are said to extract the entire *consumer surplus*. Firms that price less than the reservation price are said to be 'leaving money on the table'. Obviously, firms do not want to leave money on the table. In 1988, Taco Bell used a research methodology based on research originally conducted by Dutch economist Peter H. Van Westendorp to determine customers' reference or expected price. This methodology was developed by Gabor and Clive (1966) and others. However, until Taco Bell picked up on it, this methodology had been largely ignored in the hospitality industry. This process puts a price value on a product as determined by the perception of the target market which, in the final analysis, is the only way to set prices. Basically, this methodology helps determine the reserve price and the reservation price. Through this pricing methodology, Taco Bell learnt to bundle its products – for example, adding sour cream, including a soft drink – in a way and at a price where the customer perceived 'value'. For the fast food industry giants, value pricing and bundling have reduced the former standard practices of discounts, coupons and direct mail as key weapons in the fast food wars.

Lewis and Shoemaker (1997) explain how research can demonstrate the way customers, in some arbitrary fashion,

establish an upper price level at which they deem the product to be too expensive and a lower price level below which the quality of the product would be suspect. This is based on expectations. In between is the 'indifference' price – the price perceived as normal for that product in a given market, given one's expectations. There are certain hotels and restaurants where we would expect to pay different prices. When we are 'surprised' by an unexpected price, we may tend to become somewhat irate. Thus, it is the responsibility of the price setter to educate the customer about prices.

Expectations should be built into the pricing decision. Research can determine what the market thinks the product should cost. This can be especially useful in the pricing of services where a cost basis is lacking for developing an expectation. Findings may indicate that the service can be priced higher; contrarily, a lower-than-expected price may offer competitive advantage. Knowledge of price expectation can help firms avoid both overpricing and underpricing.

Psychological pricing • • •

Prices cause psychological reactions on the part of customers just as atmospherics do. As noted, high prices may imply quality and low prices may imply inferiority. This is especially true for services because of their intangibility. Thus, higher priced services may sell better, whereas lower priced services may sell poorly. This is contrary to the standard economic model. Psychological reactions, however, do not necessarily correspond to reality, and it is not unusual for customers to feel that they have made a mistake.

This is also true in the hospitality industry because of the 'visibility' factor. Being 'seen' at an upscale restaurant or hotel is very important to some customers. For example, a businessman might buy inexpensive furniture for his apartment and drink ordinary wine at home. This same businessman, trying to make an impression on peers and customers, will rave about the antique furniture in the lounge and the expensive wine ordered with dinner. In other words, he wants to be seen with the product that offers the highest affordable visibility factor.

Buyers and non-buyers of products also have different perceptions of price. This contrast can be demonstrated best with the case of upscale restaurants. Many such restaurants are perceived by those who have never been there to be far more expensive than is actually the case. Commander's Palace, one of New Orleans' finest restaurants, used large advertisements

in the local paper detailing their attractively priced lunch specials to counteract this. In pricing, it is important to understand the price perceptions of non-users as well as of the users.

Another psychological pricing technique is called price-lining.

This technique clumps prices together so that a perception of substantially increased quality is created. For example, a wine list might have a group of wines in the \$30–40 range and have the next grouping in the \$50–75 range. The perception is a definitive increase in quality, which may or may not be the case.

Still another version of psychological pricing is called odd-numbered pricing. This is a familiar tactic to all. Items sell at \$6.99 rather than \$7.00 to create the perception of a lower price. Sometimes this is carried to extreme such as a computer that sells for \$1,999.99 or a car advertised at \$32,999. This tactic is often used in menu and hotel room pricing.

Value-added service pricing • • •

Value-added services are those that are added to the basic product/service that the customer buys to enhance the perception of value. These are worth evaluating because in some cases, they may not add true value, may simply increase the cost base or may eventually be passed on – in the form of higher prices – to a customer who does not really want them or perceive a higher value.

Developing a product/service for customers' specific needs that augments the standard product is a part of loyalty marketing. Business services in a guest room for which an additional charge is sometimes made with turndown service at no charge are perfect examples. Many hotels, however, instead of tailoring added services to individual needs sometimes provide customers with more services than they want or need at prices that do not reflect the value or their cost. Unfortunately, the management sometimes does not even know which services customers with similar needs really want, which should be offered as a part of the standard product or which should be offered as value options that some would pay extra for. Furthermore, because of the intangibility of many services, the management often does not know the cost of providing them; no matter how homogeneous a target market, one size does not fit all.

Because hotel managements rely almost solely on measures of customer satisfaction, they are often misled. Customers are always happy to get something for nothing and they express satisfaction on the overall offering. The property, however, has

to absorb the costs, of which they may be unaware, that may or may not have created real value in the first place. The solution to this is called flexible service offerings – particular services valued by individual customers (Anderson and Narus 1995). A hotel should first make an ‘inventory’ of these services: what is being provided to whom and on what basis. These acts apply especially to group bookings where services are often added just to get the booking. The same thing should be done for any new services that are being considered.

Customers then need to be asked the value of the service to them. This leads to activity-based pricing. The following options are now available:

1. Do not offer the service.
2. Give the service away at no additional charge.
3. Raise the price equal to the cost of providing the service.
4. Raise the price less than the cost of providing it.
5. Raise the price slightly higher to camouflage a price increase on the standard product.

This approach allows hotels to fit the service to customer needs, as well as notify customers that they do not have to pay for something they do not want. Some hotels today have turndown service on request only – but only after realizing how much it was costing them and how many customers did not want it.

Differential pricing through ‘fences’ • • •

The RM system of a hotel should be set up to offer different categories of rooms for different prices. A hotel has an opportunity to create many different types of guest rooms, some more desirable than others. An effective hotel RM system will open and close categories of rooms, giving the customer greater value for higher pricing.

The key to multiple prices and RM is that each price must represent a different product and that those who have a high reservation price will not be able to buy a lower priced product. Multi-products were discussed above. The chapter now examines how to keep those with high reservation prices from buying less expensive products. This occurs through what is known as fences. Table 11.2 shows some typical fences in the hospitality industry.

In choosing fences, it is important that the ‘fence’ makes sense to the consumer. That is, the customer must believe that the rate they are paying is based on their choices, not on the firm’s greed. For instance, the consumer needs to think ‘I need to pay more

Table 11.2 Potential fences

Rule type	Advanced requirement	Refundability	Changeability	Must stay
Advance purchase	3-day	Non-refundable	No Changes	Weekend
Advance reservation	7-day	Partially refundable (% refund of fixed amount)	Change to dates of stay, but not number of rooms	Weekday
	14-day	Fully refundable	Changes, but pay fee; must still meet rules	
	21-day		Full changes, non-refundable	
	30-day		Full changes allowed	

because having flexibility is more important than price' or 'I am paying more because I cannot decide exactly what I want to do'.

One fence that is not listed in Table 11.2 is the 'loyalty fence'. This is a fence for frequent and loyal customers. The firm that offers multiple prices must be careful that the pricing decision does not destroy loyal customers' trust in the organization and hence, their loyalty. In research undertaken in part by one of the authors, loyal hotel customers were presented with a hypothetical situation where the hotel to which they were loyal increased its rate because of anticipated demand. Consumers were then asked how this would change their attitudes and behaviours towards the hotel to which they claimed to be loyal. Findings indicated that 60% of the customers would ask the rate the next time they called for a reservation (normally, loyal customers do not ask about rates). In addition, 35.7% would call other hotels in the area to get their prices. Clearly, the loyal guest needs to be treated differently than the guest who comes for a one-night stay.

History of inventory control

Most of the history of RM and inventory control relates to the airline industry where RM was born. Airlines have been over-booking (accepting more bookings than capacity) their aircraft

for close to three decades in an attempt to reduce the revenue loss associated with passenger no-shows. The objective of overbooking algorithms is to determine the total number of seats to sell on a flight while balancing the loss of revenue associated with an empty seat and the cost of 'bumping' a passenger. Overbooking is not illegal, and most airlines overbook their scheduled flights to a certain extent to compensate for no-shows. Passengers are sometimes left behind or 'bumped' as a result. When an oversale occurs, the Department of Transportation, or its equivalent, in most countries requires airlines to ask people who are not in a hurry to give up their seats voluntarily, in exchange for compensation. Those passengers bumped against their will are, with a few exceptions, entitled to compensation.

Airline overbooking research dates back to the 1950s with Beckman's static optimization model (Beckman 1958). Later statistical models include the work of Taylor (1962), Simon (1968), Rothstein (1968, 1985) and Vickrey (1972). While the practice of overbooking is slightly less evident in the hospitality industry, it is nevertheless used to also maximize the occupancy rate. However, the nature of a hotel room makes overbooking a more delicate matter relative to an airline seat, where a delay caused by overbooking may be acceptable to the passenger. Typically hotel guests do not like being 'bumped' to another property, however near it may be.

Overbooking models can be as simple as applying historical averages of show-up rates to the company's inventory to determine the number units of product to make available beyond capacity to maximize utilization. More advanced overbooking methods use statistical models and allow analysts to choose the amount of acceptable risk involved in overbooking, account for revenues and costs associated with overbooking or use customer information to identify unique attributes that might affect the likelihood of each individual customer to no-show.

The first and the most basic inventory control systems consisted of simple databases recording booking behaviour of airline passengers or hotel guests, which allowed the analysts to perform 'post-departure' analyses of the booking behaviour of no-show travellers. The major shortcoming of these systems lay in their inability to automatically identify critical patterns in the booking cycle.

These systems were thus later improved to identify unusual booking behaviour and direct the attention of analysts on departures from the norm. These computerized systems consisted of large databases that allowed analysts to define 'usual' booking patterns and set thresholds beyond which

unusual activity was flagged for analyst review. These monitoring systems were not advanced enough to provide automated responses to changes in booking patterns or demand. However, some systems could provide recommendations to the analysts as to the appropriate course of action. The final decision remained in the analyst's hands.

The latest step in RM systems involved the addition of mathematical models to forecast demand and optimize inventory allocation based on historical data collected in booking databases as well as recent behaviour as monitored by these same databases. These mathematical models involve deterministic or statistical optimizers that communicate directly with the firm's reservation system and automatically set the availability of each individual product without user intervention.

These third-generation systems marked a crossroad in RM by moving from user-dependent systems to user-independent systems. In these third-generation optimizers, the analyst monitors the performance of the system and makes corrections for unusual events and departures from 'standard' behaviour that could not be forecasted by the system. The role is therefore reversed from first- and second-generation systems, where the analyst decided on the course of action on the basis of booking behaviour.

We next focus on the individual components of third-generation inventory management systems: overbooking, forecasting and optimization. Overbooking recognizes that travellers may fail to show up for their reserved hotel room (restaurant seat or other product) and artificially inflates the available inventory in an attempt to minimize the number of empty rooms on any given night. Forecasting can be viewed as the critical component of inventory control, as it generates the forecasts of demand for each type of room, which will be used by the optimizer to determine the availability of each product type. Forecasting and optimization involve various levels of refinement from basic day-to-day methods to more advanced length of stay systems (in the case of hotel rooms).

Overview of inventory control techniques

Overbooking • • •

As previously mentioned, overbooking is the practice of accounting for traveller no-show when determining the optimal number of inventory units to make available for sale, with the goal of filling all units. Numerous methods can be used to overbook – from simple deterministic overbooking to more advanced stochastic methods. Deterministic overbooking uses

a fixed estimate of the no-show value to set the overbooking level, while stochastic methods estimate the probability distribution of the no-show rate and use this information to make predictions of future no-show. The stochastic approaches to overbooking have the advantage of capturing changes in traveller behaviour that may not be captured in deterministic methods and further account for the stochastic nature of demand and customer behaviour.

The simplest deterministic method uses a pre-determined fixed value of overbooking, based on analyst knowledge of demand. For example, a hotel might choose to overbook by five rooms. More advanced methods might use forecasts of demand – costs of empty rooms and revenue gain of additional room – as deterministic inputs to a linear program that would solve for the optimal overbooking level based on these assumptions.

Traditionally, however, overbooking relies on stochastic models where no-show rates are estimated on the basis of historical data and the optimal overbooking level is then derived from these historical data on the basis of a pre-determined stochastic model (Belobaba 1999). Examples of such models include calculation of simple straight averages of historical no-show rates subsequently applied to future periods. More advanced stochastic models apply confidence intervals techniques to historical data and thus incorporate the history's variability in the calculation of no-shows. These systems thus adjust the forecasted no-show rates (from the simple average) based on an input confidence interval. For example, if the analysts chooses to set the no-show to ensure that the probability of a denied boarding (in the case of airlines) be less than 5%, the recommended no-show rate will be significantly lower than the average, based on the variability of historical no-show rates. Finally, state-of-the-art overbooking techniques include estimates of revenues gained from overbooking, costs incurred from overbooking and customer-specific attributes in the calculation of overbooking levels.

Forecasting • • •

More often art than science, forecasting is the process of predicting future demand on the basis of historical data. Smith (1984) provided a basis for initial research in forecasting of airline demand and led to numerous models of demand forecasting.

Typical demand forecasts are based on historical booking periods, which are further divided into rolling historical periods

and holiday or special events periods. Rolling history uses the most recent historical data to forecast demand for future booking periods. Holiday and special events history recognizes that special events or holidays differ from non-holiday periods and use year-over-year data as a historical period. Once the appropriate historical data have been identified, forecasting is typically done using stochastic approaches. For example, future demand can be estimated as the average demand for the historical data or as the sum of historical 'pick-up' between today and date of check-in (in the case of hotels). Pick-up refers to the number of guests who book between the current period and date of arrival. For example, pick-up between 90 days before arrival date and actual arrival is different from demand at the date of arrival and allows demand to be adjusted as this date gets closer. Other methods also rely on historical data but determine the forecasted demand as a weighted average of the history or use exponential smoothing techniques to put more emphasis on recent data.

While actual calculations of a forecast for demand are relatively simple, three major challenges remain. The first challenge pertains to the capacity constraints imposed on demand. Typically, the availability of hotel rooms, airline seats, rental cars or even boat cabins is limited and can be less than demand. As a consequence, historical observations are constrained observations of demand and therefore do not reflect the actual demand, but underestimate it. As a result, it becomes necessary to unconstrain (or detruncate) demand to estimate what historical demand would have been without capacity restrictions. Unconstraining (detruncation) techniques also involve stochastic approaches and can be based on booking behaviours for low-demand periods (when demand did not exceed capacity) relative to high-demand periods.

The second challenge in forecasting, once unconstrained demand has been estimated, involves estimating the impact of seasonal traffic on demand. As observed by many travel industry specialists, demand is cyclical and depends on the season. Airlines typically expect lower demand in the fall and winter, while they forecast much higher demand in the spring and summer. It therefore becomes imperative to account for these seasonal patterns when forecasting future demand so as to avoid forecasting fall demand using unadjusted summer history. Such an approach (in the case of airlines) would invariably overestimate demand for fall travel and underestimate spring demand, ultimately causing the airlines to forego substantial revenues by rejecting low-fare demand in the low-demand months and accepting too much low-fare demand in high-demand months.

Finally, the level of detail involved in a forecast also poses a significant challenge to forecasters. Indeed, the level of aggregation of historical data and future demand is critical in creating a reliable and accurate forecast. Too much aggregation yields too little information on future demand, while too much detail leads to highly variable estimates of demand that are useless. Demand can be broken into finer and finer portions, which better reflect the attributes of individual passengers and thus become more coherent groupings of demand. However, as groupings increase, so too does variability of this demand. For example, when considering the hotel inventory control problem, should the forecaster focus on individual night stays and forecast demand for future nights individually, or should the forecaster attempt to account for length of stay data? Individual night forecasts yield less variable forecasts but lose the information of length of stay, which would allow the optimizer to decide between a single-night-stay customer and a multi-night-customer. Similarly, the length of the booking periods studied to calculate pick-up information affects the reliability of a demand estimate.

All of these challenges have been addressed in some form by RM tools, but no optimal solution has yet been devised.

Inventory control optimization • • •

Given overbooking levels and forecasts of demand for future flights, hotel night stays, rental cars or cruise line cabins, the inventory optimizer sets the availability within each product category to maximize revenues. Three major approaches exist in this final step in inventory control:

1. deterministic control
2. stochastic optimization
3. advanced dynamic programming methods

Deterministic linear programs use forecasted demand as a deterministic input to a linear program, which then sets the amount of seats (hotel rooms, etc.) available at any given price. These linear programs allocate inventory and meet the capacity constraints imposed by hotel or aircraft size and can be re-optimized once a preset threshold of bookings/cancellations is reached. A general formulation of the inventory control linear program can be viewed as follows:

$$\max(\text{Revenues}) = \max \left(\sum_{i,j} X_{i,j} \times R_j \right)$$

subject to

$$\sum_{i,j} X_{i,j} \leq \text{cap}$$

$$\sum_j X_{i,j} \leq D_i$$

where D_i represents demands of type i , $X_{i,j}$ the allocation of demand type i to product type j , R_j represents the price of product j .

Stochastic approaches take into consideration the variable nature of demand for travel services or other products and compute the expected marginal revenue to be achieved from selling one additional unit of a specific product category. On the basis of the expected additional revenue from each product compared to the other products available, booking (availability) limits are set within each category. The expected revenue from each incremental unit of product type depends on the distribution of demand for each product.

These stochastic methods are the most commonly used in the travel industry as they have the advantage over deterministic methods of accounting for variability in demand. However, some limitations of these methods are that they often assume independence of product type demand: If a particular product type is unavailable, the customer will not be willing to buy any other product type. In addition, these stochastic methods also make assumptions on the distribution of demand. For simplicity purposes, it is often assumed that demand follows a normal distribution.

Advanced dynamic programming methods involve the relatively new field of dynamic programming and involve far greater computing power than deterministic or stochastic approaches. Without going into the details of dynamic programming, these methods divide the remaining booking periods into sufficiently small time increments so as to ensure that, at most, one booking will occur within each time frame. From any point in the booking period, every possible alternative will be considered and the alternative leading to the highest revenue will be chosen. This process is repeated at each time increment to ensure that the best option is always chosen from that point onwards and, ultimately, that revenues are maximized. These methods show promising results in simulation settings but have been difficult to implement because of the required computing power. In addition, optimization times are generally too long to allow for the frequent re-optimization needed by these methods.

Revenue management 'culture'

It has been argued that hotel companies tend to place too much emphasis on the technical and system-building aspects of RM and too little on the human aspects (Brotherton and Turner 2001). Although computer-based tools are a key component of an RM program, both the technology and the systems are only good as long as there are people handling the data and making decisions on the basis of the analysis. Huge investments in technology also tend to overshadow important organizational issues (Talluri and Van Ryzin 2004).

Cross (1997) argues that top management leadership and support are essential of YM. Kimes (1997: 9) agrees: 'Without a commitment [from top management], RM systems may be doomed to failure'. Top managers set the tone for the organization, and senior managers can also help provide adequate resource to the RM program if the company is to reap the highest potential revenue from the program. Furthermore, they must ensure that the best and brightest people are in the RM team. The top management will be responsible for organizing and putting together the teams and ensure that the system is continuously provided with the necessary for its operation information.

Another factor that easily is lost sight of by hoteliers is employee commitment and their involvement in problem solving. Employee commitment may be seen as a function of the staff's decision-making latitude and involvement (Hansen and Eringa 1997). As Jones and Hamilton (1992: 3) state, 'no computerized system will ever be successful without a range of skilled personnel who are involved in the process'. Revenue management has to become an integral part of everyone's work routine. 'Everyone' means all those managers and employees who have a role to play in the system (Jones and Hamilton 1992: 3), not just the managers. Their involvement in RM can share and provide some important guest information and their 'marketing intelligence'. They often include many more people than usually considered, including reservationists, front office clerks, cashiers and concierges (Jones and Hamilton 1992).

The introduction of computerized RM has also had an impact on the structure of an organization (Jauncey et al. 1995). Successful RM implementation depends on a highly trained and motivated team, often from across different departments of the property, who regularly meet to forecast the forthcoming business of the hotel (Huyton and Peters 1997). Jauncey et al. (1995) state RM team should include all heads of department and other managers concerned with reservations, accommodation and hotel business. They emphasize that the function

of the RM team is not simply to overview the process but to become directly involved in all aspects and stages of RM, including the prediction of future levels and patterns of business. Huyton and Peters (1997) stress that RM teams typically consist of the rooms division manager, the sales manager and the reservations manager. They do not mean that anyone else is excluded, but for a speedier and more effective decision-making process they think it is wise not to make the RM team too big and the original three would tend to make the best team. Donaghy et al (1997), through research on the application of RM within the British corporate hotel sector, propose that an RM team is considered essential involving, ideally, the revenue specialists, the functional specialists and a coordinator. They state that the team co-ordinator should be the general manager, who assumes overall responsibility for the implementation of RM and ensures that functional specialists work and learn from each other.

Donaghy et al. (1995) also propose that the effectiveness of an RM system is significantly influenced by the extent to which a training program is developed and provided to RM staff. To enhance awareness of YM within hotels, skills must be developed to practice such techniques proficiently (Brotherton and Turner 2001). All staff, whether managers or employees, must be involved in training sessions, not only on technology but also on company RM philosophy (Lieberman 1993), especially those dealing with sales and inquiries, to develop an understanding of its effects on their job roles and the establishment (Donaghy et al. 1995; Donaghy et al. 1998; Farrell and Whelan-Ryan 1998; Hansen and Eringa 1998). There exist many processes in RM that cannot be completed by the computer. They include isolation of the relevant numbers, discrimination between all the possible combinations of data and focus on only that which is relevant to the forecasting process and the decision at hand (Jones and Hamilton 1992).

Training classes, both before and after implementation, should be conducted at various levels of management (Talluri and Van Ryzin 2005). Talluri and VR suggest that different management level should have different training emphases. For mid-level managers, the main emphasis should be on the principles of RM. For supervisors, more training is needed on the details of the technology (at least at a conceptual level) and how the system 'thinks' in terms of coming up with its recommendations. Revenue analysts need this same training, but they also need specific training in how to use the software effectively and when and when not to override the system recommendations (Talluri and Van Ryzin 2005).

In addition, as Jones and Hamilton (1992) state, training and education should also be considered at some specific job positions which are not direct users of the RM system but their involvement can help make RM more successful. For example, concierge, sales staff, front office staff, customer service agents, and so on. They may pick up information from overhearing guests, talking to guests or through their relationships with other people. In fact, it is easy to lose sight of these staff, but they could help the revenue manager in setting rates and forecasting demand.

To implement RM successfully, it is not only important to get commitment from each department, but there must be effective communication between each department. In the past hotel departments ignored between department communication; as such, they found that because no one really understood what RM was, any problems with rates, guest complaints, or poor pricing decisions were blamed on the RM system (Cross 1997). Cross (1997) suggested organizing road shows to educate the company about RM and how it will help the hotels. Communication can also be undertaken by conducting 'focus group' discussions, by means of attitude surveys and by informally listening to what employees say (Armstrong 2003).

Finally another managerial issue related to RM culture is the development of rational incentives and reward systems. Due to the adoption of a new RM system, hotel managers may have to reconsider the business performance criteria on which they base their incentive schemes for staff in departments such as sales, marketing and reservations (Donaghy et al. 1997). Although incentive schemes ensure that reservations and sales agents are concerned with trying to increase both the occupancy and the average room rate, an incentive system that motivates employees to make decisions which do not increase hotel revenue can counteract the most sophisticated RM system (Kimes 1997). According to Donaghy et al. (1995), a productive incentive scheme within the context of YM must incorporate incentive points that are directly related to the sales generated on high-, medium- and low-demand days. If incentive schemes are based on sales volume and occupancy, or average room rate, there will be a potential conflict between individual and corporate objectives, so reservations agents and sales managers should be rewarded on revenue production rather than on talk time or number of rooms booked. Therefore, the incentive schemes will require revision to ensure that behaviour required by the YM system accords with that encouraged by the personal incentive schemes (Brotherton and Mooney 1992).

Jones and Hamilton (1992) propose formal and informal approaches that can be adopted to develop a revenue culture. The formal approaches are the following:

- Carefully select personnel who have the necessary skills in the use of IT and who can perform analyses.
- Use RM performance criteria to evaluate the business performance of properties.
- Include forecasting and RM in the job descriptions of key personnel.
- Set up a forecasting committee that includes managers from the rooms division, reservations, sales, marketing, food and beverage, banqueting and the front office.
- Modify employee remuneration to reflect improved operating performance resulting from RM.

However, they also emphasize the informal aspects of organizational life which they think as important as the formal ones, and such aspects can be useful in developing a revenue culture. The informal approaches that will support YM are (Jones and Hamilton 1992) as follows:

- Demonstrate a high-level commitment to the YM concept within the organization.
- Accept that mistakes will be made, especially in the early days.
- Involve not only managers but also all employees who have a role to play, including reservationists, front office clerks, cashiers, and concierges.
- Demystify the YM concept by keeping things simple and easy to understand and by rejecting jargon (especially that from suppliers of hardware and software).
- Reward people for implementing new techniques and for suggesting new ideas (such rewards need not be financial – use praise and increased responsibility, too, as a way to acknowledge performance and motivate workers).

Impact on performance

The extent to which YM improves hotel revenue performance has been little researched. Suppliers claim it will give an increase in average achieved room rates of between 3.5 and 5% within the first 12 months (Goymour and Donaghy 1995). One marketer claims that an RM system can earn properties \$5–10 more per room night, depending on how well the property was managed before YM was introduced (Rowe 1989). In the late 1980s, Hilton

hotels introduced an RM system, and it was reported that one hotel experienced a \$7.50 increase in transient average rate with no reduction in occupancy in the first month (Orkin 1988). Bob Regan, President of Revenue Dynamics, reported that three hotels using his company's system experienced a 5–8% improvement in room revenue (Boyce 1991). In 1999, a supplier's website cited increased revenues of 3–7% and profit increases of 50–100% (TIMS Revenue Optimisation Systems 1999).

Despite these claims, objective long-term measurement of such performance improvements has rarely been carried out and was not published in the research literature. This is partly because a number of methodological problems have to be overcome. First, the properties selected as case studies must have adopted and *fully implemented* a YM system. As the Jarvis et al. (1997) study demonstrated, some hotels believe that they have adopted YM, when in fact they have not fully done so. Second, there need to be accurate measurement of the dependent variable (room revenue) and the independent variables (occupancy and achieved room rate) both before and after the implementation and after it. Given that these variables are all key performance measures of hotel operation, such data would be readily available. Greater control over the research would be achieved if it were designed as a longitudinal study, that is, a hotel that was yet to implement YM was studied for some time prior to implementation and studied for some time afterwards. This, however, is very time consuming and costly, so historic data sets were used. The lowest level of aggregation in data would be the most desirable, which could be in weekly or monthly sales performance, but the time frame over which data need to be compared pre- and post-implementation is long. It is suggested by those implementing YM that it takes at least six months for the system to 'bed down'. Furthermore, there may be seasonal fluctuations. This suggests that a minimum of three years' data need to be considered: A full 12-month pre-implementation, 12 months during which the system is installed, tested and established and 12 months post-implementation.

The third methodological problem is the effect of extraneous variables. During the three years of sales activity to be included in the study, a number of factors may have influenced the revenue performance of the hotels, other than YM implementation. These could be either external or internal influences. External influences could be national trends, economic circumstances, national advertising campaigns by the firm or competitors and local developments relating to business demand and competitor behaviour. Internal factors affecting performance could be

a change in the management personnel within the property, in-house sales initiatives or refurbishment.

Jones (2000) attempted to tackle these issues in a study of three hotels in the United Kingdom. Despite this, it remained difficult to be sure that any change in performance derived from the implementation of a YM system. However, from discussions with senior managers in each of the properties, it is clear that their *perception* is that YM is extremely effective. What is clear is that post-YM implementation, all hotels appear to be achieving better ARR, although even this depends on the years compared. Managers also agreed that performance improved largely due to YM's impact on rate setting and rate control. Some managers identified that the reduction in discounting that accompanied the 'fair rate' pricing may have deterred some business, but this was more than offset by the improved ARR. Jones (2000) concludes that

- There is growing evidence from a number of sources that YM may improve yield performance by around 4% in the United Kingdom.
- Such improvement largely derives from better management of the average rate achieved (rather than better management of occupancy).
- Yield improvement varies over time, probably in relation to the strength of demand. Most improvement is seen with respect to those periods when demand is strong.
- It takes some time for a YM system to be fully operational so that performance improvement may lag 6–18 months behind implementation.
- Hotels have invested heavily, in terms of both financial investment and human resources, without having any clear system in place to monitor the impact that the YM system will have on operational performance.

A study by Sanchez and Satir (2005) suggested that performance can also be affected by the 'reservation mode, that is, whether it is off-line or online. They looked at the performance of a major hotel chain's system over two years and compared off-line and online modes with respect to average price, occupancy rate and REVPAR. They found that online mode yielded significantly better average prices and REVPAR than the off-line mode. They also investigated a sub-group of hotels and found that those that switched to online mode experienced a substantial revenue increase. The issue of a distribution channel's effect on RM has also been investigated using computer simulation (Choi and Kimes 2002).

Summary and conclusions

Revenue management techniques have been used for close to three decades and have produced significant revenue gains for the companies using them effectively. In the process of improving the efficiency of RM, numerous avenues are currently being explored. Forecasting remains a very difficult discipline in constant need of improvement. Current forecasting methods, while suited to differentiated pricing environments, are rather inadequate at forecasting demand in undifferentiated environments, as currently faced by airlines. Optimization relies on very restrictive assumptions, such as the independence of fare product demand and the normal distribution of that demand. Lastly, alternative approaches to RM currently investigate the possibility of moving away from traditional methods and forecasting altogether to use choice model approaches. Choice models determine the probability that a customer, guest, etc. will choose any of the available alternatives and thus differ from traditional forecasting methods. However, the calibration of such choice models remains a challenge in the transportation industry.

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