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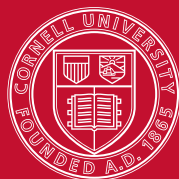
Cornell Hospitality Report

Setting Room Rates on Priceline:

How to Optimize Expected Hotel Revenue

by Chris K. Anderson, Ph.D.

Cornell University
School of Hotel Administration

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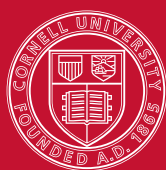
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EXECUTIVE SUMMARY

This report and tool combination develops a novel approach to set prices on Priceline.com to maximize revenues received from releasing rooms to Priceline. When setting rates on Priceline, hotel properties face a straightforward auction-like pricing decision. Priceline is an opaque channel with no property information communicated to the consumer. As such other factors (e.g, brand, amenities, location) play no role in setting rates. Properties face what appears to be a dilemma—set prices higher to make more revenue but potentially lose the sale, or set prices lower to make the sale but leave some money on the table. This report provides a brief introduction to Priceline.com and discusses the daily data that properties receive from Priceline. The report then outlines how these data can be used to the advantage of the property in setting Priceline rates. A fully functional model implemented in Excel accompanies this report in the form of a Cornell Hospitality Tool. As the user of this model you simply copy and paste data you receive from Priceline into the tool.

All model inputs are automatically updated and optimal prices calculated.

ABOUT THE AUTHOR

Chris K. Anderson, Ph.D., is an assistant professor at the Cornell University School of Hotel Administration. Prior to his appointment in 2006, he was on faculty at the Ivey School of Business in London, Ontario, Canada. His main research focus is on revenue management and service pricing. He actively works with industry, across numerous industry types, in the application and development of RM, having worked with a variety hotels, airlines, rental car and tour companies, and numerous consumer packaged good and financial services firms. His research has been funded by numerous governmental agencies and industrial partners. He serves on the editorial board of the *Journal of Revenue and Pricing Management* and is the regional editor for the *International Journal of Revenue Management* (canderson@cornell.edu).

Setting Prices on Priceline:

How to Optimize Expected Hotel Revenue

by Chris K. Anderson

The pricing of services online has dramatically changed how service firms reach customers. Online travel sales are expected to exceed those of traditional sales channels by 2008 with 60 percent of these online sales through supplier-managed websites and 40 percent through online travel agents (OTAs) like Expedia, Orbitz, and Priceline.[1] Exhibit 1 summarizes the sales volume of the leading OTAs through the first three quarters of 2006. The industry's initial reaction to pricing online was favorable, as from a marketing standpoint, firms now had several new methods to reach customers with the opportunity to increasingly segment customers via these new channels. Although third-party sites made the first move, service providers have increased efforts to move customers back to firm-managed distribution channels (brand-specific websites and call centers) in an effort to control costs, such as commissions and fees, and to maintain direct contact with the customer.

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[1] PhoCusWright's *U.S. Online Travel Overview*, 6th Edition, December 2006.

A parallel effort involves streamlining prices and creating price parity (equivalent prices regardless of booking method) across all distribution channels. The argument for price parity is that it instills some level of trust with customers, since they don't need to shop around for a particular service provider's best prices. From the consumer standpoint, online travel agents like Orbitz, Expedia, and Travelocity and meta sites like Kayak, which consolidate prices offered by different online agents and by suppliers, have greatly simplified shopping, because consumers can easily compare prices.

The unusual auction-style mechanism used by Priceline.com, combined with its opaque approach, means that the consumer does not know what brand is providing the service until purchase is completed, and service providers' revenue management algorithms are disrupted. Consumers cannot shop around, and suppliers have difficulty setting the highest possible price. Priceline is currently the most popular opaque channel (and fourth largest online travel agent in market share, as outlined in Exhibit 1).

Despite the opaqueness of the process, it is possible for hoteliers to price their rooms to sell on Priceline without leaving money on the table and without being undercut by competitors. This report and its accompanying tool explain the optimal pricing of rooms on Priceline. This is worth doing because Priceline is the one online channel that provides great potential upside of differentiated pricing without some of the drawbacks associated with rate parity. In this report I outline the data which Priceline provides properties and how to use those data to maximize revenue from rooms released on Priceline.

Priceline.com

Priceline originated as the "name your own price" marketplace, where consumers indicate what they want to pay for service via a bid which is then accepted or rejected by participating service providers. More recently, Priceline also started giving consumers the choice of shopping Priceline like a traditional online agency (that is, shopping for rates from competing service providers), or using the original name-your-own-price option as depicted in the screen capture in Exhibit 2.

Using the example of a hotel room, the consumer choosing the bid option (that is, name your own price) can often receive discounts of 50 percent off stated rates for simply choosing a service but not a particular hotel brand. For its part, the hotel benefits by filling the room, but suffers the disadvantage of forgoing potentially higher rates that customers who want to pick a brand might be willing to pay via other channels. Even without being able to pick a hotel brand, bidding consumers still have considerable control over the service experience. After choosing a city, consumers

EXHIBIT 2

Priceline website showing conventional online agency approach and proprietary name your own price option

EXHIBIT 3

Sample page showing Priceline's hotel tier and location selector

EXHIBIT 4

Naming a price window

select a sub area within that city and a star level, as shown above in the sample screen capture in Exhibit 3.

Step 3 is the submission of a bid, as shown in Exhibit 4. Once the bid is submitted to Priceline, the consumer usually finds out in a few minutes whether it has been accepted. If the bid is successful the consumer will receive details on the

hotel that has accepted the bid. If the bid fails the user may offer a new bid after 24 hours on the exact same sub area and star quality combination, or bid again instantly or at any time by changing the sub area, star quality, or both. Most critically for a revenue manager, Priceline provides its clients a report of this bid activity. My purpose is to enable hotel revenue managers to make the best use of Priceline's bid process to sell rooms at the best possible price.

Understanding Bids on Priceline

If a property is providing rooms to Priceline, the property is provided daily reports of activity for its market (the sub area and star quality as shown in Exhibit 3). Exhibit 5 displays a hypothetical daily report, summarizing missed opportunities from customer bids for proposed arrivals in September 2007. The report indicates when the customer wished to check in, how long that guest wanted to stay, and the price the person offered. For example, a would-be guest offered $44 to check in on Tuesday, September 4, and stay for 2 nights. Your hotel turned that

Exhibit 5

Sample Priceline daily report

priceline.com®HOTELS

Report for the day of 9/4/07

Attn: Revenue Manager
Director of Sales
General Manager

DAILY DEMAND REPORT
ALL CURRENCIES IN $USD

	Date	Offered RN	Booked RN	Offered Revenue	Booked Revenue	Conversion	Avg Offer Price	Avg Booked Price
OPAQUE	09/04/07	102	3	$7,887	$195	2.9%	$77	$65

MISSED OPPORTUNITIES ON 9/4/07
Room Nights = 99
Revenue = $7,645

Check In Date	Check in Day of Week	Length of Stay	Number of Rooms	Your Priceline Rate*	Offer Price	Declined Revenue	Reason**	Booked by Others
09/04/07	Tue	2	1	$65	$44	$88	HI	
09/05/07	Wed	3	1	$253	$54	$162	HI	
09/05/07	Wed	3	1	$195	$49	$147	HI	Y
09/06/07	Thu	2	1	$148	$48	$96	HI	
09/07/07	Fri	3	1	$64	$52	$156	HI	Y
09/07/07	Fri	3	1	$64	$52	$156	HI	Y
09/07/07	Fri	1	1	$65	$44	$44	HI	
09/08/07	Sat	4	1	$229	$96	$384	HI	
09/08/07	Sat	4	1	$229	$92	$368	HI	
09/10/07	Mon	2	1	$229	$79	$158	HI	
09/12/07	Wed	1	1	$195	$61	$61	HI	Y
09/14/07	Fri	4	1	$217	$85	$340	HI	
09/14/07	Fri	3	1	$126	$61	$183	HI	
09/14/07	Fri	3	1	$126	$48	$144	HI	
09/16/07	Sun	2	1	$332	$132	$264	HI	
09/16/07	Sun	2	1	$332	$132	$264	HI	
09/16/07	Sun	2	1	$332	$105	$210	HI	
09/16/07	Sun	4	1		$41	$164	NR	
09/17/07	Mon	1	1		$140	$140	NR	
09/18/07	Tue	1	1		$154	$154	NR	
09/18/07	Tue	1	2		$96	$192	NR	

person down because the bid was lower than your desired price, $65. That proposal also failed with competitors, but a bid for an arrival the next night was scooped up by a competitor. For a September 5 check-in, your hotel declined a $49 bid for that night (your price was $195), and one of your competitors accepted that $49 bid.

For those not familiar with the process involved in the above auction, properties provide Priceline with a certain level of inventory (rooms) for each arrival day and indicate what prices they are willing to accept for those rooms (shown in Exhibit 5 under "Your Priceline Rate"). When setting rates on Priceline, properties face a straightforward auction-like pricing decision. Because Priceline is an opaque channel, hotels face a simple dilemma—set prices higher to make more revenue but potentially lose the sale, or set prices lower to make the sale but leave some money on the table. A property releasing inventory to Priceline needs to manage the tradeoff of pricing its inventory too low (and forgoing revenue) or pricing it too high and losing a sale. The dilemma can be unraveled with the information provided in these reports, which is all that is required to develop a rigorous data-driven Priceline pricing strategy that will on average maximize revenue from Priceline sales.

A property receives via email a daily report similar to the one shown in Exhibit 5 as a PDF file. The report summarizes all bids made on the prior day for any check-in dates. These reports can be imported into Excel, with reports for consecutive days appended to the bottom of past reports and then sorted by check in date. Once sorted by check-in date, properties will have a summary of customer bids by check-

EXHIBIT 6

Number of bids received by days before arrival
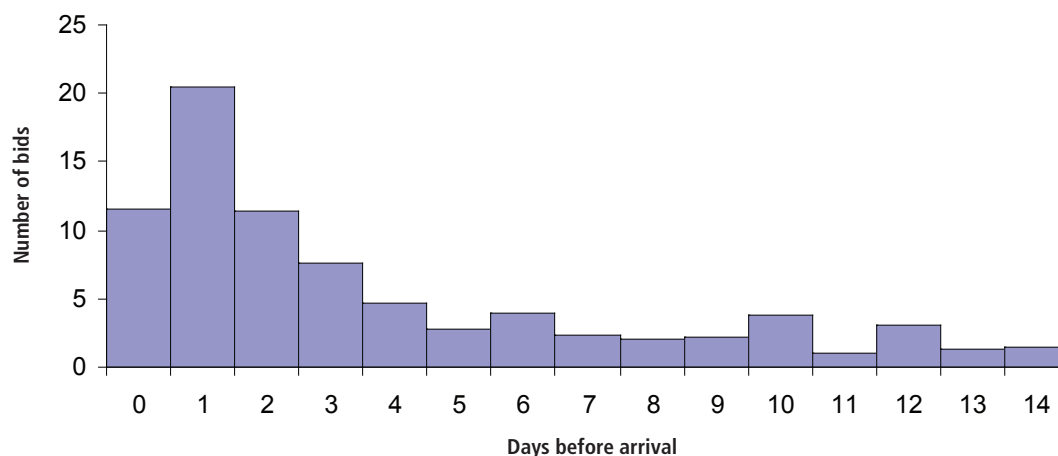
EXHIBIT 7

Relative frequency of offer prices
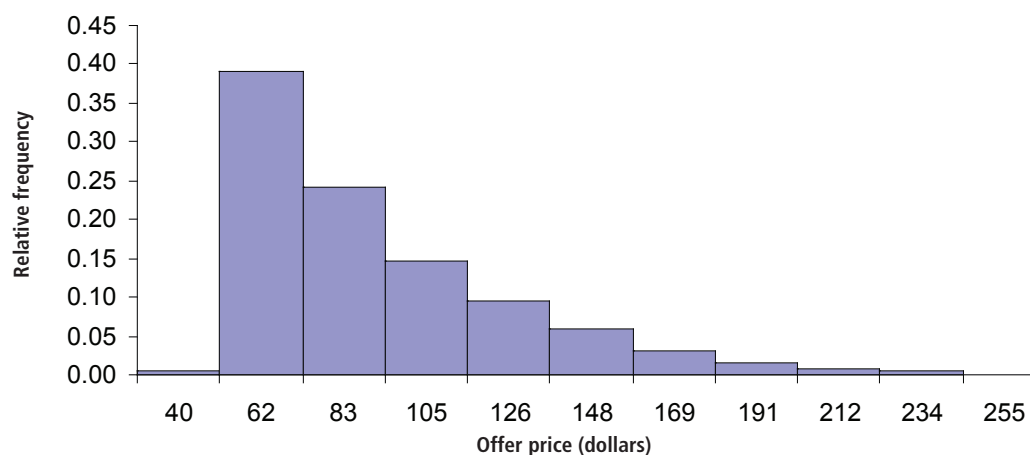
in day as well as the number of requests or bids received (also by check-in day). The requests can be further sorted by days prior to check in (check in date minus bid date). Plotting graphs of this sorted information provides information similar to that found in Exhibits 6 and 7. Exhibit 6 displays a bar graph or histogram of the number of requests received (for a given check-in date or day of week) by the number of days prior to check in, while Exhibit 7 summarizes the relative frequency of bids offered. To adjust for the fact that posted rates (on regular channels) vary over time, the data in Exhibit 7 can be expressed as a discount percentage (i.e., Priceline bids divided by regular rates, as shown in Exhibit 8).

Exhibit 6 shows the average number of bids placed (e.g., averaged across all Monday check-ins for September) for check-in days as a function of days before arrival (DBA). Exhibit 6 helps one understand how many bids a property would expect to receive for an arrival day as a function of DBA, which is effectively an indication of Priceline-based demand. For the property displayed here, the majority of Priceline activity occurs in the three days prior to arrival, with twenty bids placed the day prior to arrival, although a stream of requests runs up to fourteen days out.

Exhibit 7 shows the relative frequency of prices offered on Priceline (occurrences at a given price divided by total

Exhibit 8

Relative frequency of Priceline discounts, percentage off regular stated price
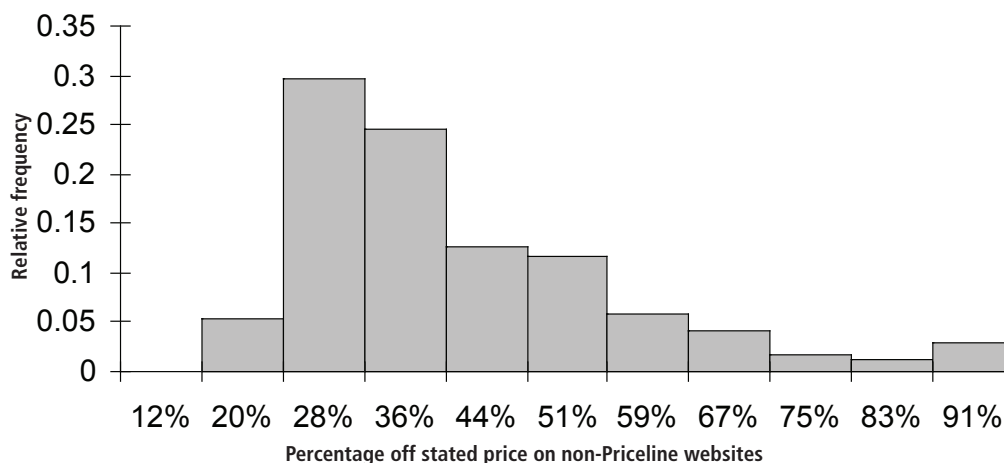
occurrences). The bar height indicates the relative frequency—for example 40 percent of all bids placed were for prices between $40 and $62, and approximately 25 percent of the bids came in between $62 and $83. If all the bar heights were summed they would add to 1.00, or 100 percent. Exhibit 8 shows similar information, but instead of raw prices, the prices are scaled to regular posted rates (e.g., as posted at Expedia) to indicate the percentage discount. Exhibit 8 allows more arrival days to be consolidated (and graphed together), because dividing the Priceline price by regular prices standardizes the data (on the assumption that while prices may be different, discounts offered by consumers tend to behave the same).

Let's refer to Exhibit 6 as an arrival distribution because it represents the distribution (relative number) of requests made by days prior to arrival. Exhibits 7 and 8, then, are willingness-to-pay distributions, representing the percentage of demand at a given price (Exhibit 7) or at a particular discount level (Exhibit 8).

The Chance of Making a Sale on Priceline

This section explains the underlying calculations used to determine the best Priceline rates. If you are not interested in the mechanism, you may wish to skip to The Priceline Pricing Tool section, for a discussion of how to use the tool.

Using the information presented in Exhibits 6, 7, and 8, you can describe the likelihood that, given a price released to Priceline, you sell a certain number of rooms. To present the underlying equations, I use the following notation. Let the size of the customer base interested in a room be represented by the random variable N (the value of this variable

is drawn from the data in Exhibit 6). Say that a randomly selected customer has a willingness to pay represented by the random variable, B, the distribution function of which will be denoted by $F_B(.)$ (drawn from the data in Exhibit 8). If the price your hotel posts is p, then anyone with a willingness to pay greater than p would buy the room. The fraction of people willing to pay more than p would be the sum of all the bars to the right of price p in Exhibit 7 (or the corresponding discount in Exhibit 8), $1\text{-}F_B(.)$ This is the area to the right of p, while $F_B(.)$ is the area from 0 to p. We refer to $1\text{-}F_B(p)$ as the probability a randomly selected customer will be willing to purchase the product (the likelihood that the customer's willingness to pay is greater than p).

Say that your hotel had two customers make requests on Priceline. Given that you are willing to accept a price of p, the probability that they both get a room is

$$[1\text{-}F_B(p)] * [1\text{-}F_B(p)] \text{ or } [1\text{-}F_B(p)]^2.$$

The probability that one of them accepts the rate (and the other does not) is $2 * [1\text{-}F_B(p)]*[F_B(p)]$, where $[1\text{-}F_B(p)]$ is the probability that one bids high enough, and $[F_B(p)]$ is the probability that the other's bid is too low. The product of these probabilities is multiplied by 2, as either can be the winner (or loser). For the case where we have n potential customers we can generalize the above two-person example using the binomial probability distribution. Let $D_n(p)$ denote the number of people who will buy the product if the price is p—that is, $D_n(p)$ is the value of a binomial random variable and, for $0 \le x \le n$,

$$P[D_n(p) = x] = \binom{n}{x} [1\text{-}F_B(p)]^x [F_B(p)]^{n\text{-}x} \qquad [1]$$

Similar to the two-person example, with n bids placed the probability of x sales involves the probability of a success

EXHIBIT 9

Priceline data

	A	B	C	D	E	F	G	H	I	J	K	L	M
			Check in			**Your**				**Booked**			
		Check in	**Day of**	**Length**	**Number**	**Priceline**	**Offer**	**Declined**		**by**	**Posted**		
1	**Shop Date**	**Date**	**Week**	**of Stay**	**of Rooms**	**Rate***	**Price**	**Revenue**	**Reason****	**Others**	**Rate**	**Discount**	**DBA**
2	8/31/2007	08/31/07	Fri	1	1	$65	$47	$47	HI	Y	$199	24%	0
3	9/1/2007	9/1/2007	Sat	1	1	$65	$51	$51	HI	Y	$199	26%	0
4	9/2/2007	9/2/2007	Sun	1	1	$62	$48	$48	HI	Y	$199	24%	0
5	9/2/2007	9/2/2007	Sun	1	1	$62	$45	$45	HI		$199	23%	0
6	9/3/2007	9/3/2007	Mon	2	1	$63	$52	$104	HI	Y	$199	26%	0
7	9/4/2007	9/4/2007	Tue	2	1	$65	$44	$88	HI		$199	22%	0
8	9/5/2007	9/5/2007	Wed	1	1	$253	$48	$48	HI	Y	$253	19%	0
9	9/7/2007	9/7/2007	Fri	2	1	$65	$48	$96	HI	Y	$199	24%	0
10	9/7/2007	9/7/2007	Fri	2	1	$65	$48	$96	HI	Y	$199	24%	0
11	9/7/2007	9/7/2007	Fri	2	1	$65	$45	$90	HI		$199	23%	0
12	9/7/2007	9/7/2007	Fri	1	1	$65	$48	$48	HI	Y	$199	24%	0

to the power x, $[1-F_B(p)]^x$ and the probability of a failed bid to the power of n-x, $F_B(p)^{n-x}$ with $\binom{n}{x}$ describing all the possible combinations of x successes and n-x failures.

Given that we don't know ahead of time how many bids will be made on Priceline, we can include the number of requests (n) as a random variable. The probability, $f_p(.)$, of the number of people willing to buy at the price p becomes

$$f_p(x) = \sum_n P[D_n(p) = x]\, P[N = n] \qquad [2]$$

Where $P[N = n]$ is the probability that the number of bids N equals n. Equation [2] is simply a sum of [1] over all possible values of n multiplied by the probability that n customers make bids. In the accompanying Excel model I assume that $P[N = n]$ follows a Poisson distribution[2] and that $F_B(p)$—where p is in the form of a discount (versus a price) as in Exhibit 8—follows a *Beta* distribution.

Model Development

The following develops a model for a property that changes prices on Priceline every day, based on its revenue management goals. Let $V(t, r)$ represent the expected revenue for a property with r rooms to release over the next t days for a given arrival day. The firm's objective, to maximize this expected revenue by choosing prices (or discounts) to post, can be formulated as:

$$\max V(t, r) = \sum_n P[\,p_t \min(r, x) + V(t-1, (r-x)^+)\,]\, f_p(x) \qquad [3]$$
$$V(0, r) = 0$$

---

[2] Named for the 19th-century mathematician who discovered it, a Poisson distribution expresses the probability of the occurrence of a number of events in a given period of time, if those events occur independently (that is, they are random) but at a known average rate.

On each day, the property posts a price p to Priceline and sells x, up to r rooms. The following day the hotel updates its price, selling up to r - x rooms, until such a time as it has no rooms left to sell on Priceline for that arrival day or the day has passed and the rooms are valueless, $V(0, r) = 0$.

The Priceline Pricing Tool

The spreadsheet tool also available on the chr.cornell.edu site implements the above model. The following figures are screen captures from that file. As a demonstration, Exhibit 9 displays data similar to those of Exhibit 5 in an Excel sheet. This sheet is simply created as you cut and paste data from the PDF file reports in Exhibit 5 into Excel. Column K is user entered and represents regular posted prices for the specified Shop (bid) date (column A) and check in date (column B).

Exhibit 10 shows the resulting summary Excel table created automatically (requiring no user input) using the data from Exhibit 9 (which you've pasted in) to summarize the number of bids made for each arrival day as a function of how many days in advance of arrival the bids were made. You can toggle Check in Day of Week to be an individual day of week (e.g., Mondays) or include All Days of Week, if, for instance, you believe that bidders' behavior is dramatically different by arrival day of week (say, more price sensitive customers are bidding for weekend rooms versus midweek business travelers who are less affected by price).

Exhibit 11 summarizes the data further. The information in rows 5 and 6 is from the summary table in Exhibit 10 and is used to describe the distribution of the number of bids made as a function of DBA. The # of requests (row 6) is the total number of bids (for the selected day of week in

Arrival distribution data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Check in Day of Week	Fri ▾														
2																
3	Count of Offer Price	DBA ▾														
4	Check in Date ▾	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
5	8/31/2007	1														
6	9/7/2007	11		4	3	1										
7	9/14/2007	4	3	1	2	2	3	4	1		1	3	1	1	1	
8	9/21/2007	2	8	4	3	4	1			1				1		3
9	9/28/2007	6	5	3		2		2	3	2		2		1	1	
10	10/5/2007							1	1	4	1		3		3	
11	10/12/2007														1	2
12	Grand Total	24	16	12	8	9	4	7	5	7	2	5	4	3	6	5

Arrival and discount distributions
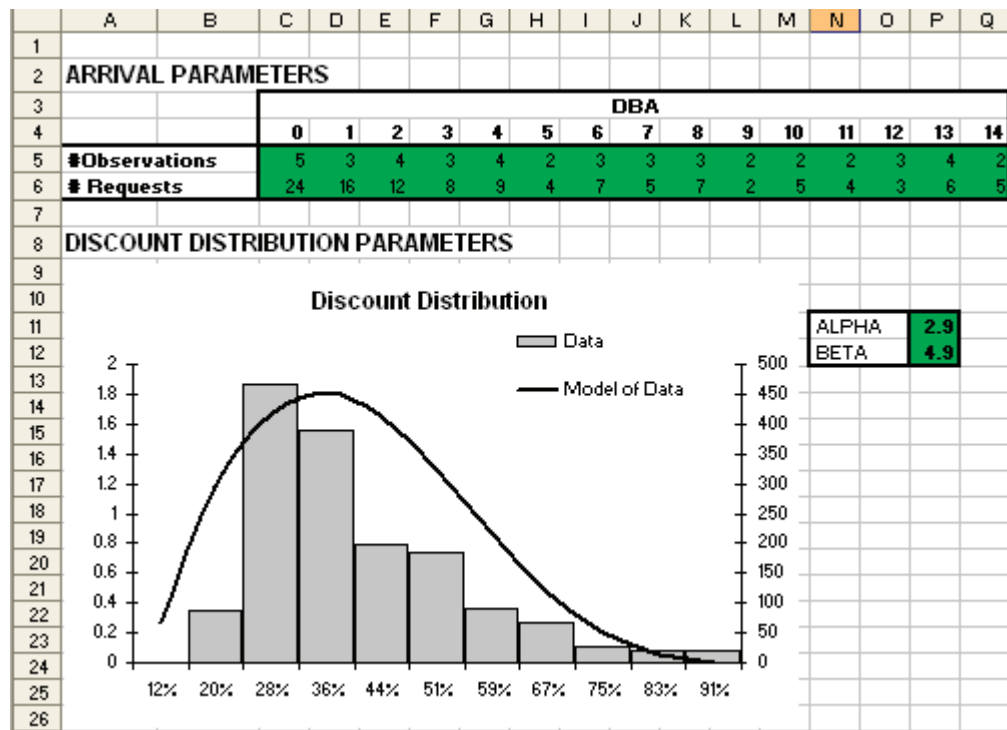
EXHIBIT **12**

Optimal discounts to post on Priceline

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
27																	
28		NUMBER OF ROOMS TO RELAEASE ON PRICELINE															
29		10															
30																	
31		MAXIMUM DBAs TO START PRICING ON PRICELINE															
32		14															
33		CALCULATE DISCOUNTS															
34						OPTIMAL DISCOUNTS											
35																	
36							DBA										

ROOMS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.43	0.53	0.57	0.57	0.57	0.55	0.53	0.52	0.5	0.51	0.46	0.49	0.48	0.44	0.47
2	0.38	0.48	0.51	0.52	0.52	0.51	0.48	0.48	0.46	0.46	0.42	0.44	0.43	0.4	0.42
3	0.35	0.44	0.47	0.49	0.48	0.47	0.45	0.45	0.43	0.43	0.39	0.41	0.4	0.37	0.39
4	0.33	0.41	0.44	0.45	0.45	0.45	0.43	0.42	0.41	0.4	0.37	0.39	0.38	0.35	0.37
5	0.31	0.38	0.41	0.43	0.43	0.43	0.41	0.41	0.39	0.39	0.36	0.37	0.36	0.34	0.35
6	0.3	0.36	0.39	0.4	0.41	0.41	0.4	0.39	0.38	0.38	0.35	0.35	0.35	0.33	0.34
7	0.29	0.34	0.37	0.38	0.39	0.39	0.38	0.38	0.37	0.37	0.34	0.34	0.34	0.32	0.33
8	0.29	0.32	0.35	0.37	0.38	0.38	0.37	0.37	0.36	0.36	0.33	0.34	0.33	0.32	0.32
9	0.29	0.31	0.33	0.35	0.36	0.37	0.36	0.36	0.35	0.35	0.33	0.33	0.33	0.32	0.32
10	0.29	0.3	0.32	0.34	0.35	0.35	0.35	0.35	0.35	0.34	0.33	0.33	0.32	0.31	0.31

the summary table) with the # of observations (row 5) the number of arrival dates with bids made at the corresponding DBA. The number of requests divided by the number of observations is the average number of bids made. The discount distribution graph is calculated from column L in Exhibit 9, where column L is the Priceline discount (Priceline bid/regular rate). The bar graph is the actual data, and the solid line represents the theoretical curve fit to the data under the assumption that bids follow a Beta distribution with parameters alpha (2.9) and beta (4.9) that are used to describe the shape of the curve. The parameters are calculated automatically by the model and updated when you paste in new data.

Using the Model to Determine Prices for Priceline

On a daily basis, your hotel's revenue manager or general manager receives the Priceline summary reports (Exhibit 5), copies the data displayed in columns B through J in Exhibit 9, and pastes those data from the PDF file into the data sheet in the tool. Fill in the date in column A to record the date of the report. You also input the posted rates in column K. These are simply your regular rates (say, unqualified Expedia rates) for the given combination of proposed check in date and inquiry date. Ideally, you would repeat these steps each day as you receive new data from Priceline. When new data are added to the Data sheet, all parameters will be updated automatically by the tool.

No user intervention is required for the updated calculations. The only new information required of you is to input the number of rooms you wish to sell on Priceline and the number of days you will accept offers for those rooms. You enter the number of rooms you want to release (cell B29 in Exhibit 12) on Priceline over the next 14 or fewer days (cell B32, Exhibit 12). Then you click on the Calculate Discounts button:

CALCULATE DISCOUNTS,

and the optimal discounts will be provided as in Exhibit 12.

To read the table in Exhibit 12, go down to the line showing the number of rooms you wish to release. I have highlighted five rooms, for example. Then read across to the column with the number of days before arrival. I have highlighted seven days, for example. Based on the calculations that I outlined above, the tool gives you an optimal price to post of 41 percent of your regular rate. That rate is the one that you input above, most likely the rate you've given other online travel agent sites. If you sold three rooms at that rate on the seventh day out, the table gives you the proposed

discount for the remaining two rooms. Two rooms left on Priceline on the sixth day out means that you would raise prices to 48 percent of stated rates.

Summary

As I have demonstrated here, the data provided to hotel properties by Priceline is sufficient to develop a targeted method of pricing inventory on Priceline as well as adjusting these prices to sales (or non-sales). The method and resulting tool presented here can easily reside alongside any existing revenue management (RM) system, but an important opportunity exists to incorporate it into a RM system.

If you were to incorporate these calculations in your revenue management algorthithms, Priceline would become a proactive part of your distribution strategy rather than an avenue to auction distressed inventory. Along these lines, Priceline bidding activity appears to have a longer "booking profile" than is found with traditional channels. That is, many customers bid on Priceline before they make purchases on non-opaque online agents' sites. Given the leading nature of Priceline activity, bidding activity on Priceline could be used to augment existing forecasting systems. This may be especially valuable for core business properties that have short booking profiles. ■

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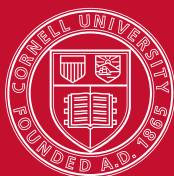
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