**Infrastructure Planning and Management**
**Risks and Challenges in Infrastructure - Part 2**

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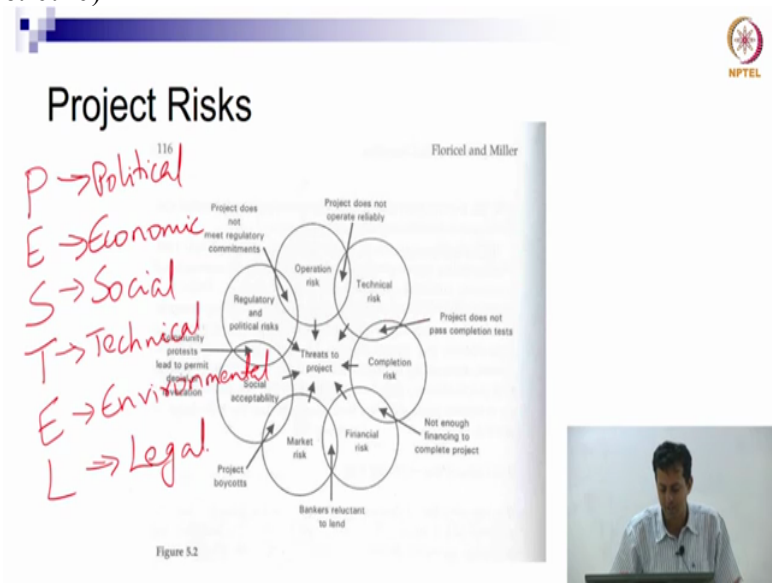


The different types of risks, I think Swapnika has talked about all of these. But one acronym that I found useful is this thing called PESTEL which people use in several parts of the world. P stands for the political risks, all kinds of regulatory governmental risks, all risks that can come through changes in the view of government organization towards the project. So it could be a change of government, so the picking away the concession from a private player, it could be change in regulation, it could be a very slow judicial system that does not allow you to seek redress effectively all of that.

So the E stands for economic. So these are all your market risks. So there is a stagnation in the economy, there is a recession, people are not able to pay, you are not able to sort of make enough revenue or whatever reason, there is a shortage in demand. All of those kinds of risks are economic, financial in some cases, fall under the E. Interest rates go up, et cetera. S is the social risks. People liking the project or not liking the project protesting against the project, so that is another category of risks to look at. T stands for technical or technological. These are the engineering risks.

So I am building a flyover, whatever collapses, what if my foundation sink, what if as I am ()(01:40) under the ground, parts of the road collapse. So all of these are technical challenges, technical risks that I have to mitigate. E are the environmental risks, so what I am doing to flora and phona, I am just destroying forest to create a road, what does that do? How does climate change play an impact? What do environmental action groups have to say about this? And L sometimes stands for legal risks.

And legal risks are often separate from political risks because legal risks are risks, changes of law, judiciary, all of that but political risks is, it relates more to elected representatives, political parties and so on. So this is just another way of slicing and dicing risks, there are many ways. But to really bring the, so I seek all of these subsets which we talked about.

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And so I think these are the two main categories and I want to spend a minute on each. There is the decisioneering school of thought and the managerial school of thought. Essentially we know we have risks, right? Any activity you have risks, walking skateboard you do about the risks. The two schools of thought, one is deal with it in terms of probabilities and that is the…

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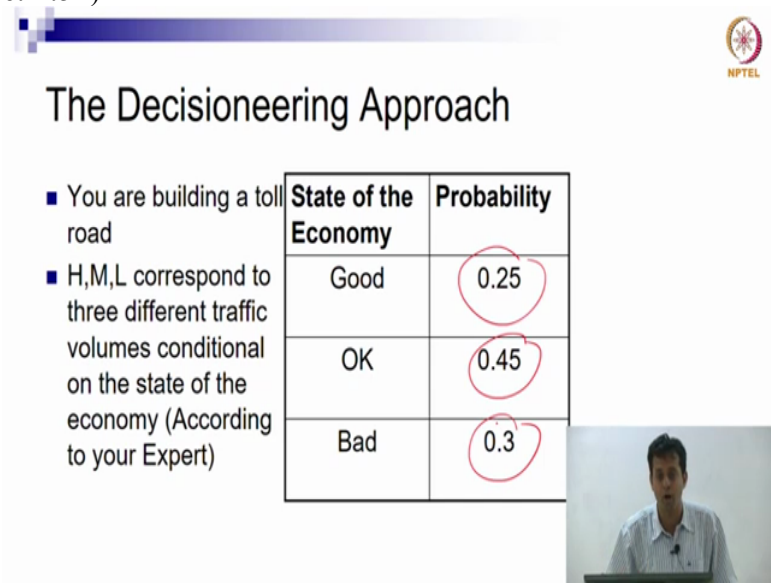


So that school looks like, it looks at risks like this. Since you are building a toll road, there are risks. People may or may not use the road. So economic conditions may be such that lot

of people try about the road, they may not, there are risks. So let us speak about probabilities. One probability that I want to understand is what is the state of the economy going to be going forward. So maybe there is a 25 percent probability that state of economy will be good, growing, 10 percent. 45 percent probability that the state of the economy will be either good, not bad, I mean sort of relatively slow but steady growth, 5 percent.

But there is a 30 percent chance that my growth might dip to very low levels or might actually be negative. All of these have an influence on traffic. Presumably the economy grows, there will be more jobs, more people commuting, traffic will increase. If the economy is poor, then perhaps there will be reduction in traffic. But again the relation between the state of the economy and the traffic need not necessarily be one on one.

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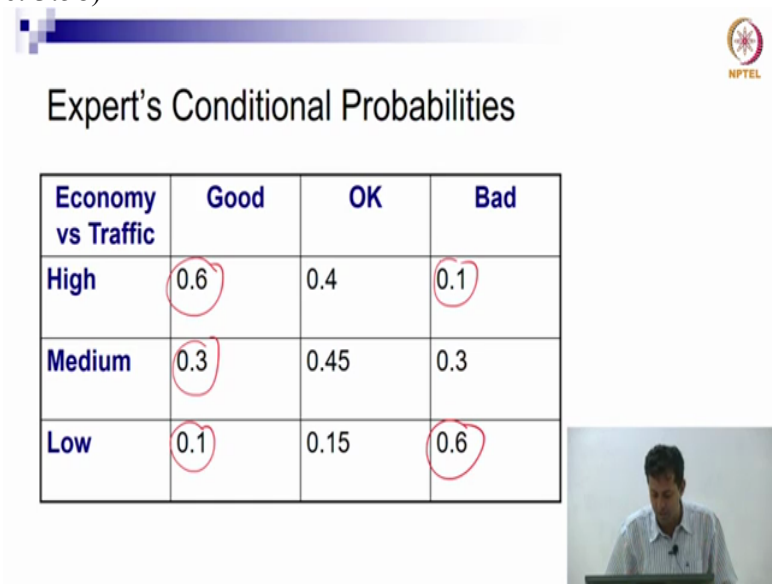


So for instance, you might have, I will show this table. If the economy is high, there is a 60 percent chance that traffic will also be very good or the traffic will be high. The economy is good, there is a 50 percent to 60 percent chance, but there is a 30 percent chance that the traffic may not really increase very much because there are many drivers. Just because the economy is better, we are all not going to start using the road; maybe the economy grows in a way that actually reduces the need for people to drive on the roads because telecommunication functionality is available.

Maybe the jobs that are created are essentially being created overseas; maybe we are using our engineering skills to design structures or whatever abroad. And therefore although the economy is growing, we are getting more projects, our people are prospering and earning more money does not necessarily mean more people are travelling on the road. So maybe

they are actually travelling less because now they are sitting in front of computers, skipping or whatever.

So there are various factors that play. So I have this table that says if the economy is good, there is a good chance that traffic will be high and a small but there is some chance that the traffic may not really be that high. On the other hand, if the economy is bad, there is a pretty large chance that the traffic might get affected but relatively low chance that despite the economy being bad, traffic will pick because people are really looking for jobs. So they are actually going to travel further and further to pick up jobs. So this is, somebody has done this analysis based on data and come up with these probabilities. So you can probabilitize the situation. And then you sort of say okay, this costs the millions dollars to build.

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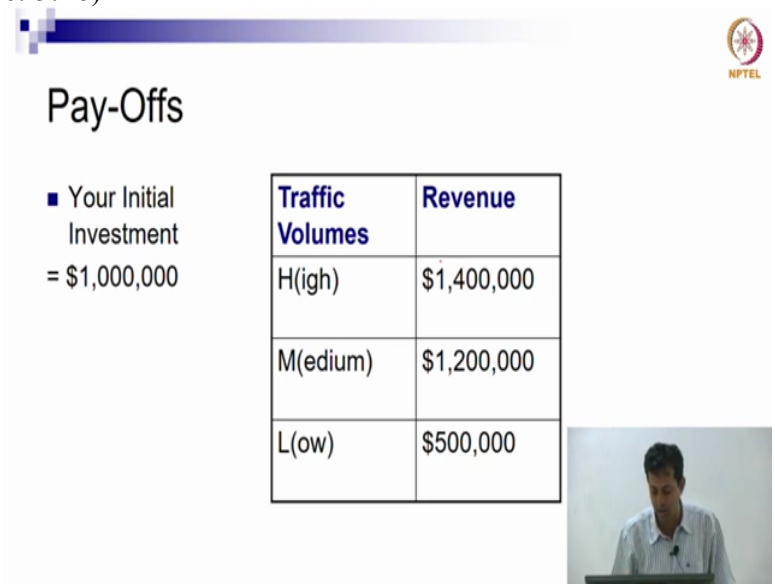


If the traffic volumes are actually high, then I might make a revenue of 1.4 million. If the traffic volumes are medium, I make a revenue of 1.2; traffic volumes are low, I only make half a million which would incur a loss. So then I can build these decision trees.

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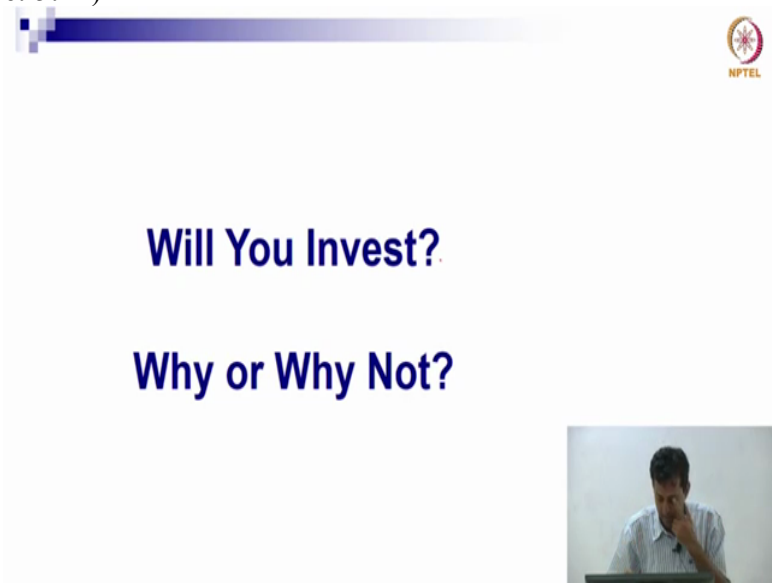


So obviously I want to do, there is uncertainty or there is a risk. The only thing for sure is this is going to cost me a million to build the road. The rest of it depends on the state of the economy, the state of traffic that will determine how much revenue I get. There is a lot of fussiness involved. So I can engineer this by looking at things like decision trees.

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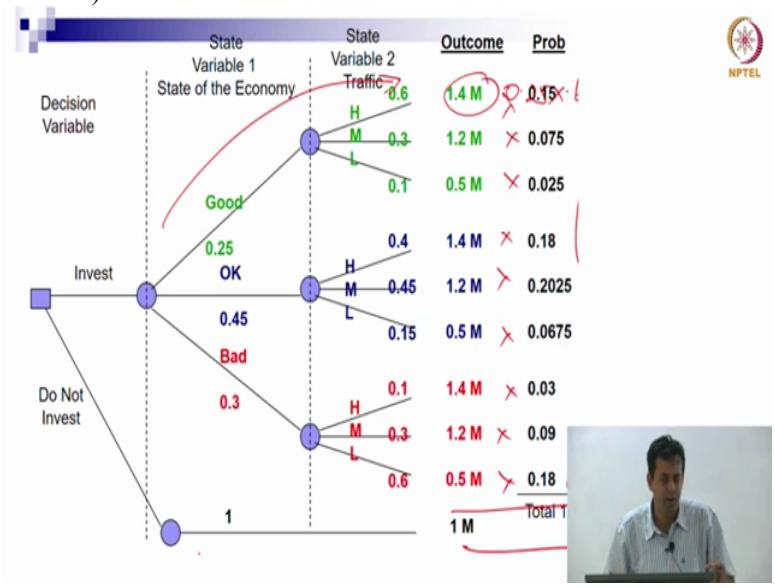


So I can say okay, if I make a decision to invest, then there is a 25 percent probability that the economy will do good, 45 percent it will be okay, 30 percent that it will be bad. If the economy does well, there is a 60 percent chance that traffic will be high, 30 percent chance. So these are various states. The economy could be good, and the traffic could be high. The economy could be good, the traffic could be medium. The economy could be bad, the traffic could be high. So these are all states. Depending on each state there is a revenue.

Every time there is a high traffic, I am going to make 1.4 million. Every time there is low traffic, I am going to make half a million. So each of these possible pathways have a probability associated with them. So this particular pathway that I have just sort of marked here, there is a 25 percent chance that the economy will be good and the 60 percent chance that if the economy is good, traffic is also high, which means there is a 0.25 times 0.6 probability. So what is this 0.15? So 15 percent probability that I will achieve this outcome.

Similarly each of these outcomes have a probability. So this had a 15 percent probability, there is 7.5 percent probability. Each of these outcomes have a probability. So now I can actually find what we call an expected value of the project. By essentially multiplying the probability, there is a 15 percent chance I will make 1.4 million. There is a 7.5 percent, I will make 1.2 million. There is a 2.5 percent chance, I will make 0.5 million and so on. So I can just multiply all of these and add that up.

And of course the total of these probabilities will be 1 because these are the all the possible states of the universe as far as my road is concerned, so total probabilities add to 1. So if I do not invest on the other hand, you could think about it as I have essentially saved the million. So if I invest, I am expecting a certain return. If I do not invest, I have sort of saved the million.

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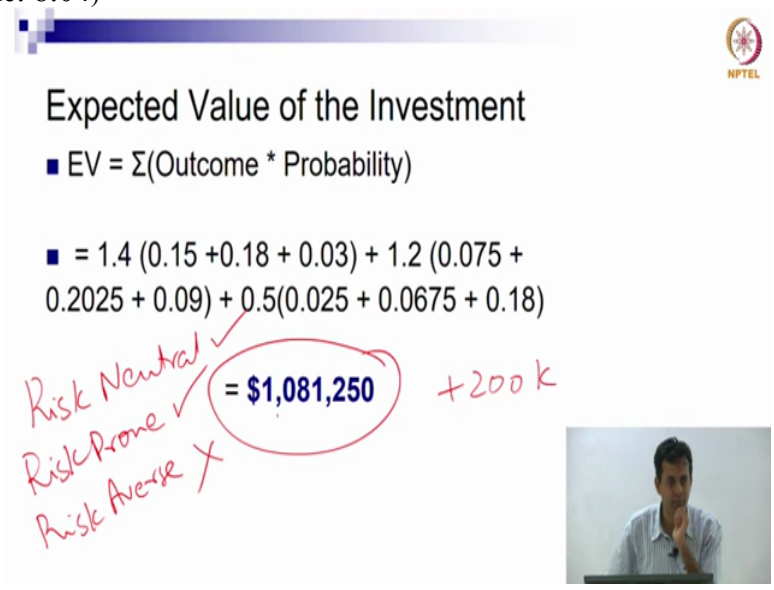


So if you do the mathematics, we do the multiplication which is what we talked about. The expected value of the investment comes out to 1.08 million. If I invest in the road, my expected outcome is 1.08 million. I will never get 1.08 million, I will either get 1.4, 1.2 or 0.5 because the traffic will be high, medium, low, I will get one of these three. But because there

is probabilistic, the expected average value of what I get is computationally 1.08 million against an investment of 1 million. So there is a marginal profitability associated with this investment.

So here I have taken risks, I have put them into a probability tree, I have come up with an outcome and now I have to make a decision on that outcome. If I have better projects to invest in, I might discard this project. If I have no other project to invest in, then I might give it some serious consideration. A risk neutral person would say I invest 1 million, I get 1.08 million back. I am making a profit, there are no other opportunities on the horizon, it makes sense for me to do this. So risk neutral person would say yes. A risk prone person, person who is keen taking 6 would also of course say yes.

A risk averse person might look at it and say look, hang on, it is 1.08, that is not whole lot greater than 1. It is about marginal and there is probably, there are enough chances that I might end up with the 500,000 dollar outcome. So the profits are not high enough for me to justify to be the risk of taking the 500,000 dollar outcome and as a result of which I am not going to invest. So you arrive at a decision variable based on probabilistic analysis and then you decide based on your risk perception what you want to do. Risk covers person and all these risk profiles that you can build, I am sure there is some online tool where you can figure out what your risk profile is and there are categories.

There are other things you might also want to do and this is where, people, Indian PPPs might go in and say I want some viability gap funding. This is barely viable, I am not willing to take the risk, can you provide me with like 200,000 viable grant so that my overall profitability is likely to be closer to 1.2. And so now I come up with instruments but these instruments are rooted in probability. I have asked for 200,000 because I have ended up here with a calculation of 1.08. If I ended up here with a calculation of 1.2, I might have asked for 50,000 or very little.

So essentially what we are saying is put numbers. Use numbers to assess these risks and then try to sort of figure out financial means or other means to actually, or there are ways in which you can work with these numbers. There are ways in which I can change the probability. Can I do something to improve the state of the economy? So essentially work with numbers. Still it becomes the collective risk profile of the organization. So essentially you find some way of summing up, so these are all, obviously there is no science to it, you can take individual profiles, figure out some way of summing them up et cetera.

But this is the probabilistic approach. So this is a very simple way of looking at probability. There is no variation. So I can do, and we will talk a little bit later in the class about doing things like Monte Carlo simulations et cetera which are the slightly just more advanced. So instead of saying the probability is 0.3, I will give myself a distribution and I will sample that distribution. So little bit more statistics come into it but roughly this is the principle, decision tree, decision analysis based on this principle.

There are far more complex ways of doing things. So particularly when you are launching say space vehicles, there you have to be a little bit more careful about the kind of numbers you throw out because these are heavy investments. But roughly this is the idea. This is decisioneering. So let us put it this way. You and I are going to play a game, we are going to toss a coin. Heads, I will give you a crore, tails you got to give me a crore. Will you play the game?

Okay, heads I will give you a crore, tails you got to give me 99 lakhs when you play the game. If it is a heads, you get 100 crores, you get a crore. If it is tail, you give me 99 lakhs. How many of you play that game? Honestly, how many of you if that was a real-world proposition, one person. So what does that mean? Probability wise, you should play that game. The chances of you, the expected value is higher, you win more than you lose with equal probability. And technically if I told you, you could play this game a 100 times you might think a little bit differently because there is equal chances to win or not.

Student is answering: (())(12:52).

But you only get one shot at this game. It is a one shot game. Okay, so this is in some ways the difference between a risk prone person and a risk averse person. So risk prone person might say I will take the chance. A risk averse person might say look, the downside of losing is actually much more than the upside of winning. So this is a profile question, so that is what a risk averse person does. So maybe you cannot understand why people do not like 1.08 but looks like everyone in the class falls within the risk averse category. It is probably looking at 1.08 and saying it is not worth doing this project.

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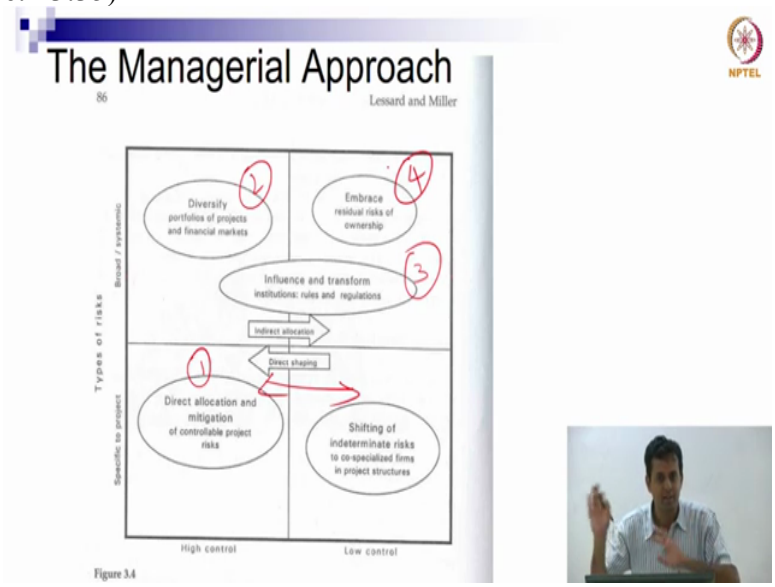


So that is one approach, right? But there is the other approach that says come on, look you cannot make, take all of these fussiness in the world and put it into numbers and assume that those numbers have a sanctity that you can take decisions based on that. I mean on what basis are you saying the probability is 30 percent and not 25. What if it was 50 percent? How do you really know the future? So the managerial approach says do not do it quantatively, let us do it qualitatively. And this is sort of again Swapnika presented this slide.

So you take a project, you take the risks, you figure out what to do with them. Maybe first, you try to allocate or mitigate risks. What does that mean? The basic principle of risk management that you will hear everywhere is allocate risk to the person who is best able to bear that risk. That is the most oft quoted state. What does that mean? Essentially that means I am Chennai metro rail, I want to build underground tunnels. There is a risk of the tunnels collapsing, what do I do with that risk? And the answer is let me figure out the most qualified contractor and give that risk to that person because that person is the best qualified person to manage that risk.

So this perhaps is the person who has built railway tunnels all over the world. So essentially I have allocated risks to a person who understands those risks much better. That person hopefully has the experience of being able to tell me exactly where to do my soil boring. He probably, or he or she understands how I analyze soil profiles and can figure out where does the soil need to be stabilized, where can I just run tunnel bore? So they probably understand how to deal with that risk.

So the first thing you do is you try to figure out how do I allocate these risks. Another risk could be that I borrow money dollars from the World Bank, but I am earning money in rupees here. So this power plant is set up by borrowing money from the World Bank in dollars but the power is being sold to Indian citizens who are paying me in rupees. Now I have to repay the World Bank. But if I have to repay the World Bank to that dollar amount, what happens if the rupee falls? So today I do not know whatever we had, 72 odd.

So 70, which means, yeah so 72, so I had to repay the World Bank a dollar, I would have to repay 72 rupees. But tomorrow if it becomes 75 rupees, then the World Bank is saying just give me my dollar. But I have to now give 75 rupees from people. I have got to go and ask them for 2 and half extra rupees and they are going to ask me, look, why do I need to give you extra money for the same service? So there is an exchange rate risk. Now how do I bare this risk? So maybe the government bares this risk or the World Bank bares this risk.

And we say although you have given me a dollar, we are going to count it as 72 rupees and I am going to repay you 72 rupees because you are lending in many markets and some markets currencies will go down, some markets currencies will go up, net net you will be compensated, so let us just do lending in the local currency. So all of those are risk allocation, or risk mitigation. Again if you go back to the Chennai metro example of the tunnels who are collapsing, maybe a risk mitigation technique is drill more boreholes, do not drill a bore well every 100 centimeters because then you do not know what is there in between.

Dig one every 25 meters, then you get better soil profile and you have fewer chances that you hit some rock that your tunnel boring machine is going through et cetera, so that is direct allocation and mitigation. So you do as much of that as possible. But then there are still some risks available. And so this is also I think, these two are both direct allocation and mitigation, shifting of risks, right all of that.

But then at some point, when you run out of ideas, and there are still residual risks, what do you do? So everyone, you try to sort of hedge your financial risks et cetera but those risks are not going away. Yes, you were able to hedge the World Bank's loan but your coal supply for your power point is coming from Indonesia. And Indonesia is telling you the same thing, they are saying pay me in ringgit or whatever they use, and that is Malaysian, I have no idea, currency that they use there.

So you cannot hedge all of your risks. So do you do then? Then perhaps you try to diversify. So you have a portfolio of projects with the understanding of, for instance, demand risk. How do you hedge demand risk? Like economy might go bad, traffic on your road might fall so in Tamil Nadu. So what do you do? Perhaps you can have roads in five different states in India and you could do it in such a way that some of those diversify your portfolio with the understanding that if something happens economically, if something happens politically, one project might suffer but consequently there is an equal probability that another project might do well.

And therefore you actually do not put all your exit one basket, so that is this strategy. This is the typical mutual fund investment strategy. I can invest in stocks and take a risk or I can invest in mutual funds, the idea is if I have 10 funds in my basket, probably 2 to 3 are going to do poorly but 2 or 3 will compensate, I will diversify. And then finally, and of course I can also try to influence and transform. So can I come up with, if some of these issues are legal, can I come up with ways in which I can change the legal environment?

So for instance, if the number of people on the road reduces, let us say I want to now come up with a scenario where I want to increase the total, so net-net my overall revenue remains the same. Now whether that is the right or wrong is a different question. But let us say this is what I want to do. Can I influence the contract? Can I influence the law to allow me to put in a clause that says if traffic dips, I will do something else?

So can I start influencing the project to create more safeguards against my risks? If none of this works, then you got to take some risk. At the end of the day, when you walk out of this class and you walk back to the hostel, there is that risk that you are going to get or back to the hostel you are going to get run-over by the institute. So at some level, you can diversify. So if you are bicycling with somebody, then you can find the best, safest biker, so you can allocate the bicycling risk to that person.

You can maybe diversify by trying to take different routes each time, so you minimize the probability of getting it. But at some point, there is always some residual risk that you have to address. So the managerial approach says forget probability, do it qualitatively, negotiate, figure out who can take which risk, maybe even price it. Figure out if you can influence institutions to reduce those risks and if none of that works, then whatever you embrace risks. So these are the risk management philosophies. So that is why, we will get into risk management later, but what we want to talk about now are specific risks that projects face.

And the first set of risks we are going to talk about are the technical risks, the construction risks. So we will take two cases, Montreal Olympics which is an International case, relatively old. The Project from Hell which is an Indian case, relatively new. So we will sort of look at international, Indian, old, new et cetera. So it depends on who you are within the company. So obviously top management is trying to look at also a diversification strategy but any individual project you will enter only if you feel that that project has a chance of succeeding.

So you do make decisions on an individual project level. But that company, for instance let me give you an example of oil exploration. Here is an area where you think there are some dividends to be paid by exploring for oil. So you have a couple of projects in that area but who knows, maybe you will run out of oil very quickly in that area. So I want to make a decision on that project based on some data and some understanding and some contracts et cetera. This is why I would go there because I feel there is a chance of that project will be successful.

That is what the project manager does. Now the CEO has a fixed budget, and they want to sort of invest in projects. I would probably foolish for investing three projects in the same area. I might want to invest in one project probably in the Baltics or in the North Sea where there is some oil there, one project in some other area. So I will diversify where I invest from that perspective. But even if I go to the North Sea, I am going to make sure that I do a risk assessment before I get into that project. So you do it in both levels.

So there is no composite but companies will do a bit of both. Also it depends on the kind of company, so banks for instance do tend to, in my view tend to do a lot more mathematical calculation. Project sponsors not as much. So project developers tend to be more gut feel oriented, more managerial in their risk approach and it is also in some ways a bit personality driven. So today there is a big, there is a lot of sanctity given to numbers like big data machine learning et cetera. Numbers can tell us quite a bit.

So we seem to be going a little bit more towards the decisioneering side. Traditional people in projects will say look, all kinds of earthquakes can happen, typhoons can happen, you cannot really predict any of these. It really has to be more managerial, so we look at case studies and we can decide which approach would be better. Okay?