

Supply Chain Analytics
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Lecture-32
Time Value of Money in Supply Chain

Welcome back friends, in last two stations we were discussing about uncertainty in network design decisions, uncertainties are of different types, we discussed that network decisions are long term decisions, so you need to be very careful about developing those networks where you are developing the factories, where you are developing the warehouses, where you are developing the depots, and what are the sizes of these things.

And we discuss different types of uncertainty which may come because of demand, which may come because of price, which may come because of fluctuations in the exchange rate and because of business models also. We also discussed that flexibility can be one answer for handling this types of uncertainty. If you have 3 case in your supply chain, if your supply chain is adaptable it can align and it is assign.

So these 3 case we discussed in detail in our area two sessions and in this particular session we will see that because the decisions related to network, these are long term decisions, so you need to take extreme care with respect to financial aspects of these decisions, so in this particular session we will see with the help of some numerical examples that how we take care of those aspects.

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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

All these things we have discussed in our earlier session about flexibility in the supply chain, we discussed about adaptable alignment and agility in the supply chain, now coming to long term financial decisions in the supply chain we will like to discuss this discounted cash flow analysis, you are making a project a supply chain decision of making a warehouse at a location X.

Now you are expecting some cash inflows with that decision, so you have a choice whether you want to develop at X location or at Y location and how much cash flows you will get in future 10 years from warehouse at location X, how much cash flow you will get from the warehouse which you are making at location Y and then you can compare the inflows of cash for X and Y, because the cost of developing the warehouse at two locations may also vary.

So you will have a net present cash flow from these two alternatives and which other alternative gives you better net cash flow that is obviously your choice. Similarly you have a very common situation in this type of discussion, and whether to develop your own facility or you can develop some kind of lease agreement or you can have some on the spot market decisions, so for the same location X we have these multiple options.

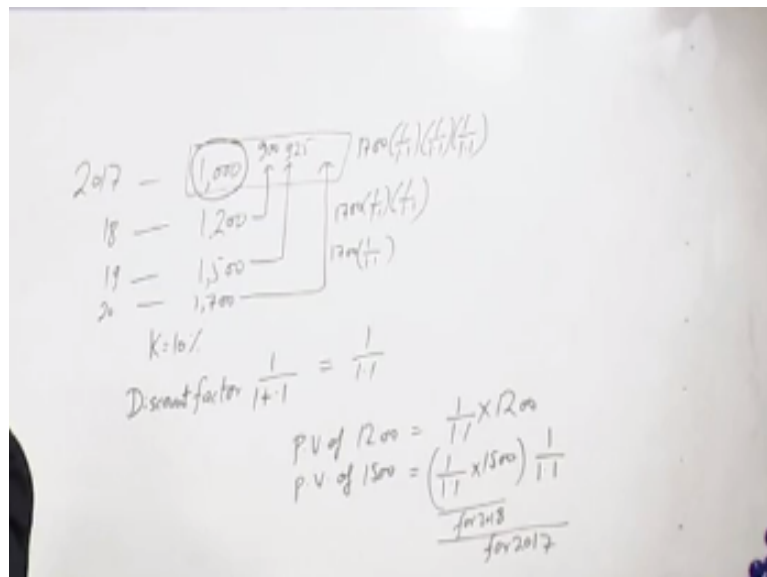
I can develop my own warehouse, I can purchase the land, and develop a warehouse, I can also take a decision that somebody is offering me a lease agreement for 5 years, so I can sign that lease agreement and it is also possible that in some cases I may not have consistent use of that facility for 5 years, so whenever there is a requirement I can go the spot market and can see whichever option is available I can use that for my purpose.

So all these possibilities are there and when all these possibilities are there I need to evaluate these possibilities and later we will also see that how can we build element of uncertainty into these decisions, so that is what we are going to discuss in this particular session, so now because supply chain diseases are in place for a long time so they should be evaluated as a sequence of cash flows over that period.

So as I just discuss that I am planning for next 5 years, I am planning for next 10 years, so what is the sequence of cash flows over that 5 year period, 10 year period that is going to decide my supply chain decision with respective network design. Now discounted cash flow DCF evaluates the present value of any stream of future cash flow and allows managers to compare different cash flow in terms of their financial value.

The point is that when we are getting future cash flows today it is 2017 and in 2017 I am getting some cash flow let us say 1000 rupees, in 2018 I may get 1200 rupees, in 2019 I may get 1500 rupees.

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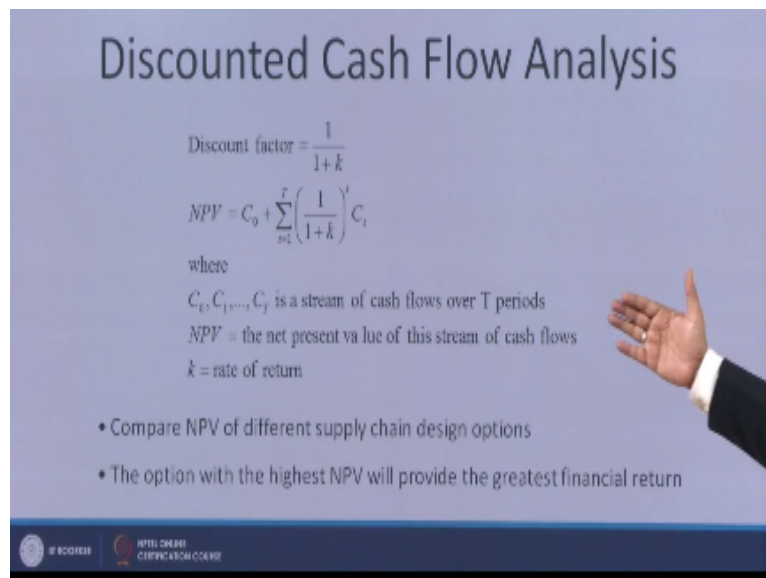
So in these discounted cash flow I will calculate the present value of these future cash flows and what is the total present value what is the total present value of all these future streams of cash flow that I will evaluate and on the basis of that I will take a decision about my network places, it is very very important to understand that a dollar today is worth more than a dollar tomorrow.

This is a very very important concept in our management and we all know about this concept of time value of money. If today with 100 rupees I can purchase 1 kg of rice, so tomorrow with same 100 rupees I may not be able to produce 1 kg of rice it may be 900 grams of rice that I will be able to purchase by that 100 rupees, so the meaning is the money today is which is there in your pocket that is more valuable than what you are going to get tomorrow.

So for that purpose it is quite possible that in absolute terms 1200 is more than 1000 rupees and 1500 looks more than 1200 and 1000 rupees but it is quite possible I have not considered the rate of discounting, but it is possible that the present value of 1200 rupees is just 900 rupees and present value of 1500 rupees maybe 925, so though in the absolute term 1200 and 1500 these values are, these figures are more than 1000, but when I am talking their present value it is equal to 900 or 9:25 maybe.

If I consider suitable discounting factor, so I need to see what is the total present value of all these future cash flows that is my analysis of discounted cash flow. Now for that purpose it is very simple and those who have some knowledge of financial management and even in the classes of project management also we discuss this time value of money in greater details, here we are just touching these aspects.

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Discounted Cash Flow Analysis

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

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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Now discount factor is $\frac{1}{1+K}$ where K is the rate of return and on the basis of this $\frac{1}{1+k}$ becomes discounting factor, so for example if I consider the value of $k = 10\%$, so my discounting factor becomes this discounting factor is $\frac{1}{1+k}$ that is 0.909 and if I want

to calculate the present value of 1200 rupees so present value of 1200 equals to 1 upon 1.1×1200 so that is the present value of this stream.

When I want to calculate the present value of 1500 for this period for present value of 1500 for 2017, so this is the present value of 1500 for 2018 and then again I will multiply this by 1 upon this discounting factor, so this is for 2018 and then this becomes for 2017 and similarly if I have a future cash flow of 2020 of let say rupees 1700 and I want to calculate the present value of this 1700 for 2017.

So this will be a step-by-step process 1700×1 upon 1.1 will give me the present value for 2019, then this factor multiplied by again 1 upon 1.1 will give me the present value for 2018 and then this value this factor multiplied by the discounting factor of 1.1 will give me the present value of this 1700 for 2017, so if I want to generalize the formula for calculation of this present value.

So C_t is the future value of a particular time period t , it has to be multiplied it has to be I just need to see this much formula one upon $1 + K$ to the power $t \times C_t$, C_t is the future flow of cash let say at the T th period, so this is the value of that, now I want to calculate the future cash flow for all the periods, I want to add the sum of that.

So what I am doing in 2017 if I want to calculate the cash flow of all future streams, so I will add this 1000 plus this value plus this value plus this value all these, so the generalized way of putting this formula is this cash flow for the original period. The period of starting that is C_0 that is here and then C_t C_1 , C_2 , up to C_t is the stream for all the period 2018, 2019, 2020 etc. and sum total of that from $T=$ to 12 capital The

So this will become my net present value, the formula for calculation of net present value, so this formula we will compare net present value of different supply chain design options and option with the highest NPV will provide the greatest financial data, so that will become our options, that will become the choice for us. So let us have some data and with the help of the data we see that how can we use this formula for determining a supply chain decision.

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NPV Example: ABC Logistics

- 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.
- $k = 0.1$



Now in this example one numerical example we consider that how much space to lease in the next 3 years, that is the question is 100,000 units and we require 1000 square feet of space for every 1000 units of demand, that is the rate of demand which is there, the revenues 1.22 dollar per unit of demand, now the alternatives are decision is to taken whether to sign a 3 year lease or obtained warehouse on the spot market.

You can find one ever you for 3 year lease or you can have as per the requirement go to the spot market and whatever alternatives available you can select that alternative from the spot market, so these are the 2 choices available to you, now the cost is that if you are signing a 3 year lease in that case the cost is 1 dollar per square feet and these spot market the cost is 1.2 dollar per square feet.

Always you will find that spot market rates are higher than the lease and the reason is also very simple because in the lease for the supplier as well as for the customer it is a guaranteed agreement for a particular period of time. In case of spot market it is not so today is there tomorrow not be there and you are fulfilling the immediate requirement and therefore the normal circumstances a spot market rates are more than the live rates. Now let us see how to handle such type of questions and the rate of return is 10%.

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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

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

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


Now in this case for leasing warehouse space on the spot out market, expected annual profit, when you talk of expected annual profit so this is the annual demand, this value is the annual demand, this is the revenue that is 1.22 dollar per unit, that is the revenue you have and in the spot market you are paying this much price 1.20 for per square feet, so your expected annual profit is 2000 rupees.

Now 2000 rupees you are getting in all 3 years, for all 3 years the profit is same 2000 2000 2000, so you have same cash flows C_0 in the first year, C_1 in the second year and C_2 in the third year, so C_0 2000, then 2000 upon this discounting factor $C_1 \times 1$ upon $1 + K$ that is 1.1 and C_2 2000 $\times 1.1$ whole square, so that is this. So the value of net present value the total cash flow in terms of present value is 5,471 dollars.

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NPV Example: ABC Logistics

For leasing warehouse space with a three-year lease:

Expected annual profit = $100,000 \times \$1.22 - 100,000 \times \$1.00 = \$22,000$

Cash flow = \$22,000 in each of the next three years

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

$$= 22000 + \frac{22000}{1.1} + \frac{22000}{1.1^2} = \$60,182$$

The NPV of signing the lease is \$54,711 higher; therefore, the manager decides to sign the lease

However, uncertainty in demand and costs may cause the manager to rethink his decision

This when you are not going for the lease agreement, you are doing on the spot arrangement for your requirements. The other alternative is you can go for the lease arrangement and in that is when you are going for the lease arrangement the same revenue 1.22 that figure we are trying from the this value that is the revenue 1.22 per unit of demand, so same figure come here that $1.22 \times 100,000$.

Now the cost is less, cost of lease agreement is 1 per square feet, so this expected it becomes 22000 and because of this expected annual profit 22000 you are going to have 22000 in each of next 3 years so 22000, 22000 here, 22000 here and 22000 here. Same rate of return you will apply and 1.1, 1.1 square and this is the net present value when you are having the lease for 3 years

So the net present value is much higher of signing the lease is 54711 dollar higher, therefore you can decide to sign the lease agreement and this is a very very important thing that you are signing the lease because you are getting the higher NPV, but there are in this question we have taken some very simple assumptions and these assumptions will automatically give you idea that we should do for this kind of lease arrangements.

Because the cost of lease is less 1 dollar and in that case it is 1.2 dollar, so you are expected annual profit is less. Now take a situation now we have understood how to go about the calculation but actually the problem will happen in that case when you are going to have different annual demand and in that case you will be stuck by different alternative.

So let us have that situation that in a particular situation because now we know how to calculate the NPV, again for the same thing here period in this case we had the constant demand for all 3 years, now we have a very demand for 3 years, so we are trying to build some element of uncertainty in this particular case there is no uncertainty in demand and cost, so there is no need to think much, you can directly calculate and get the answer that leasing is a better option. But in case when we have some kind of uncertainty so I am trying to build one case of uncertainty where we have uncertainty in the demand of the product.

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(1)	Lease (2) (\$)	Spot Market (3)	Revenue (4)	Net cash flow in lease (5)	Net cash flow in spot market (6)
50,000	40,000	50,000	1.5 x 50,000	(4)-(2)	(4)-(3)
10,000	40,000	12,000	1.5 x 10,000		
40,000	40,000	45,000	1.5 x 40,000		

First year you have demand of 50000 unit, the second year the demand drop suddenly and you have a demand of just 10000 units and next year you have again a very high demand of 40000 units, so these are the demand labels for three different years, now when you are going to lease in that case the space is fixed or you can say the cost of space is fixed for all the 3 years, if I am going for a lease arrangement so the cost of space is fixed that is 40000 per year.

I have to pay 40000 dollars per year, when I go for the spot marker in that case I will take a space as per the requirement, whatever is my requirement accordingly I will select this space, so I will not pay constant 40000 in case of the spot market, my demand is 50000, so I will take slightly bigger space and maybe at that time I will pay 50000 as rent in case of spot market, when demand decreases to 10000 I will pay 12000 as the rent.

And when my demand is 40000 in that case also I pay 45000 as the rent, the profit per unit which are able to generate not exactly the profit revenue, the revenue which I am debriding let us say that is 1.5 dollar per unit, so I multiply the value by 1.5 x 5000, 1.5 x 10000 and 1.5 x 40000, the difference of 4ht column and second column will give me the net cash flows in lease. This is column number 1, this is column number 2, this is 3, this is 4, this is 5.

So in case of lease I am getting the differences from column 4 and column 2 so I write these values here and then I can also calculate the net cash flows in a spot market, this is column 6 and these will be the values of 4 - 3, so here I calculate 4 - 3, and now considering the same

rent of return that is 10% I will calculate the present value of these column number 5 and column number 6 and maybe it is possible that I have you can do the calculation.

And then you can see that it is quite possible that when you complete the calculation in that case it is advantages for me to have the spot market, to go for the spot market and not to go for the lease arrangement, because here you are constantly paying 40000 in respective of whatever level of demand is there, in a spot market I am able to adjust this though I am feeling slightly higher cost here the space cost me one dollar per square feet.

Here the space cost may be 1.2 dollar per square feet and that may also very soon period to period, initially it can be 1.2 and in the third year it can be 1.4 dollar per square feet, but because I am able to optimise my space requirement in the spot market which I am not able to do in the lease market, so on the basis of this net present value calculation of my all future streams of cash flow I can take a decision that yes it is more profitable to have spot market.

So this is one small element of uncertainty with respect to demand that we built into this case and we saw that it is more profitable to have a decision which is going to help us in creating the more cash flow in the present system. Now going further into these things you will further say that we need to build more uncertainties into our demand and cost related issue, so going further we want to have the binomial representation of uncertainty and we can have some other representation of uncertainties also.

You have a price P today and tomorrow either price cut improve, improve means increase or decrease, there are two probabilities with probability P the price can increase and with probability $1 - P$ price can decrease, so in our next session we will see that how to build those types of uncertainty in our network design decisions and that will give us more practical insights about handling uncertainties in our real time analysis, So we stop here in the session today. Thank you very much.