Introduction to Accounting and Finance for Civil Engineers

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Lecture-27
Bidding (Part-6)

Good morning, namaskar and welcome to the course once again. In the last lecture if you remember we discussed the rate analysis of some direct cost items and majority of indirect cost items. In this lecture we are going to discuss one important aspects in the entire bidding process which is the understanding of bidding models. If you remember the bid price is essentially consisting of total cost+the markup amount, total cost is the sum of direct cost+indirect cost.

We have add enough discussion on these 2 aspects, now we also know that when a contractor submits the bid, his bid price is different from other bid prices. So, where does this difference come from, is it because of the difference in cost, is it because of difference in bid prices. Now in one of the lectures if you remember we discussed about pre qualification of bidders. The purpose of carrying out the pre qualification see the process is essentially to make sure that the contractors are mostly at par, they are all at equal level.

So, when you have this kind of assumption that means we are having one set of assumption that the cost of each of these contractors are more or less going to be the same. Because after all they are getting the same material from the market, they are getting the same labor from the same market, equipment hire charges are almost similar, they are hiring the engineer from the same market. So, the difference in bid price is primarily on account of bidding strategy of a particular contractor.

So, how much markup 1 contractor is putting up in his or her bid is going to decide essentially the bid price. Now if I am a contractor and I would like to know if I quote a 10% bid price or 10% markup what is the probability that I am going to win this bid. If I lower this margin from

let us say 10% to 8% how much chances have improved whether I am still going to win this bid or not, what is the probability of winning this particular bid.

Or for that matter what is the probability of getting X amount of markup amount in a particular bid all these questions are answered by bidding models. So in this lecture we are essentially going to study different types of bidding models and their applicability in the construction industry.

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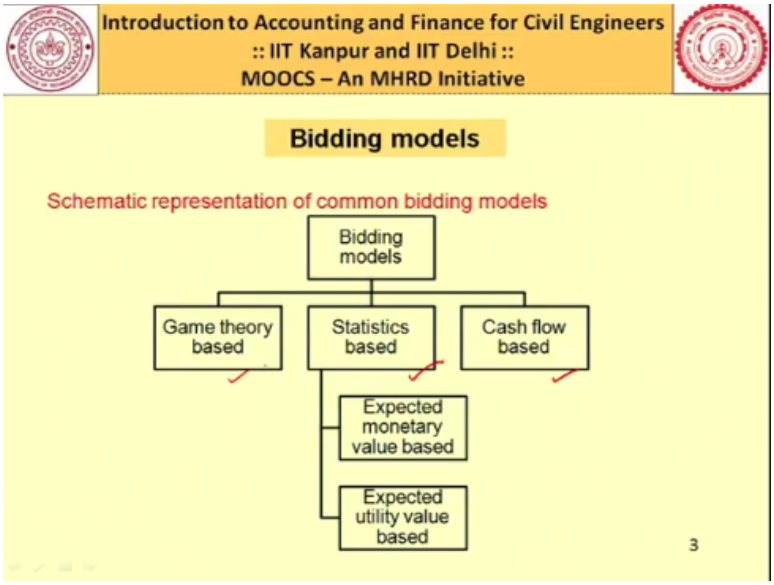

So, let us straightaway move to the bidding models, now if you look at the different types of bidding models that we have, we can classify them essentially in 3 categories. The first one we call them as game theory based, second category of bidding models are basically a statistical aspects based. Then the third one is cash flow based although game theory based and cash flow based models are not that utilized in the case of construction industry.

Yet to complete our discussion we will have just brief introduction of these game theory based models as well as cash flow based models.

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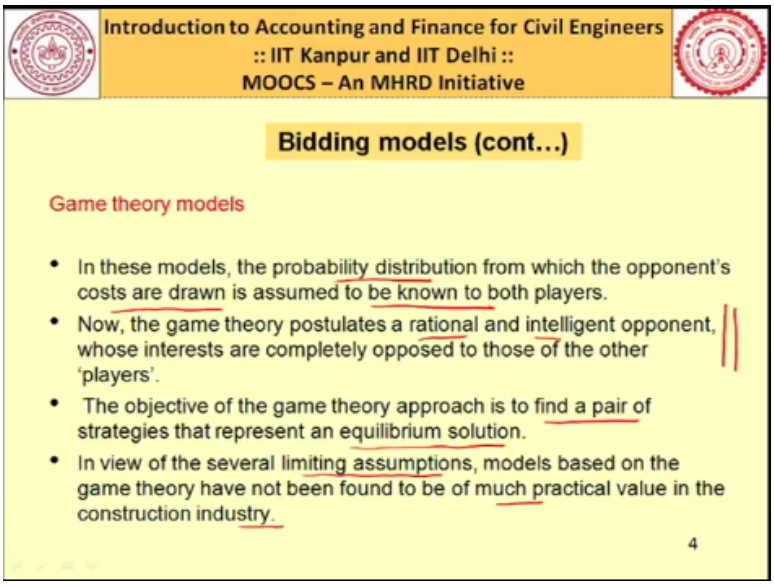

So, as far as game theory models are concern basically in these models it is assume that the probability distribution from which the opponents cost your competitors cost are drawn is assume to be known to both the players, why it is so? because the game theory essentially postulates that your opponents are quite rationale and they are also very intelligent. And their interest are completely opposed to those of the other players, so these are the rationales behind game theory.

The objective of the game theory approach is to find a pair of strategies that represent an equilibrium solution. So this is what is the game theory does, if you are applying it in the context of construction of bidding scenario. Now this game theory models have got several assumptions and several limitations and you will find that models based on this game theory they have not been found to be of much practical value in the construction industry.

They basically do not completely give you a feel of construction and the uncertainties involve. Game theories are basically used in the context of military games, military exercises and so on. So as far as construction industries concern they have not found much applications, the game theory assumes that your opponents are quite intelligent, they also know what are the strategies available to you and they also know what is strategy they should follow should you go for strategy A, should you go for a strategy B.

So, as I told you this is not of much practical significance in the construction field, so we are not going to the details of that, what is of interest to us in the construction industry is the models based on statistical data.

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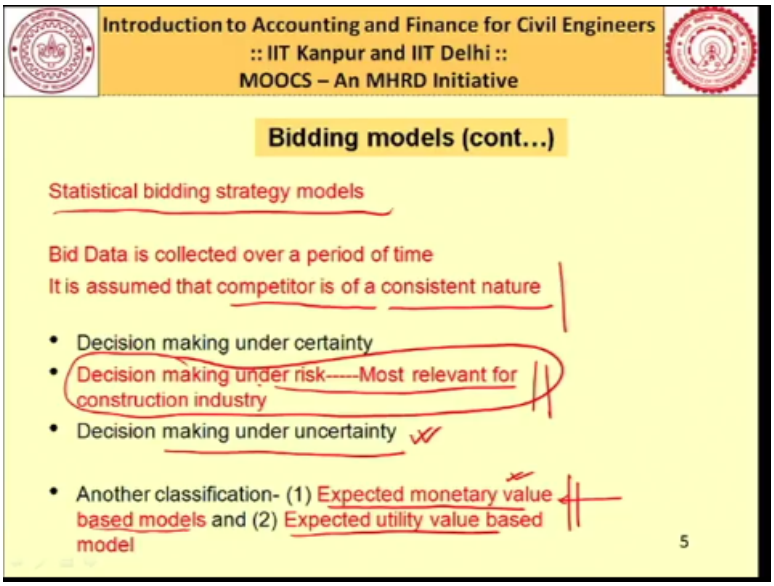

So here we are assuming that contractors do have got plenty of data from the past, from the historical encounters that they had against each of their competitors . We are also assuming here that the competitor that is your opponent is of a consistent nature. So we are assuming that he is not going to change his markup policy every now and then, so we are assuming that he is going to adopt his markup policy on a long term basis.

So, at least he is going to adhere to these strategies for let us 1 year, 1 and 1/2 year, 2 years and so on. So, what we do in these type of models we try to collect the past data from my historical records, from my experiences and the different bidding meetings that I attended against each of my competitor. So I have got those data and I am assuming further that my competitor is not changing those strategies very often.

Now in this case when you look at different models are available they essentially catered to the 3 situations. The first one is decision making under certainty which is obviously not the case in case of construction because you know construction is full of uncertainties and risk. So, the most

applicable model in statistical bidding models is the models corresponding to decisions under risk.

So, this is what is of most relevance to us as far as construction industry is concern and of course you have got this decision making under uncertainty also which we are not going to study in this particular lecture not particular lay in this particular course as well. So, what we are going to do emphasize in this particular lecture is the situation in which the decisions are to be taken under risk scenario.

Now sometimes bidding models specially the statistical bidding models are also classified under 2 categories as given here expected monitory value based model and expected utility value based models. Here also you will find expected monetary value based models are very popular in construction field and we will go into the details of these models based on these principles only.

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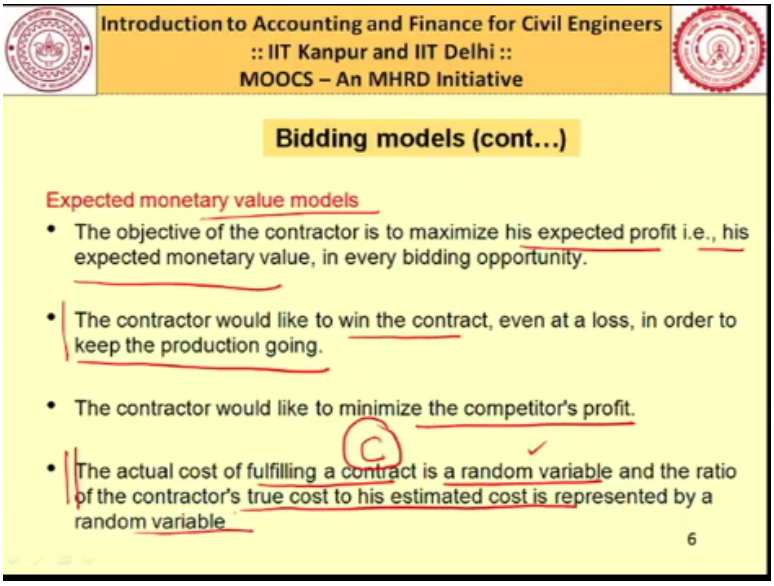

Now if you look at the expected monetary value based models here it is assume that the objective of the contractor is to maximize his expected profit. So he is trying to see that his profit is maximized right, this is what we are calling it as his expected monetary value and this he would like to do in every bidding opportunity. Now another assumption here is the contractor would like to win the contract even at a loss in order to keep the production going.

So, we are not considering fly by night operators, we are saying that whichever contractor is participating in a contracting business is there for a long term, it is not that today he is bidding for one particular job and then tomorrow he is running away no. We are assuming that this particular entity is there in the business for longer durations, the contractor would further like to minimize the competitors profit.

See first assumption if you remember it was that he would like to maximize this profit, fine if he is not able to do it you would like to see that his opponents does not make much of profit. So he would like to minimize their profit as well, so this could be another objective and this what we assume and finally the most important assumption if you see here it says the actual cost of fulfilling a contract is the random variable this is of quite interest to us.

So we are saying that the cost of fulfilling a contract cost is basically your sum of direct cost+indirect cost we are considering this as a random variable. And the ratio of the contractors true cost to his estimated cost is represented by a random variable. So this important assumption is the base of most of the splited monetary value based models. Now we will go into the details of each of these models.

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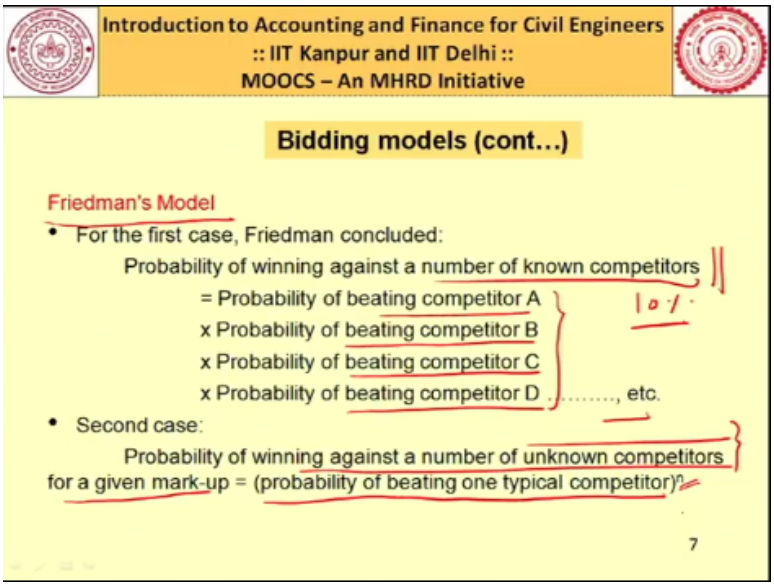

That we have to study in this particular course, now Friedman was the pioneer of all the bidding models. He basically started the discussion on these bidding models, primarily his main concern

was to estimate the markup and the associated probability. So he was trying to answer questions like what is going to be my bidding probability, if I bid at least a 10% margin against a particular competitor A.

Now in any bidding scenario you will find that you have N number of competitors competitors could be A, B, C, D or so on . In some situation you may not even know who are your competitors, but you may be knowing how many of them are there. In some of the situations in fact neither you know who are your competitors, nor you know how many of them are there, so Friedman gave his model essentially for 3 situations.

The first one in which you know who are your competitors it could be A, B, C and D and you also know how many of them are there, whether they are 5 in numbers, 6 in numbers, 7 in numbers. So, this case 1 you know your competitors, you know their numbers, second case you know their numbers but you do not know who they are and third case you really do not know how many of them are there and who are they.

So for these 3 conditions Friedman came up with a bidding model, you will see how does that model look like. But we are going to study these models only for 2 situation, in the first case when the competitors are known and number of competitors are also known. For that he concluded that probability of winning against a number of known competitors, so mark these words known competitors.

So, you know who are your competitors=probability of beating competitor A*probability of beating competitor B* probability of beating competitor C and probability of beating competitor D and so on. So suppose there are these 4 competitors, so you *their probability and this is what is the probability of winning against a number of known competitors. The number at a given markup, so suppose you are trying to find the probability of winning against a number of known competitors at 10% markup.

Suppose the management decides to bid at a 10% markup, so that means let us say they are going to apply 10% margin on their cost. So, in that case he would like to estimate what is the

probability of beating competitor A at 10% what is the probability of beating competitor B at 10%, what is the probability of beating competitor C at 10% and so on. Now this is going to give you a number let us say 0.4 or 0.6, so it could be 40% winning percentage probability, 60% probability of winning.

Now if you are not happy with these numbers you have to go down, you have to slightly reduce your markup and the see what is the next probability. And you go on doing this exercise till you have achieved a probability at which you feel yourself to be confident. So, this is how you have to apply these models, you will see in one of the examples how do we find out the optimal markup but in the next lecture right now we are discussing all the models especially theoretical aspects.

So, this is as for as his model for situation one was concern what is situation one you know your competitors that means you know their identities and you know how many of them are there. Now for the second case, second case is what you do not know the identity of your competitors but you know their numbers. For the second case he concluded that probability of winning against a number of unknown competitors just look at this point unknown competitors.

Here you do not know whether they are A, whether they are B, C or D at a given markup it could be 10%, 15% and so on. He is essentially=probability of beating 1 typical competitor raise to power n. So, for the second case when you know only the number of competitors n he concluded that probability of winning against a number of unknown competitors for a given markup=probability of beating 1 typical competitor rise to power n**.**

Now when this Friedman's model came it was subjected to lot of scrutiny from different parts of world, some researchers like his approach, some researchers did not like his approach. Now those who did not like they said that Friedman's model is the model which gives very pessimistic results, why because this is basically a power model, when you say power model it is basically the multiplication of different probability.

So suppose there are 2 competitors and I have let us say 50% chance of beating each of them at let us say 10%. So the probability of winning the bid will be how much 1/2*1/2, so it is giving me only 1/4 So, it is 0.25 but ideally I should have got 1 in 3 that means 33% because I have got equal chance of beating them at 10% markup. So, 50% chance of beating A, so that means for every 3 job that I bid I should have got 1 job.

But this model if you calculate using it is formula you are getting only 0.25 1/2*1/2 it is 1/4 and this value will further go on reducing if the number of bidders are more. So, that is why people criticize it is saying that it is quite a pessimistic model nevertheless this model gave rise to plenty of other models to follow. So in that sense Friedman is to be considered as father of bidding model, because it was the only who started thinking on these lines that if I have to bid at this markup what is going to be my probability and so on.

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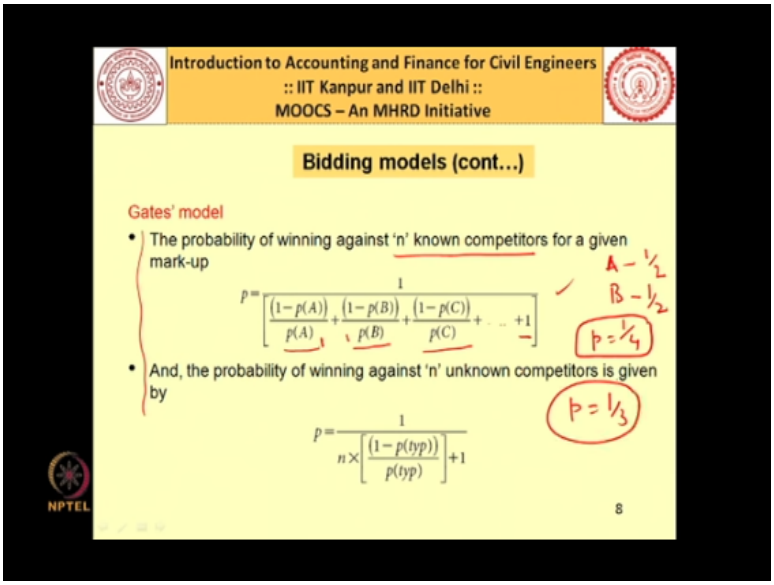

Now Gate's was one of it is opponents who criticize his models when entry and he came up with an alternate model which is known as Gate's model, he also gave his model for 2 situations. In the first case you know the identity of competitor and you also know how many of them are there. So for the first case when you know that there n known competitors, the probability of winning at a given markup it could be 10%, 15% or 20% is given by this formula p=1 upon 1-pA, pA is probability of beating A/probability of beating A+1-pB/pB+1-pC/pC.

So where pA, pB and pC are probability of beating competitor A at a given markup pB is probability of beating competitor B at a given markup. And pC is probability of beating competitor C at a given markup+if you see at the end he is adding this 1. Now if I do the same example which I gave you in the context of Friedman's model if you apply it here what you will get let us say I have 2 bidders A and B.

Rather these are my 2 competitors and at 10% markup I have a equal chance of beating A as well as B let us say 1/2and 1/2. So, through Friedman I got this probability as 1/4 whereas if you look at this particular scenario logically I should have been getting 1/3, so this is what you get it if you are using the Gate's model. So, let us say pA is ½, so 1-1/2 which is 1/2/1/2 1, so this becomes 1 likewise for this 1-pB upon pB this will also become 1.

Because if your pB is 1/2, so 1-1/2 is 1/2/pB which is 1/2, so 1 and at the end you have 1, so 1/3 you are getting it for this situation if you are applying Gate's model. Now for the second case when you know the number of bidders n but you do not their identity that means they are unknown competitors he gave this expression p=1 upon n*1-p typical we will see what typical bidder means basically this is a probability of beating a typical bidder and here also you can see at the end we are adding 1.

So if you have 4 unknown bidders and with the probability of beating a typical bidder as 1/5 you can apply this expression and find out the probability of winning. So, these 2 models were quite popular and so for also you will find people still continue to use these 2 models.

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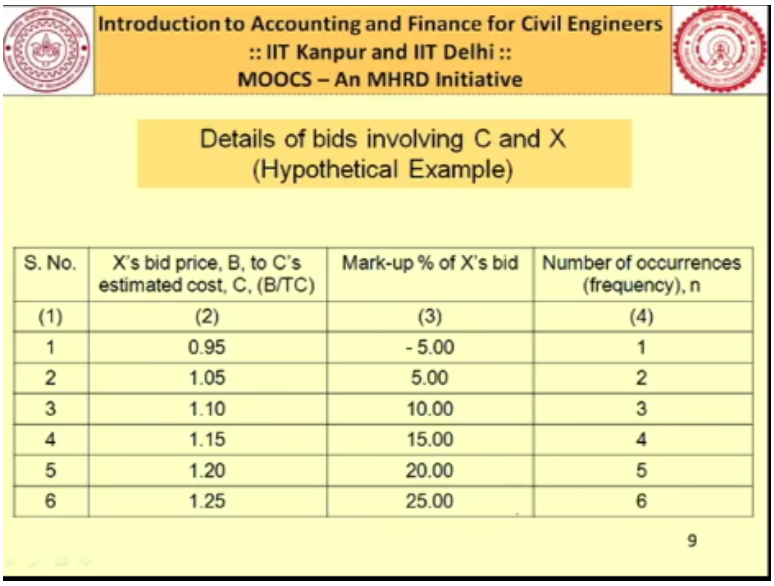

Now in order to understand and apply these models we have to find out what is the probability of beating a typical competitor as well as what is the probability of beating competitor A, B and C and so on. So how do we generate this data that is the thing that we have to understand and subsequently how do we represent those statistical data. So that it gives in the probability values, so that these values can be used in either the Friedman's model or Gate's model that is what we are going to learn.

So if you remember the bidding process, the contractor what it has done every contractor what it has done, it has combined the technical bid and the financial bid in 1 envelope. So you have a separate envelope for technical bid, you have a separate envelope for financial bid. These 2 packages are put together in 1 big envelope and they are deposited at the right time whenever it is due in the client's office.

Now after that what does client do, client will first open the technical document, technical bid and it will make sure that the earnest money deposit, the power of attorney, the cash flow schedules, the construction schedules everything whatever was desired under the technical bid is available from all the contractors. If someone has missed out something the client will write a letter that look we have opened your technical bid and we found these documents missing.

So, then the contractor would reply and then once the client gets satisfied with the technical bid then they will call all the bidders saying that we are going to open your financial bid on such an such date and such and such time. So, when that time comes the financial bids are open 1 by 1 in front of all your opponents, so normally the client will announce that ok contractor A has quoted a price of 55 crore, 67 lakhs, 37,483 something like this.

So, likewise they will announce the bid prices of all the bidders, so remember this information is there with all the bidders. And in a close industry kind of a situation where you meet your opponents quite often in a month you maybe meeting them some of them 3 or 4 times. Because for a different for a particular type of project you will find there are not many contractors. So, every now and then you will be meeting them, so this meeting and this bid opening result is there with everyone.

Now we are going to utilize this data to generate the probability values, probability of beating competitor A, probability of beating competitor B and so on at different markup levels, how we are going to see now. Now let us say for example in order to understand the various probabilities what I have done is I have compared my bid prices and others bid prices. Let us say I am comparing my prices with my opponent A or some opponent X.

So, let us say I am the contractor C and I want to make a strategy against competitor X, so what I will do, I will collect all the data wherein I met contractor X on a particular project. So, let us say last 1 year 1 and 1/2 year I will see in which project I met this contractor X and how much price he had quoted. This is known to be from the bid opening result, I also know my price, I am contractor C I know my price.

In addition to my price I also know my cost, so you remember the difference between price and cost, price is basically cost+markup. So, if I am contractor C I know both my cost as well as my markup and so I know my total price. Now what I am going to do is I will compare my opponent X price with my cost because I do not know his cost, I know his price, how much price he has quoted in project number 1, project number 2 I am knowing this what I do not is his cost.

But I know my cost, so what I will do on my cost I can find out how much margin did he apply do you understand. Because you as a contractor C know your cost, so what I will do I will divide cost from his price because that price has been told to me by my client in the bid meeting, in the bid opening result rather in the bid meeting right. So, this is how what I have done I have compare let us say a list of projects where I met contractor X and I compile this particular table.

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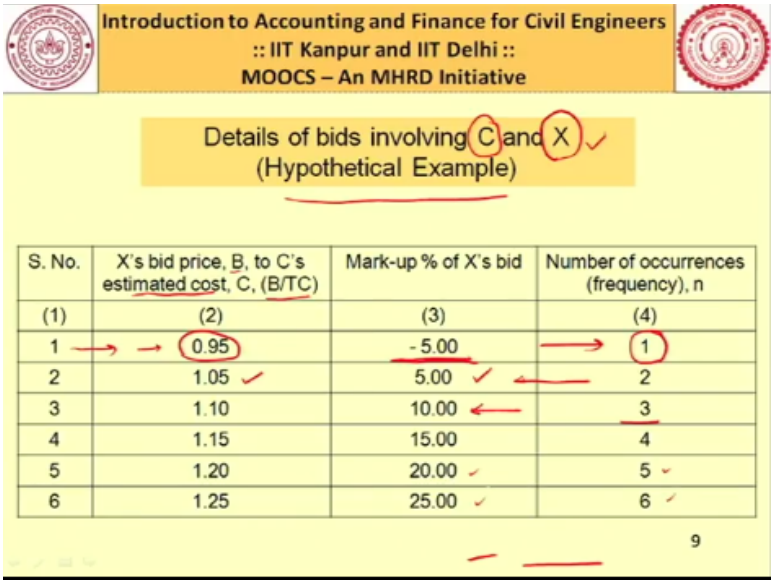

Remember this is just an hypothetical examples, so the data which I am showing you is not real. I will also show you a real project data but little later. So, what I have done is let us say I am contractor C and I am comparing my cost with my close competitor X. So what I have done I have collected the bid price of X and I have divided it by my total cost for that particular project. So, let us say for example serial number 1, X is bid price B to C is estimated cost, I am C.

So I am finding this ratio B/TC, B is my opponent X bid price and TC is my total cost on this project. So I find that this is 0.95 what does this mean that the contractor X quoted 5% below my cost in one project out of a number of projects in which I encountered him. So this what it is written here, so how much markup did he apply on my bid price it is -5%. That means if my cost is 100 he quoted a price of 95 rupees, this happen in 1 project out of let us 36 projects wherein I met him.

These 36 projects from where did I collect how much time I took, so the data for this 36 projects whereas spread around 1, 1 and 1/2year time frame. You will be tempted to look for longer duration data but there is risk involved here because it might so happen that the competitor might have changed his bidding strategy. So you should not get tempted to provide or to keep large set of data, so you take the data from let us 1 year to 1 and 1/2 year time frame.

So, that would give you very accurate result even though you have got not many large set of data, so these data were collected for a period of 1 and 1/2 year and let us say for 36 project you have got the data in which you competed against contractor X. So in one project as you can see here his bid price was 5% lower than your cost, in 2 occasions his bid price was 5% above your cost.

So, B/TC ratio is you can see 1.05, on 3 occasions he quoted 10% above your cost, on 4 occasions he quoted 15% above your cost, 5 occasions he quoted 20% above your cost, 6 occasions he quoted 25% above your cost.

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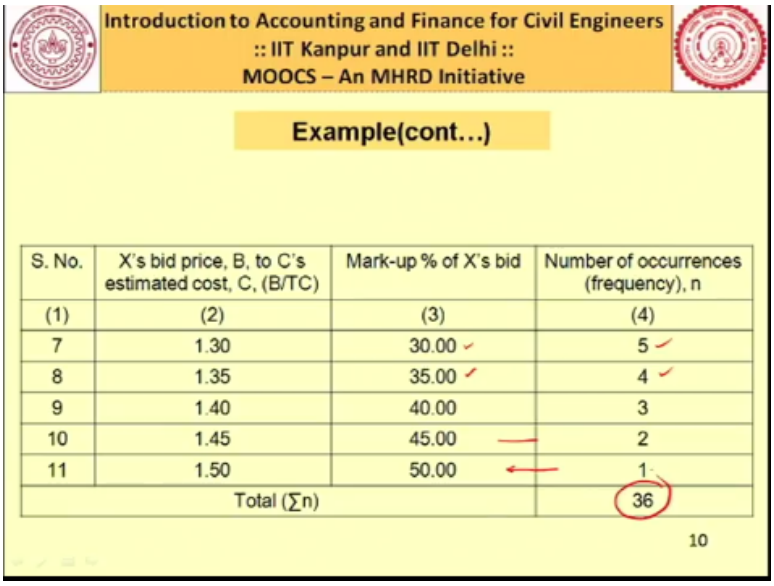

Some more datas are there on 5 occasions he quoted 30% above your cost, on 4 occasions he quoted 35% above your cost, 3 occasions 40% above, 2 occasions 45% and 11 occasion even 50% above your cost. So, what I did I took my cost because that is what is known to me, in some cases there might be a situation in which some contractors plant a spy in your opponents

company, so in some cases it is quite possible that they may be aware of your cost also but we are not discussing that case.

We are discussing a case where all the contractors are behaving in a ethical manner and in such situation you will not be knowing their cost. So what we will do is we will try to find out what percentage above or below they quoted above my cost right, so this is what has been done in this case.

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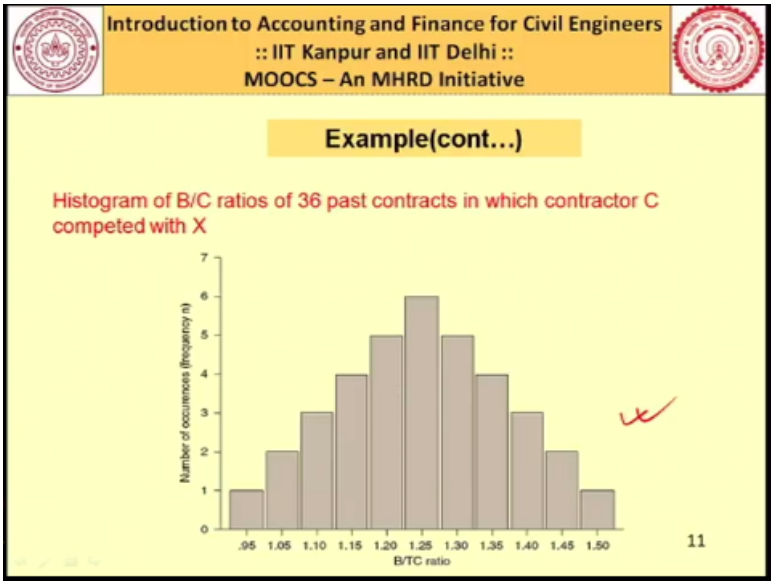

Now if you try to put a histogram for this 36 projects hypothetical cases you will get a diagram something like this.

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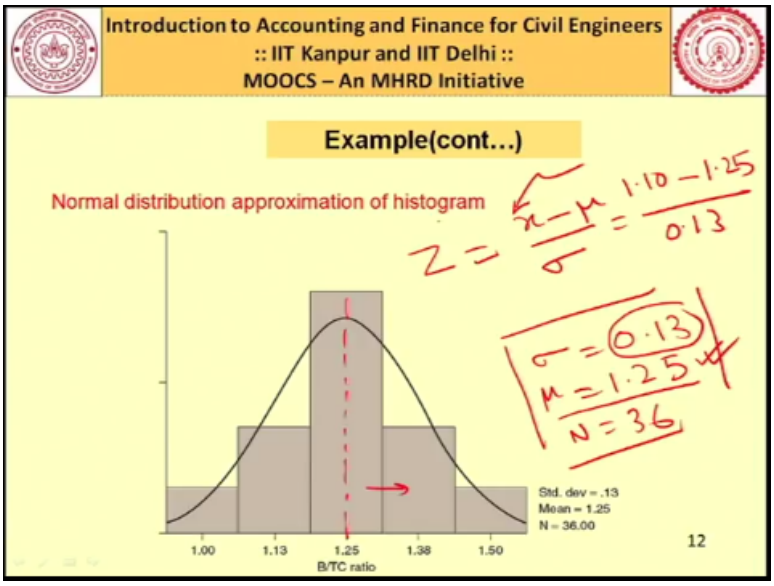

Now from these histograms you can very well generate a normal distribution curve, you will find that you get a curve like this and for the data which I showed you, you can calculate the sigma value and you can calculate the mean value. So in this case the mean is coming to be 1.25 and sigma is coming as 0.13 and N as you know it is 36. So for 36 value of the projects I could find that my competitor X is quoting on an average 25% above my cost this what it means.

So you can see that this is your mean value, so about 50% of the project he is quoting below 25% above your cost and 50% of the cases he is quoting 25% above your cost. This is what the mean value means and standard deviation is 0.13, now knowing this diagram for competitor X, for competitor Y and so on. You can generate the probability values how, what you will do let us say I want to bid at a markup of 10% above my cost.

So my X is going to be 1.10, 10% above my cost, so I will calculate the normal variant, how do we define normal variant, it will be Z=X-mu upon sigma. So, this is the formula that you are already familiar with X-mu upon sigma. Now I am interested in finding my probability of beating competitor X at let us say 10% markup on my cost. So X becomes 1.10, mu is already known to me 1.25, sigma is already known to me it is 0.13.

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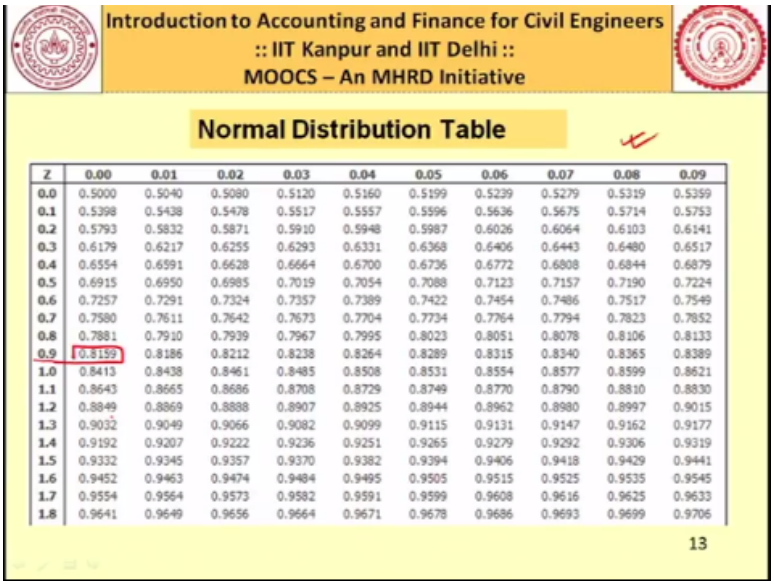

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706

So, this value I will locate it on a table like this, this normal distribution table you are already familiar with this, suppose my Z is coming to be 0.9, so I have read this probability 0.8159. So, corresponding to Z=0.9 I am getting a probability value of 0.8159, so likewise I can calculate the probability of beating competitor X at any given markup percentage. Now depending on how keen I am in beating him I can go on changing my markup percentage.

So this is how you can calculate the probability of beating competitor X, if you have got data against competitor Y you can find out the probability of beating competitor Y, probability of beating competitor Z and so on. And that is how you can calculate the probability of winning using Friedman's model or for that matter Gate's model. Now I will take up the case wherein I do not know who are my competitors and I know how many of them are there.

So I know N but I do not whether they are X, Y or Z, so what I will do is instead of beating competitor X, Y and getting lost against Z why not target to beat the lowest bidder. So what I will do is from my past encounters against each of my competitors I will gather the data on my lowest bidder. So on different encounters I will find out who were the lowest bidders and what was their price, now that price I am going to compare against my total cost.

So, that means I will like to know on my total cost how much was the lowest bidder above or below. So, this type of data I generated and this is coming from a real case taken from Indian markets.

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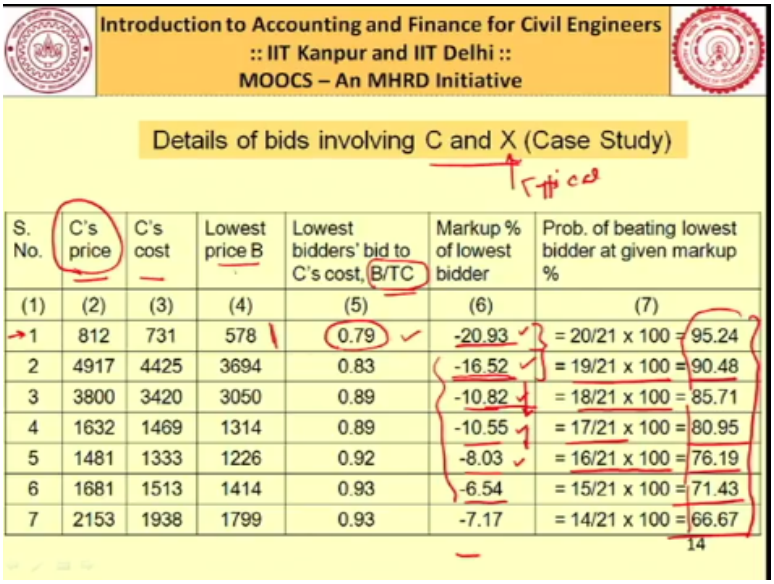

S. No.	C's price	C's cost	Lowest price B	Lowest bidders' bid to C's cost, B/TC	Markup % of lowest bidder	Prob. of beating lowest bidder at given markup %
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	812	731	578	0.79	-20.93	= 20/21 x 100 = 95.24
2	4917	4425	3694	0.83	-16.52	= 19/21 x 100 = 90.48
3	3800	3420	3050	0.89	-10.82	= 18/21 x 100 = 85.71
4	1632	1469	1314	0.89	-10.55	= 17/21 x 100 = 80.95
5	1481	1333	1226	0.92	-8.03	= 16/21 x 100 = 76.19
6	1681	1513	1414	0.93	-6.54	= 15/21 x 100 = 71.43
7	2153	1938	1799	0.93	-7.17	= 14/21 x 100 = 66.67

14

And here you find I am comparing C with X again now in this case X we are calling it as a typical bidder who is the lowest bidder. So I am not interested in beating A, B, C separately but getting lost against D ultimately nothing happens I lost, so I will try to beat the lowest bidder itself. So now I am going to tell you the data which I collected long back from the Indian market and this data is there with me for 21 projects if you see here.

And here I am comparing the C's price I am contractor C with the lowest bidders price. So, I know my price, I know my cost. So, I am C, C's price C's cost is known, lowest price I noted when I went for this particular meeting, bid opening meeting and that way I am able to calculate this ratio of B/TC. B is my bid price and TC is total cost, B is whether bid price of the lowest bidder and TC is my total cost.

So I found that in this particular project my competitor had quoted -20.93 below my cost, now sometimes this can happen if pre-qualification is not done. In all these situation you will find that clients had not carried out the pre-qualification that is the reason there was too much difference

in the bid prices. And bid prices primarily varied because of a difference in cost because the contractors whereof different level and that is the reason you find so much of difference.

In the second project which we noticed the lowest bidder was 16.52% below the total cost. In this 10.82% below the total cost 10.55% below total cost 8.03% below total cost. So, you find all of them here are below your total cost.

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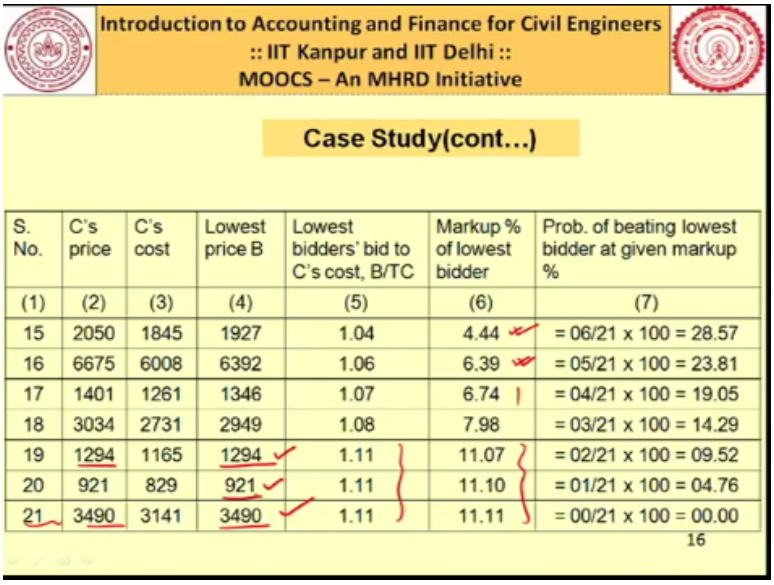

S. No.	C's price	C's cost	Lowest price B	Lowest bidders' bid to C's cost, B/TC	Markup % of lowest bidder	Prob. of beating lowest bidder at given markup %
(1)	(2)	(3)	(4)	(5)	(6)	(7)
15	2050	1845	1927	1.04	4.44	= 06/21 x 100 = 28.57
16	6675	6008	6392	1.06	6.39	= 05/21 x 100 = 23.81
17	1401	1261	1346	1.07	6.74	= 04/21 x 100 = 19.05
18	3034	2731	2949	1.08	7.98	= 03/21 x 100 = 14.29
19	1294	1165	1294	1.11	11.07	= 02/21 x 100 = 09.52
20	921	829	921	1.11	11.10	= 01/21 x 100 = 04.76
21	3490	3141	3490	1.11	11.11	= 00/21 x 100 = 00.00

And in this -4.93, 4.14, 2.31 this is 0.88 above your cost, 1.97 above your cost, 2.17 above your cost, 4.44 above your cost, 3.69 above your cost and so on. You can see in these 21 projects there are 3 projects wherein you have also become the lowest, so you can see your bid price was same as the lowest bid price. That means you got this job, you got this job, you got this job because you can see your price and lowest bidder price are same.

So, that means in these 3 cases you won the project, you won the bid. Now when you have got data like this especially when they are less than 30 you cannot carry out the statistical analysis meaningfully. So in that case what you can do is you can do the analysis in a slightly different manner what you can see is suppose from tomorrow you decide that I am going to quote all my projects below this 20.93, what I notice is 20.93% was the lowest out of all projects which some contractor apply.

So, from tomorrow let us say for my next project if I decide that I am going to quote at let us say -21% below my cost. So, if my cost is let us say 100 rupees I am going to quote at let us 79 rupees, 21% below my cost what will be the probability of my being the lowest bidder it would be 100%. Because in no circumstances anybody had quoted below this **9** 20.93%, so tomorrow if I quote at 21% below my cost there is 100% probability that I will win the bid right.

So, this is how I go on calculating the bid, now let us say if you look at this case 16.52, if you quote below this or rather above this you might be losing only these 2 out of 21 projects. So, your winning percent is could be 19/21*100, so 90.48, if you are quoting above -10.82 that means you will be winning 18 out of 21 cases likewise here 17 out of 21 cases, so probability of winning is 80.95, here probability of bidding could be 76.19, so this is how you calculate the probability.

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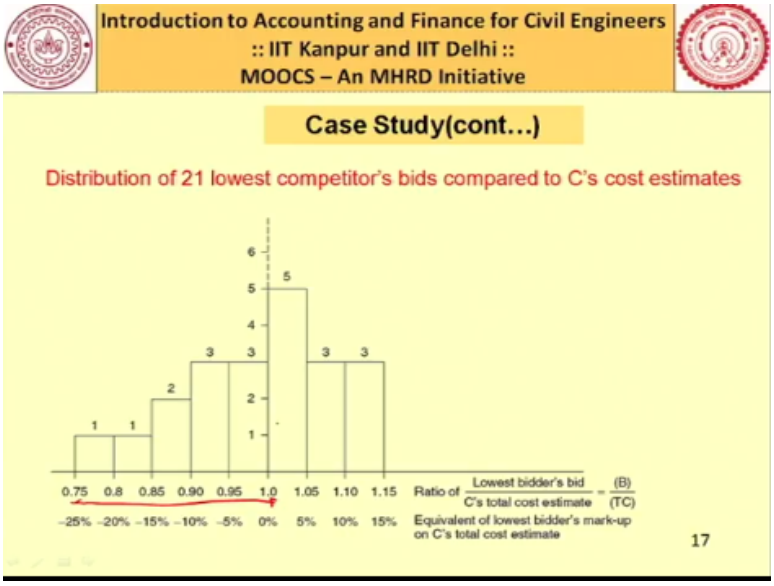

And you can put them in the histogram form and subsequently in a cumulative distribution curve I will show you in the next slide. Here you can see most of the cases are below this cost, so all these stances the contractor has your lowest bidder has been able to achieve because they have quoted quite below your total cost. So this maybe the reason because the total cost itself are different.

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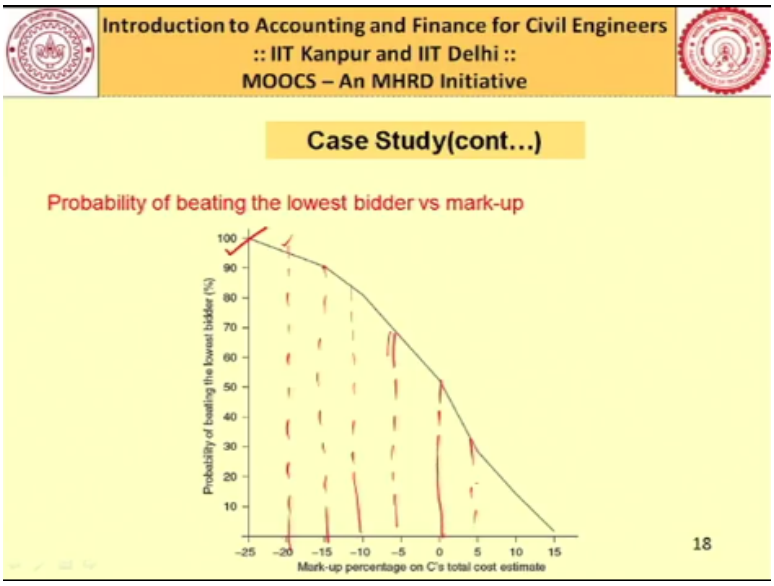

Now if you convert these values you will get a diagram like this here you can see if you decide to quote below 21% you had chance of winning 100%, if at 20% this much probability -15% this much probability. So, these values I am getting it from which table from these tables, so these are the values I have plotted, so 95.24, 90.48, 85.71 these values I have plotted. And I am getting a graph like this and this can be useful in reading out the probability of beating the lowest bidder at a given markup percentage.

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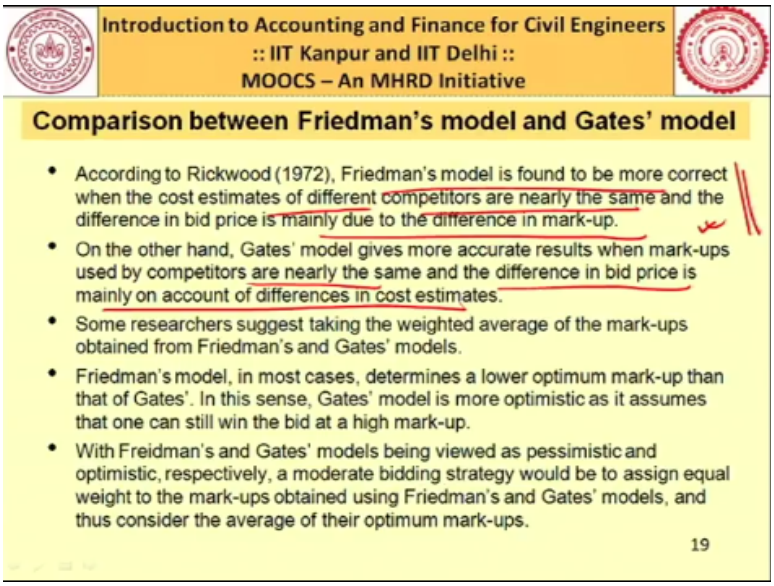

So, if you want to compare the Friedman's model and Gate's model which many of them they did one of the important contribution was from Rick wood and he said that Friedman's model is found to be more correct when the cost estimates of different competitors are nearly the same,

when is this possible, when you have carried out the pre-qualification process judiciously and the difference in bid price mainly due to the difference in markup.

So, under such situation Friedman's model is found to be more accurate. On the other hand Gate's model when it is more accurate when your markups used by the competitors are nearly the same and the difference in bid price is mainly on account of difference in cost estimate. So, Gate's model is favorable where your cost estimates are different and you find that markups are nearly the same.

Now some researchers what they suggest is to take the middle path this they say because Friedman model gives a pessimistic value whereas Gate's model gives you quite optimistic value of markup. So, they say why not use both the methods and find out the markup from both the methods and take the average. So this illustration I will show you in the next class, so I will just quickly summarize what we have learnt in this particular lecture.

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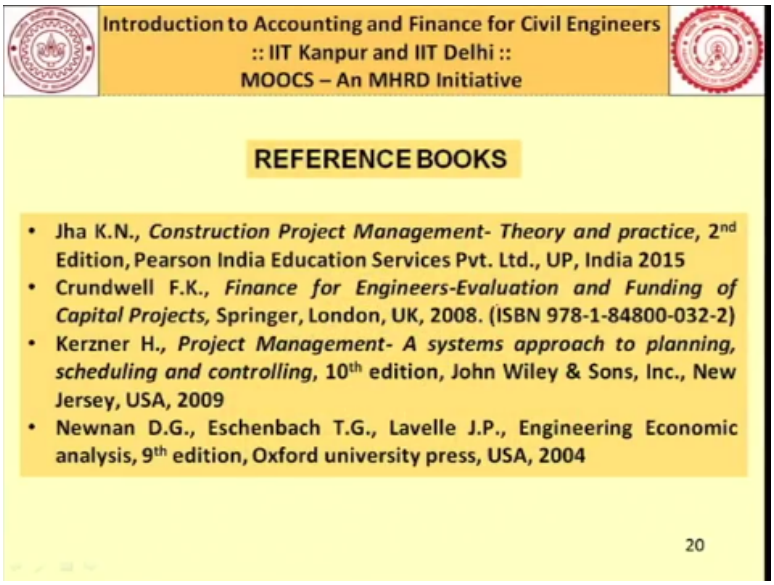

Of course these are the reference books you can go through but I will quickly summarize what we have learnt in this particular lecture. We have discuss different bidding models, there are different types of bidding models like game theory based models, then you have a statistical based model . In construction a statistical bidding models are quite popular and that to the one corresponding to expected monetary value.

We have not gone into the details of expected utility value based model because those are slightly advanced and not pertaining to our course, under expected monetary value we have discuss 2 models essentially Friedman and Gate's . These 2 models are capable of forecasting the probability of winning against different competitors for different situations one in which the identity of competitors are known, their numbers are known.

And other situation where their identities are not known but the numbers are known, so we will stop at this particular point and when we meet the next time we will discuss how to determine the optimal markup. That means at what markup percentage I should quote which will give me lots of money that will be the subject matter of the next lecture. So we stop at this point thank you for listening, thank you very much.