Project Management

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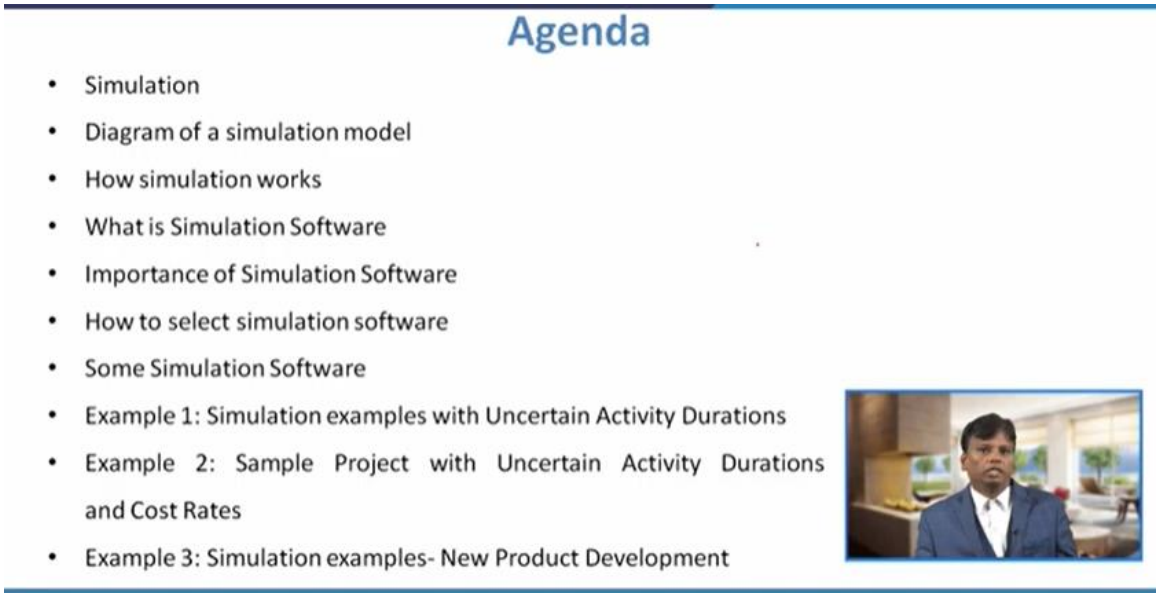
Week: 8

Lecture 39 - Simulations Software for Project Management

Dear students, in the previous class I have discussed about MS Project software. Now, we will study some more software for the purpose of simulation in the context of project management. So, this lecture will cover simulation software for project management. So, in the previous class I discussed about a demo on project management. Currently we are going to cover simulation software for project management. The agenda for this lecture is I will explain what is a simulation, then I will explain the pictorial model of the simulation, then I will explain how simulation works, then we will discuss about some of the simulation softwares.



Finally, I have taken three examples. One example is simulation examples with uncertain activity duration for a network. The second problem that we will consider uncertain activity, but we will consider the cost of that activity also. The last problem, if you are introducing a new product development, we can simulate it what is the chances of the success of that new product development or launching a new product.

Simulation

- Simulation is one of the most widely used quantitative approaches to decision-making.
- It is a method for learning about a real system by experimenting with a model that represents the system.

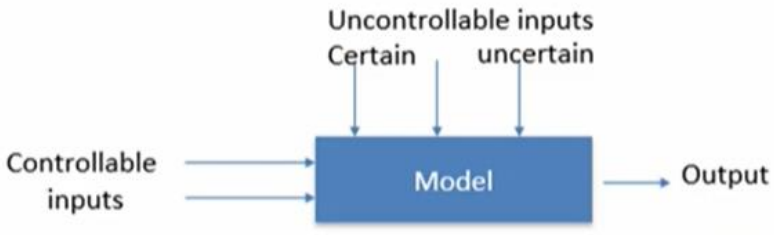
Simulation

- The simulation model contains the mathematical expressions and logical relationships that describe how to compute the value of the outputs given the values of the inputs.
- The inputs for a simulation model can be classified as controllable inputs or uncontrollable inputs.
- Uncontrollable inputs can be either uncertain or known with certainty.

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.

Now, we will discuss about simulation. Simulation is one of the most widely used quantitative approach to decision making. It is a method for learning about real system by experimenting with model that represents the system. Simulation model contains the mathematical expression and logical relationship that describes how to compute the value of the output given the value of different inputs. So here the real time situation will be converted into in the form of mathematics.

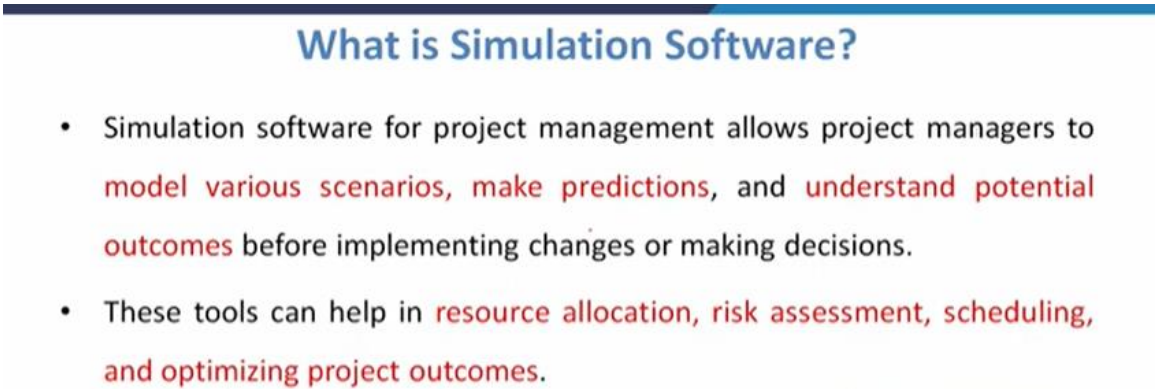
Diagram of a simulation model



There we will supply different probabilistic inputs. So if the inputs are probabilistic in nature, they can predict what will be the output. So the input for a simulation model can be classified as a controllable input and uncontrollable input. Controllable inputs can be

either uncertain or known with certainty. So this is the pictorial model of simulation.

See there are some controllable inputs, there are certain uncontrollable inputs. How simulation works? The simulation model uses the value of the controllable input and the value of uncertain input to compute the output value or value of the, as I told the value of the output. By conducting a series of experiments using a variety of values for the controllable input, so the analyst learn how the value of controllable input affect or change the output of simulation model. After reviewing the simulation result, the analyst is often able to make decision recommendations for the controllable input that will provide the desired output for the real system. So what is the simulation software? Simulation software for project management allows project managers to model various scenarios, make predictions and understand potential outcomes before implementing the changes or making decisions.



The previous class we discussed about one of the challenging task for a project manager is making trade-off. So here we can say when you make a trade-off, what will be the probable output? So that can be analyzed with the help of the simulation software. So these simulation software tools can help the resource allocation, risk assessment, scheduling and optimizing project outcomes. In this lecture, we will take one example on scheduling, how to do the scheduling with the help of simulation. Then another example we will discuss about risk assessment.

Importance of Simulation Software

Risk Assessment

- Simulation software allows project managers to identify and assess potential risks associated with various project scenarios.
- By modeling different situations and outcomes, organizations can develop effective risk mitigation strategies and contingency plans to minimize the impact of unforeseen events.

So importance of simulation software, this can be used for risk assessment. So simulation software allow project managers to identify and assess potential risk associated with the various project scenarios by modeling different situations and outcomes. Organization can develop effective risk mitigation strategies and contingency plan to minimize the impact of unforeseen events. The next application is optimized resource allocation. For example, in the previous class we discussed about whenever we do over allocation, then we have to do the leveling.

Importance of Simulation Software

Optimized Resource Allocation

- Simulation tools enable project managers to allocate resources more efficiently by modeling different resource allocation scenarios.
- This helps organizations optimize their workforce, equipment, and budget allocation to maximize productivity and reduce costs.

So that leveling and all comes out of this simulation. So simulation tools enable project manager to allocate resources more efficiently by modeling different resource allocation scenarios. This helps organization optimize the workforce, their workforce, equipment and budget allocation to maximize the productivity and reduce the cost. The next application of simulation software is scenario analysis. Simulation software allows project managers to model different project scenario and analyze their potential impact on project timelines,

cost and outcomes.

Importance of Simulation Software

Scenario Analysis

- Simulation software allows project managers to model different project scenarios and analyze their potential impact on project timelines, costs, and outcomes.

- This enables organizations to make informed decisions and choose the most effective strategies to achieve project objectives.

Importance of Simulation Software

Improved Decision-Making

- By simulating various project scenarios, project managers can evaluate the potential outcomes of different decisions and choose the most effective course of action.

- This helps organizations make data-driven decisions and avoid costly mistakes.

This enables organization to make informed decisions and choose the most effective strategies to achieve project objectives. The next benefit of simulation software is improved decision making. By simulating various project scenarios, project managers can evaluate the potential outcome of different decisions and choose the most effective course of action. So this help organization make data driven decisions and avoid costly mistake. Because what will happen if you are not doing the simulations, then you will learn only after doing the experiment.

Importance of Simulation Software

Enhanced Communication

- Simulation software provides project managers with visual representations of project data, making it easier to communicate complex information to stakeholders.
- This facilitates better collaboration, alignment, and understanding among team members, and key stakeholders.

So that will be very costly instead of doing that experiment. Mathematically you can simulate it, what are the different variables and what are the effect of these variables on the outcome. The next use is enhanced communication. Simulation software provides project managers with visual representation of project data making it easier to communicate complex information to stakeholders. This facilitate better collaboration, alignment and understanding among team members and key stakeholders.

Importance of Simulation Software

Predictive Analysis

- Simulation tools enable project managers to predict future trends and outcomes based on historical data and current project variables.
- This helps organizations anticipate potential challenges, opportunities, and changes, allowing them to proactively address issues and adapt their strategies accordingly.

The next use of simulation is predictive analytics. For example, the simulation software can be used to predict the project duration, so to predict the cost of that project. So simulation tools enables project managers to predict the future trends and outcomes based on historical data and current project variables. This helps organization anticipate potential challenges, opportunities and changes, allowing them to proactively address issues and adapt their strategies accordingly. The next important benefit of simulation is cost saving.

Importance of Simulation Software

Cost Savings

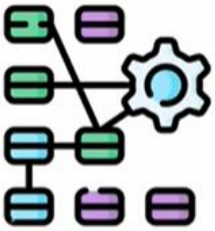
- By optimizing resource allocation, minimizing risks, and improving decision-making, simulation software can help organizations reduce project costs and improve profitability.

- By identifying inefficiencies and implementing more effective strategies, organizations can achieve better results with fewer resources.

Importance of Simulation Software

Complexity Management

- For large and complex projects, simulation software helps project managers manage complexity by modeling different project components, dependencies, and variables.



- This enables organizations to identify potential bottlenecks, conflicts, and challenges and develop strategies to address them proactively.

By optimizing resource allocation, minimizing risk and improving decision making, simulation software can help organization reduce project cost and improve profitability. By identifying inefficiencies and implementing more effective strategies, organizations can achieve better result with fewer resources. The next benefit is complexity management. For large and complex projects, simulation software helps project managers manage complexity by modeling different project components, dependencies and variables. This enables organization to identify potential bottlenecks, conflict and challenges and develop strategies to address them proactively.

How to select simulation software

- When selecting simulation software for project management, consider your specific requirements, budget, and the complexity of the projects you manage.
- It's essential to choose a tool that aligns with your organization's needs and enables you to make data-driven decisions to optimize project outcomes.

How to select the simulation software? When selecting simulation software for project management, consider your specific requirements, budget and the complexity of the project you manage. For example, in this course, I have introduced crystal ball for the purpose of simulation. The other one, the Excel also can be used for the simulation. So it is essential to choose a tool that align with your organization's needs and enables you to make data driven decisions to optimize the project outcomes. Now we will discuss about some popular simulation softwares.

Some Simulation Software

Some popular simulation software tools used in project management are:

Microsoft Project:

- While primarily known as a scheduling tool, Microsoft Project also offers some simulation features.
- It allows users to model different project scenarios and assess the impact of changes on project timelines and resources.

One is Microsoft project. While the primarily known for scheduling tool, Microsoft project also offer some simulation features. It allows users to model different project scenario and assess the impact of changes on project timelines and resources. The next software is a Primavera developed by Oracle. The Primavera P6 is the comprehensive project management tools that include simulation capabilities.

Some Simulation Software

Primavera P6

- Developed by Oracle, Primavera P6 is a comprehensive project management tool that includes simulation capabilities.
- It allows users to model different project scenarios, evaluate resource allocation, and analyze project risks.

ource: https://www.oracle.com/webfolder/technetwork/tutorials/primavera/NewFeatures/P6/P615.2NF/data/toc/746fe2a4-9d46-405d-ae52-75cfe195e6b2/Parts/index.html

It allows users to model different project scenarios, evaluate resource allocations and analyze the project risk. The next software is Simul8. Simul8 is a simulation software tool that can be used for various applications including project management. It allows users to model complex process, optimize the resource utilization and analyze the impact of different scenarios on project outcomes. The next simulation software is Arena.

Some Simulation Software

Simul8

- Simul8 is a simulation software tool that can be used for various applications, including project management.
- It allows users to model complex processes, optimize resource utilization, and analyze the impact of different scenarios on project outcomes.

Source: https://www.simul8.com/

Some Simulation Software

Arena Simulation

- Arena is a powerful simulation software tool that can be used for project management applications.
- It allows users to model complex systems, simulate different project scenarios, and analyze performance metrics.

Arena is a powerful simulation software tool that can be used for project management applications. It allows users to model complex system, simulate different project scenarios and analyze the performance metrics. Another popular model is AnyLogic. AnyLogic is a versatile simulation software tool that can be used for various applications including project management. It allows users to model complex systems using different simulation methods such as discrete event, agent based and system dynamics.

Some Simulation Software

AnyLogic

- AnyLogic is a versatile simulation software tool that can be used for various applications, including project management.
- It allows users to model complex systems using different simulation methods, such as discrete-event, agent-based, and system dynamics.

Source: https://www.anylogic.com/

The next software is Risk-AMP. Risk

Some Simulation Software

RiskAMP

- RiskAMP is an Excel add-in that provides simulation capabilities for project risk analysis.
- It allows users to model project risks, evaluate potential outcomes, and make informed decisions based on simulation results.

-AMP is an Excel add-in that provides simulation capabilities for project risk analysis. It allows users to model project risk, evaluate potential outcomes and make informed decisions based on simulation result. Now I have taken one example problem with uncertain activities durations. This problem also in the previous lecture I have explained to you but here there is one difference is there the way we are giving the input, how we are defining the different distribution for the probabilistic inputs.

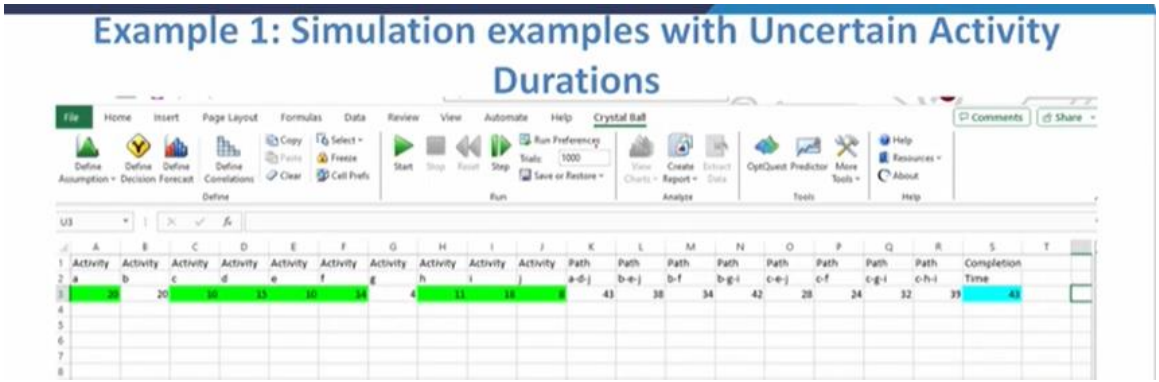
Example 1: Simulation examples with Uncertain Activity Durations

ID	Task Name	Predecessors	Optimistic Duration	Most Likely Duration	Pessimistic Duration	Expected Duration
1	Start		0 days	0 days	0 days	0 days
2	a	1	10 days	22 days	22 days	20 days
3	b	1	20 days	20 days	20 days	20 days
4	c	1	4 days	10 days	16 days	10 days
5	d	2	2 days	14 days	32 days	15 days
6	e	3, 4	8 days	8 days	20 days	10 days
7	f	3, 4	8 days	14 days	20 days	14 days
8	g	3, 4	4 days	4 days	4 days	4 days
9	h	4	2 days	12 days	16 days	11 days
10	i	8, 9	6 days	16 days	38 days	18 days
11	j	5, 6	2 days	8 days	14 days	8 days
12	Finish	10, 11, 7	0 days	0 days	0 days	0 days

vredith, J. R., Shafer, S. M., & Mantel Jr, S. J. (2017). *Project management: a strategic managerial approach*. John Wiley & Sons.

So this problem says that we have start A, B, C, D up to J there are activities there, there are predecessor is there, then there is optimistic duration is given, most likely duration is given, pessimistic duration is given and the expected duration also given. So what we are going to do? We are going to predict the project completion times. So what are the input we are going to use? Here there are three time estimates. So we are going to follow input that activity time follow beta distribution that we are going to give as input then we are going to find what is the project completion time. So I have entered in the crystal ball

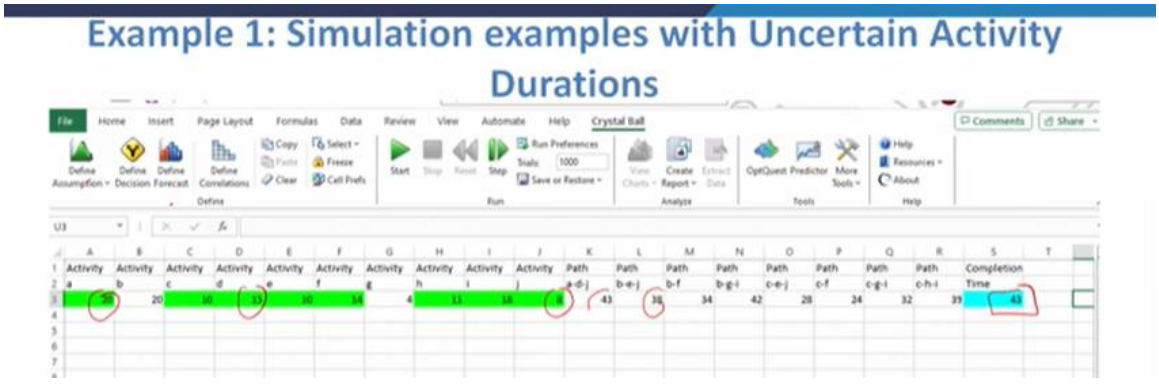
software.



So I have entered activity A then here I have defined what is the three time estimate. So you have to enter 20 then you have to click define assumptions. So that will display different distributions. We are going to choose part beta distribution. So there you have to enter the optimistic time, pessimistic time and most likely time.

Similarly you have to enter for all the activities. Next what I have done I am writing all possible path. One possible path is ADJ, next possible path is BEJ like that I have entered all possible path. So here the duration of that path for example if it is ADJ so I have to find out the sum of A activity duration plus D activity duration 35 then J activity duration 35 plus 8, 43. So similarly BEJ I am adding activity duration for B, E and J so you will get 38.

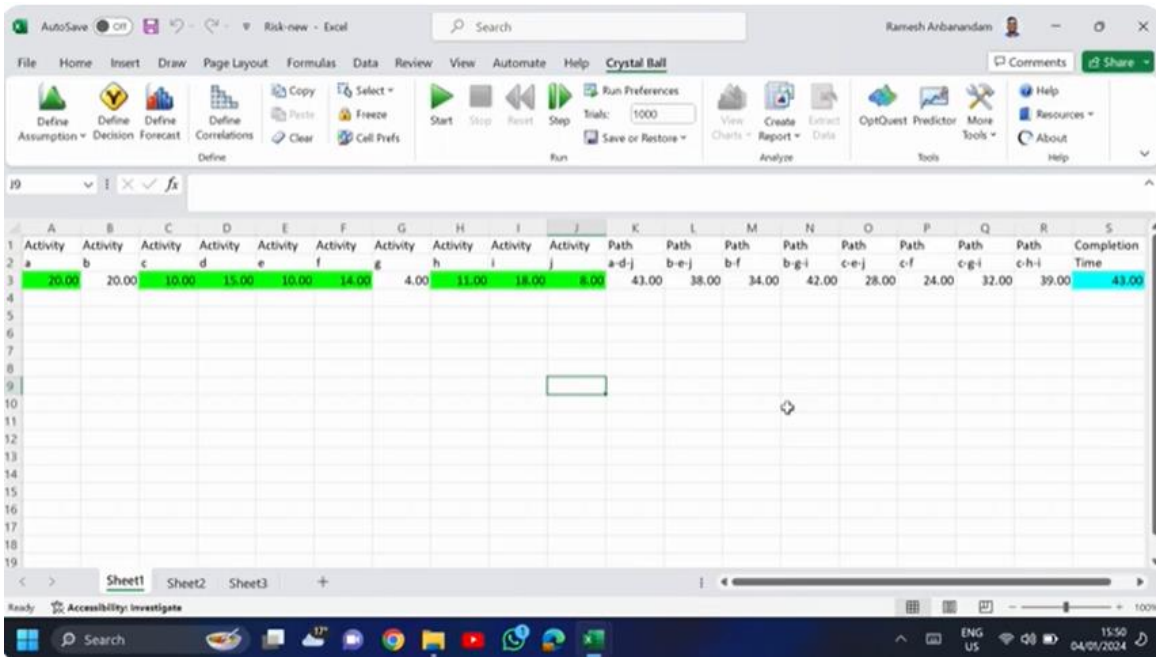
I have added the project duration for all the path. Then here in this cell you have to click this project completion cell. So then you have to go to define forecast. So when you press define forecast it will ask what is the name of that output because this is output which are going to get it.

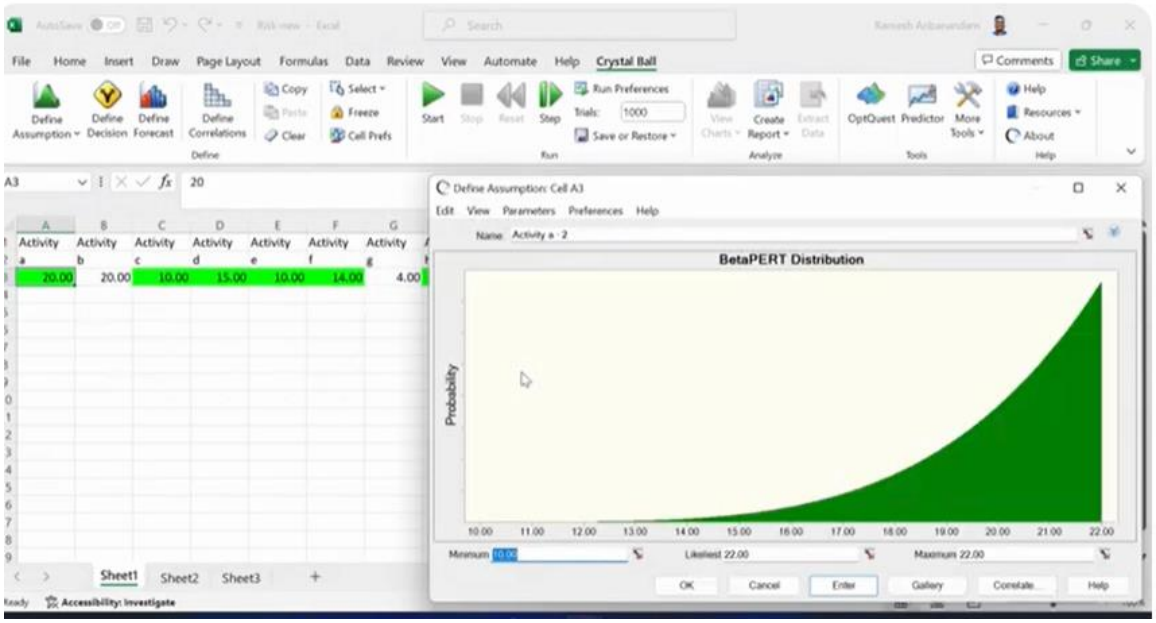


Then what is the unit of that output. So here the output name is completion time the unit is days. So this is the simulation setup. After that when you press this start button you can get the simulation will run you can get the project completion time. So it is 43 so 43 is ADJ. So ADJ is a critical path so the project completion time is 43.

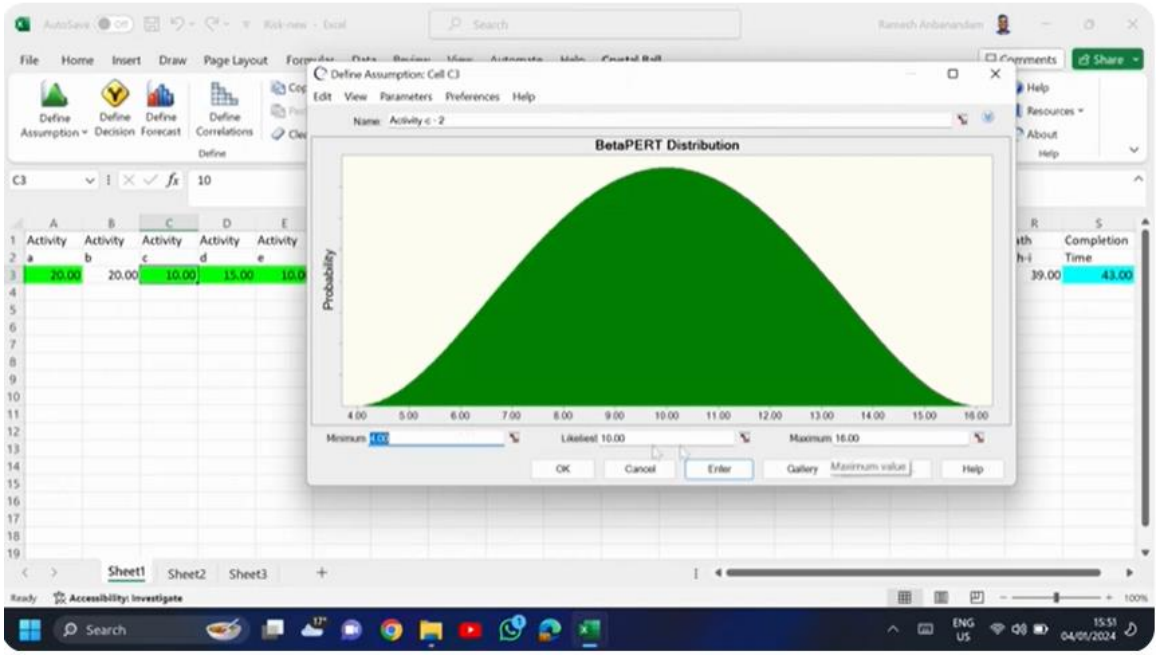
Now I will explain this simulation with the help of crystal ball. Dear students now I have

opened the crystal ball in excel. So here I have entered all the activities. So this 20 is our expected time because the three time estimate is given. So click on 20 then go to define assumptions.



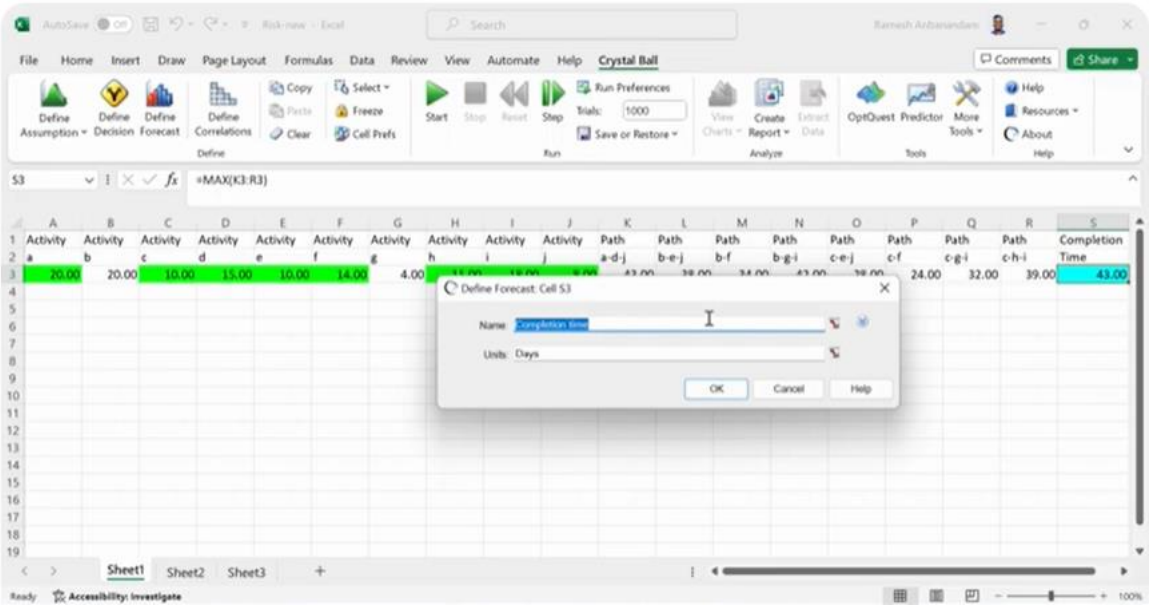


Here as I told you it follow beta part distribution you click it. So when you press ok it sees that it opened the beta part distribution you have to enter minimum value most likely value and maximum value press ok. Then 20 activity B it is a fixed one so we need not change because the input is constant non-probabilistic. For example go to C then click define assumptions then you select beta part distribution then press ok. Here you have to enter minimum most likely and maximum.



Like that I have defined the inputs for activity A to J. Next what I have done see that for I found the path ADJ. ADJ is the sum of A3 plus D3 plus J3. Similarly for all the path I have found the critical path then here what I have done I have found the maximum of all the path that is going to be my critical path that also going to be my total project completion time. And after checking here you have to go for define forecast.

So here you have to specify what is the name of that cell that is output cell where we want to get the answer. Second what is the unit of that cell. So I have entered completion time then it is days so press ok. Now when you click the start button here look at my mouse when you click on the start button so you will get the output. Already I have run it I have shown the final output in this screen.



So what it says that the total project completion time is 43 so corresponding path is ADJK. Now we will go to the next problem. This is similar to the previous problem but here what is given here, here the cost rate also given. Previously only time is given so here the cost for optimistic time, cost for normal time, cost for pessimistic time is given. So now what we are going to do apart from the duration of that activity we are going to consider the cost of completing that activity also.

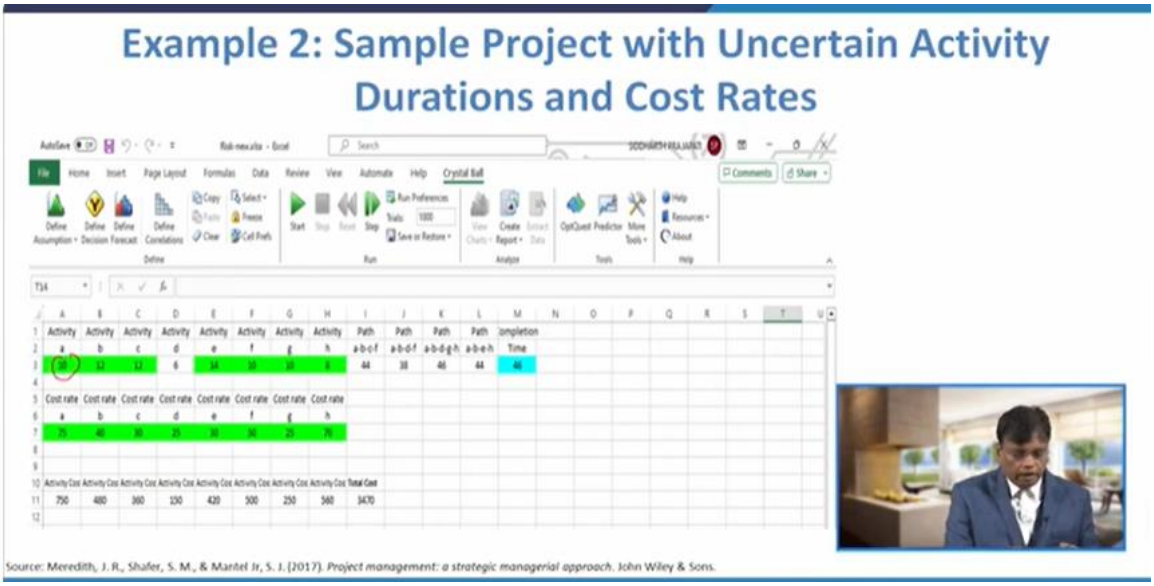
Example 2: Sample Project with Uncertain Activity Durations and Cost Rates

		Activity Durations			Cost Rates ($/Day)		
Activity	Pred.	Opt.	Most Likely	Pess.	Opt.	Normal	Pess.
a	–	8	10	16	50	75	100
b	a	11	12	14	35	40	50
c	b	7	12	19	20	30	45
d	b	6	6	6	15	25	30
e	b	10	14	20	25	30	35
f	c, d	6	10	10	40	50	75
g	d	5	10	17	20	25	35
h	e, g	4	8	11	60	70	85

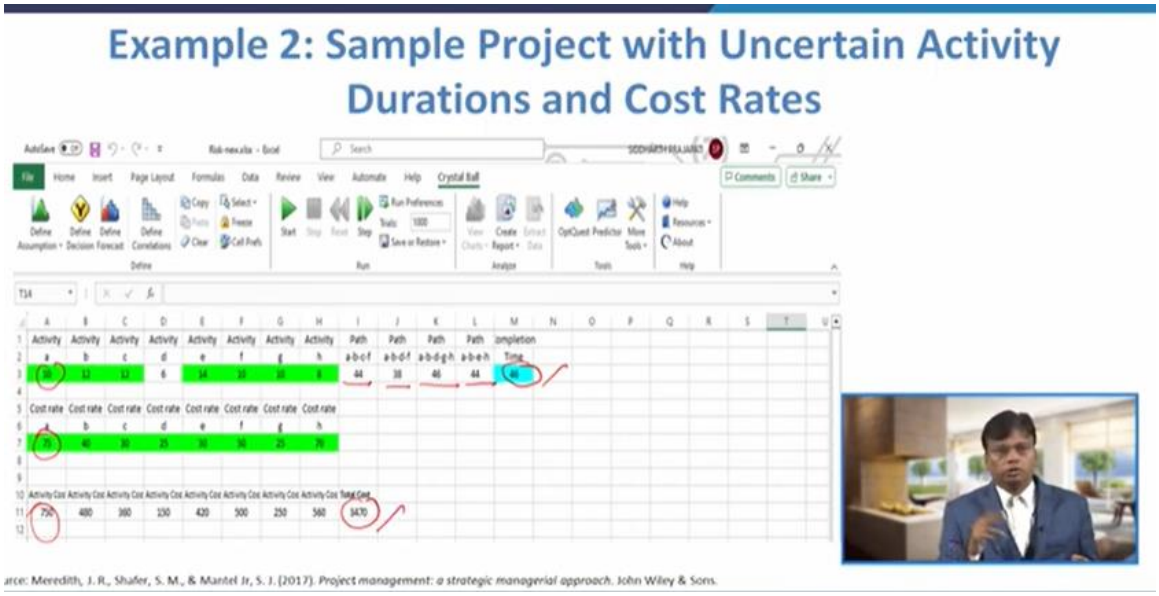
Source: Meredith, J. R., Shafer, S. M., & Mantel Jr, S. J. (2017). *Project management: a strategic managerial approach*. John Wiley & Sons.

So that we are going to simulate it. So what I have done I have entered for example I entered 10 here when I press define assumption so it will display the various distributions I have to select the bit apart distribution there I have to enter 3 time estimate that I have done it. Similarly I have to see all possible path ABCF, ABDF, ABDGF, ABEH then in this cell as usual you have to say define the forecast cell this is the unit time and the name of that cell is completion time. Now what is the addition when compared to the previous

problem is for each activity I have entered the cost. This cost also going to follow a bit art distribution because there is a 3 time estimate is there. So for each activity I am going to enter the cost also.

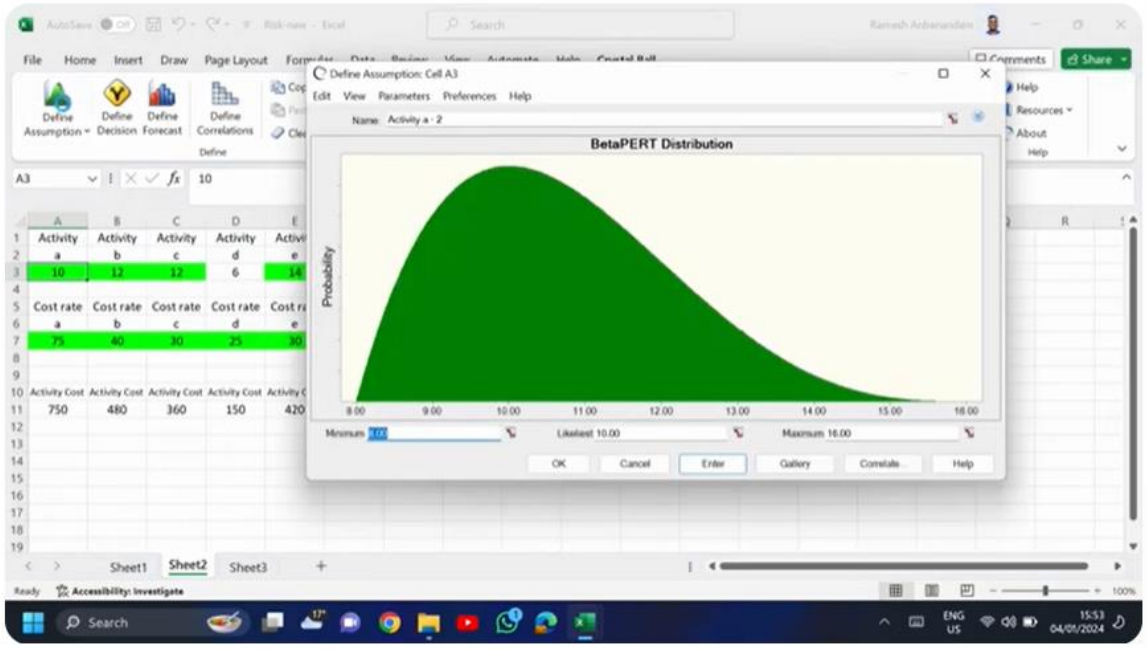


Next one I am going to multiply this activity duration and the cost for example 10 multiplied by 75 it is 750 like that I have added for all the activities. This is the total cost so I have added or everything here the completion time is the maximum of all possible paths. So when I run it so I am getting 2 output I am getting the completion time 46 days at the same time we are getting the total cost. Here there are 2 simulation the 2 part is going on one is we are optimizing the duration and the same time we are optimizing the cost also. Now demo on crystal ball simulation for problem number 2.



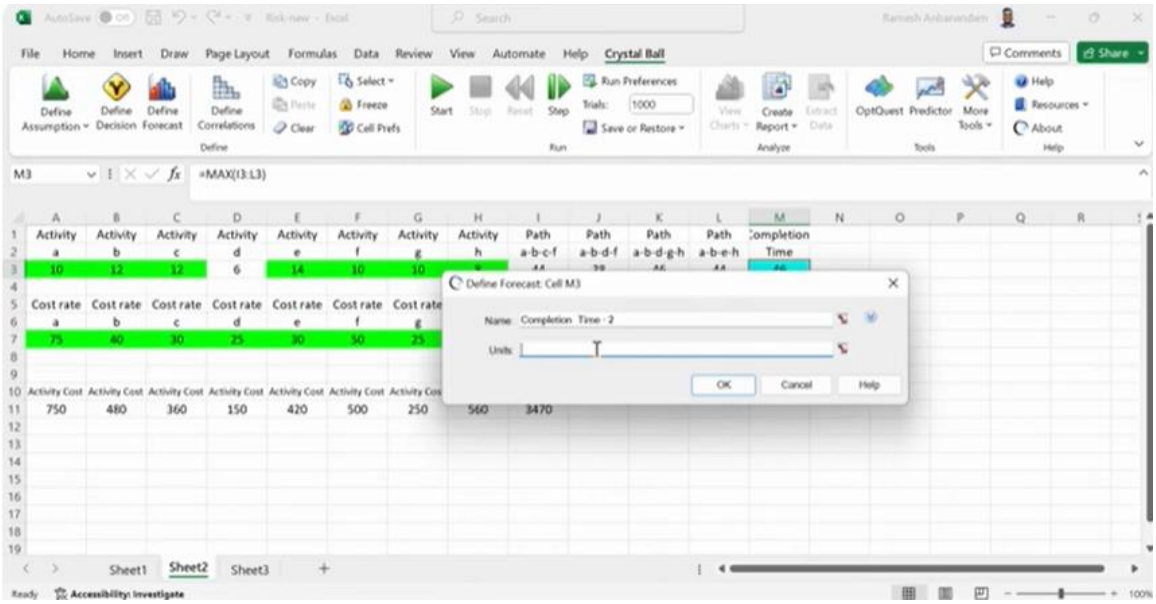
Dear students in the demo in the next problem here this problem is somewhat different from the previous problem. Here the cost of activity is also given. So as usual I have defined for example A3 I have defined what is the 3 time estimates. I have entered 8, 10,

16 like that for all the activities A, B, C, D is not required because that is the constant there is no variation in the duration of activity I have entered it. For example I have found the possible critical path possible path so one is A, B, C, F then A, B, D, F I have added corresponding the activity duration then finally completion time that is the maximum of I3 to L3.



One difference is here I have entered the cost of each activity for example activity A the cost is 75 dollar. So when I go this also follow 3 time this follow beta distribution what you have to do you go to gallery then you select beta, beta part. So now I have entered the 3 time estimate. So like that for all the cost also I have entered 3 time estimate. Next one I have multiplied the duration of that activity and corresponding the cost so I got 750, 480 some values because the answer is going to be final one.

So after that I have to define the project completion time. So here this is sum of A 1, 1 to H1 that is a total cost so this is the project completion time. So I have defined forecast as usual it is the name of the time is completion time so this is days you can enter days. So here I have entered days so when you press ok got it.



So when you click the start button you will get the result. Here I got the I have already got the result so completion time is 46 the corresponding cost is 3470. Now the next problem is new product development. So the objective of this simulation is to determine the probability that new product will be profitable. So here we are going to analyze the risk of launching a new product. So your model is developed that relates profit to various uncertain inputs such as demand, part cost and labor cost.

Example 3: Simulation examples- New Product Development

- The objective of this simulation is to determine the probability that a new product will be profitable.
- A model is developed that relates profit (the output measure) to various uncertain inputs such as demand, parts cost, and labor cost.

Because demand also going to be uncertain, part cost also going to be uncertain and the labor cost also going to be uncertain. The only controllable input is whether to introduce the product or not. So variety of possible values will be generated for the uncertain input and the resulting profit will be computed. So now we will come to the problem. So we are launching a product the product name is portable printer.

Example 3: Simulation examples- New Product Development

- The only controllable input is whether to introduce the product.
- A variety of possible values will be generated for the uncertain inputs, and the resulting profit will be computed.

Example 3: Simulation examples- New Product Development

- Product Name: Portable Printer
- Selling Price = $249 per unit
- Administrative Cost = $400,000
- Advertising Cost = $600,000
- Probabilistic input:
  - Direct labour cost = $ 45 per unit
  - Parts cost = $90 per unit
  - First year demand = 1500 units

The selling price is 249 dollar. There are certain fixed administrative cost. So 400,000 dollar for administrative cost and 600,000 for advertising cost. So these are called project parameter because it is fixed. Now we are going to consider three input.

What if analysis

- Profit = ($249- Direct labour cost per unit – Parts cost per unit) Demand - $1,000,000

$$\text{Profit} = (249-C_1-C_2)(x)-1,000,000$$

- C1= direct labour cost
- C2= Parts cost
- X = First year demand

One is direct labor cost, part cost and first year demand. We start with the problem with

a static in nature then after that we will see the probabilistic model. Suppose the first the procedure is we have to define what is objective function. So here objective function is that selling price is 249 dollar minus your direct labor cost and part cost and multiplied by the first year demand. So we will get overall revenue minus there are fixed expenditure when you subtract it we will get the profit.

So here what are the changing variables C1, C2, and X. C1 is labor cost, C2 is a part cost, X is the demand. Now what is given that the probabilistic input is given. For labor cost it follow empirical distribution. So there is a 10% chance that the direct labor cost per unit will be 43.

So 40% chance the direct labor cost will be 45 dollar. The next input is part cost which follow uniform distribution. So the minimum cost is 80, maximum cost is 100. The third input is demand. So demand follow normal distribution.

So the mean is 15,000 and the standard deviation is 4,500. Now we have to get the value for direct labor cost, similarly for the part cost, similarly for the demand. So first we are constructing an interval. How we are constructing interval? You see that the probabilities of 0.1 is given. So we are writing in the say 0.02, 0.1, so 0.1 to 0.3, so 0.3 to 0.7 because first you are finding the cumulative probability. So the cumulative probability should come on the right hand side of the interval. So an interval of random number is assigned to each possible value of direct labor cost. So that means, so instead of saying single probability, we are giving an interval of probability for each direct labor cost.

Value for the direct labor cost per unit

- An interval of random numbers is assigned to each possible value of the direct labor cost so that the probability of generating a random number in the interval is equal to the probability of the corresponding direct labor cost.
- Table shows how this process is done.

Direct Labour Cost per unit	Probability	Cumulative Probability	Interval of random numbers
$43	0.1	0.1	0.0 but less than 0.1
$44	0.2	0.3	0.1 but less than 0.3
$45	0.4	0.7	0.3 but less than 0.7
$46	0.2	0.9	0.7 but less than 0.9
$47	0.1	1	0.9 but less than 1

Value for the direct labor cost per unit

- The interval of random numbers from 0 up to but not including 0.1 is associated with a direct labour cost of $43, the interval of random numbers from 0.1 up to but not including 0.3 is associated with a direct labour cost of $44, and so on.
- Labour cost so that the probability of generating a random number in the interval is equal to the probability of the corresponding direct labour

Direct Labour Cost per unit	Probability	Cumulative Probability	Interval of random numbers
$43	0.1	0.1	0.0 but less than 0.1
$44	0.2	0.3	0.1 but less than 0.3
$45	0.4	0.7	0.3 but less than 0.7
$46	0.2	0.9	0.7 but less than 0.9
$47	0.1	1	0.9 but less than 1

This table shows how this interval was created. So interval of random numbers from 0 but not including 0.1 is associated with 43, this one. So the interval of random number 0.1 but not including 0.3, this is associated with 44. Like that it will come for the whole table. So labor cost, so that the probability of generating random number in the interval is equal to the probability of the corresponding direct labor. What you have to do? You have to generate a random number, then you have to look out where that random numbers occurs in this interval. For example, that I will explain in the next slide. So with this assignment of random number intervals to the possible values of the direct labor cost, the probability of generating random number in any interval is equal to the probability of obtaining corresponding value for the direct labor cost.

Value for the direct labor cost per unit

- With this assignment of random number intervals to the possible values of the direct labor cost, the probability of generating a random number in any interval is equal to the probability of obtaining the corresponding value for the direct labor cost.

Direct Labour Cost per unit	Probability	Cumulative Probability	Interval of random numbers
$43	0.1	0.1	0.0 but less than 0.1
$44	0.2	0.3	0.1 but less than 0.3
$45	0.4	0.7	0.3 but less than 0.7
$46	0.2	0.9	0.7 but less than 0.9
$47	0.1	1	0.9 but less than 1

Thus, to select a value for the direct labor cost, first we have to generate a random number between 0 to 1. If the random number is at least 0 but less than 1, we select the direct labor cost is 43, 0 to 0.1. Suppose if the random numbers comes in this interval, we have to

select this is our labor cost. If our random number comes in this interval, then you have to select this is the labor cost.

Random generation of 10 values for the direct labor cost per unit

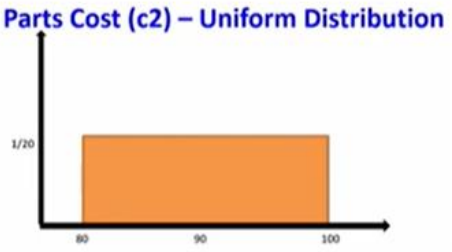
Trial	Random number	Direct labor cost $
1	0.9109	47
2	0.2841	44
3	0.6531	45
4	0.0367	43
5	0.3451	45
6	0.2757	44
7	0.6859	45
8	0.6246	45
9	0.4936	45
10	0.8077	46

Direct Labour Cost per unit	Probability	Cumulative Probability	Interval of random numbers
$43	0.1	0.1	0.0 but less than 0.1
$44	0.2	0.3	0.1 but less than 0.3
$45	0.4	0.7	0.3 but less than 0.7
$46	0.2	0.9	0.7 but less than 0.9
$47	0.1	1	0.9 but less than 1

Like this, for example, you see I have generated a random number 0.91. Where this 0.91 occurs, 0.91 occurs.

Value of the parts cost C2

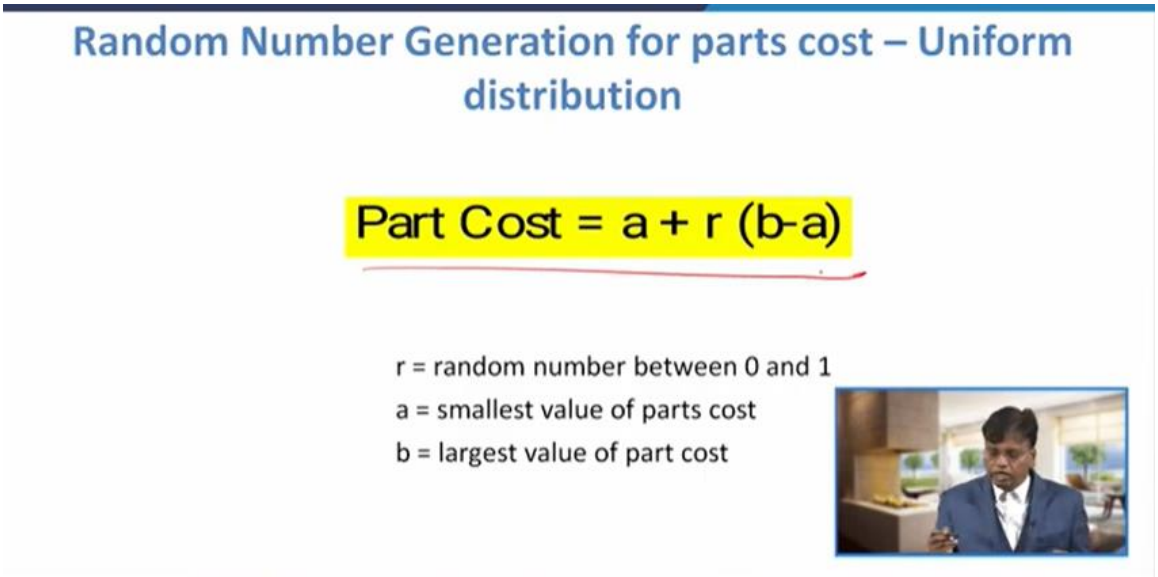
- Each trial in the simulation also requires a value of the parts cost and first-year demand.
- Let us now turn to the issue of generating values for the parts cost.
- The probability distribution for the parts cost per unit is the uniform distribution shown in Figure



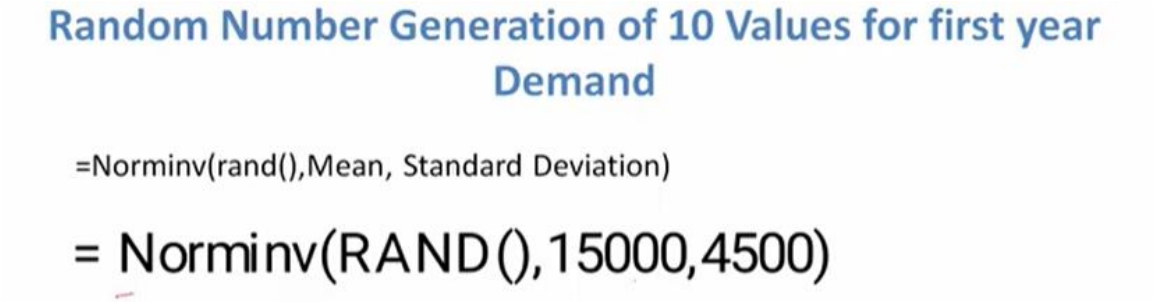
What is the corresponding direct labor cost? This is 47. For example, here 0.03, where 0.03 will be there here. So corresponding labor cost is 43. So like this, I have to generate random number, then you have to get the direct labor cost.

Next we have to get the value for the part cost. Now each trial in the simulation also requires value for the part cost and first year demand. Let us now turn the issue of generating value for the part cost. So the probability distribution for the part cost per unit follow uniform distribution. Because this random variable is a different probability distribution, then the direct labor cost, we use random numbers in a slightly different way

to generate the value of the part cost. So what we are going to do? We are going to follow this formula for generating random number for the part cost.



So a is the lower limit of that uniform distribution. b for example, like this. So this is a, this is b. So this is a + r is the random number. So we have to generate a random number from calculator 0 to 1, then we have to substitute here. We know what is a, we know what is b, so we will get a part cost.



So for different random numbers, we will get a different cost. The last one is we have to generate random number for demand. So for that the excel you can directly you can use norm in the inv function, rand, mean of the distribution and the standard deviation of the distribution. I am going to run this simulation model with the help of excel, then I got the summary statistics. So the summary says that mean profit is this much, standard deviation this much, so maximum profit is this one.

Summary statistics

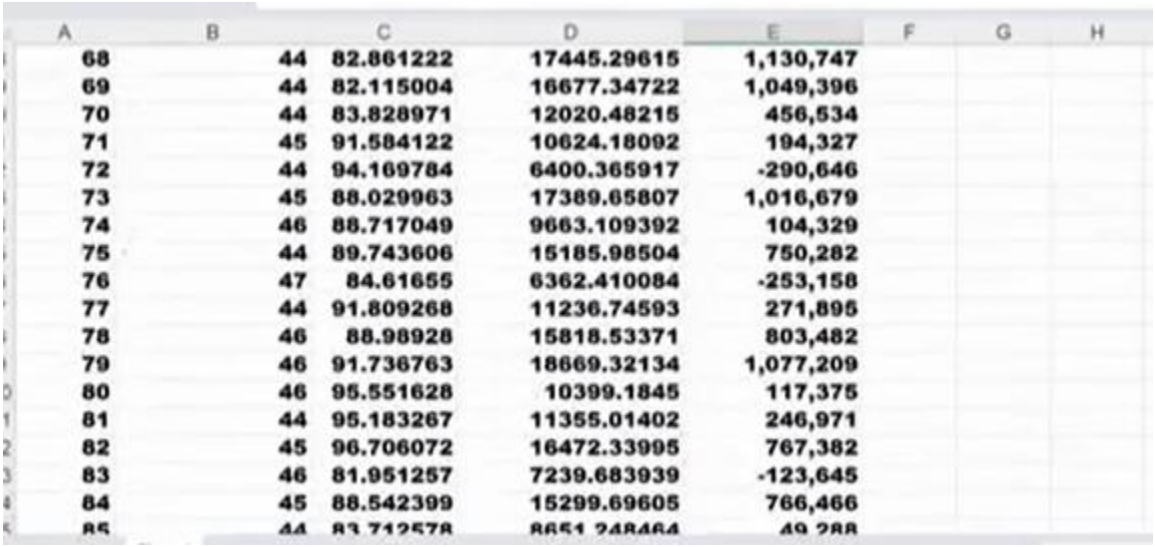
Mean profit	728990.11
Std deviation	506548.0909
Minimum Profit	-752383.6154
Max. profit	2242573.017
No. of Loss	28
Probability of Loss	0.056

So number of loss is 28 out of total number of trials. So 28 upon total number of trials will tell you the probability of loss. So here at present it says there is a 5 percentage chance that the new product will not be successful. So this is the way to do the risk analysis. This I will explain with the help of excel. Now here we are launching the product, we are going to see the risk of launching the product.

The selling price is already entered it, administrative cost has entered and advertising cost also entered it here. Now you see that how I am taking the input for direct labour cost. So I have entered the probability of lower limit and upper limit and what is the corresponding labour cost. That is one input. The next input is a part cost which follow uniform distribution, lower limit, upper limit is given.

	A	B	C	D	E	F	G	H
7				Distribution				
8	Direct Labour Cost (C1)			Lower Limit	80			
9	Probability Lower Limit	Probability Upper Limit	Direct Labour Cost Per Unit	Upper Limit	100			
10	0	0.1	43					
11	0.1	0.3	44					
12	0.3	0.7	45		Demand (x)			
13	0.7	0.9	46	Mean	15000			
14	0.9	1	47	Std	4500			
15								
16								
17								

Then the demand for the first year demand is that follow normal distribution, the mean I have entered and standard deviation is entered. Now see here I have already run it, so here I made it 500 trials, 500 trials. Now you see that how I am going to get the labour cost. So labour cost is here I am going to use VLOOKUP function.

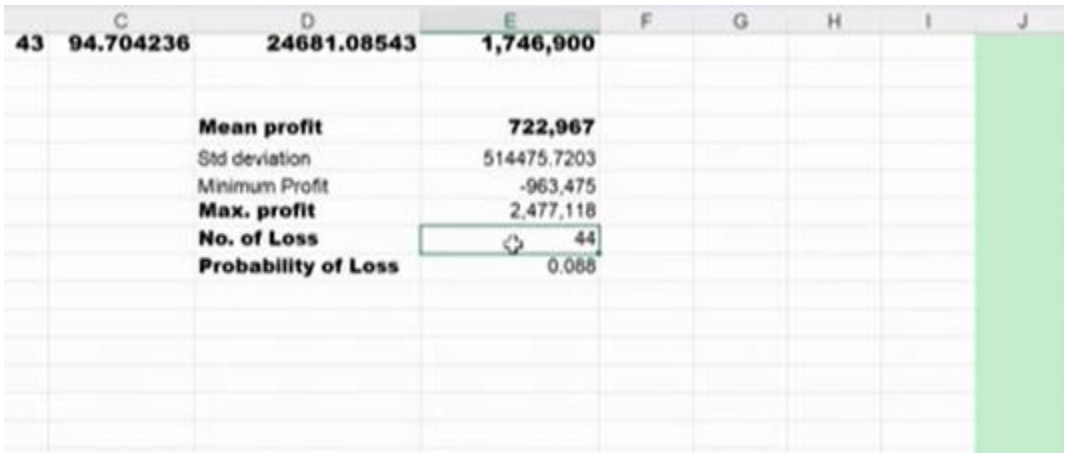


	A	B	C	D	E	F	G	H
	68	44	82.861222	17445.29615	1,130,747			
	69	44	82.115004	16677.34722	1,049,396			
	70	44	83.828971	12020.48215	456,534			
	71	45	91.584122	10624.18092	194,327			
	72	44	94.169784	6400.365917	-290,646			
	73	45	88.029963	17389.65807	1,016,679			
	74	46	88.717049	9663.109392	104,329			
	75	44	89.743606	15185.98504	750,282			
	76	47	84.61655	6362.410084	-253,158			
	77	44	91.809268	11236.74593	271,895			
	78	46	88.98928	15818.53371	803,482			
	79	46	91.736763	18669.32134	1,077,209			
0	80	46	95.551628	10399.1845	117,375			
1	81	44	95.183267	11355.01402	246,971			
2	82	45	96.706072	16472.33995	767,382			
3	83	46	81.951257	7239.683939	-123,645			
4	84	45	88.542399	15299.69605	766,466			
5	85	44	83.712578	8651.248464	49,288			

So VLOOKUP function, “RAND” then I am going to select A10 to C14, third. So what is going to happen? So we are generating random number, that random number is looked at the table. So where it matches the corresponding value in C3, that is why I entered 3, the third row, third column. C3 is pick up.

So for example it is 46. So when you press F9 you will get different result, 45, 45. This is a part cost. This is a labour cost. Similarly for the part cost, you see I have used this “a” plus “RAND” then “b” minus “a”. So ”a” is I have fixed at E8, you see I have freeze that cell, then rand, then E9 minus E8.

So I got the part cost. The next one I have to generate random number which follow normal distribution. So for that purpose I have used norm, inv, rand, mean of the distribution and standard deviation of the distribution. Then I have used our objective function. Objective function is the profit. We know that it is the selling price minus part cost and labour cost multiplied by demand minus your administrative cost and advertisement cost.



	C	D	E	F	G	H	I	J
43	94.704236	24681.08543	1,746,900					
		Mean profit	**722,967**					
		Std deviation	514475.7203					
		Minimum Profit	-963,475					
		Max. profit	2,477,118					
		No. of Loss	44					
		Probability of Loss	0.088					

So here I got profit. So when you press F9 you see that it is keep on updated. So like that I have run 500 iterations. At the bottom I have made the summary statistics. So summary statistics like this, mean profit, I found what is the mean, standard deviation of the mean I have got it and minimum profit also I got it, maximum profit also I got it. You see that I found number of losses. For this purpose I am counting in the profit column how many values are less than 0, that is a negative profit.

That I counted as number of losses. So here I got 44 for this iteration. So it would not be constant when you keep on press F9, you will get different values. Then what is the probability of loss? So number of losses upon total number of iteration.

I have taken 500 iteration. So here I got 0.06. When you keep on press F9 you see that the value of loss will not exceed 10%. So what we are concluding, here it is 11% but very rarely it will be 11. So when you launch this product, the probability of loss is less than 10%. So this is the way to use Excel for doing the simulation.

Dear students, in this lecture I have explained the role of simulation for project management. Then I have given various commercially available simulation softwares. Then I have explained different advantages of simulation software in the context of project management. Then I have taken a three example for explaining role of simulation for project management. The first example is to predict the project completion time that I have done with the help of crystal ball simulation. The second example, here not only considering the project completion time, because simulated what is the total cost of the project also.

That we have done with the help of crystal ball. The third example, I have explained how to use Excel for doing the simulation to predict risk of launching a new product. Thank you.