Decision Making with Spreadsheet
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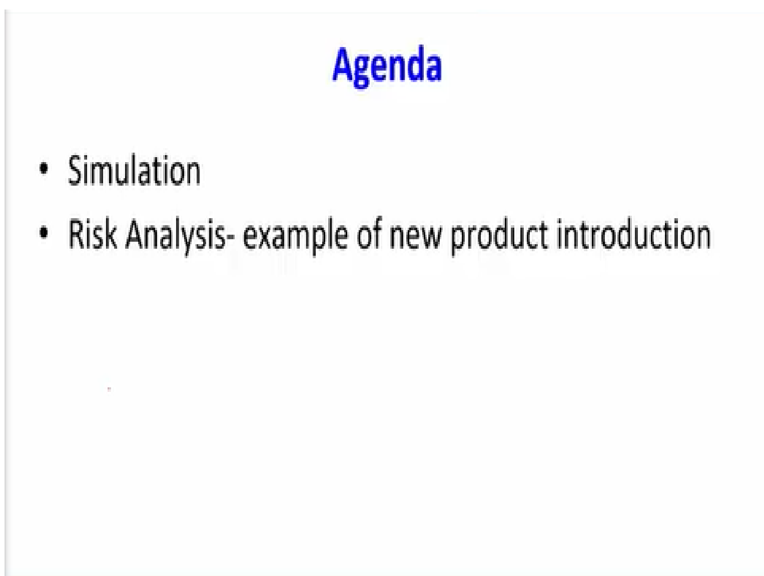
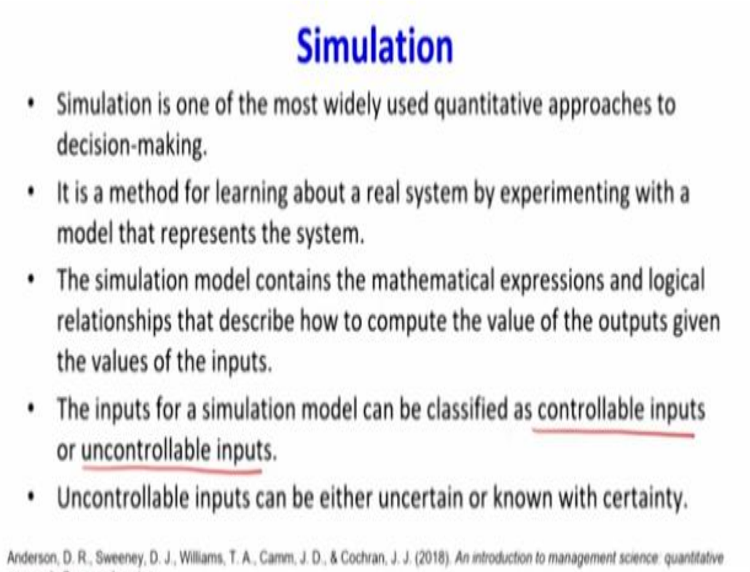
Lecture - 41
Financial Risks Associated with the Development of a New Product - I

Dear students, today I am going to discuss a new topic called simulation. In this lecture, I am going to explain how to use your Excel for doing the simulation. I have taken one example, which is the introduction of a new product. So, the example says, if you are introducing a new product, what is the probability of success? This is a very common problem for your business. So, this problem we are going to solve with the help of excel.

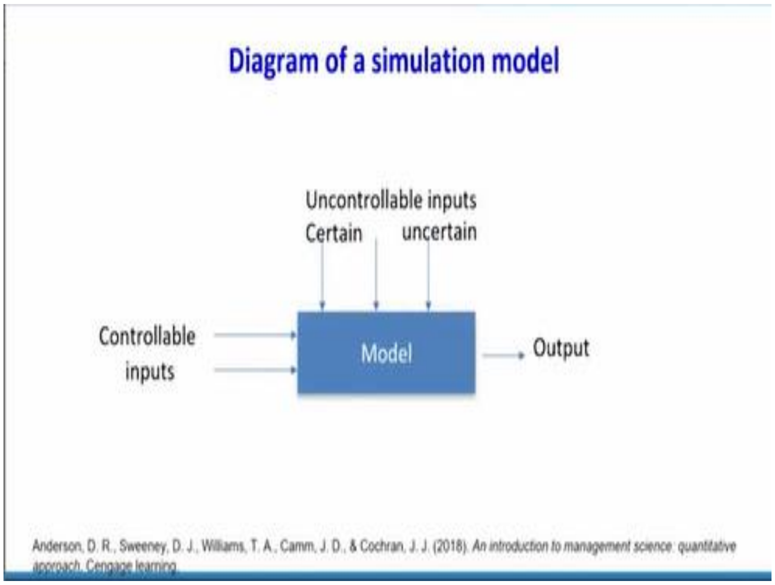


The agenda for this lecture is, first, we will introduce what the simulation is, some basic concepts, and some very common applications. After that, I will explain the concept of risk analysis. What is the risk here if a company is introducing a new product? What is the possibility of success? How much risk is there for launching or introducing a new product? That is an example that you will solve in this lecture.



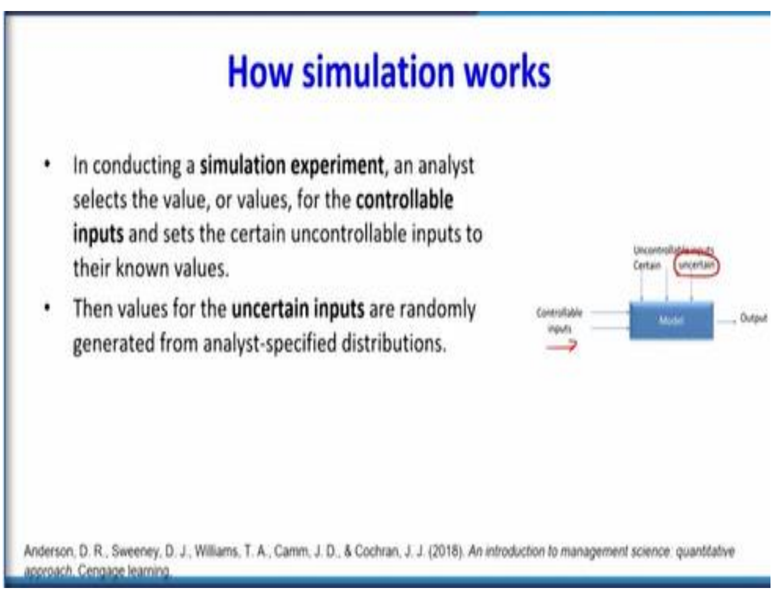
First, we will explain what simulation is. So, simulation is one of the most widely used quantitative approaches to decision-making. It is a method of learning about a real system by experimenting with the model that represents the system. So, we are going to consider a model, that model will represent the real system. A simulation model contains a mathematical expression and logical relationship that describes how to compute the value of outputs given the value of the inputs.

So, we are going to consider a mathematical model because the model can be in any form. It may be geometrical modelling also, but here we are going to consider a mathematical model. The inputs for the simulation model can be classified into two categories: controllable inputs and uncontrollable inputs. So, uncontrollable inputs can be either uncertain or known with certainty. The latter part of the lecture will explain what this controllable, uncontrollable input is.



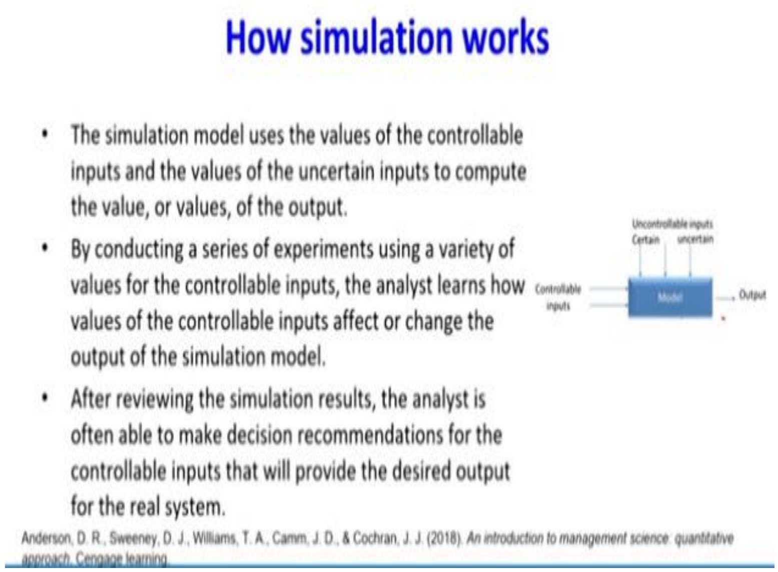
If I look at this picture, you see there is a right-hand side, there is output; there are controllable inputs. Controllable input is the decision that you are going to take; suppose launching a new product, it has to be launched or not. That is a controllable input. So, when launching new products, there are many variables that are not in your hand that may be certain or uncertain. If it is certain, there is no problem, but if it is uncertain, that is the case where we need the concept of simulation.

If the inputs are uncertain, how is that going to affect our output? That is the purpose of this lecture.



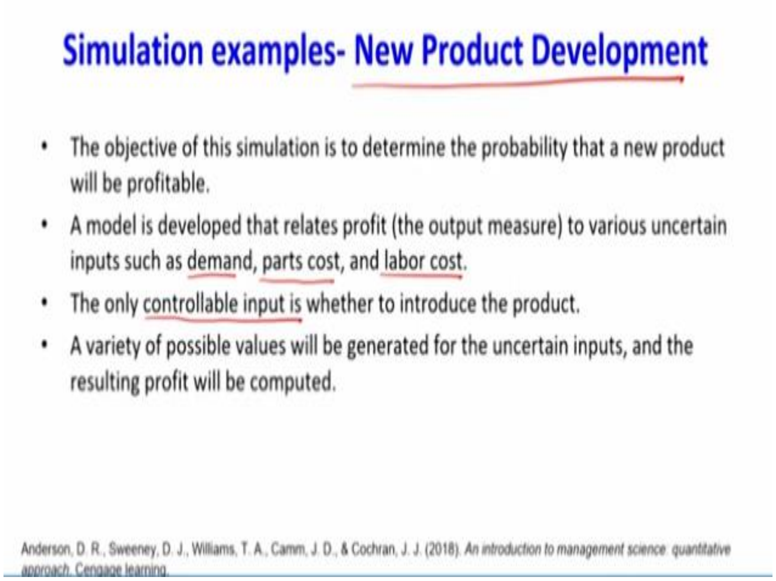
How does simulation work? In conducting a simulation experiment, an analyst selects the value or values for the controllable inputs and sets certain uncontrollable inputs to the known values. So, here we know the controllable inputs, and we are going to assume the values for uncontrollable inputs. Then, the values of uncertain inputs are randomly generated. Here, these uncertain inputs may follow any distributions.

It may be empirical; it may be uniform, or it may be a normal distribution. So, it is randomly generated from an analyst-specified distribution. So, we need to know in advance what this input follows, what kind of distribution, whether it is uniform, and whether it is normal.



The simulation model uses these controllable inputs and the value of uncertain inputs to compute the values of the output. So, the simulation model will use these uncertain inputs to get the values. By conducting a series of experiments using a variety of values for controllable inputs, the analyst learns how values of controllable inputs affect and change the output of the simulation model.

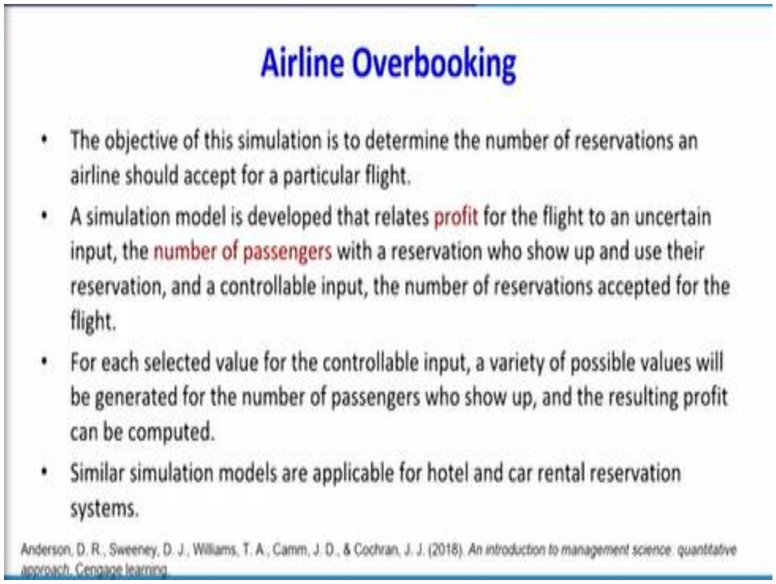
So, we are going to see how these controllable inputs are going to affect the output of the model. After reviewing the simulation result, the analyst is often able to make decisions and recommendations for the controllable inputs that will provide the decided output for the real system. So, we will be considering various inputs, so for what range of inputs we are giving, we are getting the best output. So, that controllable input is our solution for the simulation.



So, the objective of this simulation is to determine the probability that the new product will be profitable or not. So, here we are going to consider this example of new product development. So, we are going to see the probability of success; a model is developed that relates profit to various; the profit is here output measures to various uncertain inputs such as demand, part cost, and labor cost.

So, in this example, we are going to consider three uncertain inputs, which may be the demand for that product. Obviously, demand cannot be fixed, value of demand we may not know in advance. And then, there is a variability of the part cost, same material cost and there is variability in the labour cast. So, these are the three inputs. The only controllable input is whether to introduce the product or not.

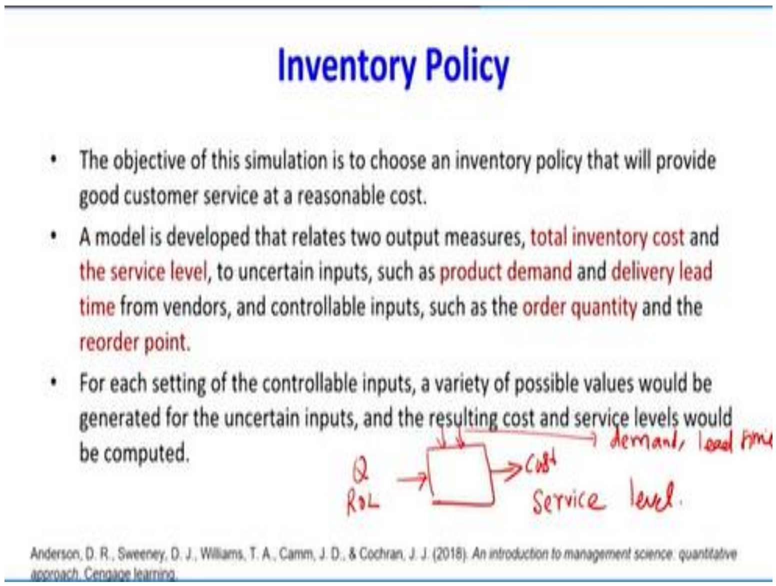
Here, this decision of whether we should introduce the product or not is our controllable input. What are the uncontrollable inputs? Demand, part cost, and labor cost. So, a variety of possible values will be generated for the uncertain inputs; that is, your demand, part cost, labor cost, and resulting profit will be computed.



Like this, there are so many applications of simulation. Another example is another application of simulation is airline overbooking. You might have seen the ticket fair. Sometimes it is higher, sometimes it is lower. So, there they use the concept of simulation; how do they use it? So, the objective of this airline simulation is to determine the number of reservations an airline should accept for a particular flight.

A simulation model is developed that relates the profit for the flight to an uncertain input and the number of passengers with the reservation who show up and use their reservation, and a controllable input is the number of reservations accepted for the flight. For each selected value of controllable inputs, a variety of possible values will be generated for the number of passengers who show up, and the resulting profit can be computed.

This similar type of model, simulation models, is applicable for hotel and car rental reservation systems. This is our second application.

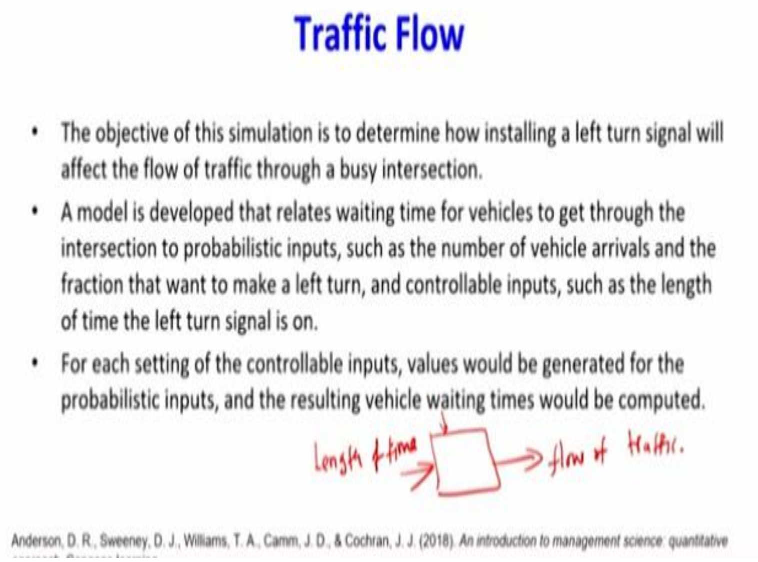


So, the third application is inventory policy. We will be solving this problem as an inventory policy. The objective of this simulation is to choose an inventory policy that will provide good customer service at a reasonable cost. In the previous lecture, we have studied different inventory policies. Whenever the demand is probabilistic in nature, then we can use the concept of inventory for simulation.

A model is developed that relates two output measures; what are they? Total inventory cost and service level. This is due to uncertain input from vendors regarding product demand and delivery lead time. Controllable inputs such as order quantity and reorder points. So, for each setting of controllable inputs, a variety of possible values would be generated for uncertain inputs, and then the resulting cost and service levels would be computed.

So, here, the output of the model is cost and service level. What are the inputs? We can say product demand delivery lead time. So, here we can say these are the uncontrollable inputs; what are they? Product demand and delivery lead time. What are the controllable inputs? What should the order quantity and reorder level be? Quantity to be ordered and reorder level are controllable inputs. What are the uncontrollable inputs?

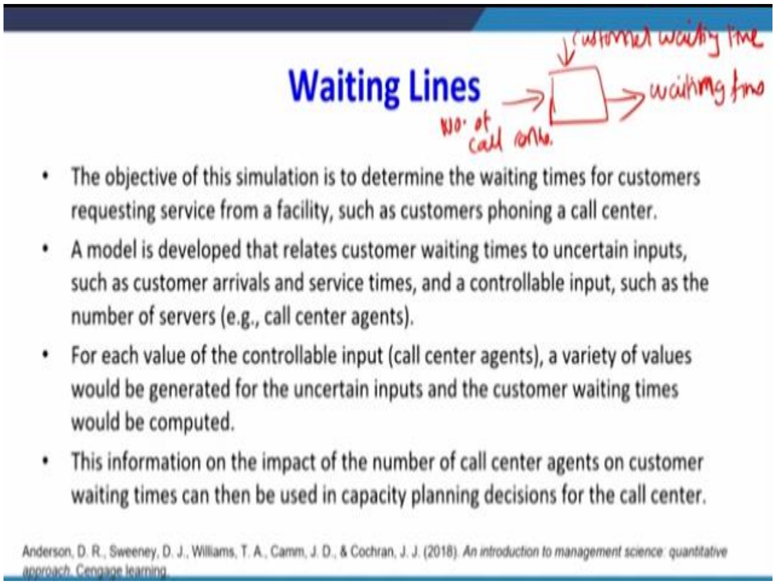
These are not in the hands of the decision maker; one is the product demand, here I am writing, and the other one is lead time. This is an inventory policy.



Another application of simulation is traffic flow. Here the objective of this simulation is to determine how installing a left turn signal will affect the flow of traffic through a busy intersection. A model is developed that relates the waiting time for vehicles to get through the intersection to probabilistic inputs, such as the number of vehicle arrivals and the fraction that they want to make a left turn.

The controllable input, such as the length of the time to the left turn signal, is on. So, here, the input is, and here, we can also consider controllable inputs and uncontrollable inputs. What are the controllable inputs? Length of the time for the left turn. What is the uncontrollable input? Waiting time is a probabilistic input. What is the output? The traffic, the flow of traffic. So, what will happen?

When the length of the left turn signal duration is high, what will happen the flow will be high; the flow of the traffic will be high. Because there will not be too much traffic. We can use simulation to analyse the traffic.

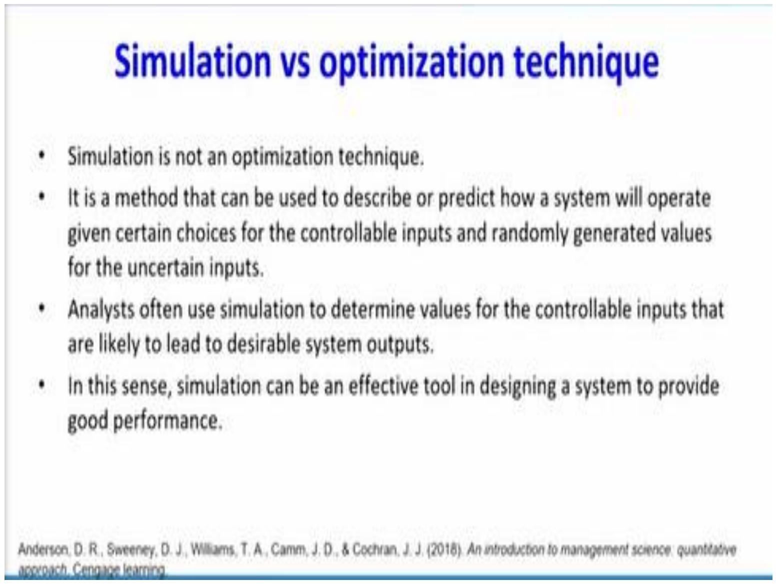


Another common example is the waiting line. Here we will be. After some lectures, we will also be studying this waiting line example. The objective of this simulation is to determine the waiting time for customers requesting service from a facility, such as a customer phoning a call centre. A model is developed that relates customer waiting time to uncertain input, such as customer arrivals and service times.

Controllable inputs, such as a number of servers. For each value of controllable inputs, a variety of values would be generated for uncertain inputs and the customer waiting time would be completed. This information on the impact of a number of call center agents on customer waiting times can be then used in capacity planning decisions for call centers. So, here is what we can see. This is a simulation model; here, we can see controllable inputs, uncontrollable inputs, and output.

What are the uncertain inputs of customer waiting time? Then, the customer arrival and arrival pattern are uncontrollable inputs. What are the controllable inputs? Call center agents, number of call center agents. What will be the performance measures of this model? The waiting time. What will happen? If you have a number of call centers and call agents, the customer waiting time can be decreased.

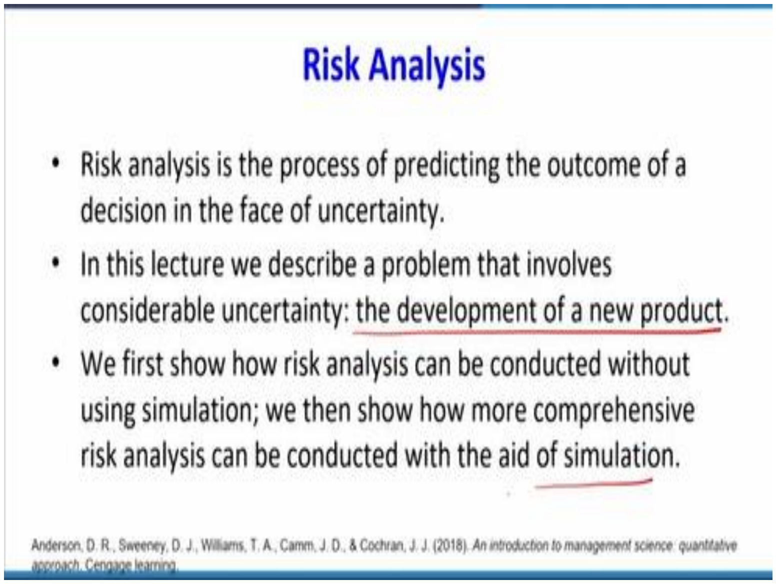
Because the customer does not need to wait for a longer time, people will not wait, and they will go to some other services. So, for waiting line applications also, we can use simulation. We will be taking one example here, for this waiting line problem also, then we will solve it with the help of Excel.



Another important point is simulation versus optimization techniques. Many times, people are confused about whether the result you are getting out of the simulation is an optimized solution or not. Here, the point is a simulation is not an optimization technique because, in every trial, you may get different results. So, you may not get the optimized values here. So, simulation is a method that can be used to describe.

Or predict how the system will operate given certain choices for the controllable inputs and randomly generated values for uncertain inputs. So, analysts often use simulation to determine the value of controllable inputs that are likely to lead to desirable system output. In this sense, simulation can be an effective tool in designing a system that provides good performance. In a waiting line example, what is a good performance?

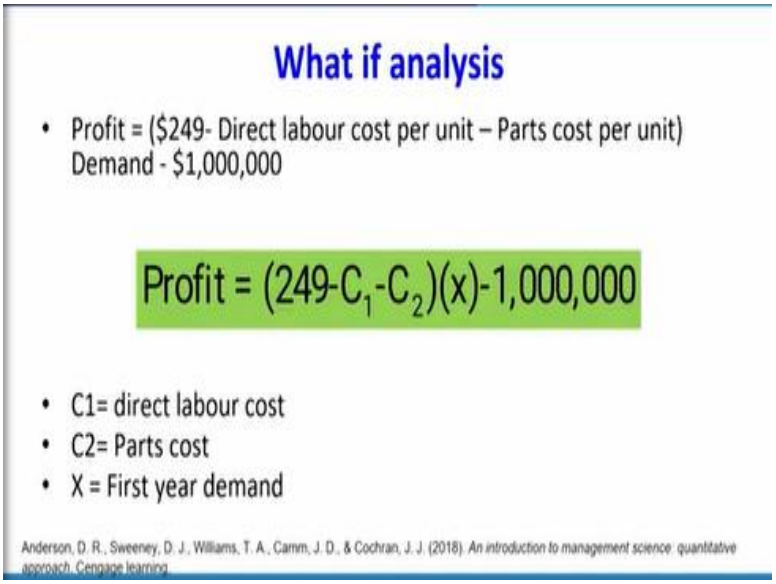
So, we should not ask the customer to wait, say more than two minutes or one minute; that is our good performance because, in a call center, if the customer is calling, he may not be willing to wait.



So, here, the example that I have taken in this class is risk analysis. What is the risk analysis? Risk analysis is the process of predicting the outcome of a decision in the face of uncertainty. In this lecture, we describe the problem that involves considerable uncertainty, that is the development of a new product. We first show how risk analysis can be conducted without using simulation.

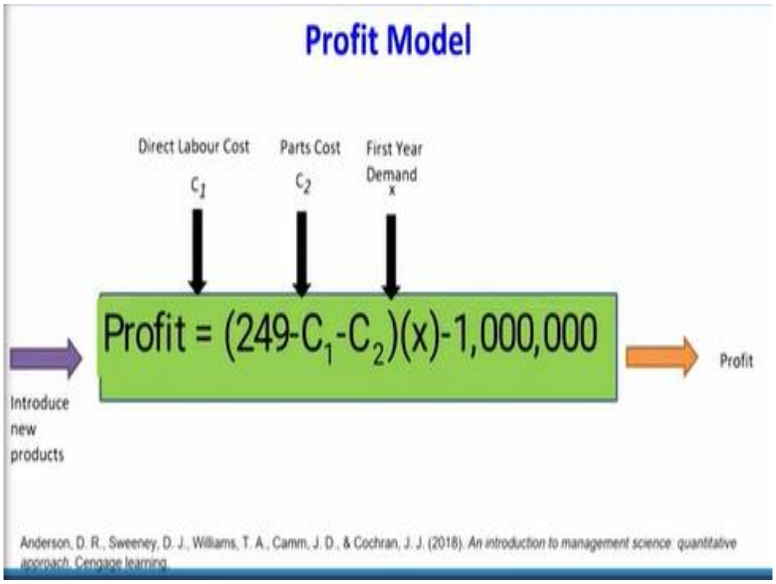
Then, we show how a more comprehensive risk analysis can be conducted with the aid of simulation. So, first we will go to doing the risk analysis without simulation.

So, I have taken one hypothetical example; this example is taken from the reference book by Anderson et al. A company is producing a portable printer, the selling price is 249 dollars per unit, the administrative cost is 400,000 dollars, and the advertising cost is 600,000 dollars. What are the probabilistic input direct labour cost? Labor cost is 45 dollars per unit, but it may vary. Another probabilistic input is part cost, 90 dollars per unit, but it may vary. Another probability input is the first year demand, demand is 1500 units.

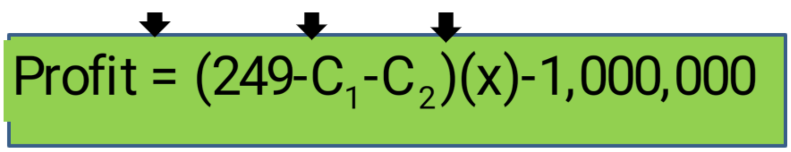


First, we will do what of analysis. So, we can write an equation for profit, what is the profit? The selling price is your 249 - direct labor cost - part cost per unit, the direct labor cost also per unit. The 249 dollars is the profit per unit. So, that will provide you the selling price - cost profit per unit. Then, you multiply by demand, which will give you the overall profit. Then, you have to subtract these other expenditures, overhead expenditures.

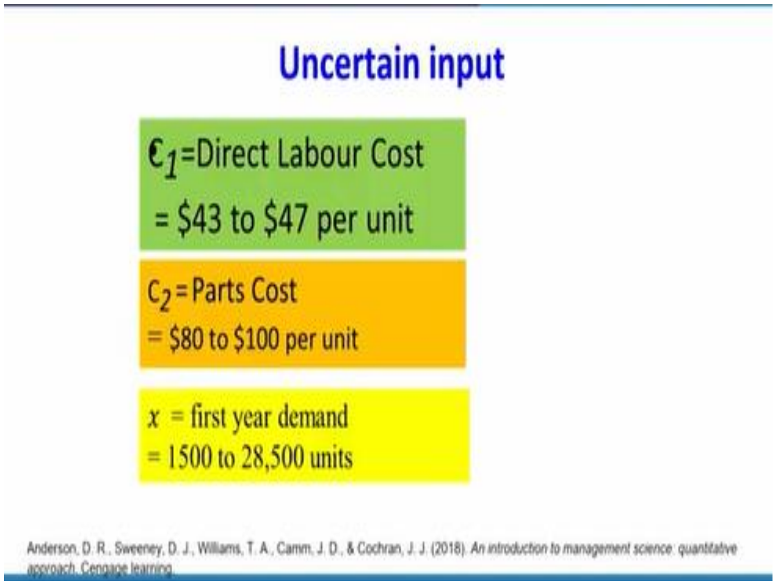
So, that is over 1,000,000 dollars. The expiration for profit is 249 - labor cost - podcast multiplied by demand - overall overhead expenditure. That is advertising cost and administrative cost.



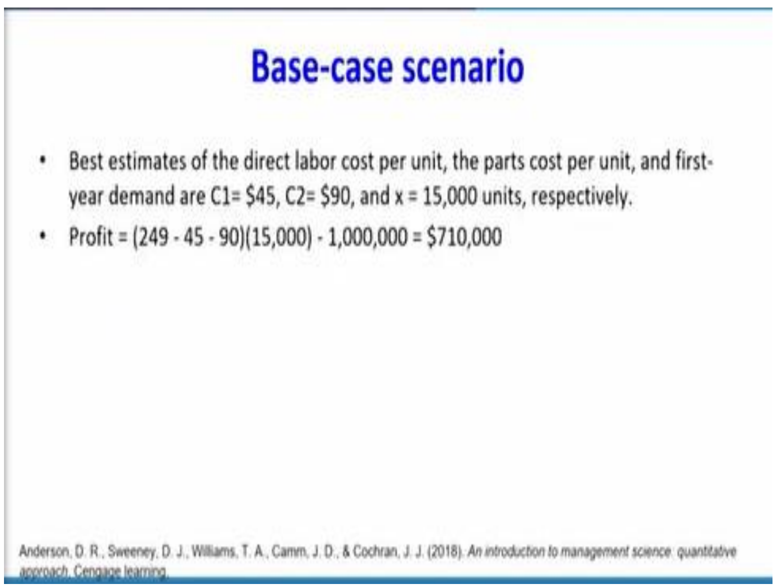
Now, first, I will explain the profit. What is this model? You see the controllable input is introducing new products, this is your controllable input. What are uncontrollable inputs, and are they probabilistic in nature? Labor cost, part cast, and first-year demand. So, the profit function can be written as 249 - C_1 - C_2 multiplied by demand - your overhead expenditure. So, that will give you the profit.



So, what we are going to learn from this model is, what will be the best case and worst case? Because, we are not going to talk about simulation, now first we will do without simulation.

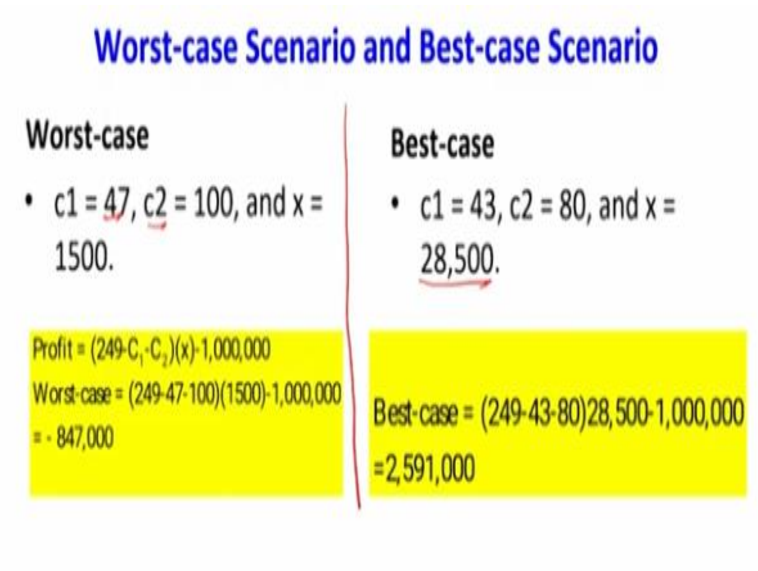


So, what are the uncertain inputs here? Labor cost, part cast, and the first-year demand.



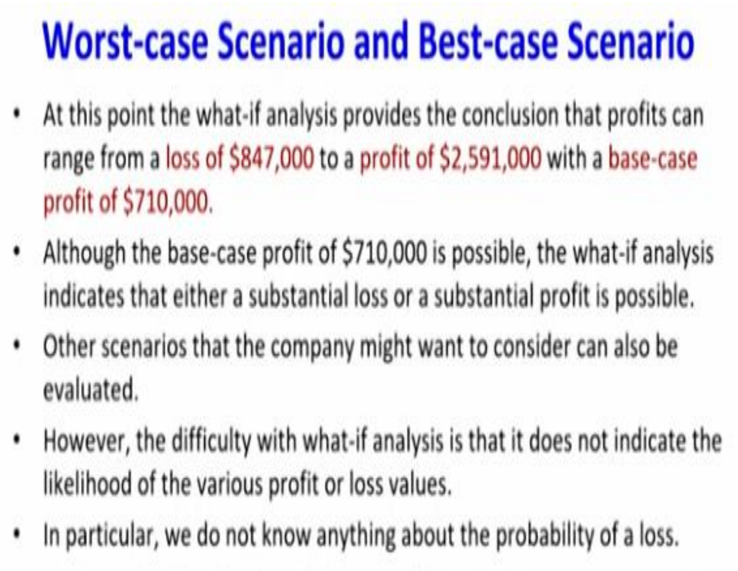
First, we will go for the base case scenario. So, the best estimate for the direct labor cost per unit, the part cost per unit that is C_1 and C_2 and x, that is demand is 45 dollars, 90 dollars, and 15,000 units. So, in the base case scenario, what will be the profit? 249 - 45 - 90 multiplied by demand - 1,000,000. So, you will be getting 710,000 dollars, which is your base case scenario.

Profit = (249 - 45 - 90)(15,000) - 1,000,000 = $710,000



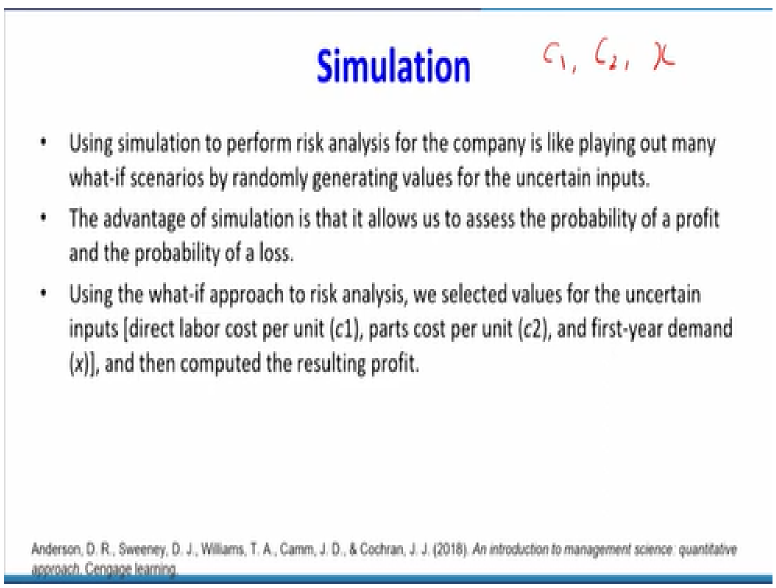
Then, we will go for worst case and best case. What is the worst case? The worst case is the highest possible value of your C_1 is 49, the highest value of your part cost is 100, and the lowest demand that is our worst case. So, when you substitute these values, how do we get 47 and 100? So, this provided the highest value of labor cost, the highest value of part cost, and the lowest value of the demand.

So, when you substitute you are getting 847,000 is the last. The best case is because it is a cost, the lowest value of your labor cost, the lowest value of part cost, and the highest value of the demand; this is also provided to you. So, in that case you will be getting 2,591,000 as your profit. So, the lower limit of the profit at the worst case is 847,000 loss and the best case is 2,591,000.



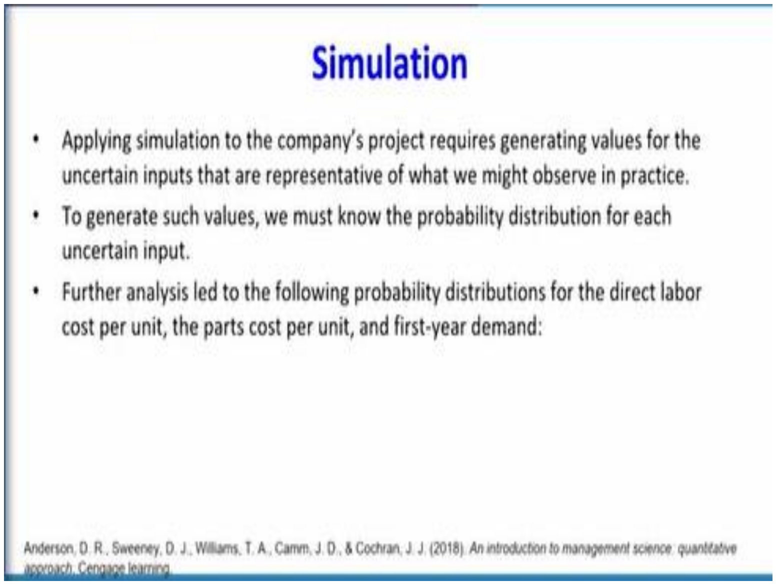
So, at this point, what if the analysis provides the conclusion that the profit can range from a loss of 847,000 to a profit of 2,591,000 with a base case of 710,000? Although, the base case profit of 710,000 is possible. The what-if analysis indicates that either a substantial loss or substantial profit is possible. So, another scenario that the company might want to consider can also be evaluated.

So, there may be different values because we have seen the extreme values of C_1, C_2, and x. So, in between these extreme values there are different combinations are possible. However, the difficulty with what if analysis is that it does not indicate likelihood of various profit and loss values, because we consider only the fixed values. We do not know anything about the probability of loss.



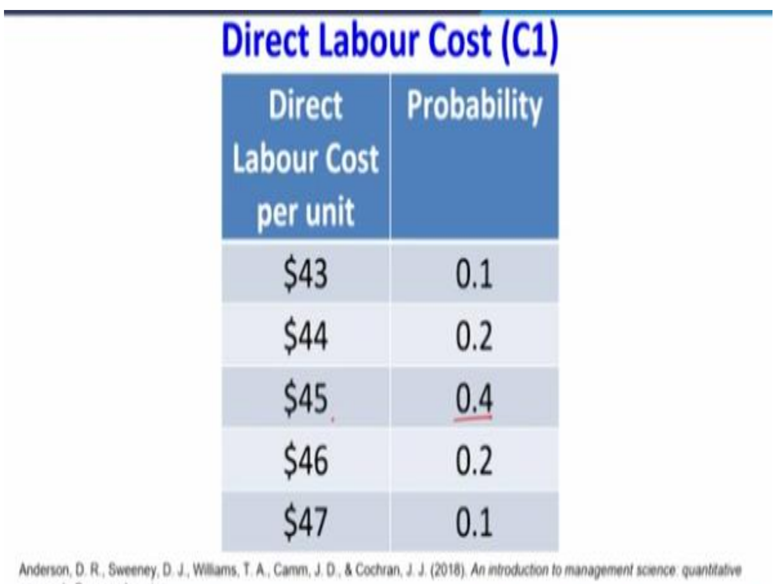
Using simulation to perform risk analysis for the company is like playing out many what-if scenarios by randomly generating values for uncertain inputs. So, here there are three C_1, C_2, and x. So, if we can substitute different values of C_1, C_2, and x, then we can get different scenarios. So, the advantage of simulation is that it allows us to assess the probability of a profit and the probability of loss.

Using the what-if approach to risk analysis, we selected the values for uncertain inputs; what are they? Labor cost, part cost, and first-year demand, then computed the resulting profit.



Applying simulation to the company's project requires generating values for the uncertain inputs that are representative of what we might observe in practice. What is the meaning of representatives? These C_1, C_2, and x should affect our profit; there are times when there are some inputs that may not affect our profit. To generate such values, we must know the probability distribution for each uncertain input.

Further analysis led to the following probability distribution for direct labor cost, the part cost per unit, and the first-year demand.

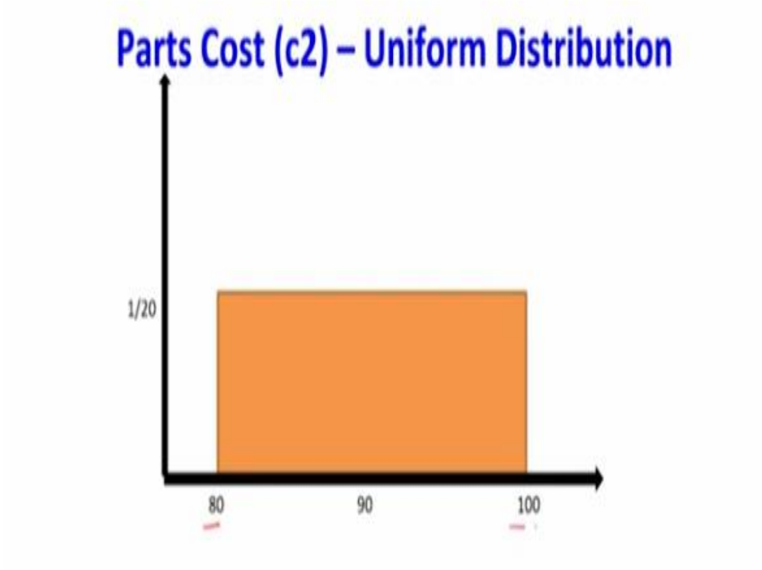


Direct Labour Cost (C1)

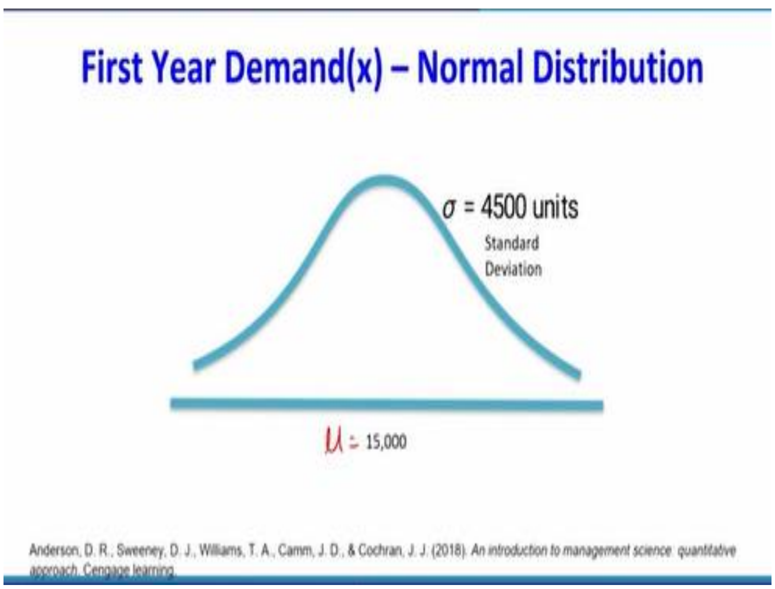
Direct Labour Cost per unit	Probability
\$43	0.1
\$44	0.2
\$45	0.4
\$46	0.2
\$47	0.1

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

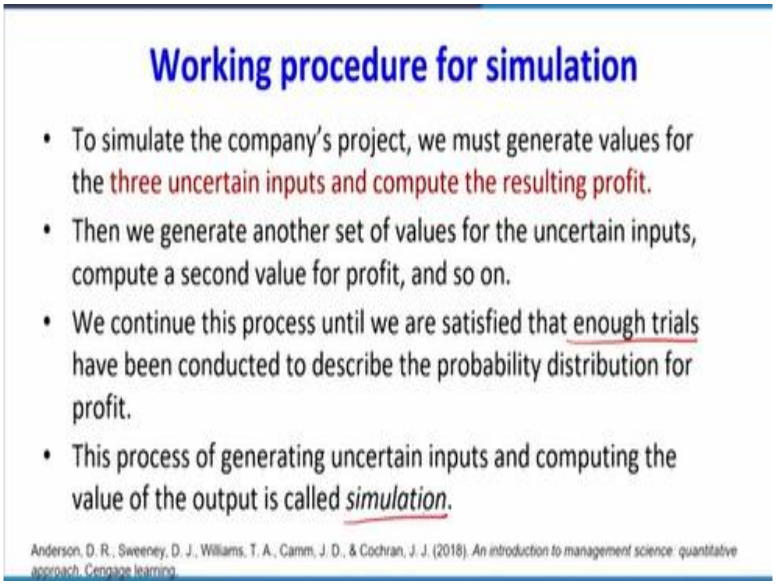
So, what are the probabilities? The labor cost follows the empirical distribution. There is a 40% chance the labor cost may be 45 dollars; this is C_1.



For C_2, uniform distribution part cost which follows a uniform distribution, the lowest value is 80, the highest value is 100; the probability is 1 upon 20.

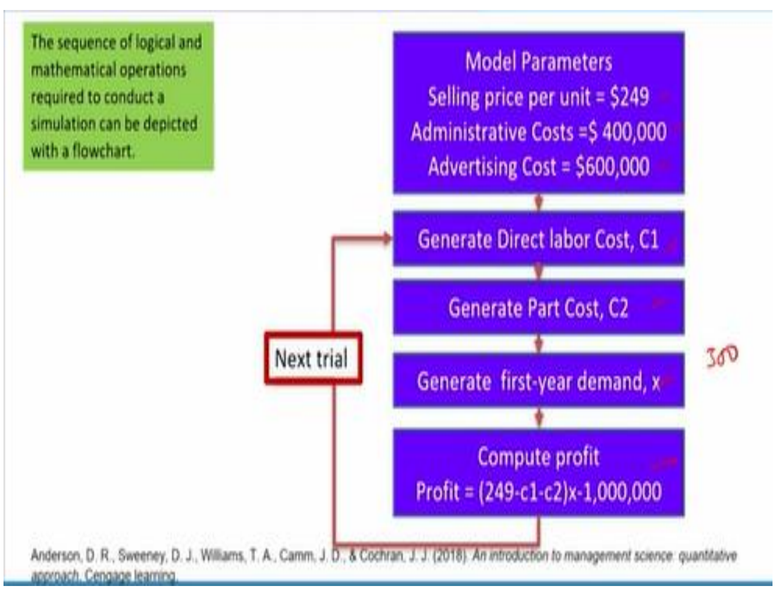


And the third one, the first year demand follows normal distribution. The mean of the normal distribution is 15,000, and the standard deviation of the normal distribution is 4500. So, we are going to use these three inputs to generate the profit.



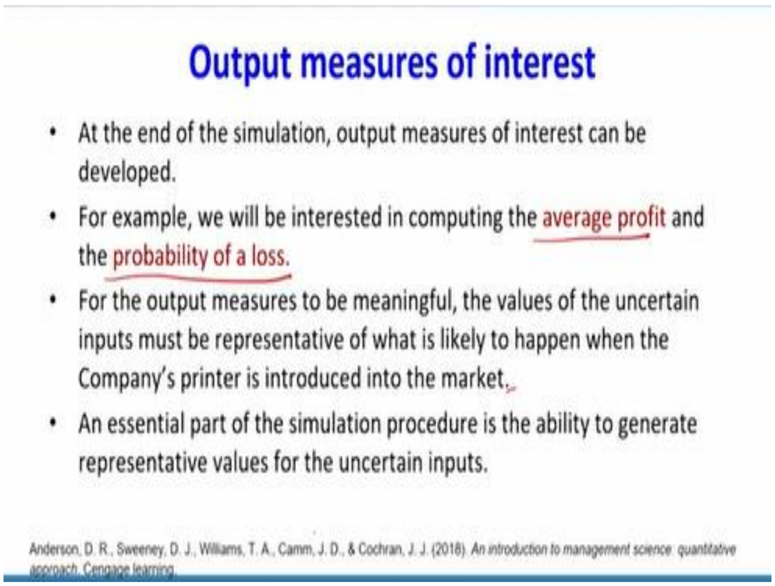
Then, the working procedure for simulation. To simulate the company's project, we must generate values for three uncertain inputs and compute the resulting profit. Then, we generate another set of values for uncertain inputs and compute a second value of profit and so on. So, we continue this process until we are satisfied with enough trials; here, enough trial is a number of iterations, and enough trials have been conducted to describe the probability distribution of a profit.

This process of generating uncertain inputs and computing the value of output is called simulation.



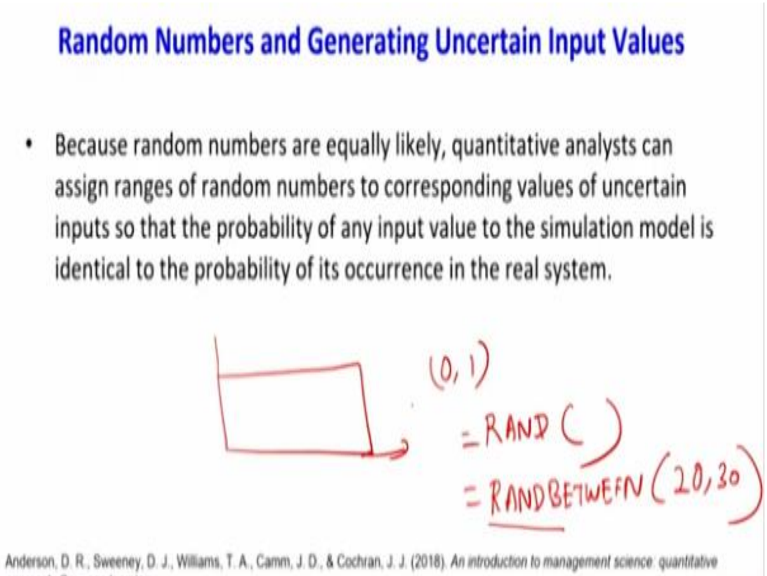
That simulation process I have explained in the form of a flowchart. So, this picture is a sequence of logical and mathematical operations required to conduct a simulation. First, what are the model parameters? Parameter means which you will not change: selling price, administrative cost, and advertising cost. What is the probabilistic input uncertain input? One is labor cost, part cost, and first-year demand.

Then, there is a profit function, we will substitute there. So, here x is the demand. So, when you substitute here, you will get one profit; then we will go to trial 2, trial 3, trial 4, and trial 5. So, we will be getting here. We are going to make 500 scenarios, 500 iterations of this profit. So, we are going to plot it.



So, output measures of interest. At the end of the simulation output measures of interest can be developed. For example, we will be interested in computing the average profit and the probability of loss. Here, probability of loss, we are saying the risk. Risk of getting too last, when we launch a new product. For the output measures to be meaningful, the values of the uncertain input must be representative of what is likely to happen when the company's printer is introduced into the market.

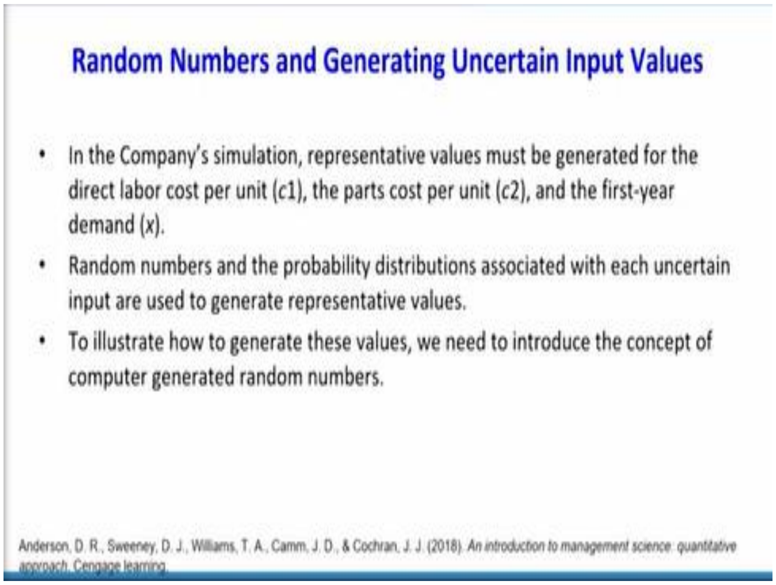
As I told you previously, these output measures should be directly affected by the input. There are sometimes some inputs that may not directly affect your output measures. But we have to consider only the inputs which are directly affecting the output. An essential part of the simulation process is the ability to generate representative values of uncertain inputs. So, that will be doing the uncertain inputs.



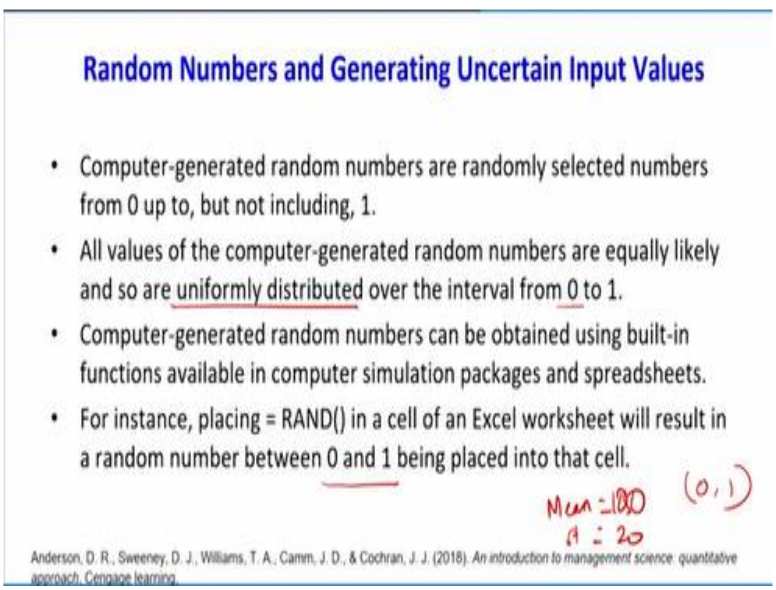
Because random numbers are equally likely, so quantitative analysis can assign a range of random numbers to corresponding values of uncertain inputs. So, the probability of any input value to the simulation model is identical to the probability of its occurrence in the real system. For the whole simulation, we are going to use the concept called random numbers, but many software packages provide random numbers.

Random numbers are called pseudo-random numbers. So, what will happen? The random numbers that follow uniform distributions are random numbers that will be between 0 and 1. For example, in Excel, there is a function called RAND. So, here, you will get the random numbers between 0 and 1. But there is another function RAND between. So, if I write 20 or 30, I will get a random number between 20 and 30. This is the pseudo-random number.

The random number that you generate from the calculator is called a simple random number. So, the random numbers will follow a uniform distribution. So, the probability of any number between 0 to 1 is the same; this is a probability, here x.



So, random numbers generate uncertain input values. In the company simulation problem, the representative values must be generated for direct labor cost c1, part cost c2, and the first-year demand. Random numbers and the probability distribution associated with each uncertain input are used to generate the representative values. To illustrate how to generate these values, we need to deduce the concept of computer-generated random numbers.

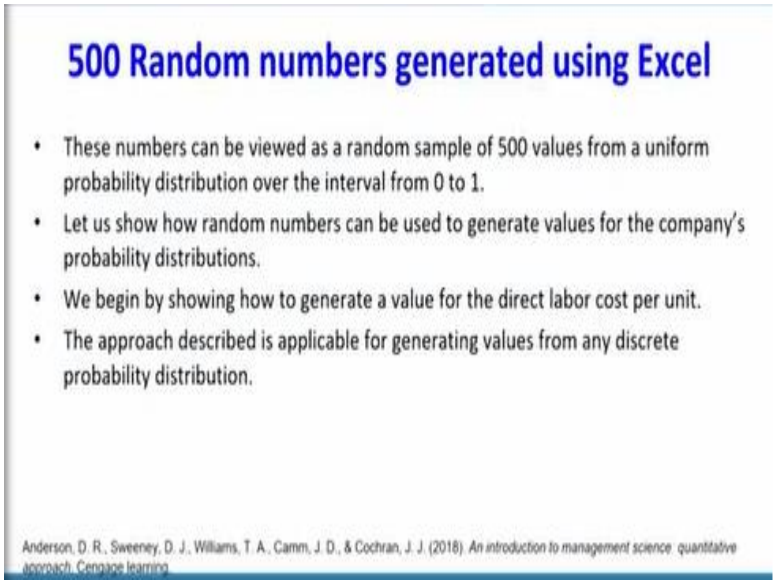


So, the computer-generated random numbers are randomly selected numbers between 0, but not including 1. All the values of computer-generated random numbers are equally likely and so uniformly distributed over the interval 0 to 1. So, computer-generated random numbers can be obtained using built-in functions available in computer simulation packages and spreadsheets. For instance, placing RAND in a cell of an Excel worksheet will result in a random number between 0 and 1.

There are, in the previously I was saying, there are certain computer generate random numbers, that random numbers called pseudo-random numbers, which would be 0 to 1. For example, I want to have random numbers that follow a normal distribution, say mean 100 standard deviations, say 20; I may get a set of values so that values are called pseudo-random numbers. But if you are getting computer random numbers between 0 to 1, that is your ordinary random number, which follows uniform distribution.

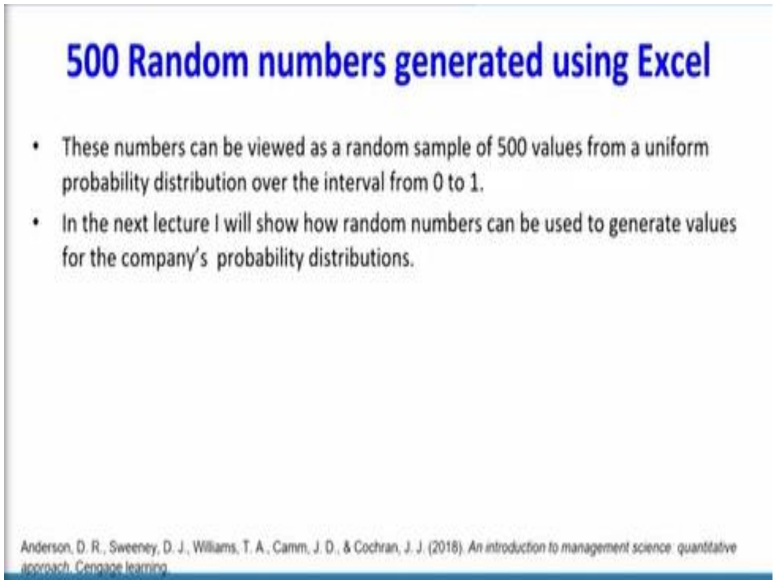
	1	2	3	4	5	6	7	8	9	10
1	0.746407	0.12412	0.333071	0.109062	0.636436	0.967724	0.57188	0.878941	0.477945	0.245946
2	0.099508	0.556495	0.595425	0.32258	0.932489	0.007998	0.527719	0.042468	0.512929	0.7949
3	0.880732	0.942159	0.95732	0.775873	0.717088	0.837816	0.220827	0.738778	0.337467	0.251582
4	0.498311	0.605725	0.020621	0.936854	0.720903	0.469627	0.393261	0.281968	0.59379	0.31116
5	0.30922	0.912648	0.595232	0.563389	0.301426	0.926165	0.68178	0.857969	0.42094	0.402043
6	0.459368	0.874032	0.886284	0.059064	0.668656	0.980598	0.156557	0.553263	0.17393	0.22058
7	0.6375	0.855644	0.376458	0.381181	0.141805	0.892378	0.250693	0.607271	0.689426	0.385949
8	0.945339	0.690864	0.452027	0.942238	0.97955	0.966917	0.815241	0.616397	0.196093	0.758899
9	0.659469	0.197812	0.879692	0.388823	0.592263	0.462418	0.805116	0.967345	0.382692	0.354811
10	0.797707	0.346873	0.842727	0.875072	0.991549	0.214914	0.258297	0.970922	0.942896	0.529266
11	0.604907	0.512954	0.509565	0.906537	0.778303	0.390303	0.155879	0.59524	0.478744	0.971117
12	0.766461	0.361151	0.906343	0.533584	0.959139	0.848697	0.572993	0.369837	0.100783	0.511228
13	0.071657	0.404181	0.41004	0.87264	0.928351	0.026902	0.390253	0.467889	0.818656	0.462552
14	0.858459	0.827262	0.842566	0.891742	0.644189	0.802311	0.281391	0.661286	0.098786	0.343697
15	0.525349	0.90032	0.004939	0.112439	0.547055	0.371393	0.512133	0.612349	0.829939	0.832211
16	0.934406	0.584604	0.453852	0.811645	0.928188	0.125238	0.687453	0.229126	0.857777	0.775081
17	0.328249	0.27569	0.871947	0.573503	0.465688	0.730993	0.221822	0.638518	0.491399	0.975378
18	0.433301	0.884802	0.668517	0.366798	0.935817	0.139881	0.893069	0.15269	0.087035	0.858496
19	0.126257	0.509909	0.353187	0.717166	0.81222	0.857878	0.269282	0.300564	0.034762	0.32862
20	0.824423	0.109511	0.669714	0.918381	0.243903	0.76513	0.1496	0.240898	0.922945	0.447416
21	0.706911	0.210176	0.548488	0.907823	0.648349	0.401566	0.942137	0.964481	0.104052	0.221275
22	0.50284	0.619526	0.717833	0.749517	0.370999	0.169443	0.265063	0.998836	0.731051	0.197179
23	0.977995	0.018452	0.715326	0.358637	0.824204	0.367601	0.174822	0.170639	0.297209	0.31606
24	0.272628	0.621853	0.46016	0.701477	0.964378	0.347165	0.480722	0.021625	0.612735	0.716608
25	0.477842	0.336695	0.465792	0.546834	0.304073	0.877522	0.358892	0.432625	0.80814	0.878043
26	0.278086	0.92809	0.91817	0.836598	0.133629	0.327479	0.843974	0.809837	0.952269	0.574237
27	0.203011	0.236802	0.439054	0.773646	0.567515	0.379925	0.088426	0.393207	0.917383	0.206862
28	0.378581	0.168644	0.34481	0.134837	0.938515	0.690034	0.691903	0.820165	0.761334	0.732159
29	0.718359	0.503631	0.802642	0.286141	0.360428	0.568491	0.419501	0.218858	0.556532	0.062714
30	0.273941	0.037512	0.440437	0.409006	0.61703	0.464931	0.404034	0.447262	0.821605	0.325446
31	0.157473	0.362704	0.147934	0.706546	0.655578	0.996607	0.162355	0.915688	0.218909	0.563435
32	0.722397	0.113855	0.256686	0.642155	0.498153	0.665533	0.892584	0.065565	0.340197	0.379758
33	0.900429	0.289669	0.287722	0.864751	0.588437	0.245918	0.018367	0.106678	0.41215	0.123626
34	0.086866	0.936096	0.172764	0.505868	0.027737	0.784271	0.005699	0.947418	0.707652	0.109588
35	0.036617	0.1742	0.793038	0.769925	0.608322	0.549927	0.870537	0.833262	0.497573	0.438288
36	0.932954	0.418076	0.844365	0.010465	0.237285	0.823183	0.52461	0.707722	0.443371	0.557721
37	0.5107	0.588502	0.706028	0.06127	0.322621	0.073269	0.234576	0.387779	0.327956	0.169164
38	0.689736	0.245412	0.025145	0.979906	0.10162	0.07169	0.707611	0.388195	0.365627	0.43734
39	0.502546	0.658254	0.962417	0.29827	0.215685	0.24843	0.839638	0.533848	0.955463	0.86792
40	0.630226	0.868017	0.668912	0.035481	0.797534	0.902554	0.927782	0.926925	0.082583	0.753289
41	0.220007	0.696565	0.330786	0.745588	0.338087	0.129802	0.326763	0.132787	0.869198	0.458746
42	0.496787	0.560131	0.648298	0.380427	0.499552	0.942638	0.364199	0.873415	0.894854	0.457367
43	0.366951	0.068963	0.110699	0.876765	0.421133	0.080646	0.992581	0.047719	0.957629	0.740633
44	0.268466	0.590565	0.61751	0.693673	0.300677	0.134745	0.789414	0.254436	0.114527	0.531412
45	0.534701	0.752814	0.8313	0.095544	0.944086	0.893145	0.289476	0.400216	0.913543	0.140083
46	0.730751	0.757207	0.378599	0.133013	0.254638	0.932914	0.654279	0.232148	0.073359	0.733999
47	0.905021	0.188229	0.698256	0.287972	0.280702	0.172171	0.939116	0.85814	0.564682	0.209682
48	0.362732	0.229182	0.003814	0.477288	0.361579	0.013869	0.072946	0.119738	0.506824	0.504979
49	0.403362	0.605515	0.945898	0.813367	0.828414	0.206285	0.369095	0.06381	0.266579	0.271168
50	0.609898	0.533451	0.272988	0.934729	0.66347	0.548951	0.262878	0.019545	0.31589	0.996926

So, this is an example: I have generated 500 random numbers with the help of this RAND function. You see that all the values are between 0 to 1, but 1 will not be there.



The 500 random numbers were generated using Excel. So, these numbers can be viewed as a random sample of 500 values from a uniform probability distribution over the interval from 0 to 1. Let us show how random numbers can be used to generate values of companies' probability distributions. So, we begin by showing how to generate a value for the direct labor cost per unit. This approach described is applicable for generating values of any discrete probability distribution. Now, I will explain how to use Excel for generating random numbers. As I told you, for example, if I keep my cursor here, see that, if I type equal to RAND when you close the bracket, I got your random numbers 0.9450, I can drag it. So, these are the random numbers between 0 and 1. If I press F9, you see that the values of random numbers are getting updated. On your keyboard, if you press F9, the values of random numbers are getting updated.

Like this, at the bottom, I have generated 500 random numbers, you see that generated 500 random numbers. In Excel, there is another function called RAND between that says equal to RAND; see that RAND between if I type, say 20, say 50, see that I can drag it, this also I can drag it, you can drag it. Then, if I press F9, you see that your random numbers are getting updated. So, this RAND between is a function to generate random numbers between, say, for example, 20 and 50. The RAND function is to generate random numbers between 0 to 1.



These numbers can be viewed as a random sample of 500 values from a uniform probability distribution over the interval 0 to 1. These numbers follow uniform distributions between 0 and 1. In the next lecture, I will show how random numbers can be used to generate the values of the problem that you are discussing now, that is, the portable printer. How can these inputs for the problem be generated with the help of probability distributions?

Dear students, in this lecture, I have introduced the concept of simulation, and then I have explained various applications of simulation. Then, in the simulation model, I classified the input into two categories; one is controllable inputs, and the other one is uncontrollable inputs. Then, I have taken a sample problem of the introduction of the new product and what is the risk of introducing the new product, with the help of base case, worst case, best case, and what-if analysis.

After that, I explained how to generate random numbers with the help of Excel. In the next lecture, we will continue the problem that we have discussed, and we can solve that problem with the help of Excel. Thank you very much.