**Decision Tree Analysis**

The key steps in decision tree analysis are as follows

1. Identify the problem and alternatives.
2. Delineate the decision tree.
3. Specify the probabilities and monetary outcomes.
4. Evaluate the various decision alternatives.

Remember the decision points, also called decision forks, denoted by D, and the alternative actions are available for experimentation and actions are possible at these points, while the chance points, called chance forks, denoted by C, are the points where the outcomes are dependent on a chance process and the likely outcomes at these points.

**Example # 1**

The scientists at Spectrum have come up with an electric moped. The firm is ready for pilot production and test marketing. This will cost Rs. 20 million and take six months. Management believes that there is a 70% chance that the pilot production and test marketing will be successful. In the case of success, Spectrum can build a plant costing Rs. 150 million. The plant will generate an annual cash inflow of Rs. 30 million for 20 years if the demand is high or an annual cash inflow of Rs. 20 million if the demand is low. High demand has a probability of 0.6, while the probability of low demand is 0.4. What is the optimal course of action using decision tree analysis.

**Solution # 1**

C21; P(C21=0.6)

(30 million per year)

D21 (150 million)

C11; P(C11=0.7) C22; P(C22=0.4)

D2

(20 million per year)

D11 (20 million) D22 (Stop)

D3

C12 D31 (Stop)

D1

P(C12=0.3)

D12 (Do Nothing)

Stages of evaluation

**At C2**







**At D2**

D21 = EMV(D21) = 194.2-150=44.2

D22 = EMV(D22)= 0

As D21 > D22, hence D21 is selected

**At C1**

EMV(C1)=0.7\*44.2+0.3\*0=30.9

**At D1**

D11 = EMV(D11)=30.9-20.0=10.9

D12 = EMV(D12)=0

As D11 > D12, hence D11 is selected

**Example # 2**

An oil company while evaluating the oil basin is considering three alternatives, which are (i) drill, (ii) conduct seismic test before at a cost of Rs. 20000 to find the nature of the underlying oil basin and (iii) do nothing. If the company drills then it is likely to find the oil basin as (i) dry, (ii) wet or (iii) soaking. A dry well yields nothing, while a wet well provides moderate quantity of oil and a soaking well generates substantial quantity of oil. If the oil company conducts seismic tests, then it can learn about the underlying structure of the oil basin before deciding whether to drill for oil or not. The underlying oil basin structure may be one of the following, which are (i) no structure, (ii) open structure or (iii) closed structure. If no structure is found then the prospect of finding oil is bleak. If an open structure is discovered then the prospect of finding oil is fair, while finally if the structure is closed then the prospect of finding oil is bright.

The oil company also knows the following which are

Probabilities of various oil bearing states

P(state is dry)=0.50

P(state is wet)=0.25

P(state is soaking)=0.25

Probabilities of various soil geological states

P(no structure)=0.40

P(open structure)=0.30

P(closed structure)=0.30

Also we have the following joint probability distribution between underlying geological structure and oil bearing state.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Oil bearing state | Underlying geological structure | | | | Marginal probability of the state |
|  | No structure | Open structure | Closed structure |
| Dry | 0.32 | 0.15 | 0.03 | 0.50 |
| Wet | 0.04 | 0.10 | 0.11 | 0.25 |
| Soaking | 0.04 | 0.05 | 0.16 | 0.25 |
| Marginal probability of the geological structure | | 0.40 | 0.30 | 0.30 | 1.00 |

Finally the oil company also has the following set of information regarding the net present value of the three states, which are: (i) NPV(Dry state)=-0 6 million;(ii) NPV(Wet state)=0.8 million and (iii) NPV(Soaking state)=2.4 million

**Solution # 2**

**At C1**



**At C3**



**At C4**



Dry

C11; P(C11=1/2) 0.6

Wet

D11 (Drill) C12; P(C12=1/4) 0.8

Soaking

C13; P(C13=1/4) 2.4

D11 Dry

(Drill) C31; P(C31=4/5) 0.6

Wet

D21 (Drill) C32; P(C32=1/10) 0.8

Soaking

D2

C33; P(C33=1/10) 2.4

D22

C21 (Do not drill) Dry

P(C21=4/10) C41; P(C41=1/2) 0.6

(No structure) D31 Wet

(Drill) C42; P(C42=1/3) 0.8

D12 C22 Soaking

D3

D1

Conduct C43; P(C43=1/6) 2.4

Test P(C22=3/10) D32 Dry

0.02 (Do not drill) C51; P(C51=1/10)

C23 D41 Wet 0.6

P(C23=3/10) (Drill) C52; P(C52=11/30)

(Closed Structure) Soaking 0.8

D4

C53; P(C53=16/30)

D42 2.4

(Do not drill)

C22

(Open Structure)

D13

Do

Nothing Stages of evaluation

D13

**At C5**



Hence at the decision points we have

D2 D21 (Drill) and EMV(D21) = -0.16

D22 (Do not drill) and EMV(D22) = 0

D3 D31 (Drill) and EMV(D31) = 0.367

D32 (Do not drill) and EMV(D32) = 0

D4 D41 (Drill) and EMV(D41) = 1.513

D42 (Do not drill) and EMV(D42) = 0

**At C2**



Hence at the decision points we have

D11 (Drill) and EMV(D11) = 0.50

D12 (Conduct seismic test) and EMV(D12) = 0.544

D13 (Do nothing) and EMV(D13) = 0

Based on the above evaluation of alternatives we can find that the set of decision strategies as follows, from which we choose the optimal decision strategy

|  |  |  |
| --- | --- | --- |
| Path | Probability | NPV |
| D12→C21→D22 | 0.40 | 20000 |
| D12→C22→D31→C41 | 0.15 | 620000 |
| D12→C22→D31→C42 | 0.10 | 780000 |
| D12→C22→D31→C43 | 0.05 | 2380000 |
| D12→C23→D41→C51 | 0.03 | 620000 |
| D12→C23→D41→C52 | 0.11 | 780000 |
| D12→C23→D41→C53 | 0.16 | 2380000 |

So:

E(NPV)= 



SD(NPV)= 



We can make our decision accordingly as one may want to (i) maximize return or (ii) minimize risk or (iii) make a balance between them, i.e., max{return/risk} or min{risk/return}.

Dry

C11; P(C11=1/2) 0.6

Wet

D11 (Drill) C12; P(C12=1/4) 0.8

Soaking

C13; P(C13=1/4) 2.4

D11 Dry

(Drill) C31; P(C31=4/5) 0.6

Wet

D21 (Drill) C32; P(C32=1/10) 0.8

Soaking

D2

C33; P(C33=1/10) 2.4

D22

C21 (Do not drill) Dry

P(C21=4/10) C41; P(C41=1/2) 0.6

(No structure) D31 Wet

(Drill) C42; P(C42=1/3) 0.8

D12 C22 Soaking

D3

D1

Conduct C43; P(C43=1/6) 2.4

Test P(C22=3/10) D32 Dry

0.02 (Do not drill) C51; P(C51=1/10)

C23 D41 Wet 0.6

P(C23=3/10) (Drill) C52; P(C52=11/30)

(Closed Structure) Soaking 0.8

D4

C53; P(C53=16/30)

D42 2.4

(Do not drill)

C22

(Open Structure)

D13

Do

Nothing

D13

Ways of managing project risk are

(i) juggling between fixed and variable cost; (ii) priing strategy; (iii) sequential investment; (iv) improving information; (v)financial leverage; (vi) insurance; (vii) long term arrangements

Risk profile method

We must be aware of the probability distribution of NPV (an absolute measure) and try to convert the same to probability distribution of profitability index (relative measure).

Risk adjusted discounted rate method



where

rk = risk adjusted discounted rate for the kth project

rf = risk free rate of interest

n = adjustment for the firm′s notional risk

dk = adjustment for the differential risk for the kth project

Hence



where

NPVk = Net Present Value for the kth project

 = Expected or estimated cash flow for the kth project at the tth time period

rk = Risk adjusted discounted cash flow for the kth project

Ik = Net present value of investment for the kth project

We can also have the formulae as



where

NPVk = Net Present Value for the kth project

 = Expected or estimated cash flow for the kth project at the tth time period

rf = Risk adjusted discounted cash flow for the kth project

Ik = Net present value of investment for the kth project

αk,t = certainty equivalent coefficient for the kth project at the tth time period

If

αk,t = 1, then the person is risk indifferent

αk,t < 1, then the person is risk avoider

αk,t > 1, then the person is risk indifferent

Certainty index

In general we may term it as the probability of being positive, i.e., if we say the certainty index of procuring raw materials on time is 85%, then it means that the probability that the raw materials are obtained in tie are 85%

Thus in a problem we can have the following information

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Item | Certainty equivalent coefficients | | | |
| 1st year | 2nd year | 3rd year | 4th year |
| Research and Development | 0.68 | 0.65 | 0.55 | 0.50 |
| Marketing | 0.78 | 0.73 | 0.66 | 0.61 |
| Starting the project | 0.90 | 0.84 | 0.76 | 0.70 |
| Procuring raw materials | 0.85 | 0.80 | 0.77 | 0.74 |

Note: Remember the time frame for each item/sub-project is different

In evaluation remember that if there are three stages for the completion of the project such that we can have A leads to B then to C and then D or A to C then to B and then to D, then the corresponding probability would be calculated utilizing

P(A)\*P(B|A)\*P(C|A and B)\*P(D|A, B and C) and

P(A)\*P(C|A)\*P(B|A and C)\*P(D|A, C and B)