

**Supply Chain Analytics**  
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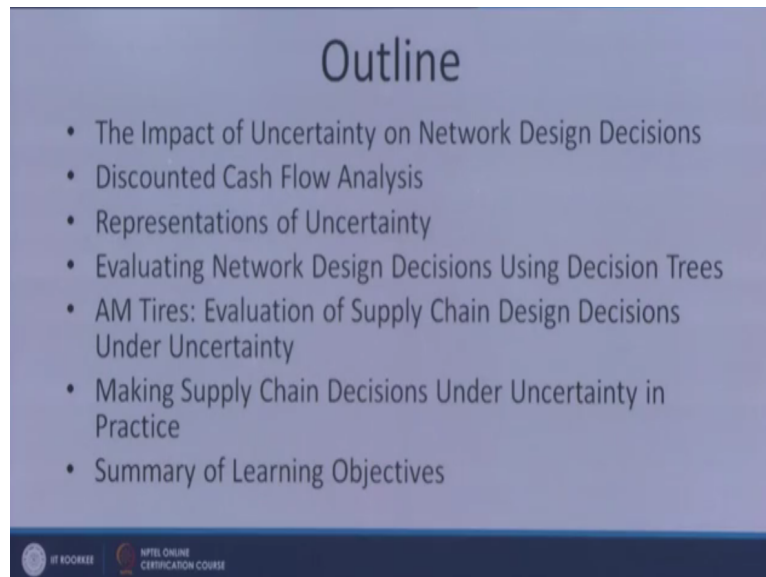
**Lecture-28**  
**Uncertainty in Network Design**

Welcome back, in our last session we discuss the different types of issues in developing a supply chain network, developing a supply chain network is meaning the location of facilities, the role of facilities and the sizes of facilities. But all those decisions which we took in our earlier session are with respect to a very certain type of environment. But we all know the environment is not certain.

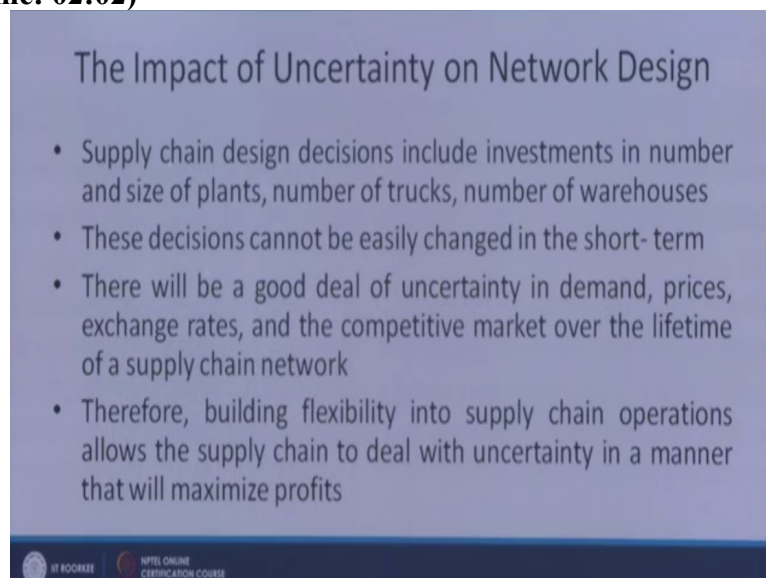
And particularly in case of India in recent past we all have seen that there are lot of uncertainty in the external environment and those uncertainties must affect the supply chain decisions, if you do not take into account those uncertainties it is very difficult to develop a very responsive type of supply chain, responsive the meaning here is the supply chain which can handle the challenges of the existing environment.

So for that purpose it is quite necessary that we need to evolve our models, we need to evolve of the calculations, so that our decisions are with respect to uncertainty of the environment, so now in this session we will focus that what are the different types of uncertainties and how to design a network, how to design a supply chain with respect to those uncertainty in the external environment.

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so let us see the outline of this lecture and here will see the impact of uncertainty on the network design, and when we talk of impact of uncertainty on the network design, so first thing which we are looking since last two, three lectures that supply chain decisions include investments in number and sizes of the plants than your transportation facilities the number of warehouses you want to have.

And probably after warehouses the role of customer comes, so if I am Maruti Udyog Limited, if I am Hero Honda, if I am LG, if I am Samsung. So I look up to that stage where I need to provide the finished goods in my warehouse, so these are the decisions which I am looking with respect to network design and where uncertainty can play a very important role. Now another important thing with respect to network design that you cannot change these decisions.

The very important here is that these are long term decisions, these are very long term decision and it is easily not possible to change these decisions in the short term, you are developing a facility the point is very simple that you are developing the facility like let say a manufacturing facility, but developing a manufacturing facility a plant for making motorbikes will take 2 years or 3 years of time.

You are developing a facility like refinery, it may take 4 years of time, now when it is taking such a long time in just erecting the facility, so you can very well understand that it is not possible that you should change these decisions in the short term, so you have to be very through, very practical, pragmatic, so that whatever decision you take these are long term decisions.

So that is the second important that whatever decisions we are taking with respect to uncertainty, these decisions cannot be changed in the short term, these are long term decision. Then another important point is there will be a good deal of uncertainty in demand, demand increases, decreases, you talk of demand of these air filter which we wear on our like mask, last year in the month of October and November in NCR area where was a severe problem of smoke and demand of mask the air filter increases all of a sudden to every high level.

But do you think can we develop a new manufacturing facility all of a sudden to fulfill the that excessive demand of air filters which was high uncertain nobody has predicted no weather forecast was there that this type of demand may come, but all of a sudden there was something in the external environment, the happening of Deepavali, the crop cutting at Punjab and Haryana and all that things happen simultaneously, there was no wind in the year.

So that it can take away all that pollutants from the air and it was like night in the day and as a result demand of those production increases, so there are fluctuations with respect demand, with respective prices, you have another example same in India the issue of demonetization came in the November last year and as a result of that prices of so many products particularly if I talk of gold, the prices of gold started cussing out.

The gold was considered to be one of the very important type of investment in India but because of the issue of demonetisation the prices of gold starts decreasing, so the uncertainty

is there with respect to prices also, you have an increasing trend of prices, but all of a sudden something happens and prices may decrease or something may happen prices may shoot up in India many times we hear stories about escalating prices of audience, escalating pulses.

And that is also the part of uncertainties with respect to prices, then exchange rates the dollar versus rupee, pound versus rupee, Yen versus rupee, so that type of uncertainties are also there and then the uncertainties with the competitive market over the lifetime of a supply chain, that how the competitive landscape of the market will change, these uncertainties will also be there.

We know few years back Nokia was one of the popular brands in the market, one of the popular brands of mobile phone, so in a country like India if you ask anybody which mobile you want to have, Nokia was a popular answer, but now what is this situation Nokia is almost nowhere, the Samsung and then a lot of Chinese brands and a lot of local Indian brands are also making a good space, a good presence in the mobile market of India.

So the competitive landscape of the market of a particular product in the supply chain over its time is also very very uncertain. Once upon a time Bajaj scooters was the pioneer two-wheeler of this country and now days even scooter product is nowhere in the market, forget about Bajaj, Bajaj is also shifted from scooter to motorbike, so there are plenty of such examples where over the lifetime of a product, the competitive situation changes.

And initially we know that Sony cameras used to compete with the Kodak cameras, Kodak cameras used to compete with Canon cameras, but nowadays what is happening Sony cameras are competing with the camera of Apple which is inbuilt in the mobile phone, so that is a new type of competition which is coming up. So it is not necessary that competition may come from your own product over the lifetime of a product, competition may come from a different category of product.

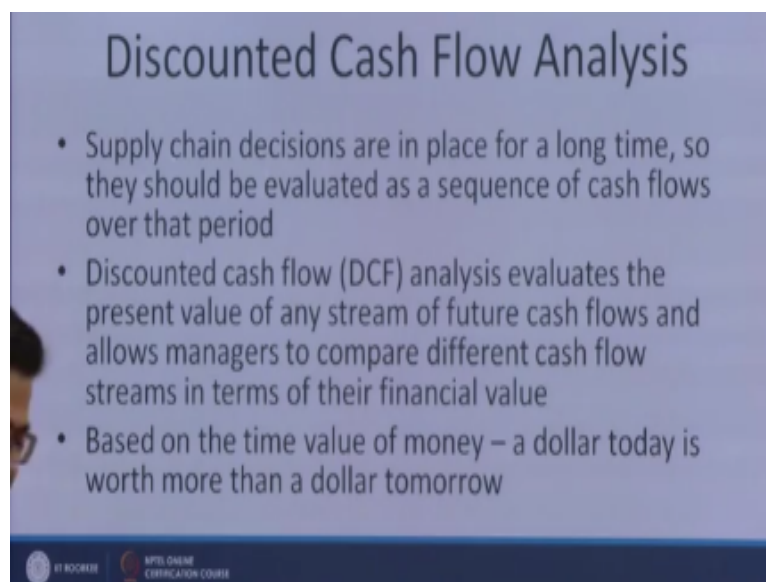
One newspaper is not competing with another newspaper but one newspaper may compete with another sports news paper may compete with the televisions, newspaper may compete with social media, so you know that different different types of things are happening in the environment and therefore this uncertainty with respect to competitive market over the lifetime is also a very important type of uncertainty.

And you need to be ready to face the challenges coming from the competition in your market, therefore what we say that building flexibility in to supply chain operations along the supply chain to deal with uncertainty in a manner that will maximize the supply chain surplus, the answer for handling the uncertainty is to build to infuse the element of flexibility in your supply chain, with flexibility in your supply chain you can probably handle all these issues.

But what is the flexibility, what is the optimum level of flexibility, how much flexibility we should built into our supply chain, a system which is completely flexible cannot survive a system which is completely reset also cannot survive, so you need to have a balance of rigidity and flexibility, so in this particular station and then few more sessions after this we will discuss that how much flexibility at what stage of the supply chain that flexibility should be included.

And the impact of uncertainty on the network design is now concluded that for that purpose we need to have flexible supply chain, without flexible supply chain you cannot handle uncertainty of the network design.

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**Discounted Cash Flow Analysis**

- Supply chain decisions are in place for a long time, so they should be evaluated as a sequence of cash flows over that period
- Discounted cash flow (DCF) analysis evaluates the present value of any stream of future cash flows and allows managers to compare different cash flow streams in terms of their financial value
- Based on the time value of money – a dollar today is worth more than a dollar tomorrow

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Now for that purpose there are different types of modelling approaches to develop the concept of uncertainty in the supply chain network. One of the approach is discounted cash flow analysis, one of the approaches discounted cash flow analysis, now supply chain decisions as discussed just now all very long term decision, when we are talking of developing of a facility, in that case it is certainly every long term decision.

You cannot develop a new depot, you cannot develop a new warehouse in one night, you can take some decisions which are for the short term, you can start outsourcing all of a sudden, you can stop outsourcing because demand is not there, so that type of decisions are possible within very limited time, but developing a facility like warehouse, developing a facility like manufacturing is not a short term decision.

And therefore supply chain decisions are for long time, so they should be evaluated as a sequence of cash flows over that period. Now when I am developing a manufacturing facility and I feel that the life of this facility is 20 years or 25 year. I am developing a warehouse I consider the life of warehouse is 30 years. In 30 years time how much cash flow will be generated on the basis of that we will take decision.

So this is one very simple method where over the alternative which are available to us. We will calculate that which alternative is giving how much cash flow to us, and depending upon that cash flow we will take the decision that whichever alternative gives us maximum cash flow, maximum positive cash flow that is the choice for our network decision, so now what is the discounted cash flow analysis.

So this DSF discounted cash flow analysis evaluates the present value of future cash flows and allows managers to compare different cash flows in terms of their financial value. The meaning is that if you have some money today in your pocket that is more valuable than what you are going to get tomorrow, the money the last point says this based on the time value of money this is a very important concept in the classes of finance and accounts.

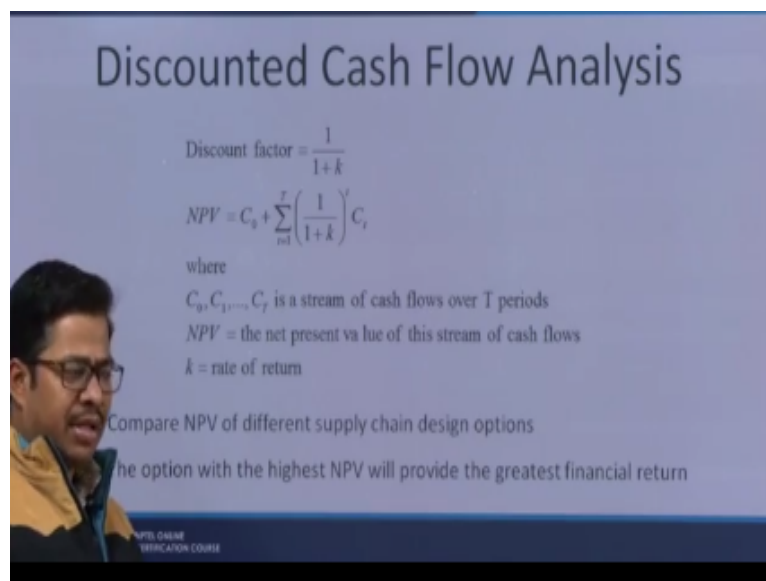
You must have heard about time value of money even in the classes of economics also you have heard about time value of money, in the classes of project management also you would have heard about time value of money. So will not go into detail of time value of money analysis but time value of money says that a rupee today is worth more than a rupee tomorrow, so if you have 1 rupee today and 1 rupee can buy 1 Kg of rice for you.

And today with that 1 rupee you can buy 1 Kg of rice now after one year again you have 1 rupee in your pocket but at that time you will not be able to buy 1 Kg of rice with that rupee, you may be able to buy 900 grams, 800 grams of rice from that 1 rupee. So it is now the

purchasing power of that rupee has decreased by 100 grams or 200 grams over 1 year span. So that is the time value of money that rupee which is today in your pocket it is more valuable than what you are going to get tomorrow.

So based on that we will calculate in this discounted cash flow analysis we will calculate the present value of various future cash flows over a period of time which we are going to get and then we will see that what is the total present cash flow value of various alternatives, so now going further the formula for such calculation if we see so in that K, this K is the rate of return, normally in our day to day discussion we say that K is nothing but rate of interest.

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The slide is titled "Discounted Cash Flow Analysis". It contains the following text and formulas:

Discount factor =  $\frac{1}{1+k}$

$$NPV = C_0 + \sum_{t=1}^T \left( \frac{1}{1+k} \right)^t C_t$$

where

- $C_0, C_1, \dots, C_T$  is a stream of cash flows over T periods
- NPV = the net present value of this stream of cash flows
- $k$  = rate of return

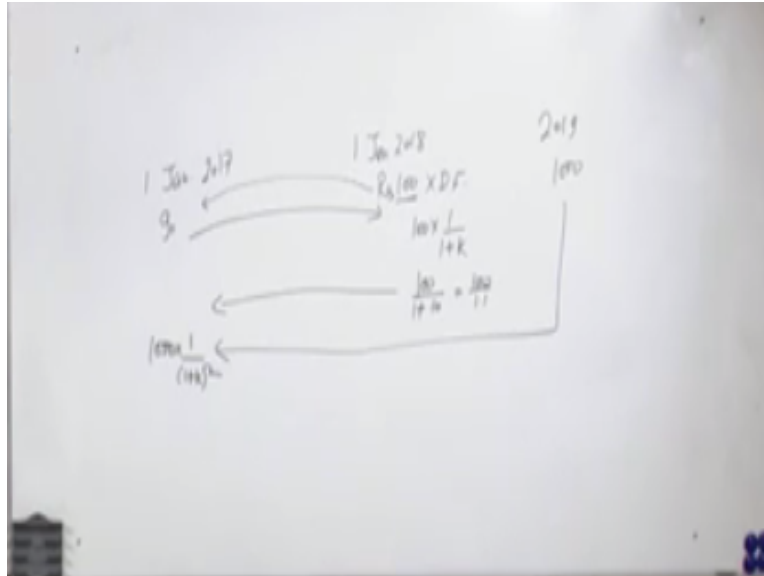
Compare NPV of different supply chain design options

The option with the highest NPV will provide the greatest financial return

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K is nothing but rate of interest in our language of supply chain or in the language of finance and accounts we say K is rate of return, so this becomes rediscounting factor 1 upon 1/K.

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The meaning of discounting factor is if I am today having this is 2017 1 January, so I will get on 1 January 2018 Rs. 100, so what will be the I want to know what will be the value of this 100 rupees which are going to get on first January 2018 on this first January 2017 and as I am seeing the value of today money is more than what I am going to get tomorrow, so what is the meaning of discounted factor that today's 90 rupees, today's 90 rupees let us say I take simply a statement just to explain you that today's 90 rupees maybe 100 rupees of tomorrow.

So today's 90 Rupees is equal and 100 rupee of tomorrow, so I need to calculate that if I am going to get 100 rupees tomorrow what is the value of that 100 rupee in today's context, so that is the use of discounting factor so, I will multiply 100 by that discounted sucked so  $100 \times 1 \text{ upon } 1 + K$ . so if it is let say rate of return is 10% so  $100 \text{ upon } 1 + 0.1$ , so  $1000 \text{ up on } 1.1$ .

So that will be the present value of that money, so this is the use of this discount factor, now then you have the total net present value, the second formula for total net present value, I am going to get not only on 2018 the project on my warehouse my factory is for 10 years, so 2018, 19, 20 and so on, for next 10 years I am going to get some cash flows, it is 100 rupees then 1,000, than 10000, then 50000 and 75000 so on like that.

So I will like to calculate the present value on first January 2017 of all those future streams of cash flows and for that purpose here I come with this formula that is seen is the cash flow which I am getting today in many times this  $C_0$  is negative because today I am not get take any positive cash flow, the cash flow which I am receiving is represented as a positive cash flow and cash flow which is going from my pocket is represented as negative cash flow.

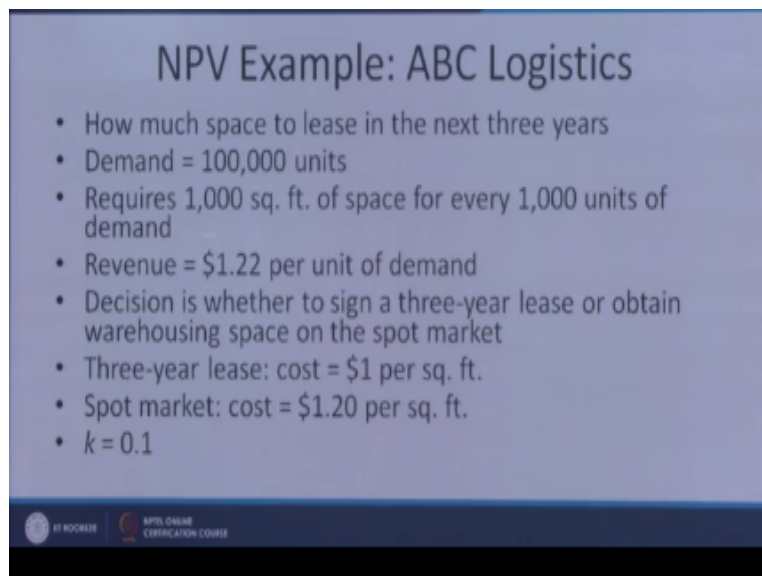


So the first year because I am putting my money into that facility development so in most of the cases we will see that  $C_0$  is negative, most of the time  $C_0$  is negative and then this second term in this expression represents the sum of all the future cash flows and their present value, so  $C_T$  is like for 2018 we discussed  $C_t$  is 100 rupees,  $E$  becomes 1, and  $1 + 1K$ , if I am getting in 2019 if I am getting in first January 2019 let us say 1000 rupees.

So in that case I want to calculate its present value, so it will be  $1000 \times 1$  upon  $1 + K$  to the power 2, because now it is 2 years back, so that is this term, so if there are  $T$  total  $T$  periods for which I am going to get the cash flows so this is how you will get  $T$  sum of those future cash flows with their present value, so this becomes the total net present value in this case of discounted cash flows.

So this we will compare this cash flow often this total net present value we will compare for different alternative, different supply chain design options and on the basis of that the option which gives me the highest net present value, the highest NPV that will give me the highest financial return, because of financial return of the supply chain surplus is the objective which we discuss in the very first session that we want to maximize the supply chain surplus.

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The slide is titled "NPV Example: ABC Logistics" and lists the following details:

- How much space to lease in the next three years
- Demand = 100,000 units
- Requires 1,000 sq. ft. of space for every 1,000 units of demand
- Revenue = \$1.22 per unit of demand
- Decision is whether to sign a three-year lease or obtain warehousing space on the spot market
- Three-year lease: cost = \$1 per sq. ft.
- Spot market: cost = \$1.20 per sq. ft.
- $k = 0.1$

At the bottom of the slide, there are logos for "IIT ROORKEE" and "NPTEL ONLINE CERTIFICATION COURSE".

So we will do this calculation so that my supply chain surplus is increased and with the help of this example of one company known as ABC logistics, we will see the use of this NPV method and in this case the example is that how much space to leave in the next 3 years this

is the objective, but the demand is 100000 units it requires 1000 square feet of space for every 1000 units of demand.

The revenue is 1.22 dollar per unit of demand, now what is the alternative which are available, alternatives are decision is weather to find a 3 year lease or obtained warehouse space on the spot market, the 3 years lease cost 1 dollar per square feet and spot market cost is 1.2 dollar, 1 dollar 20 cents per square feet, so smart work and slightly costlier and the rate of return is 10% the rate of return is 10% which is also written as 0.1.

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**NPV Example: ABC Logistics**

For leasing warehouse space on the spot market:

Expected annual profit =  $100,000 \times \$1.22 - 100,000 \times \$1.20 = \$2,000$

Cash flow = \$2,000 in each of the next three years

$$NPV(\text{no lease}) = C_0 + \frac{C_1}{1+k} + \frac{C_2}{(1+k)^2}$$

$$= 2000 + \frac{2000}{1.1} + \frac{2000}{1.1^2} = \$5,471$$

So this is the data available to US and now we will use this NPV method, now for releasing warehouse space on the spot market, one option is to consider the spot market and is other option is to have clearly and other the second option is the spot market, now taking the calculation of the spot market in the calculation of spot market the expected annual profit expected annual profit is this one lakh units.

And the data for revenue from one unit is 1.22, so this is the profit and this is the cost of the space 1.2 square feet so you because 4000 square feet is useful for thousand units of demand so if you have 100000 units you require 100000 square feet, so total area is this much so you have the annual profit of 2,000 dollars. Now cash flow for 3 years will be 2,000 dollar each year.

When you are going for the spot market no list, so 2000 in the first year, 2000 in the second year and 2000 in the third year, for each of 3 years you are getting 2000 and for first year the

rate of return is  $1 + K$  1.1 done for the second as I explained there it because 1.1 the whole square, so it is 1.21. The calculation yields the total net present value of 3 years cash flow is 5,471 dollars.

That is with case of spot market, now before I go for the next slide I request my students that they should practice the same calculation with the lease option and I am waiting for a moment that you complete your calculation and then you can match your results with our results that when we are going for using of warehouse.

So this is the expected profit and non-profit this is revenue and this is the cost of the land. So our profit is 22000 and 22000 is the profit we are going to get and because of that other cash flows 22000, 22000 and this is a factor of return 1.1 and 1.2 the square, so our total net present value of cash is 16182 and you can see it was 5471 earlier and now it is 60000, so there is a difference of around 54711 which is significantly higher.

So now you have a very clear option that you will decide to sign the lease, you will not go to the spot market because in case of export market our profit has just 5,000 dollars and hear the present value of our profits is 60000 which is much higher and therefore our decision is this, now in this particular case we were very sure now can I think, can I ask you one question that this is a case of again lot of serenity in the market, lot of certainties are there in the market.

But it is quite possible it is quite possible that you will need to rethink your decision because of uncertainties in demand and cost. Now in case you have signed this is lease for 40 so you need to pay this much rent because you have taken the space, so whether you are able to sell this much or not the respective of that you have to pay this much amount to the other party to the provider of the space.

And in that case your profit me your net present value be significant go down, it is also possible here for 3 years we have taken a flat rate of return 10% it may also change with time and some predictability you can do that next year it will be 10% rate of return and after that it will be 15% and then it will be 16% etc, etc. so in that case also you can have different denominators here.

If you have different rate of return, so according to those different rate of returns you may have different denominators because here with same rate of return for all the period we have same value of  $k$  in denominator for all the years. Now what I was saying that it spot market though here it looks that our profits are very very less, our net present value is just 5400 rupees in case of least arrangement it is 60000.

But it quite possible that you are not able to use this much space, you see your data that you require 1000 square feet of space for 1000 units. Now if in a particular year on a day to day basis after second year you realise that the demand for next year maybe just 10000 units, for some reason you realise that demand is just 10000 units, so you will take only 10000 square feet for 10000 minutes.

And in that case you can save lot of money which you are giving to your space provider but in case of these lease arrangement you have no such option, so therefore uncertainty in demand and cause many times forces not to go for long term relationship, not to go for long term this type of lease relation, though here with the data because we have not infused the element of uncertainty in this example yet.

We are only considering that you have all rate of return, you have a fixed demand, you have fixed cost everything is fixed and in that case obviously with this simple calculation we can conclude that this lease arrangement is made is a suitable arrangement, but when we go for uncertainty there will be two types of representation of uncertainty that we will discuss in our next session.

So here without any kind of uncertainty our discounted cash flow model is a very suitable model to take decision about different type of supply chain alternatives. In our next session we will see that how we are going to inbuilt the element of uncertainty in the network decisions. Thank you very much.