Course Name - Operations and Revenue Analytics

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Week - 05

Lecture - 24

Welcome, friends. So, as we are already discussing the situation of constrained supply for revenue optimization. In our last video, we discussed that whenever there is constrained supply and the constraint is lower than the optimal level of demand, as in the case of unrestricted supply, then only this situation is a valid situation. Now, let us see a few more interesting aspects related to this particular constrained supply. In this particular session, we are going to discuss the opportunity cost related to constrained supply, the case of market segmentation and supply constraints, and then we will also summarize some of the important principles we have discussed with respect to constrained supply.

Let us first understand the concept of opportunity cost in this particular scenario. We all know what the meaning of opportunity cost is. Opportunity cost is when we are doing a particular work and earning some kind of benefit from that work. This work is done at the compromise of the second-best work. If, let us say, I am putting my money into an investment in a bank.

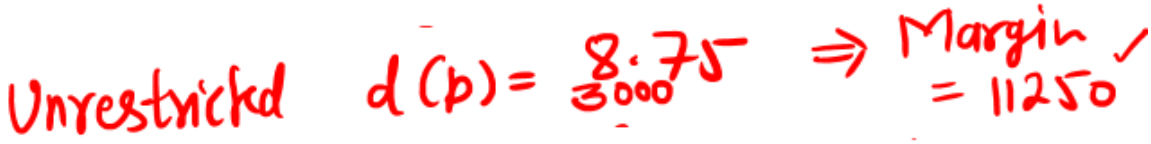
So, if I am not putting my money into an investment in the bank, what is the other use of that particular money? So, if I am getting X revenue from earning interest in the bank. Then, this X minus Y becomes the opportunity cost. So, opportunity cost always exists because you have limited resources. There are various things which require the use of those limited resources.

So, you have to be very selective and we always want to minimize our opportunity cost so that the cost is always a kind of a loss. So, we want to minimize that opportunity cost

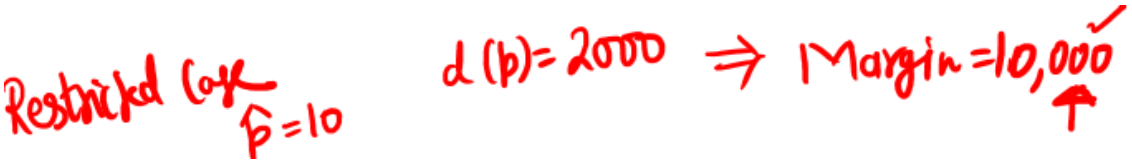
as much as we can. Like, if you recall the example which we were discussing with the help of a particular price response function that was 10000 minus 800p.

d(p) = 10000 – 800p

Now, when there was no restriction unrestricted, so our d(p) was coming 8.75 and the margin if you recall from our earlier class was around 11250 that was the margin we were getting.



Now, when we came the restricted case and we realize that we should have our run out price equals to 10 rupee at that time, our demand we were able to fulfill as 2000 and in this unrestricted it was 3000. And at that level our margin was 10000.



So, these calculations we have already done in our earlier videos and now you can see that 11250 minus 10000 that is 1250 rupees. That is the total opportunity cost because of restricted supply, because of the restricted supply we are having opportunity cost or we are paying opportunity cost of 1250. Can we reduce this opportunity cost and reducing this opportunity cost means can we increase this margin. Can we increase this margin so that this opportunity cost can further be reduced that we will see in this particular session, that what are the different types of strategies and their implementation so that our opportunity cost is further reduced.

You get the highest level of profit you get the highest level of profit when there is unrestricted supply. So, my objective, my aim is that can I achieve profit margin of 11250

rupees, but let us see that up to what level we can go or up to what level we can reduce our opportunity cost. It is the same thing maximizing the revenue in the restricted case or minimizing the opportunity cost will always help you in achieving the same objective. So that you understand now this concept of opportunity cost which actually signifies the maximum amount the seller is willing to pay and the interesting question is how much the seller is ready to pay for one additional unit of supply is called the marginal opportunity cost. So, we will see in the next slides that how are we going to calculate this marginal opportunity cost.

So, here you see on your screen that the previous question: the marginal cost at 2000 is the contribution at the rate of 2000 capacity minus at the rate of 2001 capacity. Our demand for the unrestricted case is coming to 3000. Now, our capacity is restricted to 2000. Now, let us say our capacity is b1 equals to 2001. So, the question is: what is the reduction in our marginal cost if my capacity increases from 2000 to 2001?

So, this difference of the marginal cost—the difference of opportunity cost—is known as marginal opportunity cost. So, this is clear from this expression: the margin in the case of capacity 2001, the margin in the case of capacity 2000.

$$\dot{m}(2001) - \dot{m}(2000) = \$10002.50 - \$10000 = 2.50$$

So, when you have 2001 as your capacity, your total revenue will be 10,002 rupees 50 paisa, and when you have a capacity of 2000, your margin is 10,000. So, the marginal opportunity cost—this is marginal opportunity cost. Now, let us see in this table.

Available capacity	Contribution at $8.75	Optimal price	Optimal contribution	% Change	Marginal opportunity cost
≥3,000	$11,250	$8.75	$11,250	0	$0.00
2,500	$9,375	$9.38	$10,950	16.8	$1.25
2,000	$7,500	$10.00	$10,000	33.3	$2.50
1,000	$3,750	$11.25	$6,250	66.7	$5.00

So, this table shows the contribution, optimal price, and marginal opportunity cost for cases of constrained supply. So, for example, if the available capacity, as I was talking, is 3000 or more than 3000. It is more like unrestricted supply: 3000 and more than 3000 are all cases of unrestricted supply. So, the contribution at the rate of 8 rupees 75 paisa is 11,250. The optimal price is 8 rupees 75 paisa here in this case, and the optimal contribution is 11,250, and therefore, there is no marginal opportunity cost.

Now, let us see the value which we know that is 2000 capacity we have already done this calculation. So, at 8 rupees 75 paisa the contribution is 7500, but this run out price you can say that these are run out prices. So, at 2000 the run out price is 10 rupees and the optimal contribution at 10 rupee is 10,000. So, from 7500 now the contribution is increased to 10,000. So, there is a percentage change of 33.3 percent and then you can also calculate the marginal opportunity cost that is 2.5 rupees as we just calculated at 2000.

Now, similarly you can calculate and see that how these values are coming at 2500. So, if I capacity has 2500 the contribution at the rate of 8 rupees 75 is 9375. You will calculate the run out price using this equation d(p) equals to 10000 minus 800p is equals to 2500 and here you will get the p cap equals to 9.38. If you solve this equation the optimal price at capacity of 2500 will be 9.38. Similarly, 10,000 minus 800p equals to 1000 and corresponding p cap will be 11.25.

So, this calculation of 10 we have already done in our previous classes, but you can do these calculations on your own as I just explained here. And then accordingly your optimal contribution which is coming from this particular equation that is p minus c into level of capacity. So, like in this case it will be 9.38 and the cost price you remember we are contributing as 5 rupees into 2500. So, this value will be this and same we have done for others also and this percentage change is with respect to the contribution which you are getting at 8.75 and the contribution you are getting at whatever optimal price you are keeping at this level. And then at that level of 2500, if you are having one more unit, if you are going to have one more unit how the marginal opportunity cost is going to

increase or at 1000 level how the marginal opportunity cost will incur that is given in this last column.

So, as you see the last column as you see this last column one interesting you can say implication you can easily get that as my available capacity is decreasing. As available capacity is decreasing marginal opportunity cost is increasing, as my capacity is increasing marginal opportunity cost is decreasing, so you need to be, you need to be as close to optimal level of capacity that is 3000, as you are moving away from 3000 your marginal opportunity cost is continuously increasing. As you can see that it was earlier 1.25 it jumped to 2.50 and it further jumped to 5 rupees that is significant increase in the marginal opportunity cost. So, it becomes a kind of a principle you can say in case of restricted supply that by reducing the available capacity, our marginal opportunity cost is continuously increasing. Please remember or in fact, I can write this that available capacity, if available capacity is decreasing, this will lead to increase in marginal opportunity cost.

Please remember this very important outcome of this whole discussion. So, therefore, if you are having a system with limited capacity try to increase the capacity of your system, so that your marginal opportunity cost can be reduced. Now, that is one strategy we just discussed that for reducing my marginal opportunity cost, I have to increase the capacity of my available servers. There is one more you can say important strategy for increasing the contribution from my limited capacity and that strategy is market segmentation strategy. Now, in the market segmentation strategy, what we are going to do that for that limited capacity, I may consider 2, 3 different segments of the customers and I may charge different optimal prices for different segments of the customers.

So, we have one example to explain you this particular point. Like, there is a particular stadium where the sitting capacity is 60,000 and customers can be segmented into two broad categories, one is the students of the university and then the general public. As you can easily make, we may charge a lower price to students and we may charge a higher price to the general public. So, we have to see that what should be the prices, we should charge to students and general public, so that we can take maximum revenue with this limited number of seats available to us in our stadium. Now, for that purpose it is easy to

understand that if you have two market segments, you will have two price response functions, separate price response functions for separate market segments.

So, here you see that for general public the price response function is given as equation number A and for the student the price response function is given as equation number B. Now, p_g is the price we are charging to the general public and PS is the price we are charging to the student community. Now, if this type of pricing system is there, we are

$$\text{General public:} \quad d_g(p_g) = (120{,}000 - 3{,}000p_g)^+$$

$$\text{Students:} \quad d_s(p_s) = (20{,}000 - 1{,}250p_s)^+$$

looking to have the total you can say our demand and this capacity is fixed that is 60,000 seats are there. And if our university feels that they want to charge a single price for the entire group of customers, whether they are general public or students, so what we are going to do the p_g and p_s are the cases, when they are charging two different prices for different market segments.

But, right now we are taking a variation of this situation, where the university is deciding that they want to charge only single price for the entire market segments.

So, in a way there is no segmentation because you are going to charge the same price. Now, here, you will simply add both these price response functions A and B. And then you have the solution of that because on the left hand side d(p) is equals to 60,000. So, by solving this you will get the optimal price as 20 dollars and this is our total gross revenue. So, this is the case where you have single demand curve. and obviously you can easily solve this.

What if Stanford can only charge a single price to all?

In this case, the aggregate demand curve is:

$$d(p) = (120{,}000 - 3{,}000p)^+ + (20{,}000 - 1{,}250p)^+$$

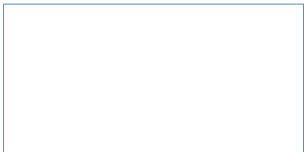
and the optimal price will be $20.00. At this price, Stanford would sell exactly 60,000 tickets, grossing $1,200,000.

So, this becomes 1,40,000 minus 4250p. So, this becomes in fact 1,40,000 minus 4250p and that you have solved and by solving this, you got the price of 20 dollars. Now, when we are looking for a different price, you will see that there is a situation that in this case it is quite possible that all the tickets at the 20 dollar may go to the general public. Students find it difficult to buy tickets at 20 dollars. So, all the tickets may go to the general public and students are totally out of the market, because of their they are not willing to pay that high prices. Now, there is a survey which says that students are willing to pay maximum 16 rupees.

Students are willing to pay maximum 16 rupees. So, now university is thinking to charge different prices to students and different prices to general public. So, earlier situation same price to these all the customers, now they want to have a different price for different market segments and now in this case this optimization problem becomes like that you want to maximize your revenue which is coming from public and student community. And the total capacity, total demand of general public and total demand coming from the student community should be less than equals to 60,000, because that is the constraint in solving this particular equation. Now, in this case of revenue maximization, prices for students and the general public, the marginal opportunity cost is you see that $2p_g$ minus 40 for the general public and $2p_s$ minus 16 for the students.

So, when you solve this particular equation and you see that the marginal opportunity cost that for buying, let us say if there are 20,000 seats going through for students and 40000 seats for general public. So, in this case, if you are giving 40,001 seat to the public, what is the additional benefit you are going to get, what is the additional margin you are going to get? So, the difference of that is the marginal opportunity cost for the general public. Similarly, if 20,000 seats are for the students, 20,001 seat if it is going to student, what is the additional revenue you are going to get that is the marginal opportunity cost for the students. Now, when we are going to equate the marginal revenues which is coming from students as well as from public, we get this kind of relation.

We want to find the revenue-maximizing prices for students and the general public. The marginal opportunity cost is:
$2p_g - 40$ for the general public and
$2p_s - 16$ for students.
Equating the two marginal revenues and simplifying gives
$p_g = p_s + 12$.
In other words, the ticket price for the general public will be $12.00 higher than the ticket price for students.



Here we are assuming, here we are assuming, that both the group of customers students and public they are giving same level of marginal revenues and with that we are getting this relationship p_g equals to p_s plus 12, p_g equals to p_s plus 12. If, you put this you can simply see that $2p_g$ minus 40 equals to $2p_s$ minus 16. So, solving this you will get this relation that p_g equals to p_s plus 12 and it means that the ticket price for the general public will be 12 rupees more than the ticket price for the students. Whatever ticket price you are charging to students plus 12 will be the and this is coming from this concept of our marginal opportunity cost that two marginal opportunity cost we are equating $2p_g$ minus 40 equals to $2p_s$ minus 16 and this will lead to p_g equals to p_s plus 12. So, you are able to set the appropriate pricing.

Now, since you know that students are not willing to pay more than 16 rupees. So, if you keep the price of the student ticket at 16 rupees, the price for the general public will be 28 rupees. Now, the other condition in this example that must be satisfied is that the total demand from both students and the general public be equal to the capacity of the stadium, which is 60,000. So, 120,000 minus $3,000p_g$ plus 20,000 minus $1,250p_s$ equals 60,000, and if I simplify this, it becomes $3p_g$ plus $1.25p_s$ equals 80. This is the other equation we are getting. And now we have two conditions: one is p_g equals p_s plus 12. p_g equals p_s

plus 12—this is one. Let us say we have already discussed AB. In this case, we have said this is equation number 1.

This is equation number 2. So, if I solve 1 and 2, it gives me p_s equals 10.35 and p_g equals 22.35.

$(120{,}000 - 3{,}000p_g)^+ + (20{,}000 - 1250p_s)^+ = 60{,}000 \Rightarrow 3p_g + 1.25p_s = 80$ -①

$p_g = p_s + 12$ -②

Solving both conditions simultaneously gives

p_s = \$10.35 and p_g = \$22.35.

So, here you see that the gap between p_g and p_s is exactly 12 rupees, which is this condition, and the first condition is also satisfied. So, at this price, the university will sell 52,941 tickets to the general public and 7,059 seats to students, and the total revenue generated will be of this student. The earlier calculation we did was that they could sell the entire tickets at the rate of 20, and you remember that the total revenue at that time was 12 lakh.

And here, the total revenue is at a 20-rupee price. Our revenue was 10 extra, and now the revenue is 12,56,471. So, we have 56,471 as additional revenue when we are doing the market segmentation and keeping two different prices: a discounted price for the student at 10 rupees 35 paisa and for the general public at 22 rupees 35 paisa. This is increasing our total revenue by 4.7 percent, which is beneficial to all parties. Students are able to go to the stadium to watch the match because of this reduced price. The revenue of the stadium is also increasing by close to 5%. And at the same time, you are able to utilize all your 60,000-seat capacity stadium by appropriately distributing seats between the general public and the students.

So, this is another important, you can say, approach—the concept of marginal cost, which is coming from different, you can say, market segments. If you understand that concept correctly, it can help you identify the appropriate pricing label for different market segments. And if you do this market-segment-based pricing in this supply-constraint situation, it will help you improve your overall revenue from this limited supply. So,

finally coming to the end of this particular video, we understood that prices should be set for two different segments so that the marginal revenue from both segments is equal. That is what we did in this particular case of stadium pricing—for the general public as well as for students—we kept the marginal revenue at the same level, and that gave us the equations to solve. When supply is unconstrained, marginal revenues should all be set to the marginal cost. When supply is constrained, marginal revenues should still be equated, but they need to be set so the supply constraint is always satisfied. So, as we saw in the case of the first example, marginal revenue is reduced by increasing the supply, and as our supply further reduces, our marginal cost increases.

So, these are the two or three important principles we understood with this concept of opportunity cost—marginal opportunity cost in the case of restricted supply. With this, we come to the end of this particular video. Thank you very much.