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# Electronic Distribution Channels' Effect on Hotel Revenue Management

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**Abstract**
Even with the variety of distribution channels available, rate and length of stay remain the key factors in revenue management.

**Keywords**
hotel industry, revenue management, optimization, forecasting

**Disciplines**
Hospitality Administration and Management

**Electronic Distribution Channels' Effect on**

# Hotel Revenue Management

Even with the variety of distribution channels available, rate and length of stay remain the key factors in revenue management.

BY SUNMEE CHOI AND SHERYL E. KIMES

The emergence of internet-enabled distribution channels has created both opportunities for and challenges to hotels' revenue-management practices. The potential to reduce distribution costs using internet channels has made hotel managers more conscious of the need to maximize contributions to gross profit (revenue less distribution costs) rather than just the revenue obtained from a given room sale. In addition to considering rate and timing of sales, hotel managers must evaluate the effects of distribution-channel management on their current revenue-management practices and determine how to benefit from it.

Although the potential benefit associated with revenue management of distribution channels has been discussed,[1] no study has been conducted to measure this notion. In this study, we extended commonly used revenue-management forecasting and optimization methods to consider the effects of distribution channels and used a computer simulation to test the performance of the extended models.

## Problem Overview

Revenue management is the business practice of selling the right inventory to the right customer for the right price at the

*Note:* The authors are indebted to the following revenue-management and electronic-distribution practitioners: Stephanie Fabian, revenue manager, hotel-revenue management, priceline.com.; Sharon Duffy, senior director of revenue management, Hilton Hotels Corporation; and Jay Burnett, corporate manager, revenue analysis and strategy, Marriott International.

[1] See: A. Boyd, "Inventory Distribution Channel and the Practice of Revenue Management"; and V. Viswanathan, "E-Commerce and Its Evolution in the Airline Industry," papers presented at the 2000 International Revenue Management Conference, Atlanta, GA.

right time.[2] The concept of "right" in this definition means achieving the maximum revenue for the sellers and gaining the maximum value for the buyers.[3] The basic principle of revenue management is to match the room rate and timing of the sale to the buyer's needs. One offers discounted rates to stimulate demand for inventory that would otherwise go unsold, but limits the availability of the discounts to customers who are willing to pay a higher price to gain, for example, last-minute accommodations, or to those who must have a particular room at a particular time.[4] Hotel companies reported revenue increases of 2 to 5 percent as a result of using revenue management.[5]

Little attention has been paid to the revenue-management implications of using various distribution channels.

Since the hotel industry adopted revenue management in the 1980s, it has been developed and practiced by different hotel companies at varying levels of sophistication. Some hotels use daily occupancy forecasts to determine rate availability, while others develop multiple arrival forecasts for combinations of rate, length of stay, and room type, and optimize the inventory allocation at every 15th booking.

Revenue management rests on this question: What is the most profitable mix of demand for the given capacity? Inventory-allocation methods help managers to make this determination. In operational terms, inventory-allocation decisions help reservation agents decide whether to accept or reject a reservation request.

Various allocation methods have been developed for inventory-allocation problems. The EMR (expected marginal revenue) model is the most widely used model in the airline industry,[6] while bid-price models have gained acceptance for both hotels and airlines. A variety of other models exist,[7] but bid-price methods[8] are considered to work well in both the airline industry[9] and in the hotel industry.[10]

Sophisticated revenue-management systems apply an inventory-allocation algorithm to make the best allocation decisions, which are then communicated to users in the form of restrictions at each rate-bucket level. Allocation decisions are typically updated nightly for the next 90 arrival days through a rerun of the inventory-allocation algorithm based on updated demand forecasts and overbooking decisions. Since current revenue-management systems do not consider

[2] B.C. Smith, J.F. Leimkuhler and R.M. Darrow, "Yield Management at American Airlines," *Interfaces,* Vol. 22, No. 1 (1992), pp. 8–31.

[3] S.E. Kimes, "Implementing Restaurant Revenue Management," *Cornell Hotel and Restaurant Administration Quarterly,* Vol. 40, No. 3 (June 1999), pp. 16–21.

[4] R.G. Cross, *Revenue Management: Hard-core Tactics for Market Domination* (New York: Broadway Books, 1997).

[5] *Ibid.*

[6] See: K. Littlewood, "Forecasting and Control of Passenger Bookings," a paper presented at 12th AGIFORS Symposium, 1972; P.P. Belobaba, "Air-travel Demand and Airline-seat-inventory Management," MIT Ph.D. thesis, 1987; and P.P. Belobaba, "Optimal vs. Heuristic Methods for Nested-seat Allocation," a paper presented at AGIFORS Symposium (Cambridge, MA), 1992.

[7] See: R.E. Curry, "Optimum Airline-seat Allocation with Fare Classes Nested by Origins and Destinations," *Transportation Science,* Vol. 24 (1990), pp. 193–204; J. Alstrup, S. Boas, O.B.G. Madsen, and R.V.V. Vidal, "Booking Policy for Flights with Two Types of Passengers," *European Journal of Operational Research,* Vol. 27 (1986), pp. 274–288; and F. Glover, R. Glover, J. Lorenzo, and M. Claude, "The Passenger-mix Problem in the Scheduled Airlines," *Interfaces,* Vol. 12, No. 3 (1982), pp. 73–79.

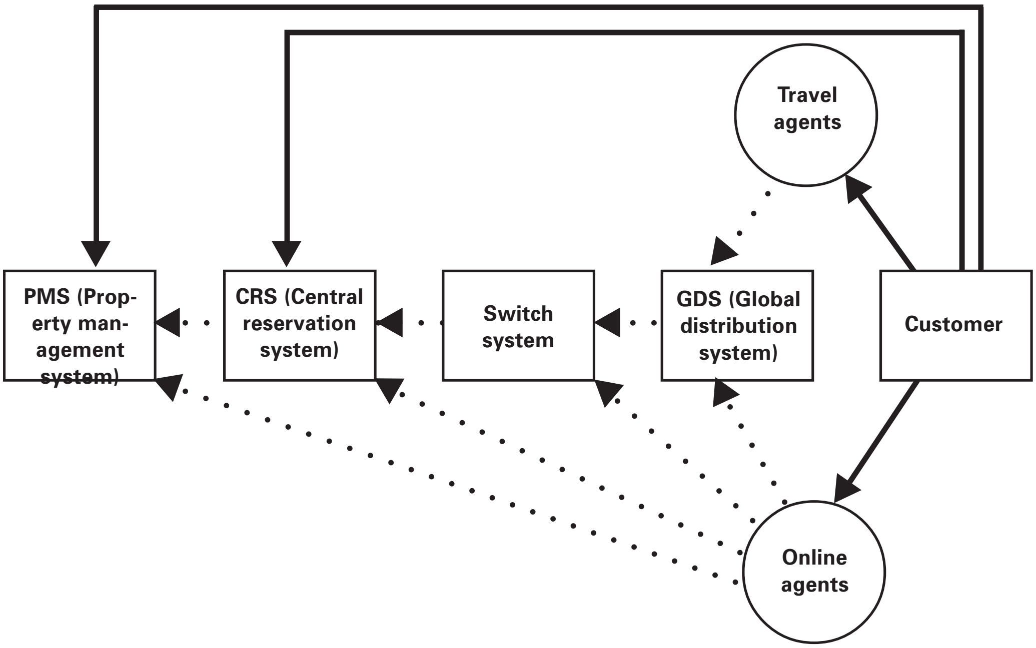
[8] Bid-price methods formulate the inventory-allocation problem as a linear-programming model. The shadow price of the capacity constraint in the model, which shows the marginal value of the last inventory unit available to the hotel, is used as the bid price to decide whether to accept or reject requests. If requested rates are equal to or higher than the bid price, they are accepted, if they are lower than the bid price, they are rejected.

[9] See: J.I. McGill and G. Van Ryzin, "Revenue Management: Research Overview and Prospects," *Transportation Science,* Vol. 33, No. 2 (1999), pp. 233–256; and E.L. Williamson, "Airline Network Seat-inventory Control: Methodologies and Revenue Impacts" (Flight Transportation Laboratory, MIT, 1992).

[10] T.K. Baker and D.A. Collier, "A Comparative Revenue Analysis of Hotel Yield-management Heuristics," *Decision Sciences,* Vol. 30, No. 1 (1999), pp. 239–256.

**EXHIBIT 1**

## Hotel-distribution channels




current market conditions, competitor practices, or any unusual market phenomena, responsible personnel generally review and adjust the system's recommendations each day.

After review, the allocation decisions are then communicated to the reservation system at the property level or at the central level, which in turn feeds the GDS routes through a switch system where appropriate.

Inventory-allocation decisions for a given future arrival day depend on the level of forecasted demand for the day. Since allocation decisions are typically made by room-rate category and length of stay, demand forecasts are required at that level. Hotels can either directly generate demand forecasts at the required level of detail or develop forecasts at an aggregate level, such as at an overall hotel level, and apply historical probability distributions of the aggregate demand at the required level of detail. The latter approach may seem inexpensive, but if demand is unstable, that approach requires frequent updates of the probability distributions and, as a result, cannot be considered a low-cost alternative. Detailed forecasts by rate category and length of stay have been shown to reduce forecast error.[11]

## Hotel Distribution-channel Management

Traditional business hotels could have three primary distribution channels: hotel direct, central reservation offices, and travel agencies. Recently, internet-enabled company web sites and various online travel agencies have become additional channels for hotels. The variable cost of a booking through these various channels can vary from nearly nothing to $35 or more.

Typically up to four systems are involved in processing booking requests from these channels (see Exhibit 1): global distribution system (GDS),

[11] L. Weatherford, S.E. Kimes, and D. Scott, "Forecasting for Hotel Revenue Management: Testing Aggregation against Disaggregation," *Cornell Hotel and Restaurant Administration Quarterly,* Vol. 42, No. 4 (August–September 2001), pp. 63–64.

switch system, central reservation system (CRS), and property-management system (PMS).

Travel agencies use GDSs, such as Sabre, Galileo, Amadeus, and Worldspan, which allow electronic distribution of hotel rooms. GDSs are connected to hotels' CRSs through an intermediary system called a switch, such as Thisco and Wizcom. CRSs then connect with a hotel's PMS to deliver the booking information to the hotel's front desk.

The management of consistent rate and availability information throughout these systems has been critical to successfully managing revenue. But not every hotel has the capability to update automatically rates in GDSs, or to ensure seamless connectivity between GDSs and their CRS.

To manage revenue by distribution channel, revenue-management forecasting and optimization models must be revised to consider the relevant information.

Internet-enabled distribution channels can be categorized into company web sites and online agencies. In general, company web sites are owned and managed directly by the hotel companies, while online agencies are third-party intermediaries between hotels and customers. These internet channels provide booking capabilities through their connections to the CRS or to existing networks (e.g., GDS–switch–CRS, switch–CRS). Depending on the systems involved in processing bookings, the cost of booking through internet channels can vary considerably.

Each system involved in distribution has a different cost to hotels. For example, GDSs charge approximately $4.00 per transaction, switch systems charge $0.36, and CRSs charge $2.50.[12] In addition, travel agents typically charge a 10-percent commission of the total booked revenue (although some airlines have unilaterally discontinued that payment). Depending on the distribution channel, the variable costs per booking can range from nearly nothing to as high as $6.86 plus 10 percent of the total booked revenue. Given that the variable cost per booking can be minimal when reservations are made through company web sites connected directly to the CRS, the potential cost-saving opportunity is considerable for hotels.

A reasonable proposition is that it is most beneficial for hotels to book reservations through the least-expensive channels, if there is sufficient demand via those channels. To manage revenue by distribution channel, revenue-management forecasting and optimization models must be revised to consider the relevant information.

## Revenue Management of Hotel-distribution Channels

In the hotel industry, distribution-channel management has been considered as a marketing tool, and distribution costs have been generally seen as inflexible. Little attention has been paid to the revenue-management implications of using various distribution channels although the implications for hotel profitability could be substantial.

Hotel revenue-management systems employ a variety of optimization methods.[13] In our study, we selected the bid-price method as our inventory-allocation model since it is a well-accepted optimization method.[14] Typically, the bid-price method is applied by rate and length of stay. To those criteria we added evaluating reservation requests by contribution (revenue less distribution cost) from the distribution channel, as well as the rate and length of stay.

For an inventory-allocation method to select the most profitable mix of demand, accurate demand forecasts are required. Various forecasting methods (i.e., pickup forecasting, regression and exponential smoothing) are employed by hotel revenue-management systems.[15] We used the

[12] S.E. Kent and C. Fraser, "Internet Lodging: Bits Plus Beds Equal Bucks" (New York City: Goldman Sachs Investment Co., 2000).

[13] See: T.K. Baker and D.A. Collier, "A Comparative Revenue Analysis of Hotel Yield-management Heuristics," *Decision Sciences,* Vol. 30, No. 1 (1999), pp. 239–256; and J.I. McGill and G. Van Ryzin, "Revenue-management: Research Overview and Prospects," *Transportation Science,* Vol. 33, No. 2 (1999), pp. 233–256.

[14] E.L. Williamson, *op. cit.*; and Baker and D.A. Collier, pp. 239–256.

[15] Weatherford, Kimes, and Scott, *op. cit.*

pick-up forecasting method[16] to develop our forecasts.

Revenue-management forecasts are done by rate category and length of stay for current-allocation methods, since allocation decisions are made at that level. Thus, a hotel with ten rate categories and seven lengths of stay would require 70 (10 times 7) forecasts for each future arrival day. For the extended-allocation method, more forecasts are required since they must be made by rate category, length of stay, and distribution channel. For example, if a hotel had three different distribution channels, the number of forecasts would increase to 210 (10 times 7 times 3) for each future arrival day.

## Hotel-reservation and Revenue-management-system Simulation

A computer-simulated hotel-reservation and revenue-management system was developed and used to test the relative contribution-enhancement performance of the extended model to the current model. In the extended approach, we revenue-managed by rate, length of stay and distribution channel, while in the current approach, we revenue-managed only by rate and length of stay.

The simulated hotel was a typical urban business hotel with 300 similar rooms available at $119, $129, and $139 per night. Customers were allowed to book only one room and stay for a maximum of three nights.

Three types of distribution channels were used: direct channels, online agencies, and traditional travel agencies. Traditional travel agencies were assumed to make bookings only through GDS–switch–CRS connectivity. Distribution cost per booking was zero for direct channels, $6.00 for online agencies, and $6.00 plus a commission of 10 percent of the total revenue for travel agencies. The contribution of each request was then calculated by rate category, length of stay, and distribution channel (see Exhibit 2).

**EXHIBIT 2**

### Contribution calculations for the simulated hotel

| Room rate | $119 | | | $129 | | | $139 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Distribution channel** | Direct | OA | TA | Direct | OA | TA | Direct | OA | TA |
| **Booking cost** | 0 | $6 | $6+10% | 0 | $6 | $6+10% | 0 | $6 | $6+10% |
| **Contribution** | $119 | $113 | $101.10 | $129 | $123 | $110.10 | $139 | $133 | $119.10 |

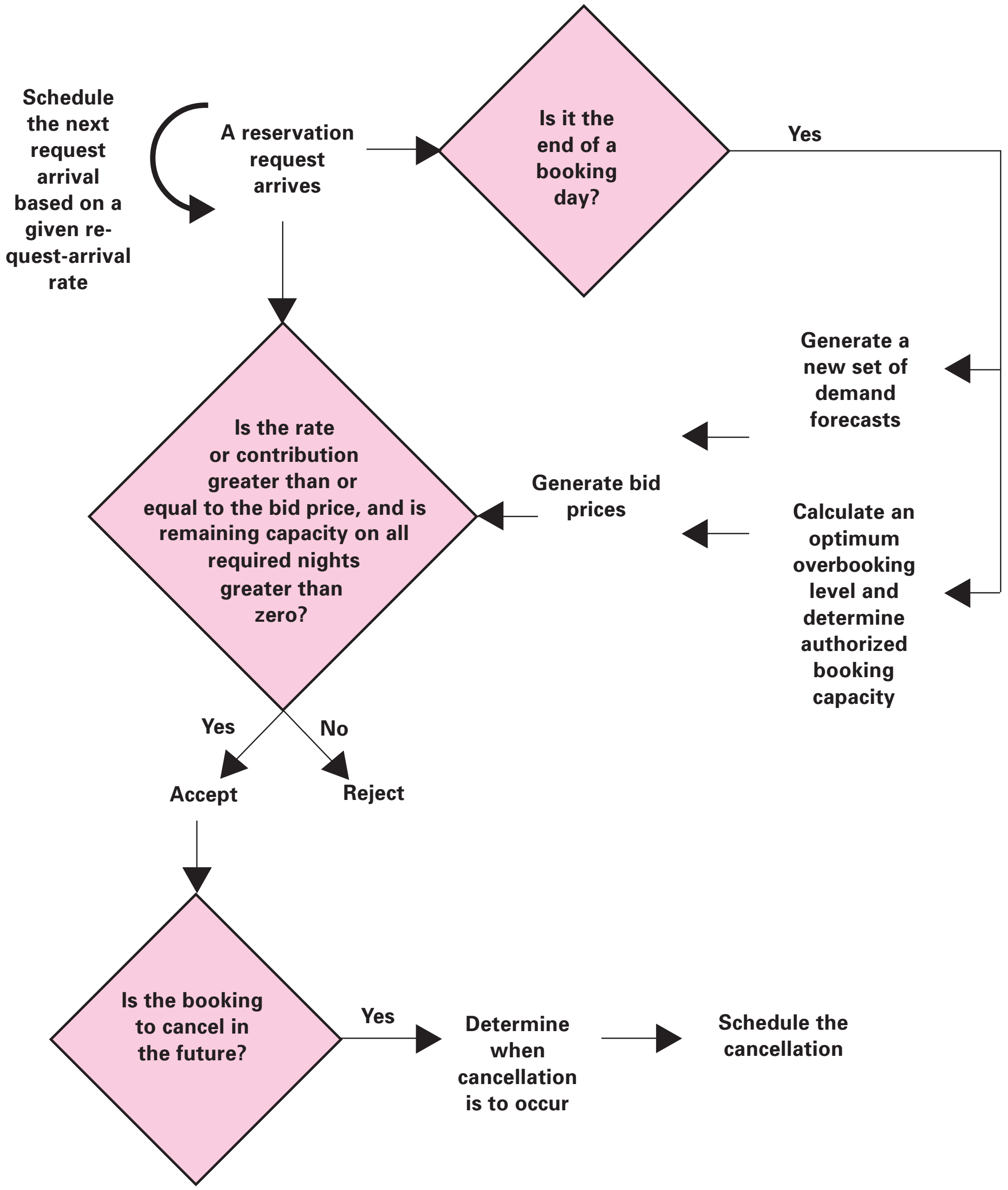
Bookings could be made up to 14 days in advance of the arrival day. As with most business hotels, the demand level was highest for Tuesdays (120 percent of capacity) and Wednesdays (130 percent), with Mondays (98 percent) and Thursdays (100 percent of capacity) being the next highest. Lowest demand occurred on the weekends: Fridays at 59 percent, Saturdays at 54 percent, and Sundays at 75 percent of capacity. About 60 percent of bookings came through direct-booking channels, 35 percent through traditional travel agents, and about 5 percent through online agencies. The number of requests for a given future arrival day increased as the arrival day approached. To simplify the simulation process, we did not permit overbooking. Since the purpose of this study was to test the contribution effects of each of the two inventory-allocation methods, as long as everything else in the simulation testing the two models was held the same (no matter whether overbooking was considered in the models), the difference in results was attributable to the difference in the two methods compared.

The system simulated a hotel's reservation-booking environment and the functions of the hotel's reservation and revenue-management systems (please see Exhibit 3, on the next page, for a graphical representation of the simulation). A total of 100 simulation runs were made for each

[16] See: E. L'Heureux, "A New Twist in Forecasting Short-term Passenger Pickup," a paper presented at AGIFORS, October 1986; R.R. Wickham, "Evaluation of Forecasting Techniques for Short-term Demand of Air Transportation," MIT master's thesis, 1995; and Weatherford, Kimes, and Scott, *op. cit.*

**EXHIBIT 3**

## Revenue-management-simulation structure



bid-price method. In each run, 56 arrival days were simulated, and the weekly contribution from the last seven days was tracked.

Reservation requests were first generated according to daily request arrival rates. The request arrival rate on a given booking day was based on the demand-intensity level for the next 14 future arrival days and request-booking patterns for the arrival days. A request was accepted only if the revenue or contribution from that request was greater than or equal to the bid price for the requested arrival day, and a room was available on all requested nights. Otherwise, the request was rejected. Once a request was accepted, the cancellation probability was calculated. If the booking cancelled, the cancellation occurred randomly between the current booking time and the end of the requested arrival day.

When the simulation clock reached the end of a booking day, the revenue-management system updated demand forecasts for the next 14 future days. Based on the updated forecasts, the system reran the bid-price method and updated the bid prices for the next 14 future arrival days.

Two forecast-aggregation approaches were tested: **(1)** disaggregate forecasts in which the forecasts were developed at the required level of detail, and **(2)** aggregate forecasts in which forecasts were developed at an aggregate level and historical probability distributions of the aggregate demand were applied at the required level of detail of rate, length of stay, and distribution channel.

Forecast performance was measured by both accuracy and contribution impact. Two measures of forecast accuracy were used: the mean absolute deviation (MAD) and the median relative absolute error (MdRAE).[17] The contribution achieved by each method was compared and tested for significance using *t*-tests.

## No Significant Difference

A summary of the inventory-allocation and -forecasting methods tested and the results obtained is presented in Exhibit 4. The weekly con-

**EXHIBIT 4**

### Summary of experiments and results

| | Experiment 1 | Experiment 2 |
|---|---|---|
| **Type of model tested** | Inventory-allocation method | Demand-forecasting method |
| **Method selected** | Bid-price method | Classic pickup method |
| **Existing model** | The method applied at the rate and length-of-stay level with a goal of maximizing revenue | The method applied at the rate and length-of-stay level, and resulting forecasts multiplied by probability distribution |
| **Extended model** | The method applied at the rate, length-of-stay, and distribution-channel level with a goal of maximizing contribution | The method applied directly at the rate, length-of-stay level, and distribution-channel level |
| **What is measured and compared** | Revenue and contribution | Revenue, contribution, and forecast accuracy |
| **Result** | There was no significant difference in the obtained contribution amount between the two models. | Extended model produced much more accurate forecast and significantly more revenue and contribution. |

[17] J.S. Armstrong and F. Collopy, "Error Measures for Generalizing about Forecasting Methods: Empirical Comparisons," *International Journal of Forecasting,* Vol. 8 (1992), pp. 69–80.

tribution achieved by the two inventory-allocation methods in each run of the simulated hotel's booking environment was recorded and averaged over 100 independent seven-night replications of the simulation run. The differences in the resulting average contribution over the replications were compared using *t*-tests. The average weekly contribution from the extended method was slightly higher than the average weekly contribution of the current method, but the difference was not statistically significant.

Applying revenue-management strategies to distribution channels may not help a hotel that already is optimizing revenues by rate and length of stay.

The disaggregated forecasting method produced a significantly higher average weekly contribution (11 percent) than the aggregate forecasting method ($p$ = 0.001). The disaggregated forecasting method produced significantly more-accurate forecasts (aggregate method: MAD = 17.9, MdRAE = 0.24; disaggregate method: MAD = 11.23, MdRAE = 0.15) ($p$ = 0.0006 for MAD and $p$ = 0.007 for MdRAE ).

## Rate and Length of Stay Make the Difference

For the simulated hotel, optimizing by rate, length of stay, and distribution channel did not significantly enhance contribution, when compared to optimizing by rate and length of stay.

Disaggregated forecasts produced more-accurate demand forecasts than aggregated forecasts and, as a result, generated significantly higher contribution levels. This result is consistent with earlier research.[18] We found that it is best to forecast directly at the required level of detail when generating forecasts by rate, length of stay, and distribution channel.

After-the-fact analysis of the results highlighted factors that may have affected model performance, including the re-optimization frequency, the gap between room rates in comparison to the amount of distribution fees, and demand-arrival patterns. As we discuss next, these factors can vary by hotel, so the results of this study may not be generalizable to all hotels.

The re-optimization frequency of the inventory-allocation method can drive the size of the contribution achieved. The linear-programming model used to generate bid prices for the allocation method requires frequent re-optimization for the best results.[19] In this study, re-optimization was performed only nightly to simulate a common practice in the hotel industry. That approach doesn't model the hotels that optimize the inventory allocation at every fifteenth booking, for instance. More frequent re-optimization could lead to bigger contribution enhancement by the extended method.

The size of the gap between room rates may interact with the cost of distribution and influence the contribution enhancement of the extended method. If distribution costs do not vary greatly and the gap between room rates is large, the extended method will not necessarily result in a contribution enhancement. Therefore, hotels with a small gap between room rates and a wide range of distribution costs are likely to attain a larger benefit from the extended method.

The arrival order of requests can make a difference in the size of the realized contribution. The bid-price method accepts requests with a requested room rate higher than or equal to the bid price. The same bid prices are used until they are updated through a re-optimization. If, for example, low-revenue requests arrive before those with high rates, as commonly is the case for hotels with a good mix of business and leisure customers, the bid-price method with a goal of maximizing revenue may allow the acceptance of the low-rate requests at the cost of turning away late-arriving high-revenue requests. However, the bid-price method that has a goal of maximizing contribution distinguishes the same-revenue requests by distribution channel used and allows acceptance of requests that satisfy the minimum-contribution requirement at the distribution

[18] Weatherford, Kimes, and Scott, *op. cit.*

[19] E.L. Williamson, *op. cit.*

channel. As a result, it is much less likely that early arriving low-contribution requests will be accepted at the cost of late-arriving high-contribution requests. Therefore, the contribution-enhancement potential of the extended model is much greater for hotels that have low-revenue demand requests arriving before high-revenue requests.

## Focus on Key Factors

The emergence of low-cost booking channels has heightened hotel managers' interest in maximizing contribution from room bookings, instead of just revenue. While the possible benefits from the revenue-management of distribution channels have been discussed before this, no one had tried to measure the effect of that effort. In this study, we found that optimizing by rate, length of stay, and distribution channel did not lead to a significantly higher contribution than optimizing only by rate and length of stay. Our findings also supported past studies that found that disaggregated forecasts produced significantly better results than aggregated forecasts.

We conclude that business hotels similar to the hotel simulated in this study will not benefit significantly from applying revenue-management strategies to their distribution channels, provided that they are already optimizing by rate and length of stay. However, this result cannot be generalized to all other types of hotels. After-the-fact analyses showed that the contribution-enhancement potential of the extended approach could vary depending on a hotel's operating characteristics. Therefore, the true size of the benefit from the extended-allocation method for a hotel can be found only by testing the application of the method to the hotel. ■

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