Cornell University
School of Hotel Administration
The Center for Hospitality Research

Five-Star Research℠ for the Hospitality Industry

Low-price Guarantees:

How Hotel Companies Can Get It Right

is produced for the benefit of the hospitality industry by
The Center for Hospitality Research at Cornell University

Gary M. Thompson, Executive Director
Glenn Withiam, Director of Publications

Advisory Board

James C. Allen, Executive Vice President, Wines, Southern Wine and Spirits of New York
Raymond N. Bickson, Managing Director and Chief Executive Officer, Taj Group of Hotels, Resorts, and Palaces, Division of Indian Hotels Company
Jan A. deRoos, Ph.D., HVS International Professor of Finance and Real Estate, Cornell University
Cathy A. Enz, Ph.D., Louis G. Schaeneman, Jr., Professor of Innovation and Dynamic Management, Cornell University
Unmesh Joshi, Chairman and Managing Director, Kohinoor Group
Jo-Anne Kruse, EVP Human Resources, Travel Distribution Services Division, Cendant Corporation
Craig Lambert, SVP Portfolio Management, CNL Hospitality Group
Mark V. Lomanno, President, Smith Travel Research
W. Michael Lynn, Ph.D., Associate Professor, Cornell University
Suzanne R. Mellen, Managing Director, HVS International
Leland C. Pillsbury, Chairman and CEO, The Thayer Group of Companies
Angel Santos, VP of Marketing for Healthcare and Hospitality, JohnsonDiversey
Janice L. Schnabel, Managing Director, Marsh's Hospitality Practice
David A. Sherf, SVP, Real Estate/Asset Management, Hilton Hotels Corporation
Judy A. Siguaw, D.B.A., Dean, Cornell-Nanyang Institute
Barbara Talbott, Ph.D., EVP Marketing, Four Seasons Hotels and Resorts
Elaine R. Wedral, Ph.D., President, Nestlé R&D Center and Nestlé PTC New Milford
R. Mark Woodworth, Executive Managing Director, The Hospitality Research Group

Low-price Guarantees
CHR Reports, Vol. 5, No. 10 (September 2005)

Single copy price US$50.00
Copyright © 2005 by Cornell University

Cornell University
School of Hotel Administration
The Center for Hospitality Research

Thank you to our generous corporate supporters.

Senior Partners

JohnsonDiversey

Nestlé

Southern Wine
and Spirits of New York

Taj
Hotels Resorts Palaces

Partners and Sponsors

AIG Global Real Estate Investment

Bartech Systems International

Cendant Corporation

Four Seasons Hotels and Resorts

HVS International

Kohinoor Group

Marsh's Hospitality Practice

Smith Travel Research

Thayer Group of Companies

Willowbend Golf Management

Wyndham International

Friends • ARAMARK • DK Shifflet & Associates • ehotelier.com • *Gerencia de Hoteles & Restaurantes* • Global Hospitality Resources • *Hospitality World* • hospitalitynet.org • *Hotel Asia Pacific* • *Hotel China* • Hospitality Initiatives India • Hotel Interactive • Hotel Resource • International CHRIE • International Hotel and Restaurant Association • KPMG Japan/Global Management Directions • *Lodging Hospitality* • *Lodging* Magazine • Mobile MoneySaver • *National Hotel Executive* Magazine • PKF Hospitality Research • *Resort+Recreation* • *The Resort Trades* • RestaurantEdge.com • Shibata Publishing Co. • The Lodging Conference • TravelCLICK • UniFocus • WageWatch, Inc. • WiredHotelier.com

Executive Summary

Low-price Guarantees:

How Hotel Companies Can Get It Right

By Steven A. Carvell, Ph.D., and Daniel C. Quan, Ph.D.

With the growth of the internet, the increase in the volume of online bookings has altered and multiplied the hotel industry's distribution channels. While this growth has driven up the profits of online travel agencies, hotel operators are experiencing a loss of control over the pricing of rooms and a potential transfer of pricing authority to third-party internet-based companies. The popularity of such services stems from consumers' desire to obtain the lowest rate within their desired market segment. One possible cure applied by many hotel chains is to offer a best-rate guarantee on their own web sites. A calculation of the option value of such guarantees shows, however, that current rate guarantees have little value to consumers. Instead, an application of option-pricing approaches demonstrates how a hotel company can structure a best-rate guarantee that would provide value to consumers by offering the guest the option of purchasing a price guarantee. Such an option would give the guest the lowest price posted on a specified set of web sites, up to the time the guest arrives at the hotel. The pricing of this option would be based on

About the Authors

***Steven A. Carvell**, Ph.D., is an associate professor in the Department of Finance, Accounting and Real Estate at the Cornell University School of Hotel Administration (sac20@cornell.edu). Much of his research has focused on developing models to incorporate real options, risk analysis, and debt capacity into hotel feasibility analysis, as well as economic value-added models applied to hotel operations. He has published in* Harvard Business Review, Cornell Hotel and Restaurant Administration Quarterly, Journal of Portfolio Management, FIU Hospitality Review, Financial Analysts Journal, *and* Journal of Business Finance and Accounting, and Leaders.

***Daniel C. Quan**, Ph.D., is an associate professor in the Department of Finance, Accounting and Real Estate at the Cornell University School of Hotel Administration (dq22@cornell.edu). His primary research focus has included real estate finance, mortgage markets, and auction markets. Among his publications are articles in* Journal of Industrial Economics, Real Estate Economics, Journal of Real Estate Finance and Economics, Financial Analyst Journal, *and* American Journal of Agricultural Economics.

a well-established exotic-option pricing formula. A demonstration of how to price this best-rate guarantee shows that its value (and its price) diminishes as the arrival date approaches, so consumers should be willing to pay for the option, because the price is set according to the likelihood that prices will change. Using this approach hotel companies should be able to eliminate the incentive for consumers to engage in search-and-switch behavior, reestablish the price integrity of their product, and simultaneously create a revenue stream from the sale of the best-rate-guarantee options to their customers.

Low-price Guarantees:

How Hotel Companies Can Get It Right

by Steven A. Carvell, Ph.D., and Daniel C. Quan, Ph.D.

THE INCREASE IN THE VOLUME OF ONLINE HOTEL BOOKINGS through the internet has reconfigured the industry's distribution channels and redistributed revenues. According to the consulting firm Forrester Research, online sales of hotel rooms for leisure travelers doubled in 2002 to $2.7 billion.

Research indicates that one in three hotel rooms will be booked online by 2006, up from less than one in ten in 2002.[1] While this growth of internet bookings has driven up the revenues and market values of internet travel agencies, the increasing use of the internet by consumers has not necessarily improved revenues for the lodging industry. The proliferation of internet travel agencies suggests that such firms provide a much-needed market-intermediation function that the lodging industry has failed to provide. At the same time, the revenues currently enjoyed by these agencies represent a leakage of potential profits that the lodging industry could reclaim.

This growing trend may be fueled partly by consumers who view hotel rooms as homogeneous within given segments, with rooms from one brand serving as a substitute for rooms from another. This commoditization trend results in consumers' choosing their hotels based

[1] Bill Carroll, "From Property to Screen: Managing Online Hotel and Lodging Distribution" (PhoCusWright Inc., 2004); see also: Bill Carroll and Judy Siguaw, "Evolution in Electronic Distribution: Effects on Hotels and Intermediaries" *CHR Reports*, Vol. 3, No. 5 (2003).

on the lowest rates available and is facilitated by the ease of searching among the various distribution channels. Not surprisingly, third-party internet-based travel companies, such as Expedia, Orbitz, and Travelocity, have become extremely popular, largely due to their ability to facilitate a low-cost search.[2] By making it easier and less "time costly" to compare room rates among different hotels, these online companies have empowered the consumer with the information to comparison shop for rooms that meet their quality and rate preferences.

The volume of internet sales adds complexity to the hotel market's already complicated competitive dynamics, since some of the inventory of rooms available for sales by online travel service (OTS) companies are provided by individual hotel owners or hotel operators to third-party internet consolidators. During slow periods, individual hotel owners and operators often release blocks of rooms for sale at deep discounts through internet travel agencies, because the operators believe that they can boost room revenue by selling rooms that might otherwise go unsold. Those deeply discounted prices frequently undercut room rates offered by the brand's own website. This process of pricing and discounting hotel rooms occurs through what is known as the merchant model, whereby internet travel companies are assigned blocks of rooms at a rate far below market and then resold over the internet at considerable markups. Extensive use of third-party internet bookings under the merchant model has resulted in the erosion of the unified pricing plans that are favored by the brand-name hotel companies. It is reasonable to anticipate that as the practice of shopping for rooms on the internet becomes more widely accepted, hotel companies will continue to battle for control and market influence over their pricing structure, inventory of rooms, and their ability to foster brand loyalty.

A brand's loss of control over room pricing and the potential transfer of pricing authority to third-party OTS companies stem from consumers' desire to obtain the lowest rate within their desired market segment.[3] From the consumer's perspective, room rates offered by comparable brands within a competitive set are uncertain and unknown at the actual time the reservations are made. Therefore, when making the initial reservation the consumer will often check prices through various distribution channels, including the hotel's own website, seeking the lowest rate for hotels in the competitive set.[4] Furthermore, because rates often change prior to their prospective arrival date, consumers face ongoing rate uncertainty. As a result of these combined forces, consumers will often continue to search after having made their reservation in hopes of finding a lower-price room to substitute for the room they already booked. If the consumer locates a lower-price room prior to the cancellation deadline, the customer will cancel the initial reservation and book at the lower rate. The combination of increased downward price pressure from third-party OTS companies and the post-reservation search-and-switch behavior of consumers stand to damage hotel profitability and pricing.

Consumers' search-and-switch behavior, as they seek better rates even after booking a room, stands to damage hotel profitability.

In response, hotel companies often believe that they can regain control over pricing though improved brand differentiation, tighter standards on inventory, and partnering with other companies to form distribution allianc-

[2] The various strategies at obtaining a low hotel-room price using the internet are well documented in the popular press. For example, see: "Suite Dreams," *Consumer Reports*, Vol. 66, No. 7 (July 2001), pp. 12–18.

[3] In a comprehensive survey of travel booking industry executives and operators conducted by PhoCusWright, price was identified as the major factor customers use websites to hotel purchases, followed by hotel brand. See: Carroll, *op.cit.*

[4] Carroll reported that 69 percent of online travel buyers shopped two or more websites for a hotel room in 2003. See: *Ibid.*

es. None of those strategies, however, addresses consumers' strong incentive to search for and book rooms at the lowest price. Instead, we suggest that potential solutions to this problem must address the consumer's incentive to search. The solution that we present here has the capacity to eliminate consumers' need or desire to search for lower rates. Our proposal, therefore, aims at increasing retention of the brand's customer base by eliminating the price uncertainty consumers face when making a reservation. If this uncertainty can be resolved at the time of the initial reservation, there will be no incentive for consumers to seek lower rates from third-party online distributors.

Hotels need a strategy that addresses consumers' need to search for lower rates by eliminating price uncertainty.

We propose that, by providing alternative forms of reservations, a hotel can effectively eliminate search incentives and therefore eliminate the likelihood that the consumer will cancel his or her reservation and switch to a lower-price room. Our model builds on the work of Quan (co-author of this report), who showed that a hotel reservation can be compared to a financial European call option given by the hotel to the guest. That is, the guest has the right, but not the obligation, to purchase the services of a hotel room at a specific date in the future at the set reservation price.[5] (Guests have no obligation to purchase since they can cancel without cost before the cancellation deadline.) Using the reservation as a call option, guests can lock in the maximum rate that they will pay for a room. If rates increase, they can hold the reservation and pay the "ceiling" price, but if rates decrease, guests can cancel the reservation and book at the lower rate. A key insight from Quan's work is that a reservation given by a hotel is valued by the customer (and has an ascertainable cost to the hotel) since it commits the hotel to sell at a fixed price when the actual rates on a given day are uncertain to both the customer and the hotel. That article in the *Cornell Quarterly* demonstrated how the price of this commitment can be determined.

In this report we expand on this analysis and propose what we call an exotic reservation (based on the term exotic option) to address consumers' migration to third-party OTS companies and their subsequent search-and-switch behavior. As a solution we propose that hotels sell their guests a guaranteed lowest-price reservation that is analogous to a "put on minimum lookback" option. A put-on-minimum-lookback option allows the option holder to purchase an item at the lowest traded price for the item over the length of the option contract. In this type of exotic reservation, the guest is guaranteed to pay the lowest price offered and booked at the hotel distribution channel employed throughout the period of the reservation (regardless of the price at the initial booking).[6] This option is not without cost, however. In this report we show how to calculate its value and in so doing determine the price that the hotel should charge for this guarantee. By providing guests with the assurance that they will pay the lowest rate offered to transient guests on a given day, there will be no incentive for them to search elsewhere. Furthermore, we use the model to determine the value of the "lowest-price" guarantees presently offered by many hotel companies. We show that such guarantees in their present form have little value to the consumer and therefore do not provide the price-guarantee feature that our proposed exotic reservation provides.

[5] Dan Quan, "The Price of a Reservation," *Cornell Hotel and Restaurant Administration Quarterly,* Vol. 43, No. 3, June 2002, pp. 77–86.

[6] Note that this is distinct from the low-price guarantee presently offered by various hotel companies. In such offers, if the customer finds a lower rate for the same quality room at the same check-in date within 24 hours of the reservation, the company will refund the difference plus 10 percent of the difference. Thus, the customer is responsible for searching and finding an alternative rate within the relatively brief period of 24 hours. Our proposal can last over any period, with the hotel company monitoring room rates on the guest's behalf.

Attempts to Forestall Search and Switch

In response to their desire to regain more control over their brands' pricing, hotel companies have devised mechanisms intended to circumvent internet travel agents and to provide disincentives to booking rooms on these sites. One such example is the creation of Travelweb.com, a site owned by Dallas-based Pegasus, with partners Hilton Hotels, Hyatt Hotels, InterContinental Hotels Group, Marriott International, Starwood Hotels and Resorts, and Priceline.com. Constituted as an internet travel agent, Travelweb is designed to circumvent the need to use other internet travel sites. Its prices are controlled, because the maximum markup within the site's merchant model is 15 to 20 percent. In theory, owners of hotels associated with this partnership would engage Travelweb.com to sell their excess inventory, but the erosion of prices would be controlled due to the limit on markups. Presumably this arrangement would provide hotels an incentive to sell their excess inventory via Travelweb, as a larger share of the room revenue would stay with the hotel itself.

However, the ability to control price discounting in this manner depends on the proportion of the market's total rooms controlled by the partners. If a large number of rooms are controlled by other hotels that are not part of the would-be Travelweb cartel and if these competing hotels release rooms that other internet travel agents (e.g., Travelocity or Orbitz) can sell at prices undercutting Travelweb, then the hotel companies in Travelweb will be forced to meet these lower prices or surrender market share.

Another mechanism aimed at regaining control over consumers' booking behavior is restricting the award of frequent-travel points to those rooms booked through the company's own website or other approved vendors. Hilton Hotels, for instance, no longer offers HHonors points and mileage to people who book rooms on bargain websites. This policy is designed as a clear disincentive to customers seeking lower prices from online travel agents. This approach will send consumers to the chain's website only up to the point where consumers value the marginal miles earned by that stay more than they value the amount saved by booking through the OTS. Since OTS sites often save customers from $10 to $40 or more per night, the value of the frequent-traveler points lost will often be far less than the amount saved. Of course, in those cases where the discount agents' and the hotels' own sites' prices are essentially identical, this will provide a marginal incentive for customers to book rooms through the company's own website.

Attempts at Low-Price Guarantees

Perhaps the chains' most salient attempt to discourage guests from making reservations through internet travel discounters is the lowest-price guarantee, which has been introduced by hotel companies such as Cendant, InterContinental, and Starwood. These programs offer the assurance that if a guest books a room on the chain's website and then finds a lower rate for the same room on the same day at the same hotel on an online distributor's website, the chain will match the lower rate. Most programs even offer an additional discount on the matched price, say, 10 percent, if a lower rate is found.

The best-price-guarantee program offered by Cendant provides an example. Cendant's guarantee promises that if a customer finds lower published rates for its hotels through any other online distributor, Cendant will match the lower rate plus an additional 10-percent discount. The customer must first book a reservation using the brand's web site. If the customer finds a lower rate online within a 24-hour period from the time of booking, the guest must submit the lower rate via e-mail to the chain's customer-service department, which must then verify the information. If the claim is verified, the chain makes good on its promise to sell the room at the matched rate plus a 10-percent discount. Such programs attempt to stop search and switch by providing consumers with the as-

surance that the rates offered at brand websites are the lowest available.

The availability of rooms offered by third-party internet sellers is largely determined by the willingness of franchisees to sell their rooms to those providers. To discourage such activities, the hotel chains often make the case that by participating in the chains' best-price-guarantee programs, franchisees can earn a higher room yield than if they had sold their rooms wholesale. The franchisees' chief benefit for participating in the chains' programs is that the franchisees' room revenue from the chains' model is higher than if they had sold the room to third-party sellers.

For example, say that a room is sold to the wholesaler for $100. Given that the usual wholesaler markup is 20 percent, the wholesaler would sell this room at its website for $120. If the room is sold by the wholesaler, the hotel realizes a yield of $100 for the room.

Internet Hotel Wholesaler (Hotels.com)	20% Markup	Rate to Consumer	Hotel Yield
$100		$120	$100

Now consider the price with the 10-percent guarantee. That is, say that the consumer invokes the 10-percent price protection and the chain sells the room on the franchisee's behalf for $108.

Price Guarantee Plus 10% Discount	Hotel Matching Rate to Consumer	Hotel Yield
	$108	$108

It is by the above logic that the parent hotel company argues that with the price-matching program the hotel will be better off if it does not sell its rooms to the wholesalers. So long as the markup for the wholesaler is higher than that of the hotel brand, the price-guarantee reservation will undercut the wholesaler's offer and retain a higher yield for the rooms.

Although rate-guarantee programs appear to give guests the assurance that by booking at the brand's website they would pay lowest rate, in actuality the 24-hour time limit essentially gives this guarantee a value of zero.[7] In contrast, a more valuable and realistic best-rate guarantee can be developed. As we explain below, the hotel can offer a rate that is guaranteed to be the best rate that a consumer will ever be able to find for that room (or a comparable room) from the date of the reservation until the date of arrival. In effect, the company would be eliminating the consumer's incentive to search the web for cheaper room rates as the arrival date approaches.

Experience tells us that if a hotel holds a large unsold inventory for a near-term arrival date, the hotel is liable to release a large number of those unsold rooms to online travel sites—thereby increasing the supply of deeply discounted rooms for sale on the internet. Any "best-rate guarantee" that does not take this market reality into account cannot be of value to either consumers or hotels.

Reservation Guarantee—Conceptual Issues

The search-and-switch problem facing the hotel industry as a result of internet shopping has been well explored in other contexts in the broad area of information economics.[8] To begin with, there is information asymmetry between the hotel operator and the guest. Only the guests know their preferences and their rationale for purchasing a room at a specific hotel. Different guests may be motivated by different hotel attributes—including brand loyalty, the location of the hotel, the service the hotel offers, and, of course, the price paid. If the hotel could perfectly observe each guest's set of preferences in all dimensions, the hotel would then be able to set its room rates based

[7] Quan, *op.cit.*

[8] The seminal works in this area include: G. Akerlof, "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, Vol. 84, No. 3 (1970), pp. 488–500; and, related more directly to the model: M. Spence, "Job Market Signaling," *Quarterly Journal of Economics*, Vol. 87, No. 3 (1973), pp. 355–374; and J. Stiglitz and A.Weiss, "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, Vol. 71, No. 3 (1981), pp. 393–410.

on each consumer's willingness to pay. Revenue-management systems take a step in this direction by, for example, setting higher room rates for weekdays, when price-insensitive business travelers book their rooms, and lowering rates for weekend dates, when leisure travelers often book and demand can be slack.[9]

As a rule, however, the hotel operator does not explicitly observe differences in guests' booking motivations when setting reservation policies. Thus, it is not surprising that no single policy will be suitable for all customers, given the diverse nature of their tastes and preferences. To achieve a closer correspondence between the rate charged and the consumer's willingness to pay, it is reasonable to explore the possibility of offering alternative types of reservations in the hope that they serve the customers better and at the same time increase the customers' interest in staying at the hotel.

Our suggested approach is to offer a menu of reservation types from which the customers themselves would select. Such a strategy would improve the match between the needs of the guest and those of the hotel operator. In implementing the specific reservation model presented here, we target the room-booking dimension that OTS companies emphasize—namely, room rates. If a hotel offers a reservation with a price-protection option, those guests who are most sensitive to price uncertainty will select the exotic reservation, while those who are less sensitive and those who have a strong brand loyalty will select the standard method of booking. For those guests, a prospective lower price from a competing property would not motivate them to switch their reservation to that other property. In this way, our model takes into account brand loyalty. The group that values brand loyalty above price is served by the normal reservation process. However, price-driven guests who have migrated to third-party websites to engage in search-and-switch behavior would find the exotic reservation attractive.

In broad terms, our proposed reservation model takes into explicit consideration differences in the preferences of hotel guests—that is, it offers guests yet another choice in reservation possibilities that is based on the way they value a hotel stay. Our proposed reservation format, concurrent with conventional forms of reservations, specifically targets those customers whose room decisions are motivated primarily by price, rather than by brand or another attribute specific to the hotel (e.g., a meeting or conference is being held at that property). Through implementation of a particular set of terms, price-sensitive customers, that is, the same ones who use OTS companies to shop for the lowest price regardless of brand, will find it in their best interest to make a reservation and look no further—thus adopting the proposed reservation terms.

With the implementation of particular terms, price-sensitive customers will find it in their best interest to make a reservation and look no further.

On the other hand, guests who are booking the hotel due to its brand (or other reasons) will not be attracted by the exotic reservation option (because it comes with a cost). Those consumers will likely find conventional room-reservation procedures to be acceptable. The concept that two (or possibly more) forms of reservations should be offered concurrently is an explicit recognition that guests have heterogeneous tastes and preferences.

Calculating the Value of the Low-price Guarantee

In this section, we present the calculations that support the low-price-guarantee model. The calculations start with the following assump-

[9] Other market segmenting pricing practices include offering low-price rooms that must be booked a certain length of time ahead for pleasure travelers and high-price rooms that have no such time requirment for business travelers. See: S. Kimes, "The Basics of Yield Management," *Cornell Hotel and Restaurant Administration Quarterly*, Vol. 30, No. 3 (November 1989), pp. 14–19.

tions. A guest makes a reservation for a room at price R at time $t = 0$ to check in on date $t = T$. The hotel guarantees that the price the guest will pay at T will be the lowest web-published price for the room from $t = 0$ through $t = T$ (i.e., check in), if the lowest web price is less than R. If the lowest price over this period is above R, the guest will pay R, the rate promised by the reservation for the room.

In the absence of this low-price guarantee, a guest will pay R at check-in for the room. At the time of booking, the future web-published prices are unknown. Although there is future price uncertainty, the guest, by making a reservation, has essentially locked in price R for the room and therefore has eliminated any price uncertainty.

The lowest web price over the period $t = 0, T$ is P_{min}. That is,

$$P_{min} = \min (P_0, P_1, P_2, \ldots, P_T).$$

By purchasing the low-price guarantee, the benefit to the guest is the difference between R and P_{min}, if $R > P_{min}$. Alternatively, if $P_{min} > R$ over the entire period, the low-price guarantee does not yield a payoff since the guest will pay R, the price the guest would have paid in the absence of this guarantee. Thus, the payoff for the guest from receiving this guarantee is

$$\textit{Guarantee payoff} = \begin{cases} R - P_{min} & \text{if } R > P_{min} \\ 0 & \textit{otherwise}. \end{cases}$$

This payoff structure is identical to the payoff to the holder of a put option—that is, the owner of the option has the right to sell the room back to the hotel at R, the reserved rate. The guest will do so only if the price of the room to the guest is lower than R, that is, only if $P_{min} < R$. Note that this is the same payoff as if the guest exercises the put option optimally.

This arrangement is sometimes called a "put option on extrema" or a "put on minimum," since the condition of the payoff depends on an extreme value (in this case, the minimum price achieved).[10] Conze and Viswanathan showed that for the case when $R \leq P_0$, the value of this option, V, is defined as shown in equation 1 of Exhibit 1 (at right). For the case of $R > P_0$, V is calculated as shown in equation 2, at right,

where

$$d = \frac{\ln\left(\frac{P_0}{R} + rT + \frac{\sigma^2 T}{2}\right)}{\sigma\sqrt{T-t}},$$

$$d' = \frac{\left(rT + \frac{\sigma^2 T}{2}\right)}{\sigma\sqrt{T}}.$$

In the equations above and at right, r is the risk-free interest rate, and $N(\bullet)$ (in equations 1 and 2) represents the cumulative distribution function of a standard Gaussian variable. σ represents the volatility of prices and is a measure of the price uncertainty over future T periods. In the next section, we will elaborate on how the volatility parameter can be calibrated using historical room-rate information.

The Nature of Hotel Price Uncertainty

A low-price guarantee has value because it offers the guest protection against uncertainty in future room rates offered by competing hotels. Since it is this uncertainty that drives our model, it is important to understand how it is characterized and how it relates to more familiar existing yield-management practices that attempt to take such factors into consideration.

Our model of hotel-room-price uncertainty parallels closely models developed in the financial options-pricing literature. An option is viewed as a contingent claim on an asset the future returns of which are uncertain. Since the option's payoff is contingent on the asset's fu-

[10] A. Conze and Viswanathan, "Path Dependent Options: The Case of Lookback Option," *Journal of Finance*, Vol. 54, No. 5 (1991), pp.1893–1907.

EXHIBIT 1

Equations relating to the value of option *V*

Equation 1

$$V = -P_0 N(-d) + e^{-rT} P_0 N\left(-d + \sigma\sqrt{T}\right) + e^{-rT} \frac{\sigma^2}{2r} P_0 \left[-\left(\frac{P_0}{R}\right)^{-\frac{2r}{\sigma^2}} N\left(-d + \frac{2r}{\sigma}\sqrt{T}\right) - e^{rT} N(-d) \right]$$

Equation 2

$$V = e^{-rT}(R - P_0) - P_0 N(-d') + e^{-rT} P_0 N\left(-d' + \sigma\sqrt{T}\right) + e^{-rT} \frac{\sigma^2}{2r} P_0 \left[N\left(-d' + \frac{2r}{\sigma}\sqrt{T}\right) - e^{-rT} N(-d') \right]$$

ture return, the option's value today is a function of the probability of having a positive payoff in the future. This probability is determined by the specification of a stochastic process that characterizes the distribution of future returns. Thus, uncertainty is modeled as a stochastic process which provides a probabilistic characterization of future returns. The overall return process is viewed as being composed of a deterministic predictable component, or drift term, and an unpredictable, stochastic component. Because an option is a claim on some unknown future value of the asset, its value is dependent on the stochastic component of returns and not on the drift term. Thus, in the calibration of option-pricing models, whereby uncertainty is measured as the volatility of the stochastic component, the uncertainty is often measured as the standard deviation of returns after those returns have been purged of all predictable movements.[11]

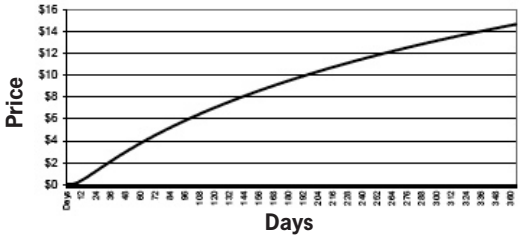
In our hotel reservation application, we analogously envision hotel-room-price movements over time as comprising these two components. In the context of hotel room rates, reasonable measures of predictable price movements are those that are forecasted by conventional yield-management models. One function of yield management is to predict future room occupancies or rates using a variety of forecasting models, ranging from time series models, such as exponential smoothing and ARIMA models, to advanced additive- and multiplicative-booking models.[12] Other predictable elements that are taken into consideration may include seasonal factors and holidays. In this area, great attention is given to predicting the future demand for rooms and the prices that should be charged. Thus, predictions from such models represent the best estimates of the future, taking into account all the predictable movement in future prices or

[11] For a readable presentation of these concepts, see: J. Cox and M. Rubinstein, *Options Markets* (Englewood Cliffs, NJ: Prentice Hall, 1985); or J. Hull, *Options, Futures, and Other Derivatives* (Upper Saddle River, NJ: Prentice Hall, 1997).

[12] S. Kimes and L. Weatherford, "A Comparison of Forecasting Methods for Hotel Revenue Management," *International Journal of Forecasting*, Vol. 19, No. 3 (2003), pp. 401–415.

EXHIBIT 2

Price of a minimum-price reservation



Note: One year with 30-percent annual volatility

room occupancies. Given this interpretation, the stochastic component can be viewed simply as the forecast errors or the residuals from the application of yield management models. Thus, a reasonable estimate of uncertainty or volatility is the standard deviation of the error term in yield management forecasts.

Since the value of the low-price guarantee depends on the unpredictable component, it is important to get an indication of its magnitude. The wide use of yield management practices has spawned numerous studies attempting to quantify their accuracy. In a study comparing the forecast performance of regression, pick-up, and multiplicative models, the mean absolute percentage error (MAPE) of forecasts ranged from 10 percent for the pick-up and regression models to over 200 percent for the multiplicative model.[13] In another study of group bookings, the MAPE ranged from 10 to 15 percent on the day of arrival to 40 percent at two months before arrival.[14] These results indicate that although yield management practices do have some reasonable forecasting ability, a substantial amount of future changes in room demand is unpredictable.

[13] *Ibid.*

[14] S. Kimes, "Group Forecasting Accuracy in Hotels," *Journal of the Operational Research Society*, Vol. 50, No. 11 (1999), pp. 1104–1110. Although such studies have focused on the performance of room-occupancy forecasts, this information is used in yield models that in turn determine the appropriate prices to charge for rooms. It follows that errors in room predictions will likely translate into errors in room pricing.

The Low-Price Guarantee: An Example

Say that a hotel offers a guest a low-price guarantee for a room that is currently priced at $125 for a date six months in the future. For that date six months out the price is $115 (that is, the guest reserves the room at $115). The guarantee stipulates that if a lower rate is offered on a specified set of web sites, the guest's rate will automatically be adjusted to the lowest competing rate. If, during the six-month period, none of the competing rates is less than the reservation price, the guest will be charged the agreed-upon $115 for the room. For the purposes of this illustration, we further assume that the annual volatility of the rates among the set of competing hotels is 30 percent and that the risk-free interest rate is 6 percent. Given these conditions, and using our pricing formula, the value of the price guarantee is $9.55. Thus, for a charge of $9.55, the guest is guaranteed to pay the lowest rate achieved for the defined set of comparable rooms for the next six months.[15] As we explain next, the price (or value) of the guarantee changes according to the circumstances.

Properties of the Low-price Guarantee Model

An important property of the guaranteed-pricing model is that value of the price guarantee decreases as the check-in date approaches. This is intuitively appropriate because the value of this commitment is largely based on the probability that the guest will find a lower competing rate. Since room rates do not normally change continuously, the probability of finding a lower rate the day before check-in is smaller than the chances of finding a lower rate a week or a

[15] In the examples here the low-price guarantee is priced for one night. Assuming an average stay of one or two additional nights and that volatility and rates do not change dramatically over that period the new guarantee would equal the number of nights times the original cost. Alternatively, one can determine the low-price guarantee across all of the nights, but this would involve a more complex assessment using an American option model. We expect to extend this model in the future, as discussed in the conclusion.

month before check-in. In fact, if the reservation were made a year in advance, the value of the price guarantee would increase to $14.63. The value of the price guarantee over the entire year is plotted in the graph in Exhibit 2.

The value of the low-price guarantee can be calculated as shown in this report, because it represents a commitment of the reservation provider to sell a room at some predetermined price prior to anyone's having full knowledge of future prices. Thus, the greater the price uncertainty for any given market, the more valuable will be this commitment. To demonstrate the effects of that uncertainty, when we restrict the market-uncertainty parameter σ to 0, or to an environment of no price uncertainty, the pricing formula will also have a value of zero. Furthermore, it follows that the value of this low-price guarantee is a strictly increasing function of σ.

From the pricing formula and the previous description, clearly the most important step in the implementation process is in selecting the volatility parameter σ. In the options literature, σ is estimated by calculating the standard deviation of price movements using a series of part prices, which are presumably representative of future price movements over the option's maturity. In the context of hotel reservations, it is important to reiterate that this parameter reflects the unpredictable component of price movements, rather than simply measuring the volatility of room rates. As a point of comparison, given the brief time interval involved, Cendant's offer of matching a lower price within 24 hours of booking has an option value of $0.00000004!

Volatility Calibration to the Merchant Model

Applying this model to the wholesale-merchant mechanism that has become common on the internet, we need to establish a realistic volatility calibration of our model. If we are to price the reservation guarantee for the merchant model, it's important that we calibrate the model parameters to mirror the terms found on the internet, which usually involves a markup in the vicinity of 20 percent.

Using our previous merchant-model example, when a room is sold for $100 to a consolidator that in turn sells it for $120, it is clear that the consolidator will never sell the room at any rate lower than $100, the room's wholesale price. Thus, in terms of the future price for the room, the price will have a lower bound of $100. A key parameter in our model is the volatility of future room rates, which determines the likelihood that the guarantee will come into force. Thus, to calibrate our model, the measure of future price volatility must incorporate the fact that observing a price lower than $100 is highly unlikely. This feature must be incorporated into the volatility parameter.

The value of a low-price guarantee for a hotel room reservation depends on the unpredictable component of rates.

One way to incorporate this information is to select a volatility measure such that there is an effective zero probability that future prices will be lower than the wholesale price of the room. Let K designate the wholesale room price. The wholesaler's mark-up is assumed to be $m\%$, and let P be the price the hotel currently charges for the room. Thus, if we use our previous model of an extrema option, the volatility we are referring to is the volatility of the wholesale room rates.

To constrain our volatility parameter, we note that our pricing model is predicated on the assumption that the dynamics of hotel room pricing follows a Brownian price process

$$\frac{dP}{P} = \mu dt + \sigma\varepsilon\sqrt{dt}.$$

Assuming Brownian motion in the formation of the hotel room price process, the price of the room at time T or the check-in date, is

EXHIBIT 3

Equations relating to the price of a hotel room, *P*

Equation 3

$$P(T) = P(t)\exp\left\{\left(\mu - \frac{\sigma^2}{2}\right)(T-t) + \sigma\varepsilon\sqrt{T-t}\right\}$$

Equation 4

$$\Pr[P(T) < K] = \Pr P(t)\exp\left\{\left(\mu - \frac{\sigma^2}{2}\right)(T-t) + \sigma\varepsilon\sqrt{T-t}\right\} < K$$

P(T), which has the form found in equation 3, in Exhibit 3.

Thus for our model, we would calibrate our volatility σ such that the probability of the price being less than *K* is infinitesimal. We see that by rearranging the terms, this probability is shown in equation 4, in Exhibit 3, which is equivalent to

$$\Pr(\varepsilon) < \frac{\ln\left(\frac{K}{P(t)}\right) - \left(\mu - \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}.$$

By definition of a Brownian process, ε ~ N (0,1). Thus, we can select a value for σ such that this probability is negligible. From the normal tables, we can select a low probability for the unit normal random variable. Consider Pr(ε) < −3 = .00135. We can solve for the volatility σ such that the right-hand side of the above expression is equal to −3. In essence, we would like to solve for σ such that

$$\frac{\ln\left(\frac{K}{P(t)}\right) - \left(\mu - \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}} = -3.$$

Numerical Example

Using our previous example, let today's room rate be $125 (that is, *P(t)* = 125) and assume that the historical mean price for this room was $120 ($\mu$ = 120). We consider a one-year time period (*T* = 1). Let the wholesale price of the room be $100 (*K* = 100). Substituting these values into the above expression and simplifying we get:

$$\ln\left(\frac{100}{125}\right) - \left(120 - \frac{\sigma^2}{2}\right) + 3\sigma = 0.$$

Solving for the volatility we see that a value of σ = 12.79 will satisfy the assumptions we have established about the volatility parameter.

Conclusion

This report is the first to identify, propose a specific use for, and price an exotic option that can be applied to hotel reservations. We begin by asserting that the observed search-and-switch behavior of consumers and the loss of pricing control by hotel companies are both connected to consumers' incentives in the market combined with the advent of internet online travel service companies. We continue by proposing that one possible cure for the problems currently facing hotel companies in their quest to maintain price integrity is to offer a best-rate guarantee. Though well meant, the current rate guarantees are shown to be essentially of no value to consumers. Instead, we show how a hotel company can structure a best-rate guarantee that would provide value to consumers no matter how far in advance the

reservation is made. In addition, we apply a well-established exotic-option pricing formula to price this best-rate guarantee so that consumers should be willing to pay for the option. Using this approach hotel companies should be able to eliminate the incentive for consumers to engage in search-and-switch behavior, reestablish the price integrity of their product, and create a revenue stream from the sale of the best-rate-guarantee options.

Family Matters

The best-rate guarantee is only one of a family of exotic options that hotel companies could offer consumers. Our preliminary analysis has identified the following other exotic reservations that could be used by hotel reservations managers and corporate travel executives to deal with the risk inherent in managing frequent-customers' room needs.

(1) *Down-and-in barrier call options*. With a down-and-in call option, the customer can purchase a guarantee whereby if the actual room rate charged rises above some agreed-upon level, say, P*, the customer will be paid the difference, thereby ensuring that the maximum price charged will be P*.

(2) *Exchange option*. Under this contract a corporate customer can switch a reservation in one hotel for a room in another property of greater quality without being subject to a higher rate. This kind of option would be useful if a corporate travel executive was booking rooms for a business meeting where the traveler was unsure of the distribution of executives who were planning to attend. Depending on whether the president, senior vice presidents, or vice presidents were attending, various levels of room reservation might be required. An exchange option allows the corporate travel executive (CTE) to reserve a room within a system, such as Marriott's, and know that the room is reserved for that day at the agreed-on rate at any Marriott-related property.

(3) *Average-price and average-strike call option.* Under this contract a good corporate customer receives a guarantee that the price paid for a series of rooms over a set time period will not exceed some pre-specified average daily rate. This type of contract would allow a CTE to budget for a known ADR over a particular time period.

We expect that future research will price each of these and other exotic options, and in so doing add new tools for hotel companies to manage the growing complexity of hotel pricing in an internet-connected world.

While the example discussed here focuses on pricing a best-rate guarantee for a single property, our system can be expanded and tailored to a specific consumer's search behavior. For example, at the onset, the guest could be asked which hotels he or she would consider switching to if the prices are lower (effectively to identify their specific competitive set, which we can call n) and which websites they use to find lower rates (which we can call m). Once n and m are known, then a computer "spider" program can be written which will continuously download the prices listed on the m websites for the n properties. So long as the list of hotels and websites is truthfully revealed by the guests and there is a system in place to transparently reveal the search process and its results to the guests, there would be no incentive for them to search and switch. ★★★★★

Do you have a response to or comment on this report?

The Center for Hospitality Research welcomes comments, whether brief responses or more formal commentaries of 1,000 to 3,000 words, on this and other reports.

To participate in this on-line forum, contact The Center's executive director, at hosp_research@cornell.edu.

Here's your chance for the best source of management information available today.

CQ

Cornell Hotel
and Restaurant
Administration
Quarterly

Subscribe to the Cornell Quarterly and gain access to the most valuable management information available today. Each issue of the Cornell Quarterly help you stay ahead of the world's fastest-growing industry.

Subscribe today, and you will see the latest information on

- Why Restaurants Fail
- How You Can Use Competitors' Web Sites to Gain Strategic Hotel Information
- How to Determine What Your Guests Are Really Saying (So You Can Make them Happier)

Available exclusively through:

SAGE Publications

cqx.sagepub.com

Special offer: Ask about the discount introductory rate!

Cornell University
School of Hotel Administration
The Center for Hospitality Research

CHR REPORTS
FOR THE
HOSPITALITY INDUSTRY

Five-Star Research℠
from
TheCenterforHospitalityResearch.org

Best-available-rate Pricing at Hotels: A Study of Customer Perceptions and Reactions, by Kristin V. Rohlfs and Sheryl E. Kimes, Ph.D.

The Agglomeration Conundrum: How Co-location Helps Some Hotels and Hurts Other, by Cathy A. Enz, Ph.D., Linda Canina, Ph.D., and Jeffrey Harrison, Ph.D.

Quantifying Impact: The Effect of New Hotels and Brand Conversions on Revenues of Existing Hotels, by Arturs Kalnins, Ph.D.

Why Customers Shop Around: A Comparison of Rates and Availability across Booking Channels, by Gary M. Thompson, Ph.D.

Also of interest:

Tools for the Hospitality Industry #6: Closing the GAPPP: Increasing Your Internal Influence with Confident Communication, by Judi Brownell, Ph.D., and Daphne Jameson, Ph.D.