Decision Making With Spreadsheet
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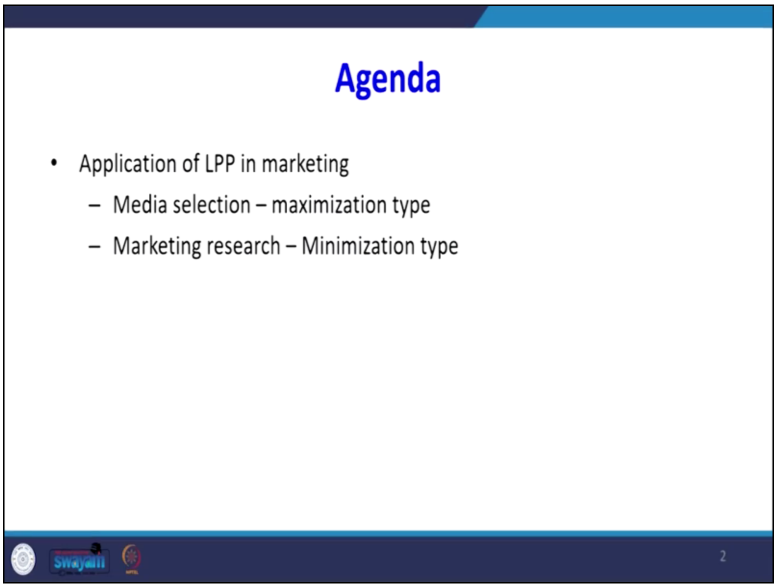
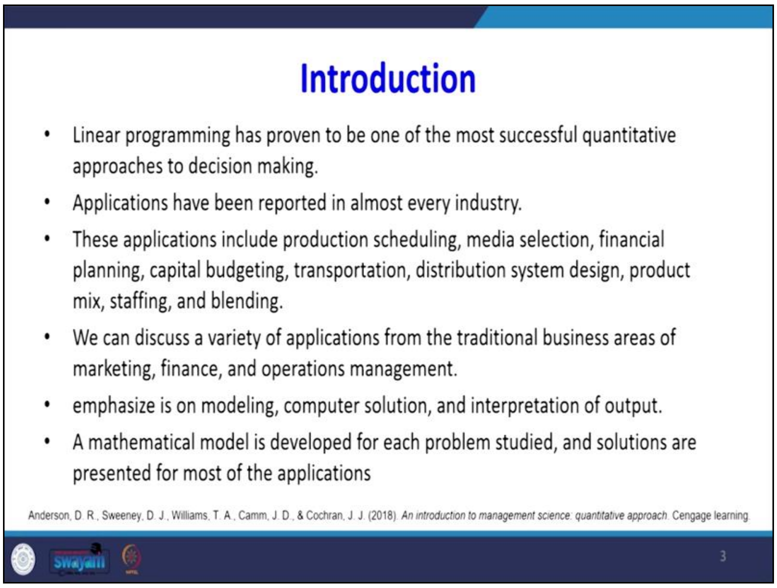
Lecture-09
LPP Applications in Marketing

In the previous class, we studied the limitations of sensitivity analysis, and I also took a problem that problem contained different types of constraints. Constraints like less than or equal to type, greater than or equal to type, and equal to type were solved with the help of Excel, and then I interpreted the result. Now, I am entering into the applications area applications of our linear programming problem. That is the agenda for this lecture.



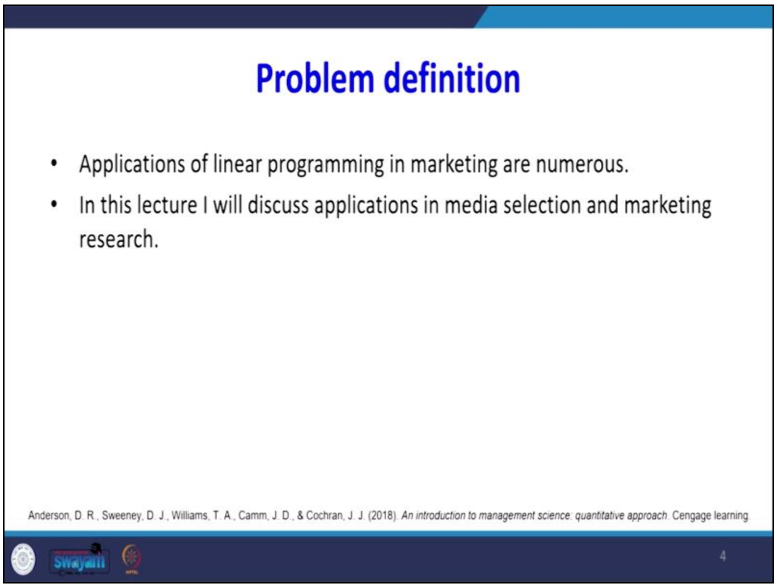
Here, what we are planning to do today is the application of linear programming in marketing. We are going to take two applications: one is on media selection, and the other one is on marketing research, which is on the agenda for this lecture.



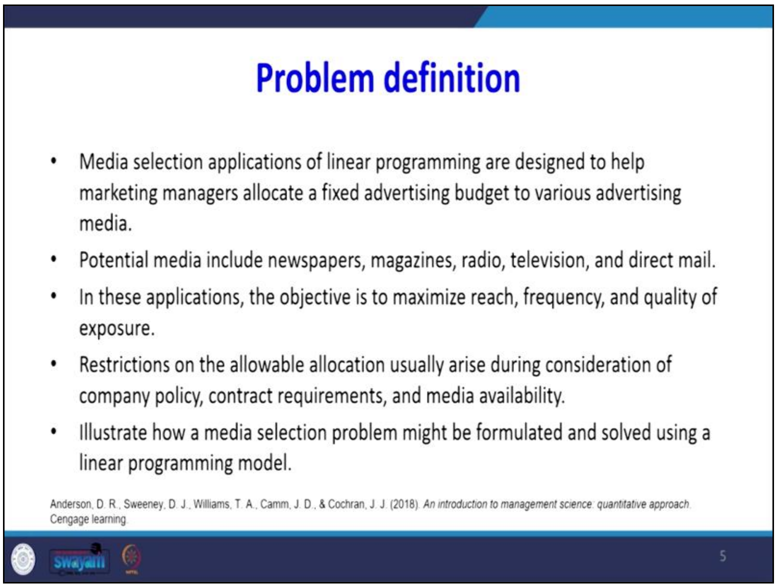
Linear programming has proven to be one of the most successful quantitative approaches to decision-making applications that have been reported in almost every industry. These applications include production scheduling, media selection, financial planning, capital budgeting, transportation distribution system design, product mix, staffing, and blending. These applications, like scheduling media selection and so on, will be covered in detail in coming lectures.

We can discuss a variety of applications from the traditional business areas of marketing finance and operations management. In this course, we are going to emphasize modeling, which means that formulating the problem once the model is done will be solved with the help of a computer solution that uses Excel and then the interpretation of the output. So, the focus of this course is the formulation of the problem in the form of mathematical equations and then solving it with the help of a solver.

And more emphasis on the interpretation of the output. So, the mathematical model is developed for each problem studied, and solutions are presented for most of the applications.



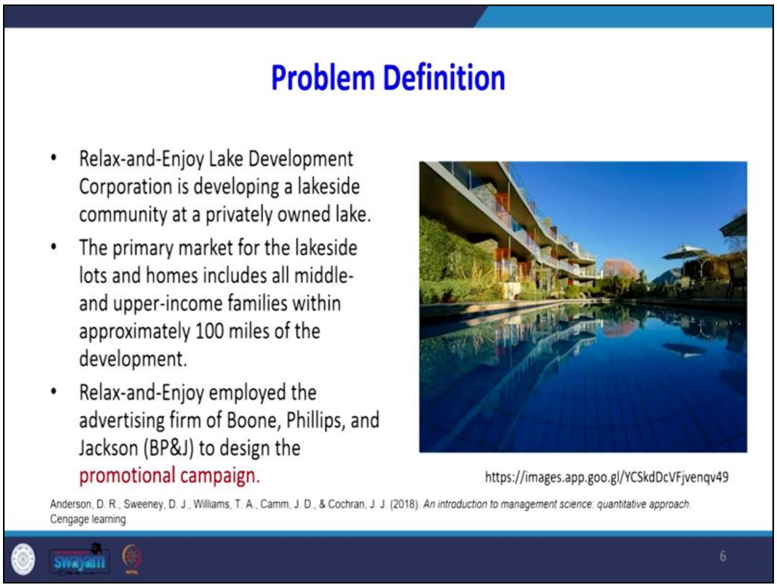
Now, let us see the applications of linear programming in marketing. So, the applications of linear programming in marketing are numerous. In this lecture, I will discuss two applications: one is in media selection, and the other one is in marketing research.



Problem definition on media selection: The media selection applications of linear programming are designed to help marketing managers allocate a fixed advertising budget to various advertising media. This is a very common problem for your marketing managers. We have a fixed advertising budget that budget should be allocated to various advertising media. So that the objective function is maximized.

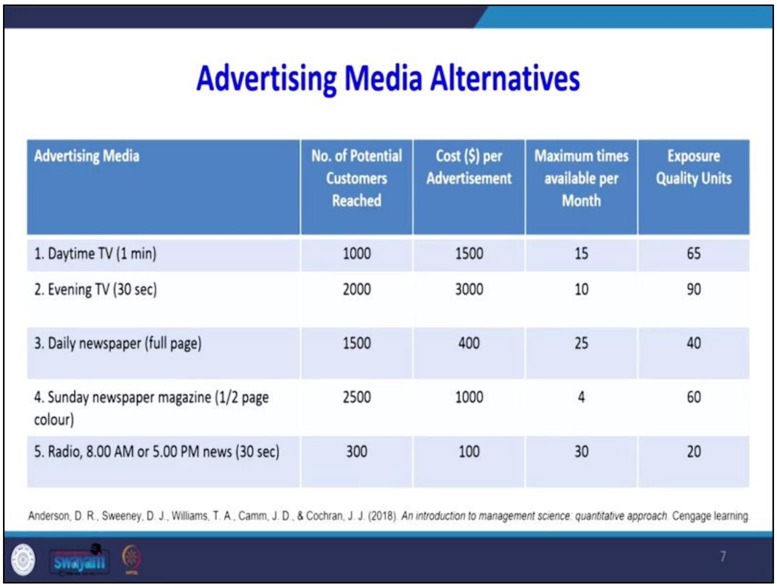
Here, the objective function, in general, is to reach the tower media. In this problem, I will explain what is exactly the objective functions. The potential media for advertising includes newspapers, magazines, radio, television, and direct mail. In these media selection applications, the objective is to maximize the reach by reaching a greater number of people and frequency. How often does that advertisement have to be played?

The quality of exposure restrictions on the allowable allocation usually arises during the consideration of company policy contract requirements and media availability. This restriction will become constrained. So, constraints may be in the form of company policy or contract requirements and media availability. Now, in this lecture, we illustrate how a media selection problem might be formulated and solved using a linear programming model. This problem is taken from the book Anderson Sweeney Williams Camp Kochran.



What is the problem definition? A company relax and enjoy Lake Development Corporation is developing a lakeside community at a privately owned lake. The primary market for the lakeside lots and homes includes all middle and upper-income families within approximately 100 miles of the development. Assuming that it is a kind of a real estate company or builders, they are planning to construct a home, that is the problem. This company employed an advertising firm. So, we call it BP and J, Boney Phillips, and Jackson to design the promotional campaign.

So, that builder is the builder is seeking the help of an advertising company for promoting their houses.



Advertising Media Alternatives

Advertising Media	No. of Potential Customers Reached	Cost ($) per Advertisement	Maximum times available per Month	Exposure Quality Units
1. Daytime TV (1 min)	1000	1500	15	65
2. Evening TV (30 sec)	2000	3000	10	90
3. Daily newspaper (full page)	1500	400	25	40
4. Sunday newspaper magazine (1/2 page colour)	2500	1000	4	60
5. Radio, 8.00 AM or 5.00 PM news (30 sec)	300	100	30	20

Anderson, D. R., Sweeney, D. J., Williams, T. A., Camm, J. D., & Cochran, J. J. (2018). *An introduction to management science: quantitative approach*. Cengage learning.

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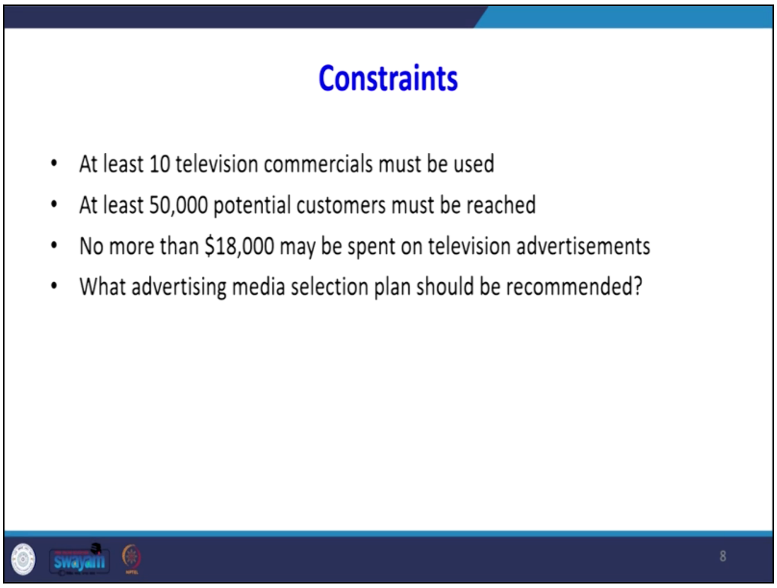
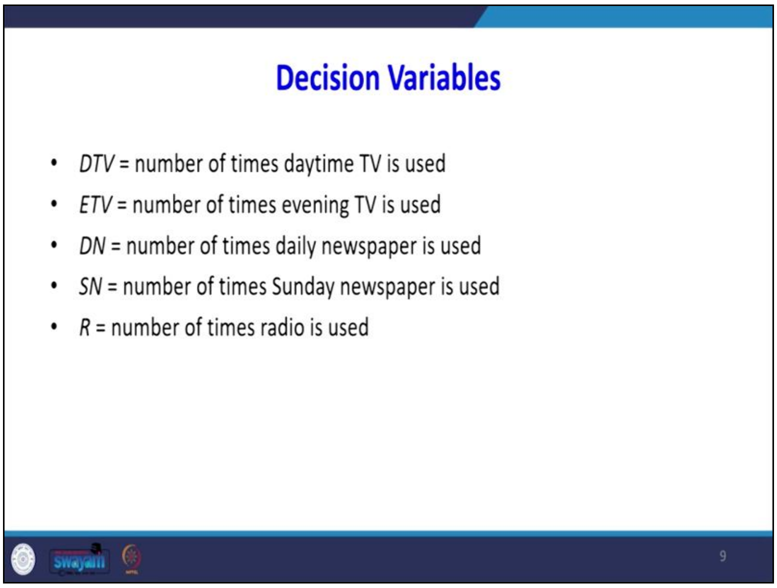
What are the different advertising media available? They can go for TV. The TV can also go for advertisements during the daytime and evening time, and this is one category. Another category is they can advertise their houses in the newspaper. The newspaper they can go for a daily newspaper and Sunday newspaper, or they can go for advertising on the radio, sorry advertising on the radio.

For each advertising medium, the number of potential customers reached is given in terms of number, say if you go for daytime TV. So, you can reach 1000 people thousand customers like evening TV 2000. You see, on evening TV, we can reach more people using the newspaper category. If you advertise in the Sunday newspaper, the reach is 2500, and there is a cost for advertisement in terms of the dollar, then the maximum times available per month.

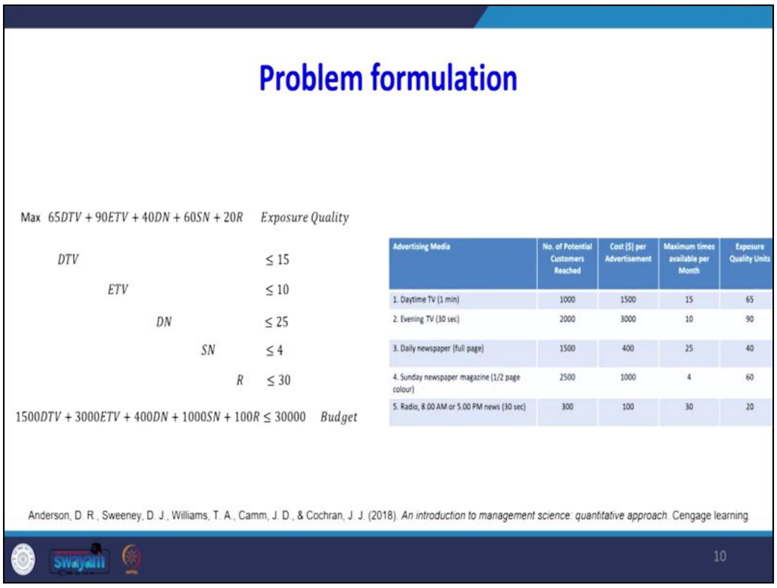
How often, for example, if you go for daytime advertisement only 15 times, you can advertise. Then, exposure quality units this is they are measured in terms of your scale. So, the higher the number it the more exposure. For example, if they advertise their homes in evening TV programs, there will be 90 exposure quality units. This is an index that was obtained. The higher the number, the better it is.



What are the constraints? At least 10 television commercials must be used. At least fifty thousand potential customers must be reached, and no more than 18000 dollars may be spent on television advertisements. The problem is what advertising media selection plan should be recommended to satisfy this constraint.



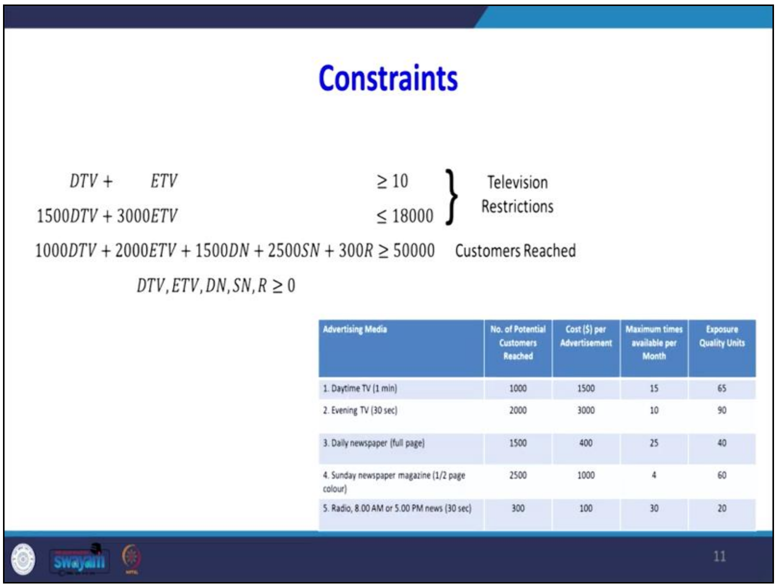
What are the decision variables day? Daytime TV, evening time, TV, daily newspapers, Sunday newspapers, and radio? So, DTV, ETV, DN, SN, and R number of times radio is used.



So, the problem definition is that first, you should go for what our objective function here is. The function we can increase is that we must increase the exposure quality units; otherwise, you can have. This is also in our objective function, with no problem, the number of potential customers reached because these two columns may be correlated because they are directly related.

However, in this problem, we are considering maximizing exposure quality. So, these are our decision variables. So, 65 daytime television, evening time television, daily newspapers, Sunday newspapers, and radio. So, DTV, ETV, DN, SN, and R are our decision variables and the time available is our constraint. For example, on daytime television, you can only go for 15 numbers. It is a frequency.

Evening time 10 daily newspapers, 25 Sunday newspapers, radio and the budget the budget is this column advertising budget. So, 1500 D TV, 3000 E TV that should not exceed your 30000 dollars that is given our problem.



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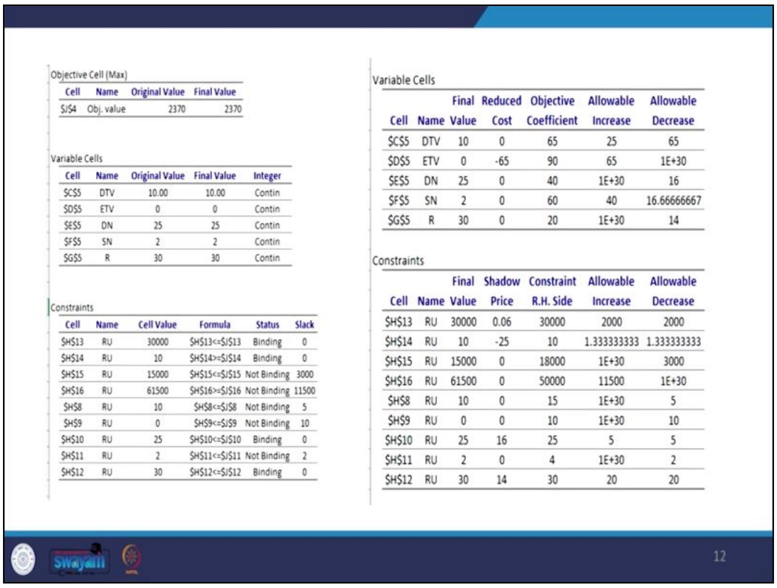
Now, let us form the constraint for televisions. What are they? The number of daytime advertisements and evening time advertisements on TV should be greater than or equal to 10, and the amount spent on television, whether it is daytime or evening time, should be less than equal to 18000 dollars. Another constraint is that we have to go for more than 15,000 customers. So, when you go for the time, see that we can reach 1000 customers in the evening time 2000, 2500, 2500, 300 it should be greater than equal to 50000. These are nonnegativity constraints.



Objective Cell (Max)

Cell	Name	Original Value	Final Value
$J$4	Obj. value	2370	2370

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$C$5	DTV	10.00	10.00	Contin
$D$5	ETV	0	0	Contin
$E$5	DN	25	25	Contin
$F$5	SN	2	2	Contin
$G$5	R	30	30	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$H$13	RU	30000	$H$13<=$J$13	Binding	0
$H$14	RU	10	$H$14>=$J$14	Binding	0
$H$15	RU	15000	$H$15<=$J$15	Not Binding	3000
$H$16	RU	61500	$H$16>=$J$16	Not Binding	11500
$H$8	RU	10	$H$8<=$J$8	Not Binding	5
$H$9	RU	0	$H$9<=$J$9	Not Binding	10
$H$10	RU	25	$H$10<=$J$10	Binding	0
$H$11	RU	2	$H$11<=$J$11	Not Binding	2
$H$12	RU	30	$H$12<=$J$12	Binding	0

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$C$5	DTV	10	0	65	25	65
$D$5	ETV	0	-65	90	65	1E+30
$E$5	DN	25	0	40	1E+30	16
$F$5	SN	2	0	60	40	16.66666667
$G$5	R	30	0	20	1E+30	14

Constraints

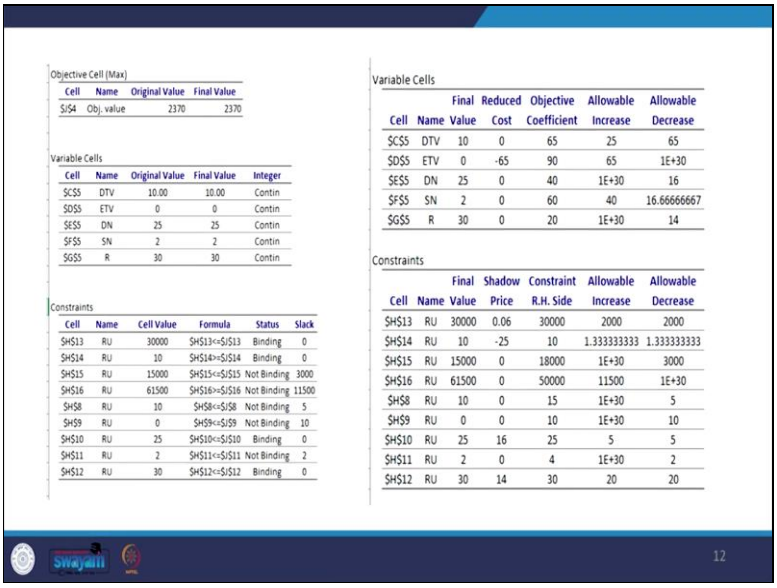
Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$H$13	RU	30000	0.06	30000	2000	2000
$H$14	RU	10	-25	10	1.333333333	1.333333333
$H$15	RU	15000	0	18000	1E+30	3000
$H$16	RU	61500	0	50000	11500	1E+30
$H$8	RU	10	0	15	1E+30	5
$H$9	RU	0	0	10	1E+30	10
$H$10	RU	25	16	25	5	5
$H$11	RU	2	0	4	1E+30	2
$H$12	RU	30	14	30	20	20

Now I have brought the screen shut off over the solution. Now, I will solve this problem by Excel.

Now, we can solve the formulated problem with the help of a solver. I have brought all the equations here on the right-hand side. I have formulated this as our decision variable where we will be getting the answer. This is the coefficient of our objective function. Here, I kept my objective function value. Here are the resources utilized as usual, which I have formulated with the help of the solver.

Now, I will solve it as a data solver because this is a maximization simple solution. I need to answer sensitivity analysis and limits. Now, I will go to the answer report. This answer report says that this is the answer to the question about daytime television: we should go for 10 numbers a day, time newspaper 25, Sunday newspaper 2 radio 30 times. We bring this here, and then we have some slack variables. There is a slack variable for some constant slack variables 0, but it is not 0 for some constraints.

Then, we can see the sensitivity analysis. In the sensitivity analysis, we can see the reduced cost, and then we can see the dual value under the shadow price column. Now, I will interpret this result.



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$F$5	SN	2	2	Contin
$G$5	R	30	30	Contin

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$H$16	RU	61500	$H$16>=$J$16	Not Binding	11500
$H$8	RU	10	$H$8<=$J$8	Not Binding	5
$H$9	RU	0	$H$9<=$J$9	Not Binding	10
$H$10	RU	25	$H$10<=$J$10	Binding	0
$H$11	RU	2	$H$11<=$J$11	Not Binding	2
$H$12	RU	30	$H$12<=$J$12	Binding	0

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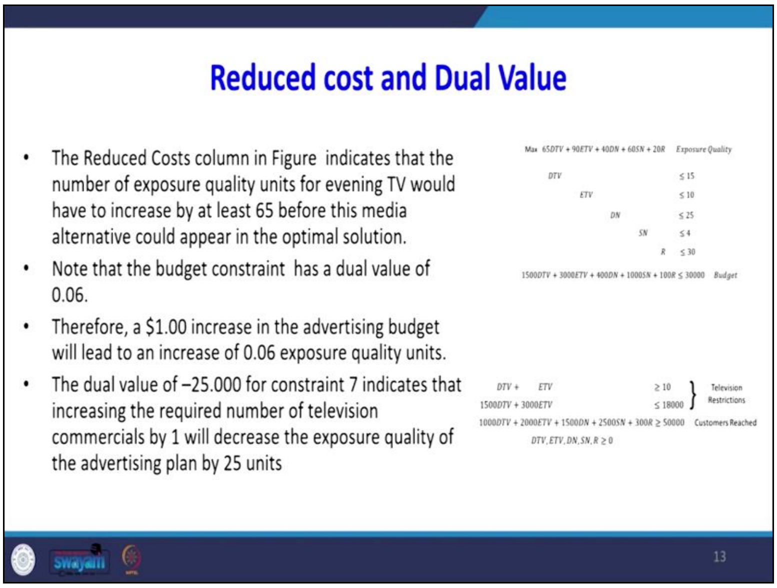
$H$8	RU	10	0	15	1E+30	5
$H$9	RU	0	0	10	1E+30	10
$H$10	RU	25	16	25	5	5
$H$11	RU	2	0	4	1E+30	2
$H$12	RU	30	14	30	20	20

I have attached a screenshot of our output so you can look at this objective function value. So, 2370 has a maximization type, and we can get the answer, say, the final value by looking at this DTV 10, 25, 2, 30. Then we can see the Slack lesson, which is equal to Slack. This is surplus variable zero less than or equal to slack is 3000, surplus variable 11500, and so on. There is also a slack variable 2. Sorry for slack values 5, 10, 0, 2.

Here, we can see the reduced cost. I will interpret this as -65, and. Then, we can get to the dual shadow price, and both are the same. Then, there is an allowable increase and allowable decrease. Now I will interpret this answer in detail.



First, you will explain the reduced cost, and I will interpret the dual value. The reduced cost column in the figure indicates that the number of exposure quality units for evening TV would have to increase by at least 65 before this media alternative could appear in the optimal solution. So, we will go back here and look at this. We are getting reduced costs -65. The reduced cost is - 65.

So, what does that mean that to get some positive value, you see that the final value is 0 to get some positive value on evening time television in your objective function? So, the T the 65 has to be added so that you will get some positive final value. So, what is our objective function? Here, you can see that we are discussing television in the evening. Yes, this is evening time television along with 90. If you add 65, then we will resolve the problem, and you will get some solution and some value for your number of evening-time television advertisements.

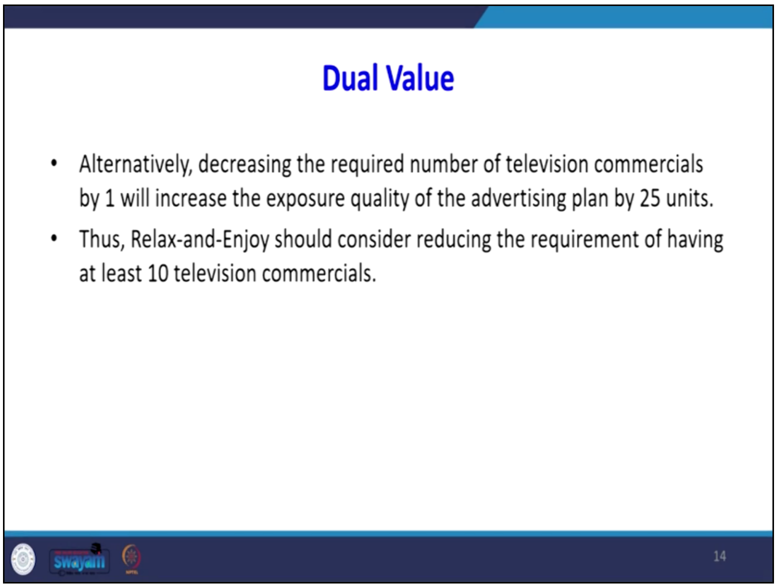
Note that the budget constraint has a dual value of 0.06; therefore, a one-dollar increase in the advertising budget will lead to an increase of 0.06 exposure quality units. I will explain the meaning of reduced cost and dual value from our Excel output. The reduced cost column in the figure, which is in the previous slide, indicates that the number of exposure quality units for evening TV we used E TV evening time TV would have to increase by at least 65.

For example, here, this exposure quality right has to be 90 plus 65, which would have to increase by at least 65 before this media alternative could appear in the optimal solution. At present, it is not the optimal solution. If you want to have some value for that evening time television, the coefficient of this one has to be increased by 90 plus 65, that is the meaning of reduced cost.

Then when we see the dual value for the budget constraint, it is 0.06, it will go back to dual value for the budget constraint is 0.06 one; therefore, a one-dollar increase in the advertising budget will lead to an increase of 0.06 exposure quality units because this is a less than or equal to time than the dual value of - 25 for constraint 7. Where is this - 25? When you go back, this is your minus 25. Then, look at the constraint type H14. Yes, this is greater than or equal to type.

As I told you, if it is a binding constraint, if the binding constraint is greater than or equal to type, if you add one resource, that will deteriorate your solution. What is the deterioration here, it is an objective function that has to be maximized. So, now the dual value is -. So, when you add one more advertisement on the right-hand side, when you add one more unit on the right-hand side, your objective function will decrease by 25 units.

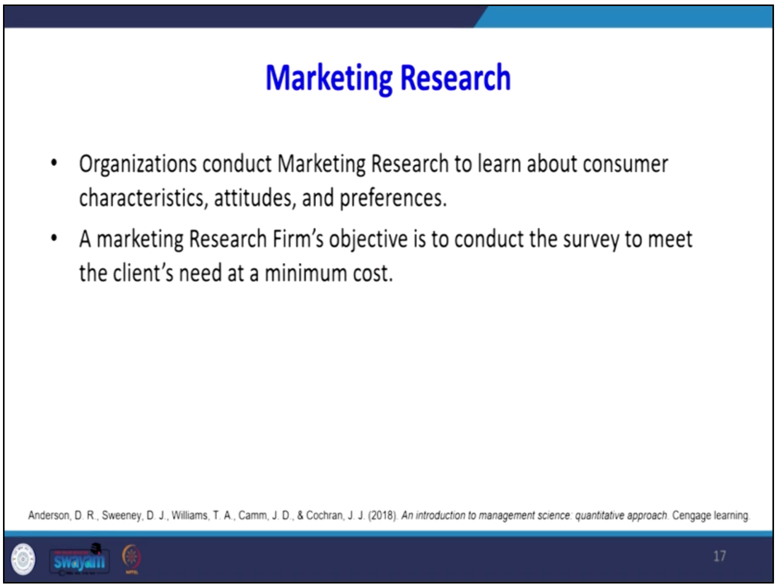
So, the dual value of - 25 for constraint 7 indicates that increasing the required number of television commercials by one unit will decrease the exposure quality because it is a negative dual value that will decrease the exposure quality of the advertising plan by 25 units.



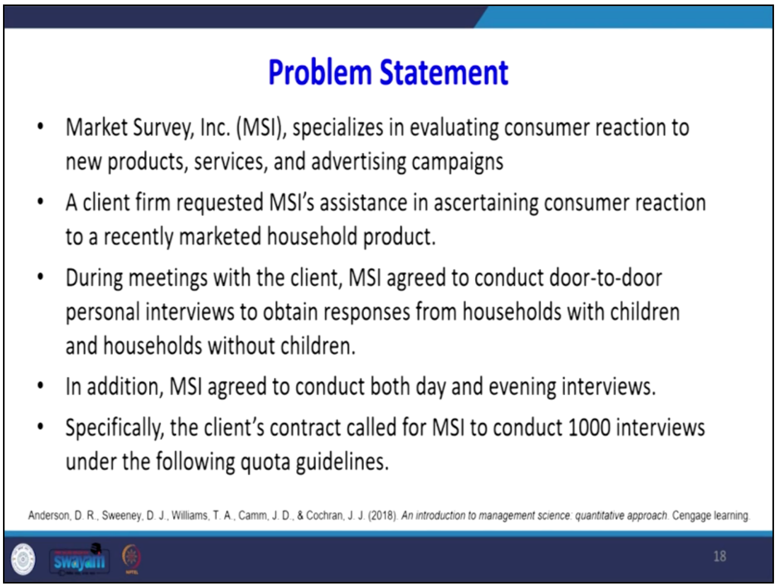
Alternatively, decreasing the required number of television commercials by one unit will increase the exposure quality of the advertising plan by 25 units. Thus this company relax and enjoy should consider reducing the requirement of at least 10 television commercials. So, what do they have to do with this constraint? We are talking about this because it is greater than or equal to type. It is a binding constraint. If you add, that will deteriorate the solution, and when you decrease, that will improve the solution. So, instead of 10, they should go for 9. If they go for 9, our exposure quality will maximized.

This is our final advertising plan. So, what this advertising plan says is to go for 10 frequency during day time. So, we know the budget for one unit. So, it will be consuming 15000 daily newspapers 25 then 10000 Sunday newspapers, 2 radio 30. So, our exposure quality will be 2370. The total number of customers reached when you multiply by for because, for each frequency, we have the number. When you multiply that, you will get we can reach 61500 customers.

We have seen the media selection problem. Now we will go for another problem, which is marketing research, where we can use our LPP for solving a marketing research problem.



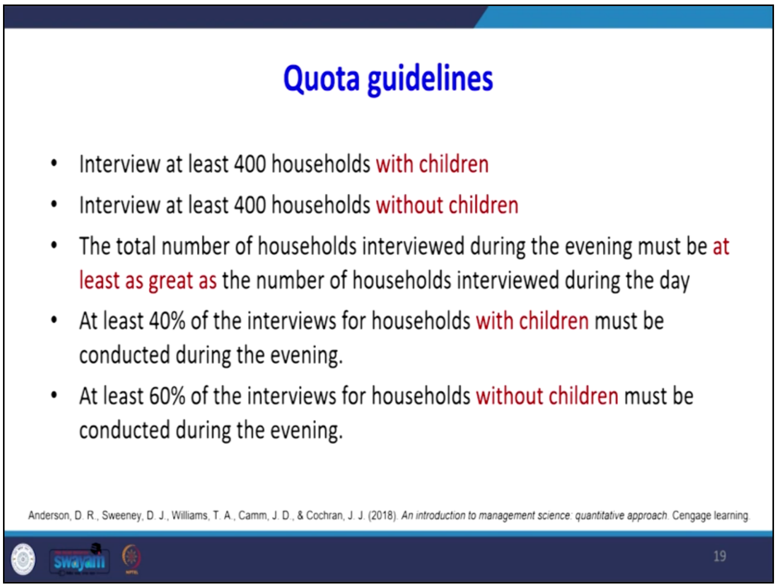
What is a marketing research? Organizations conduct marketing research to learn about consumer characteristics, attitudes, and preferences. So, in this context, your marketing research firm's objective is to conduct a survey to meet the client's needs at a minimum cost. So, here the cost has to be minimized. In the previous problem, we have maximized our objective function.



Problem statement Marketing Survey Company MSI specializes in evaluating consumer reactions to new products, services, and advertising campaigns. A client firm requested MSI's assistance in ascertaining consumer reaction to a recently marketed household product. So, the company has introduced a household product, they want to know the reaction of the customers, so with the help of a marketing research company.

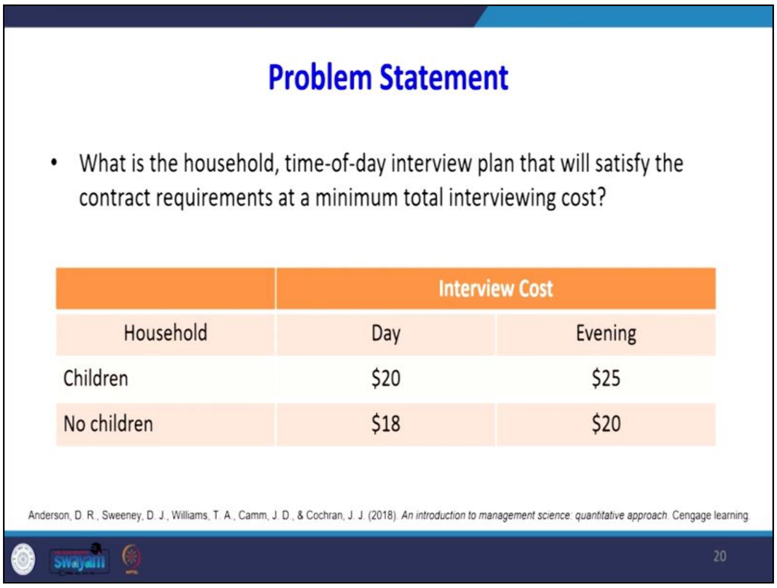
During a meeting with the client, this marketing research company agreed to conduct door-to-door personal interviews to obtain responses from households with children and households without children. So, they are giving they are planning to conduct an interview with households having children and households without children. In addition, the marketing company agreed to conduct both day and evening interviews.

Specifically, the client's contract called for this marketing research company to conduct 1000 interviews under the following quota guidelines. Quota sampling is one of the sampling techniques for collecting data on what that quota is.



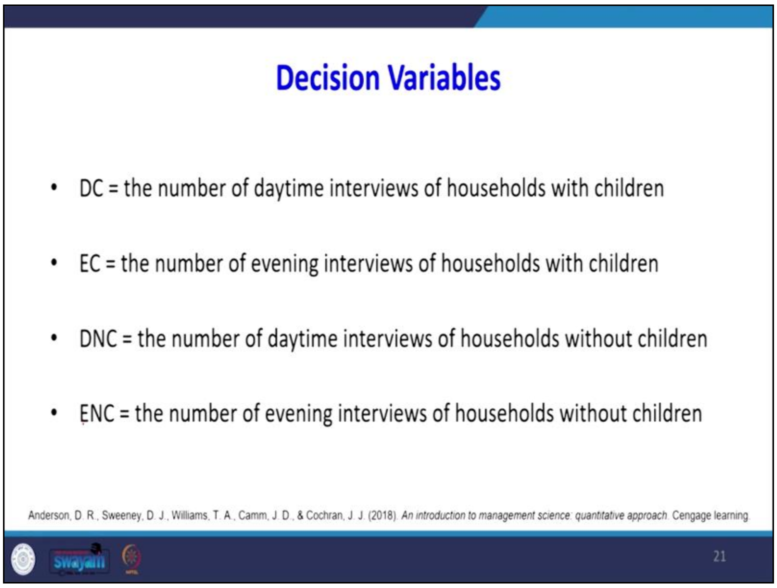
What are the quota guidelines for interviewing at least 400 households with children? That is the first requirement. Another requirement is to interview at least 400 households without children. Next one the total number of households interviewed during the evening must be at least as great as the number of households intruding during the day. Next at least 40% of the interviews for households with children must be conducted during the evening.

Another one is that at least 60% of the interviews for households without children must be conducted during the evening. These are the guidelines. So, by considering this guideline, I will go for writing the constraints.

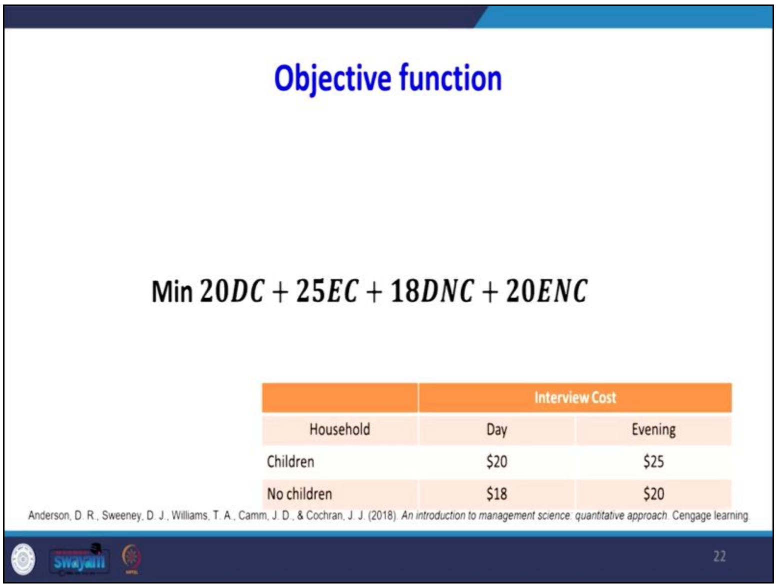


So, now, what is the problem statement? What is the household time of the day interview plan that will satisfy the contract requirements at a minimum total interviewing cost? So, the company is looking to minimize this marketing research cost. So, what are the different combinations of daytime and evening? time, they have to interview households where there are children and no children.

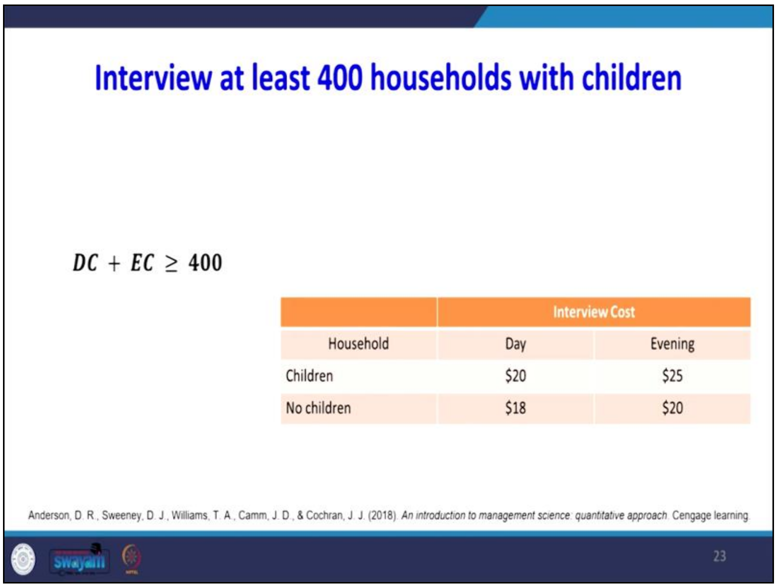
So, there are possibility days. So, we can name it DN, DC day children this is evening children this we can name it day no children this evening no children.



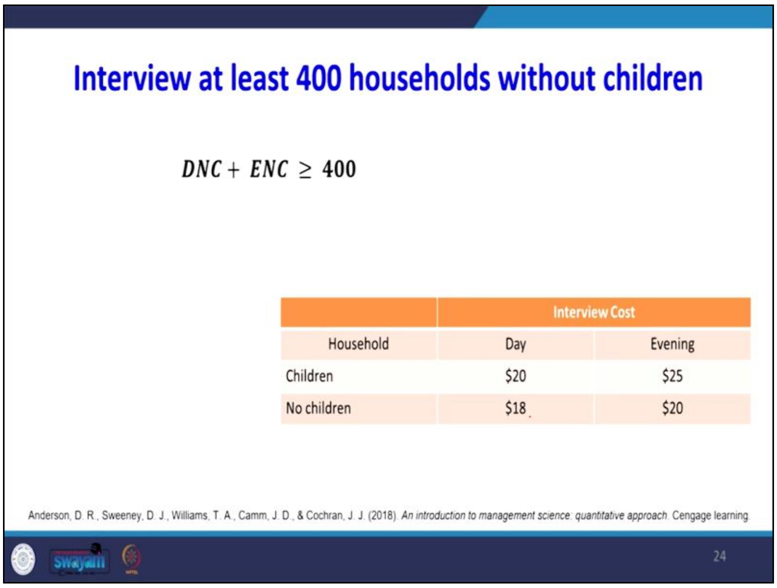
So, we have four decision variables: DC EC, DNC ENC. I have explained in the previous slides what are the decision variables.



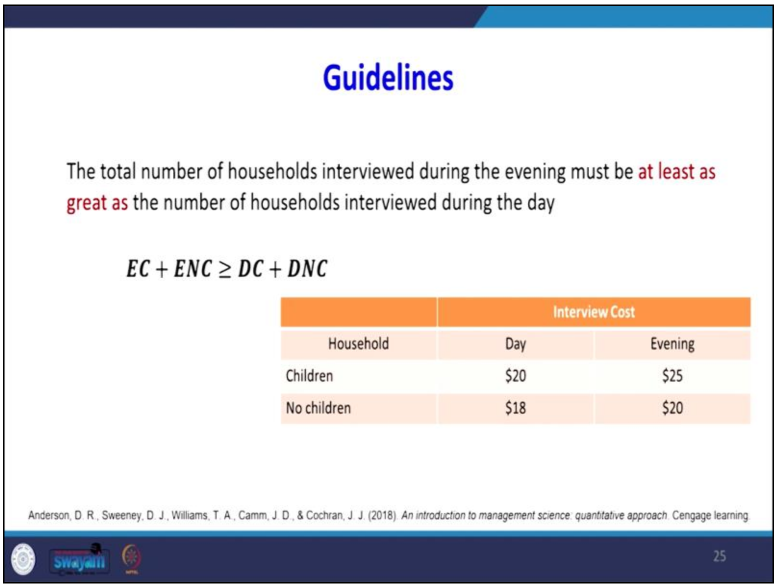
The first objective is to know the cost. For example, DC is 20 dollars. So, this has come here, then, easy evening interviewing costs during evening time in a household with children. So, 25 this one, 25 this has come here, then 18, then this is 20. So, here, we must minimize the total marketing research cost.



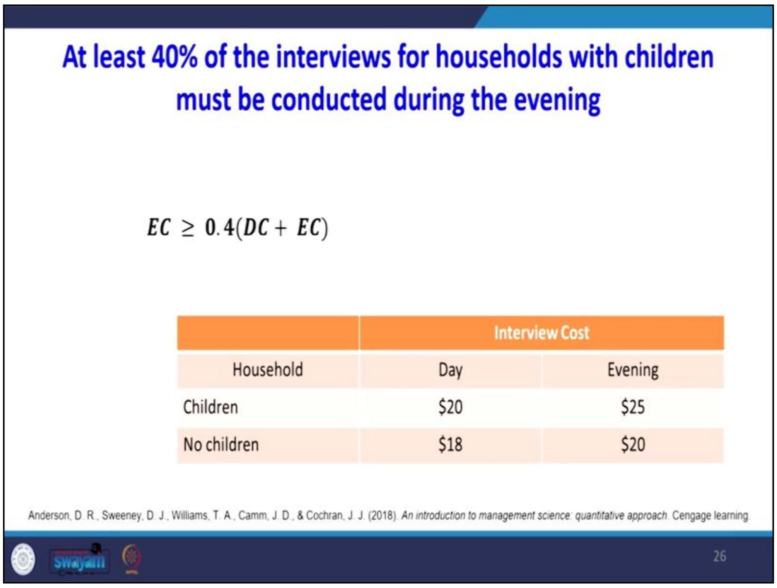
Another guideline is to interview at least 400 households with children. So, with children these two combinations. So, DC and EC should be greater than or equal to 400.



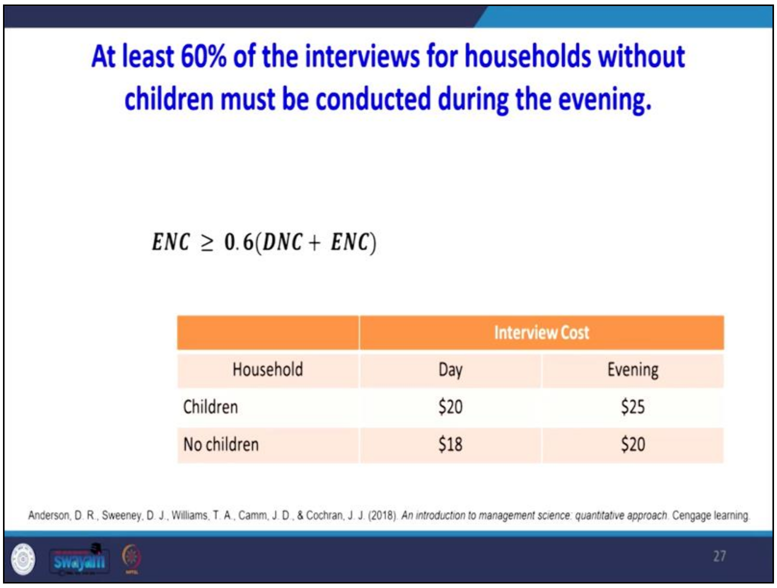
Another constraint is interviewing at least 400 households without children; similarly, here, DNC ENC should be greater than 400.



Next constraint the total number of households interviewed during the evening must be at least as great as the number of households interviewed during the day what is that that one evening this one this portions EC and ENC >= DC + DNC. So, that means the company is expecting during evening time interview a greater number of evening time interviews should be conducted whether the household with children or without children.

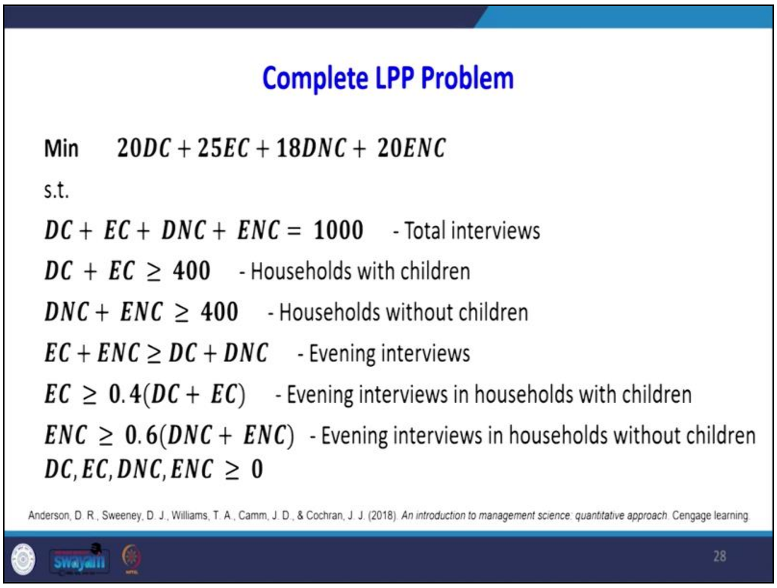


The next constraint, at least 40% of the interviews for households with children must be conducted during the evening. So, evening household with the children should be greater than equal to 0.4 40% of daytime household with children plus evening time household with children. So, that is why zero point easy that should be greater than ok EC should be greater than equal to 0.4 DC plus EC.



The next constraint, at least 60% of the interviews for households without the children must be conducted during the evening. So, evening no children should be greater than or equal to 60% of day time no children plus evening time no children.

So, that is ENC >= 0.6 (DNC + ENC).

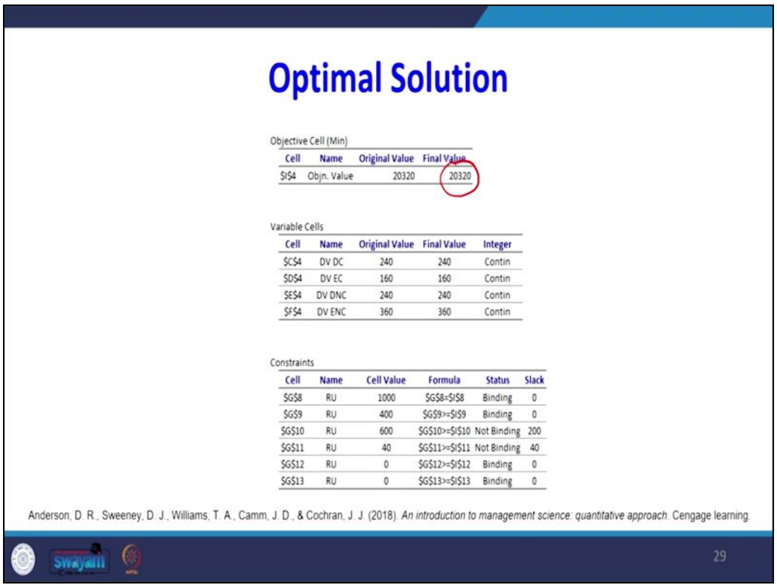


Now I have brought up the complete problem. So, the objective function is the minimization type. The total interview number of interviews should be 1000. This is equal to the type this household with the children should be greater than 400. Households without children should be greater than equal to 400, and evening-time interviews should be greater than equal to daytime interviews.

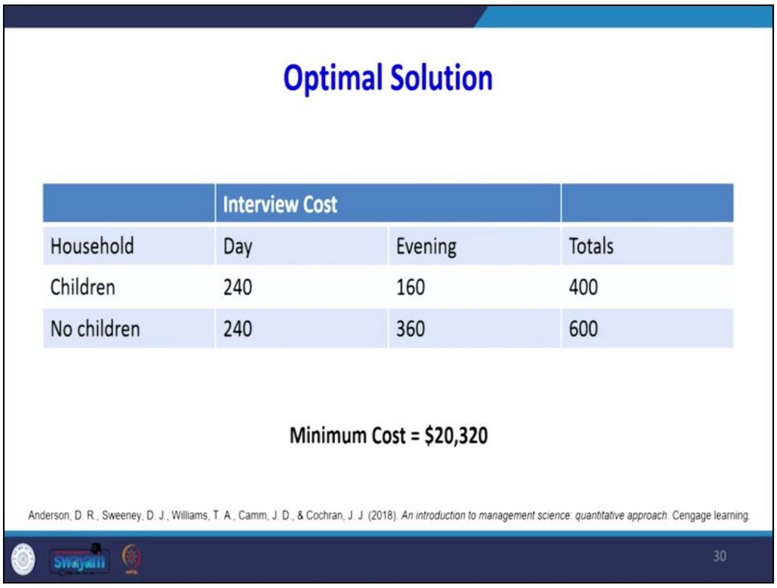
Evening interviews with households with children are even introduced to the world without children. Now, this problem is going to be solved with the help of a solver.

Now I have brought this our complete LP problem then I have formulated an excel. So, this is the decision variable where we are going to get the answer coefficient objective function. So, as usual, I have a formulator. Now I will go for solving this problem data solver. So, this is why you should be very careful. This is a minimization type because the cost has to be minimized. So, you have to select the minimization change in the cell as same, then we have taken all the constraints.

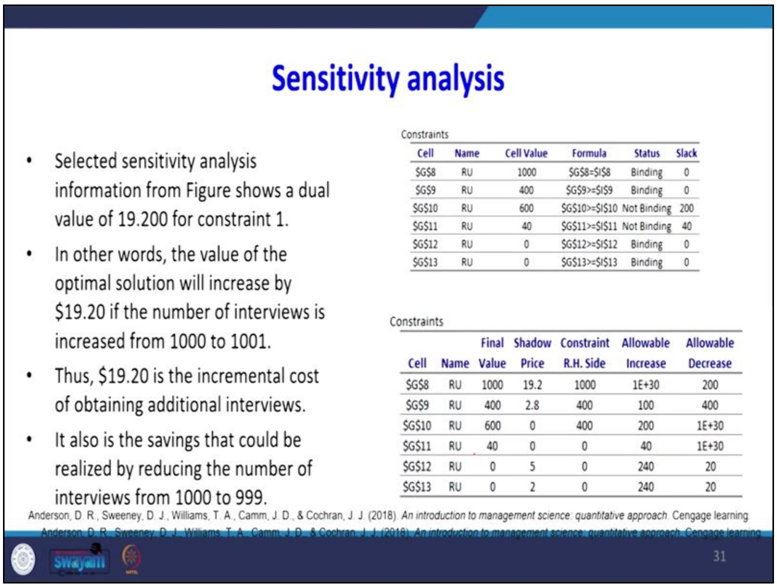
So, one constraint is equal to type, and all other constraints are greater than or equal to type when you solve it correctly. So, I need to answer and so sensitivity and limits when you solve it. So, what are we getting? So, we should household we should go for 240 interviews per day time with child households with the child. The second one is evening time with a child, so 240 interviews should be conducted in time with households with no children.



Now, this is our objective function value of 20320 dollars. So, this is the number of interviews that should be conducted: 240 160, 240, and 360. This is the decision variables: daytime with children, evening time with children, day with no children, and evening time with no children. Then, here, we can see that the slack variable is there. It is a surplus variable. So, because it is a surplus variable why we are calling it surplus variable. Look at the sign of this constraint all are greater than or equal to type ok surplus will interpret this result.



So, this is our optimal solution. So, what you have to do is go for 240 daytime households with children, 160 evening-time households with children, and a total of 400 with no children 600. That will minimize your total market research cost.



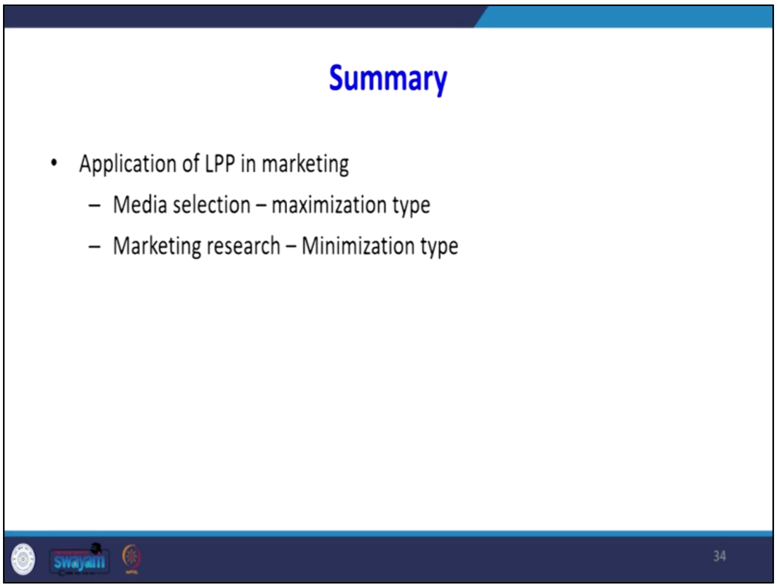
Now, let us interpret the sensitivity analysis. So, the sensitivity analysis information from the figure shows the dual value of 19.2. So this one is 19.2 for constraint number one. In other words, the value of this optimal solution will increase by 19.20 if the number of interviews is increased from 1000 to 1001 because it is equal to type. When you increase one unit, your objective function will increase our objective function, which is the minimization of cost.

So, when the number of interviews is increased from 1000 to 1001. So, the overall cost will increase by 19.2; thus, 19.20 dollars is the incremental cost of obtaining additional interviews. It is also a saving that could be realized by reducing the number of interviews from 1000 to 999. The surplus variable with a value of 200 is a surplus variable. This is why we are calling it. It is constraint is greater than or equal to type.

The surplus variable with the value of 200 for constraint 3 shows that 200 more households without children will be interviewed than required. That is, we have interviewed 200 additional units and additional sampling units than what is required. Similarly, the surplus variable with a value of 40 40 for constraint 4 shows that the number of evening interviews exceeds the number of date-time interviews by 40.

Because it is greater than or equal to type, we have achieved more than what is required. So, where we are getting this information from this column where this is slack surplus. The 0 value for the surplus variable in constraints 5 and 6 here indicate that the more expensive evening interviews are being held at a minimum. So, we should not go for more evening time interviews. Indeed, the dual value of 5 ok here the dual value for constraint 5 indicates that if there is one more household with children, then the minimum requirement must be interviewed during the evening.

The total interview cost will go up by 5. Similarly, constraint 6 shows that requiring one more household without children to be interviewed during the evening will increase the cost by two dollars, which is the way of interpreting the sensitivity analysis.



So, in this lecture, we have discussed the application of linear programming problems in the marketing area. We have taken two problems. One problem is media selection, and that problem is the maximization type. Then, with the help of a solver, we interpreted the result. The second problem is marketing research, which is our minimization type. We formulated the problem and solved it with the help of an Excel solver, and then we interpreted the result; thank you very much.