An Urgency Model of Reservation Price For Capacity Constrained Services

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ABSTRACT

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Capacity constrained services such as airlines, hotels and automobile rentals frequently use differential pricing and inventory controls to optimize revenue. A model of reservation price for capacity constrained services is proposed that reflects the urgency created by three factors: the importance of the trip (level of loss), the time pressure (time remaining) in which to take action, and the supply constraint (the number of seats rooms or cars) available. It was hypothesized that the maximum amount the consumer is willing to pay is minimized if any one of the three factors is minimized. A simple 3 X 3 X 3 within-subject experiment was used to show that all hypotheses were supported.

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Introduction

Yield management is a broad term describing various methods for managing capacity profitably. It has gained widespread acceptance in travel industries (airlines, car rentals, hotels cruise lines, etc.) and there is substantial evidence that it is effective in improving revenues (Lloyd's 1985, Cross 1986, Belobaba 1987). Given a downward sloping demand curve, a tradeoff develops between the desire to obtain the highest possible price for each unsold unit of capacity (seat, car or room) and selling all units of capacity available. The manager's problem is to know which levels of price and capacity utilization will optimize revenue.

Yield management has solved this joint optimization problem using capacity management and differential pricing tools (for a good review see Kimes 1989; Weatherford and Bodily 1992). In particular, the pricing of units of capacity presents both the consumer and the travel service manager with several problems. Consumers take issue with the fairness of differential pricing. For example, it is not uncommon that two travelers seated next to each other in an airplane will pay vastly different prices for the same flight. While consumers may perceive differential pricing as unfair, a single fare that is too high leaves seats empty, and one that is too low sells out quickly leaving no seats available for last-minute travelers.

In order to optimize revenue, yield managers need to know how many seats not to sell at a lower price so that they will have seats available to sell to consumers willing to pay a higher price. The maximum price a consumer will pay (their reservation price) for a seat on an aircraft, or room available in a hotel is an important piece of information for yield managers.

In this paper, a model of reservation price is developed that incorporates the notion of urgency. Simply put, when a situation is urgent, many people will throw money at the problem. If a product or service is urgently required, consumers will pay more than if it is not. Knowledge about the factors that make a situation urgent may assist revenue managers in understanding the maximum price that a particular consumer will pay for a seat, room or other capacity constrained service.

A Model of Reservation Price

Consider the following hypothetical situation that mimics many capacity constrained / price differentiating services:

> Suppose you have been wrongly assessed an amount of money for unpaid taxes by Revenue Canada. It is a simple matter for a tax accountant to prove your innocence, but you have only one opportunity to do so at a meting scheduled at some point in the future. If you can't get a tax accountant to represent you, Revenue Canada will seize sufficient assets to cover the amount assessed. Tax accountants who can take your case may be in plentiful, limited or very poor supply depending on the business cycle. The standard fee for this service is $100, but tax accountants are known to charge substantially more as their appointment books fill up.

The economic importance of this situation may be high ($5,000), medium ($1,000) or low ($100). Clearly, the amount of the loss incurred will impact on how important it is to secure a tax accountant's services.

The hearing date could be 1 month away (low time pressure), 1 week away (medium time pressure), or tomorrow (extreme time pressure). The situation becomes more urgent as the time available before the loss is sustained becomes shorter.

The supply of accountants who can take this case can be plentiful, limited (a few accountants may be available) or severely limited (last-minute cancellations only). As the supply of available accountants is constrained, the urgency experienced and the amount the consumer is willing to pay should increase.

Continuing with the example, a 3 X 3 X 3 main effects model of these conditions and hypothesized levels of urgency and reservation price is constructed in Table 1.

<<INSERT TABLE 1 HERE>>

Using the example, let us examine first examine the situation where the loss is low ($100). In this case, even if the availability of accountants is tight, and time remaining prior to the hearing is short (high time pressure), the urgency will remain low because the loss is not very large.

Thus, a consumer is hypothesized to pay no more than the minimum (low) price. This is the case for situations #1 – #9.

Next, let us consider the situations (#19 - #27) where the opportunity loss is high ($5,000). In situation #25, the time pressure is high (little time remaining), but a good supply of accountants is available (low supply constraint), thus the urgency is low. This is because there is no problem securing an accountant, even at the last minute. Similarly in situation #21, if there are few accountants available (high supply constraint) and the time pressure is low, the urgency is low because there is plenty of time to find other solutions. In both cases, the consumer would pay no more than the minimum price.

Similar arguments can be made regarding the other combinations. The general decision rule is that the lowest level of the three main effects is equal to the level of urgency, and the maximum price the consumer is willing to pay for an accountant's services will reflect the level of urgency experienced.

The following hypotheses describe the maximum amount a consumer is willing to pay based on the factors that make a situation urgent:

Main Effects:

H1: Loss level influences the amount the maximum amount the consumer is willing to pay.

H2: Time Pressure level influences the maximum amount the consumer is willing to pay.

H3: Supply Constraint Level influences the maximum amount the consumer is willing to pay.

Two-Way Interactions:

H4: The effect of Time Pressure on the maximum amount the consumer is willing to pay is not the same at each level of Loss (or alternately, the effect of Loss is not the same at each level of Time Pressure).

H5: The effect of Time Pressure on the maximum amount the consumer is willing to pay is not the same at each level of Supply constraint (or alternatively, the effect of Supply Constraint is not the same at each level of Time Pressure).

H6: The effect of Supply Constraint on the maximum amount the consumer is willing to pay is not the same at every level of Loss (or alternately, the effect of Loss is not the same at each level of Supply Constraint).

Three-way Interaction:

H7: The combined effect of any two-way interaction is not the same at every level of the excluded term.

Methodology:

The hypothetical example captures the same issues faced by consumers when booking airline seats, hotel rooms or other capacity constrained services. For example, price quotes by airlines at the time of booking reflect the supply of available seats and generally increases as the unsold capacity (supply) diminishes. Similarly, the consequence (Loss) to the consumer of not making the trip may be low or high, depending on the nature of the trip and other circumstances. Finally, the time remaining to make arrangements (or explore alternate solutions) also effects how much someone will pay for a seat.

Many consumers have experienced the relationship between price and time of booking for airline or hotel services. The unfamiliar tax accountant situation was used so subjects would provide responses based on their perceptions, rather than past experience.

In hypothetical situations, it is difficult if not impossible for subjects to "feel" urgency as manifested by sweaty palms, increased heart rate, and other physical indications. Perceived urgency is not a good dependent variable because urgency is felt (affect), and thus difficult to induce or measure in hypothetical experiments.

Reservation price, the maximum amount the consumer is willing to pay, was used here as the dependent variable. Reservation price is relevant to revenue managers, and has the advantage of providing a ratio-scaled measure that is well understood by all consumers.

A within-subjects (repeated measures), fixed factor levels experiment (3X3X3, see Table 1) where each subject was exposed to all treatment conditions was prepared to test the hypotheses.

Eight convenient subjects (staff and graduate students) participated in the experiment. They received a copy of the hypothetical situation and a randomized deck of 27 "situation summary" cards imprinted with the level of loss (in dollars), the time remaining prior to the hearing, and supply of accountants, as in the hypothetical situation. The subjects were instructed to briefly review the cards and then enter the amount they would be willing to pay for an accountant under those circumstances (the dependant variable). On average, it took approximately 20 minutes to complete the experiment.

Results and Conclusions:

An analysis of variance was performed using the GLM within-subjects (repeated measures) program in SPSS PC. These results are provided in Table 2. Cell means for each of the 27 treatments are provided in Table 3. All hypotheses were supported, and thus it is concluded that Loss, Time and Supply factors could form the basis of a linear regression model of reservation price for capacity constrained services that use differential price.

<<INSERT TABLE 2 and 3 HERE>>

The significant three-way interaction (Loss X Time X Supply) is an interesting phenomenon in itself. Such interactions are unusual in consumer research. In this case, the three-way interaction is primarily responsible for the decision rule that the amount the consumer is willing to pay is always a minimum if any one of the three factors is at a minimum. That is to say, a situation is never urgent (thus requiring more resources to resolve) if any one or more of the following occurs:

1. The level of loss is small
2. The time pressure to avoid the loss is small
3. The supply constraint of the service needed to avoid the loss is small.

Clearly, the empirical test of the model done here lacks the power and sophistication necessary to be conclusive. The relationship between urgency and willingness to pay also requires further research. Inducing true urgency presents difficult challenges for the experimenter, and may pose risks for the subject. Thus opportunities to verify the relationship between urgency and willingness to pay must be obtained from subjects who have had such experiences, rather than through experimentation. However, this simple experiment illustrates that the model appears to function well and is worth more time and effort to test more rigorously.

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Table 1
Hypothetical Urgency Main Effects Design

#	U = Urgency Level	L = Level of Loss	T = Time Pressure	S = Supply Constraint
1	Low	Low	Low	Low
2	Low	Low	Low	Medium
3	Low	Low	Low	High
4	Low	Low	Medium	Low
5	Low	Low	Medium	Medium
6	Low	Low	Medium	High
7	Low	Low	High	Low
8	Low	Low	High	Medium
9	Low	Low	High	High
10	Low	Medium	Low	Low
11	Low	Medium	Low	Medium
12	Low	Medium	Low	High
13	Low	Medium	Medium	Low
14	Medium	Medium	Medium	Medium
15	Medium	Medium	Medium	High
16	Low	Medium	High	Low
17	Medium	Medium	High	Medium
18	Medium	Medium	High	High
19	Low	High	Low	Low
20	Low	High	Low	Medium
21	Low	High	Low	High
22	Low	High	Medium	Low
23	Medium	High	Medium	Medium
24	Medium	High	Medium	High
25	Low	High	High	Low
26	Medium	High	High	Medium
27	High	High	High	High

Table 2
ANOVA Within-Subjects Main and Interaction Effects

SOURCE	SS	df	MS	F	Sig
Loss	10,758,282	2	5,379,141	15.623	.000
Time	3,220,859	2	1,610.430	5.722	.015
Supply	2,972,814	2	1,486,407	6.862	.008
Loss X Time	4,345,486	4	1,086,371	5.706	.002
Loss X Supply	3,489,052	4	872,263	6.233	.001
Time X Supply	1,576,002	4	394,000	4.273	.008
Time X Loss X Supply	2,273,861	8	284,233	4.485	.000

Table 3
Reservation Prices by Treatment
Means and Standard Deviations

#	Mean Reservation Price	Standard Deviation	L = Level of Loss	T = Time Pressure	S = Supply Constraint
1	65.63	43.05	Low	Low	Low
2	66.25	42.32	Low	Low	Medium
3	65.63	43.05	Low	Low	High
4	65.63	43.05	Low	Medium	Low
5	66.88	41.66	Low	Medium	Medium
6	63.13	46.52	Low	Medium	High
7	60.00	42.43	Low	High	Low
8	63.13	46.52	Low	High	Medium
9	54.38	45.15	Low	High	High
10	143.75	62.32	Medium	Low	Low
11	140.63	42.13	Medium	Low	Medium
12	200.00	110.19	Medium	Low	High
13	131.25	45.81	Medium	Medium	Low
14	234.38	64.00	Medium	Medium	Medium
15	293.75	137.42	Medium	Medium	High
16	153.13	57.38	Medium	High	Low
17	315.63	145.74	Medium	High	Medium
18	375.00	215.47	Medium	High	High
19	193.75	180.15	High	Low	Low
20	218.75	116.30	High	Low	Medium
21	278.13	155.52	High	Low	High
22	281.25	213.70	High	Medium	Low
23	400.00	155.84	High	Medium	Medium
24	956.25	750.92	High	Medium	High
25	268.75	243.39	High	High	Low
26	1100.00	1047.79	High	High	Medium
27	1662.50	1574.52	High	High	High