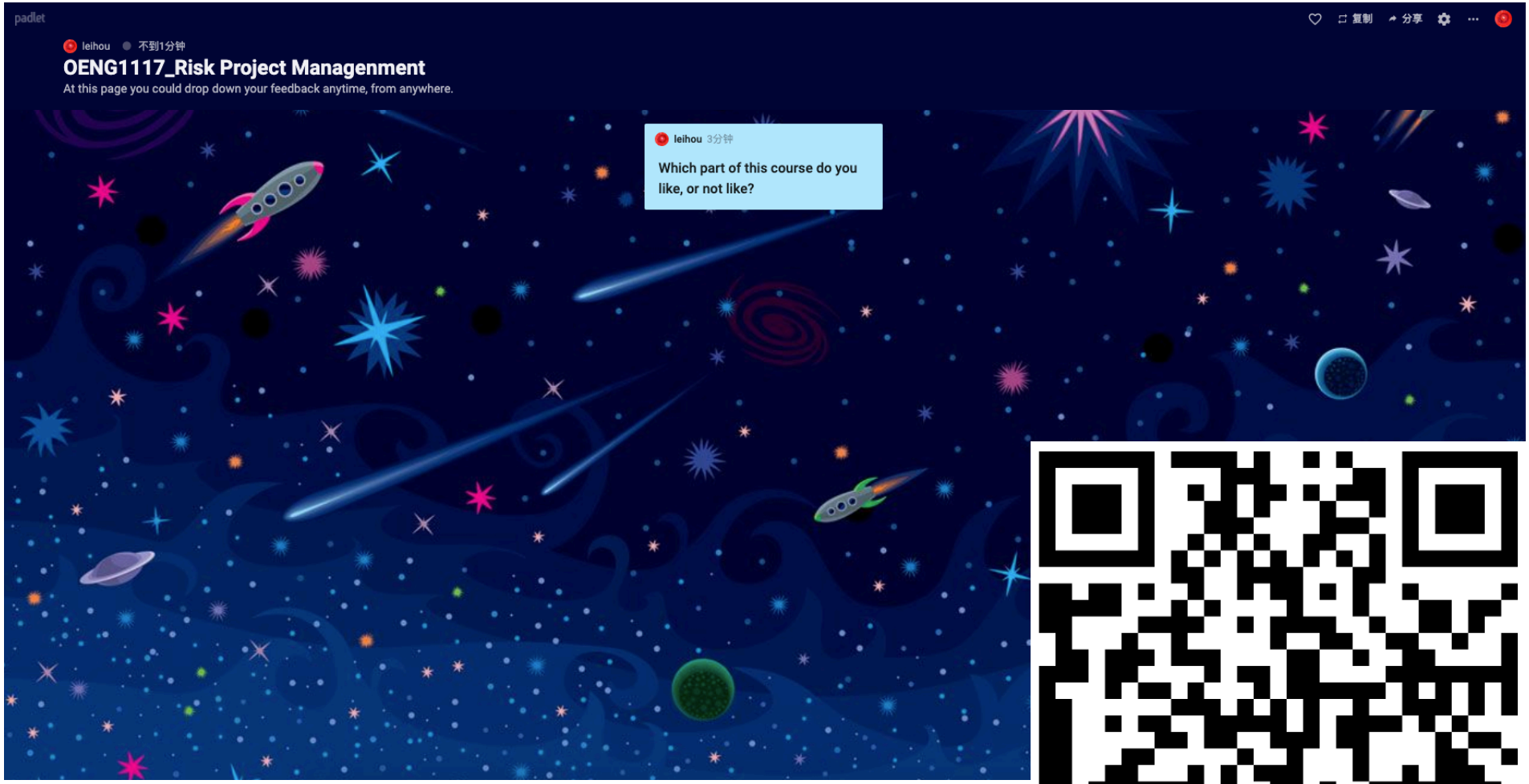
Course commenting page:



When you start to work on Assignment 2 & 3, I am planning to add 2 additional live consultations, preferably on the Wednesday or Thursday nights of Week 7 & 9.

Either you would prefer Wednesday or Thursday please let us know:

https://forms.gle/MmbRrq5q9UPLAFYL9

QUANTITATIVE RISK ASSESSMENT

&

FEASIBILITY (ECONOMICS APPRAISAL)

1. HDR Scholarship Opportunities!

2. Internship – Graduate Programs still Open!

Quantitative Risk Analysis

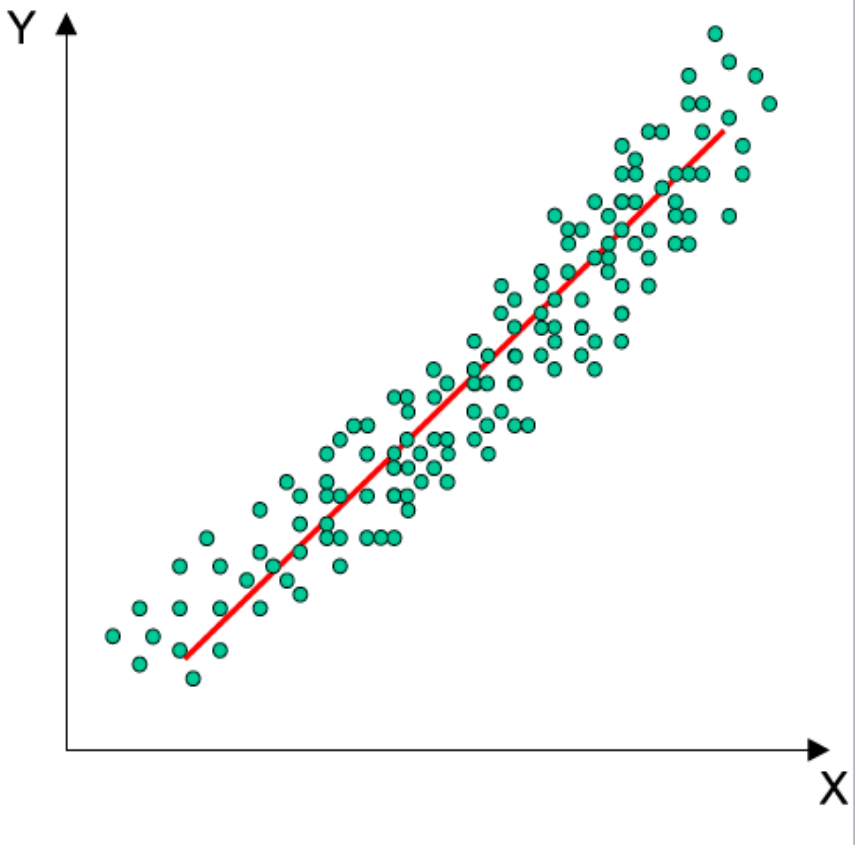
- A qualitative approach to make decisions and is more suitable for complex decision-making scenarios
- More rigorous, computational, numerical, mathematical, etc.

We will learn the following techniques:

1. Sensitivity Analysis
2. Decision Tree Analysis
3. Event Tree Analysis
4. Fault Tree Analysis

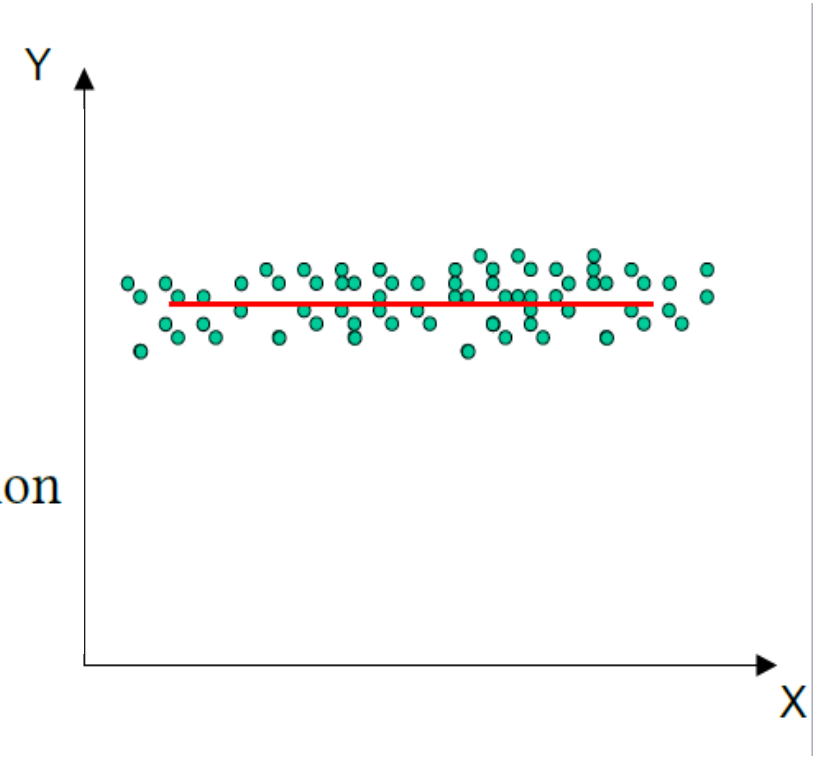
Sensitivity Analysis

- Consider a case where $Y = f(x)$ and the function f is a "black box"
- We can sample Y for different values of X to reassemble the relationship
- Here: X is a sensitive parameter



Sensitivity Analysis

- Here, X is not sensitive
- Can be "seen" visually
- Can be measured by the linear regression coefficient



Sensitivity Analysis

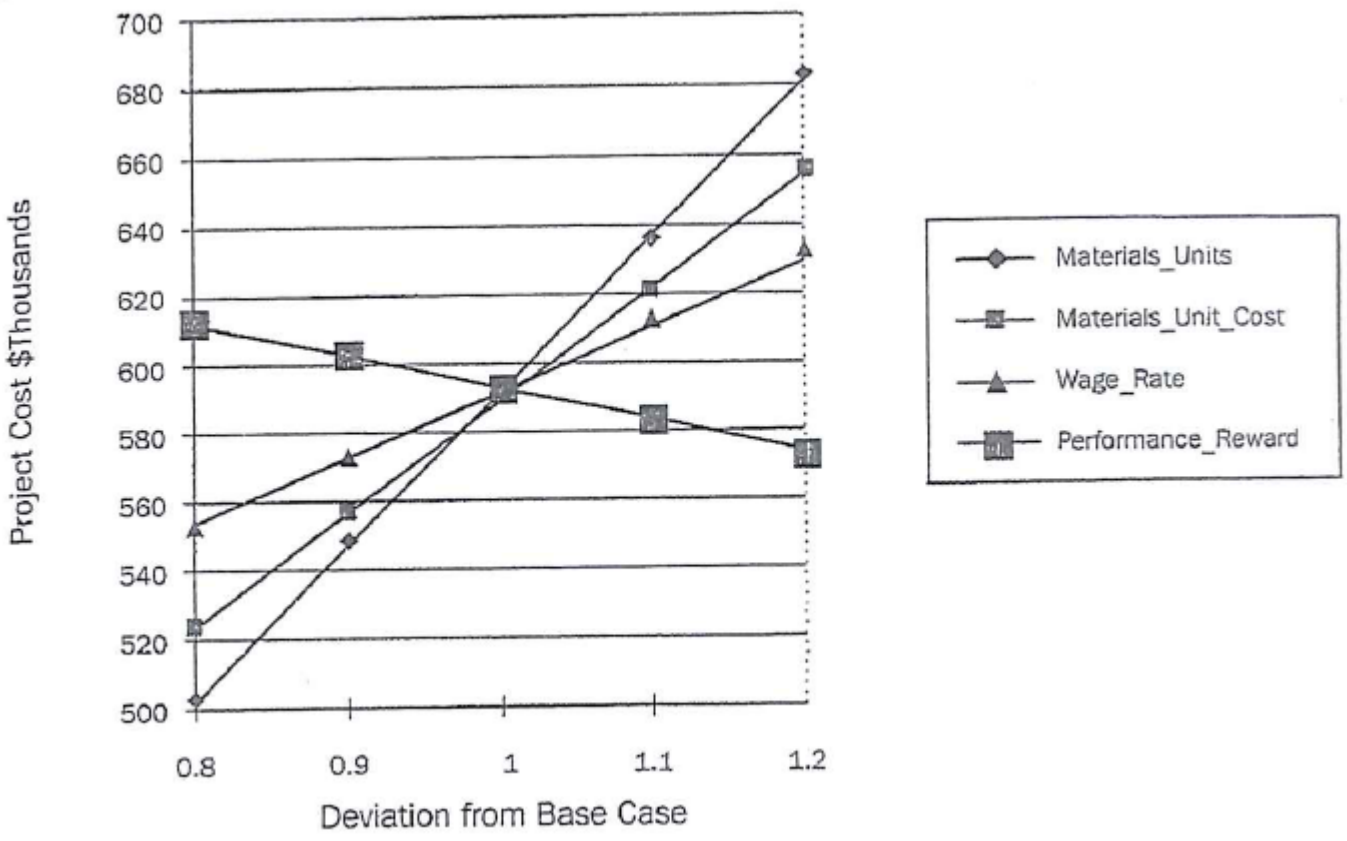
- Sensitivity analysis examines each project risk on its own merit. It is an analysis process to determine which risks could affect the project the most.

- All other risks in the project are set at a baseline value. The individual risk is then examined to see how it may affect the success of the project.

- The goal is to determine which individual risks have the greatest impact on the project's success and then escalate the risk management processes on these risk events.

Sensitivity Analysis using Spider Diagram

- Only one variable is changed at a time, holding the other variables at their base-line value



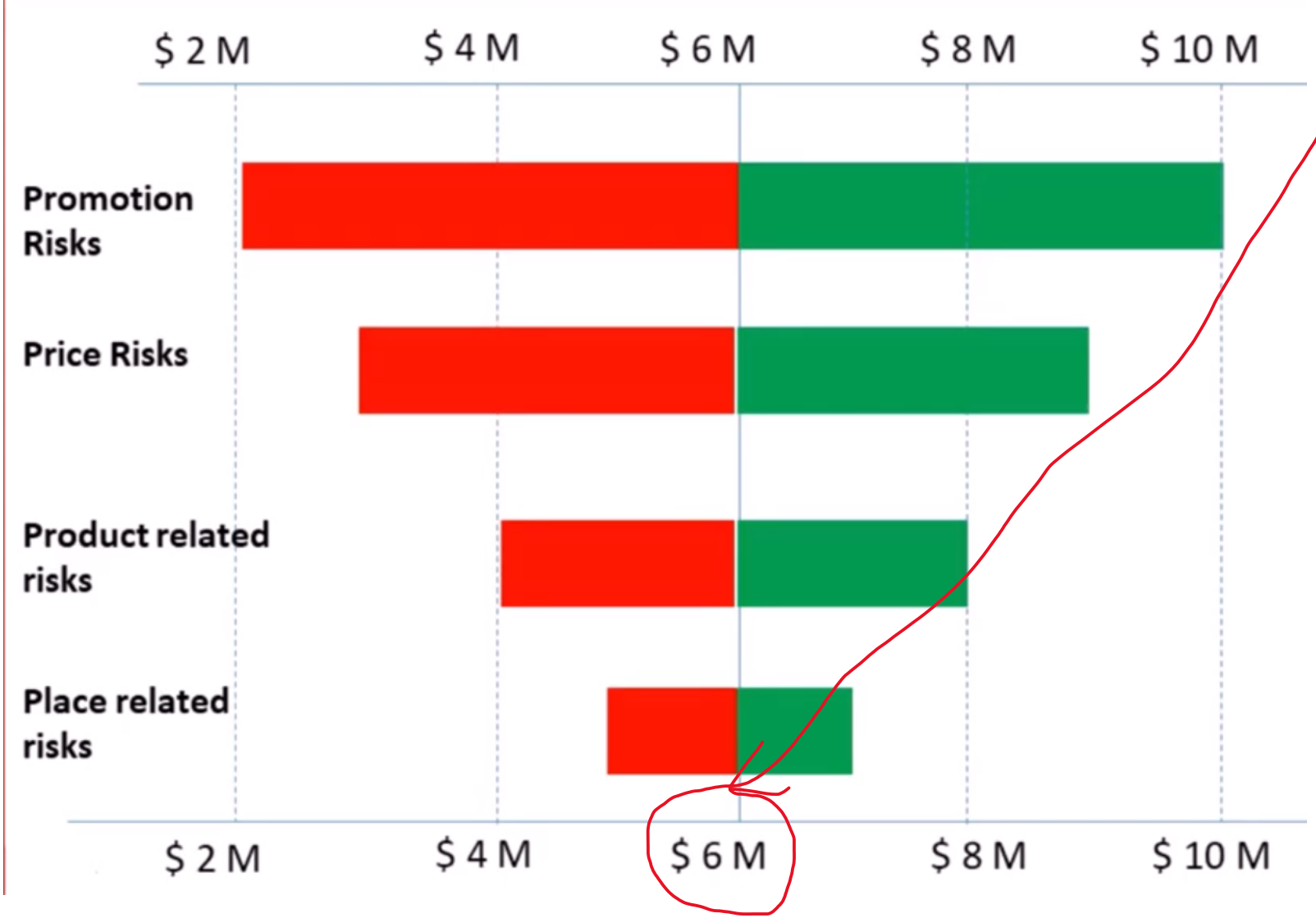
Sensitivity Analysis using Tornado Diagram

Example:

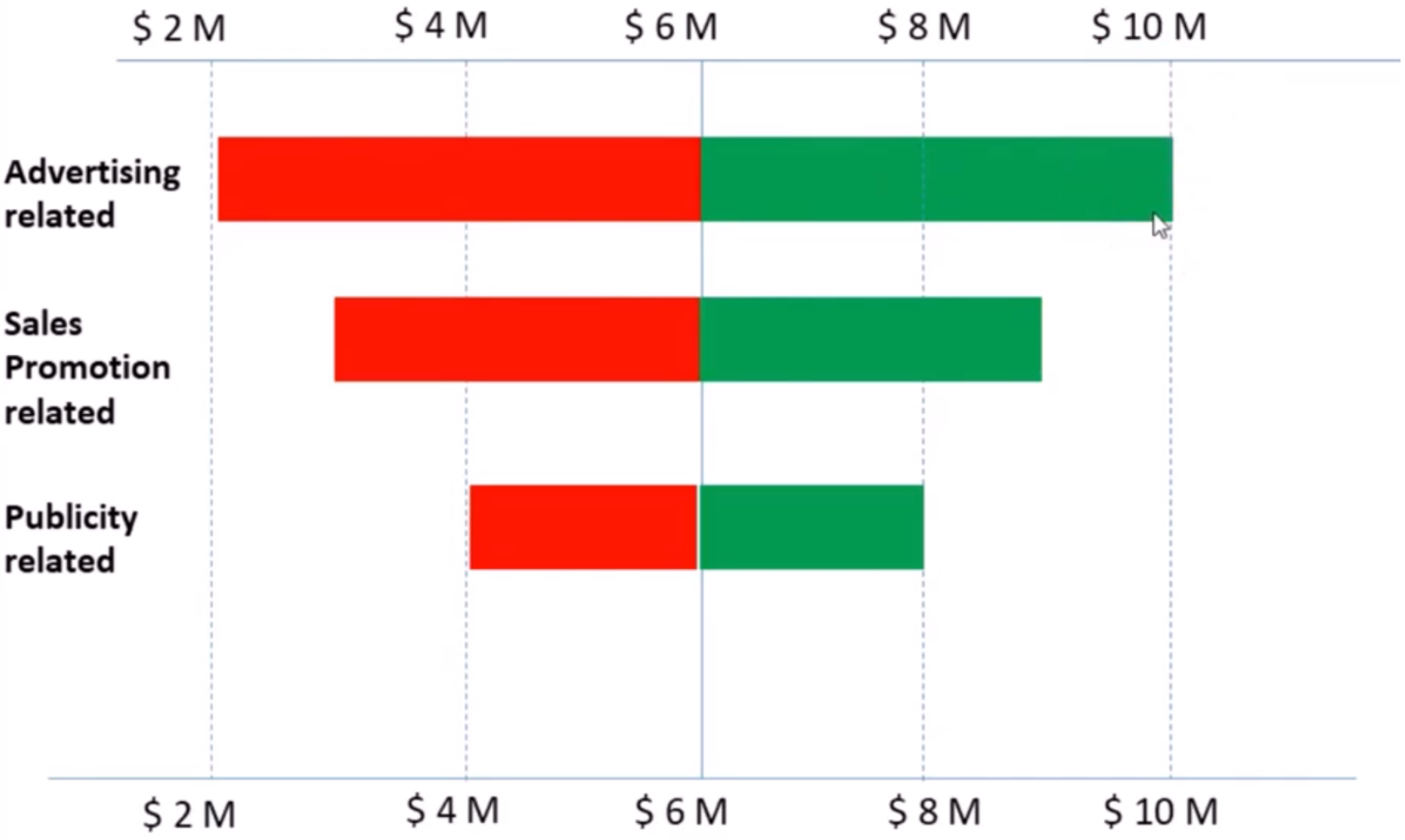
“We want to release new product in the market. Our target profit is $6 million by the end of this year”

We are interested to know – Which individual risk in the marketing category can influence our project objective to a greater extent?

Sensitivity analysis: Target profit = $6 M



Sensitivity analysis – Promotion

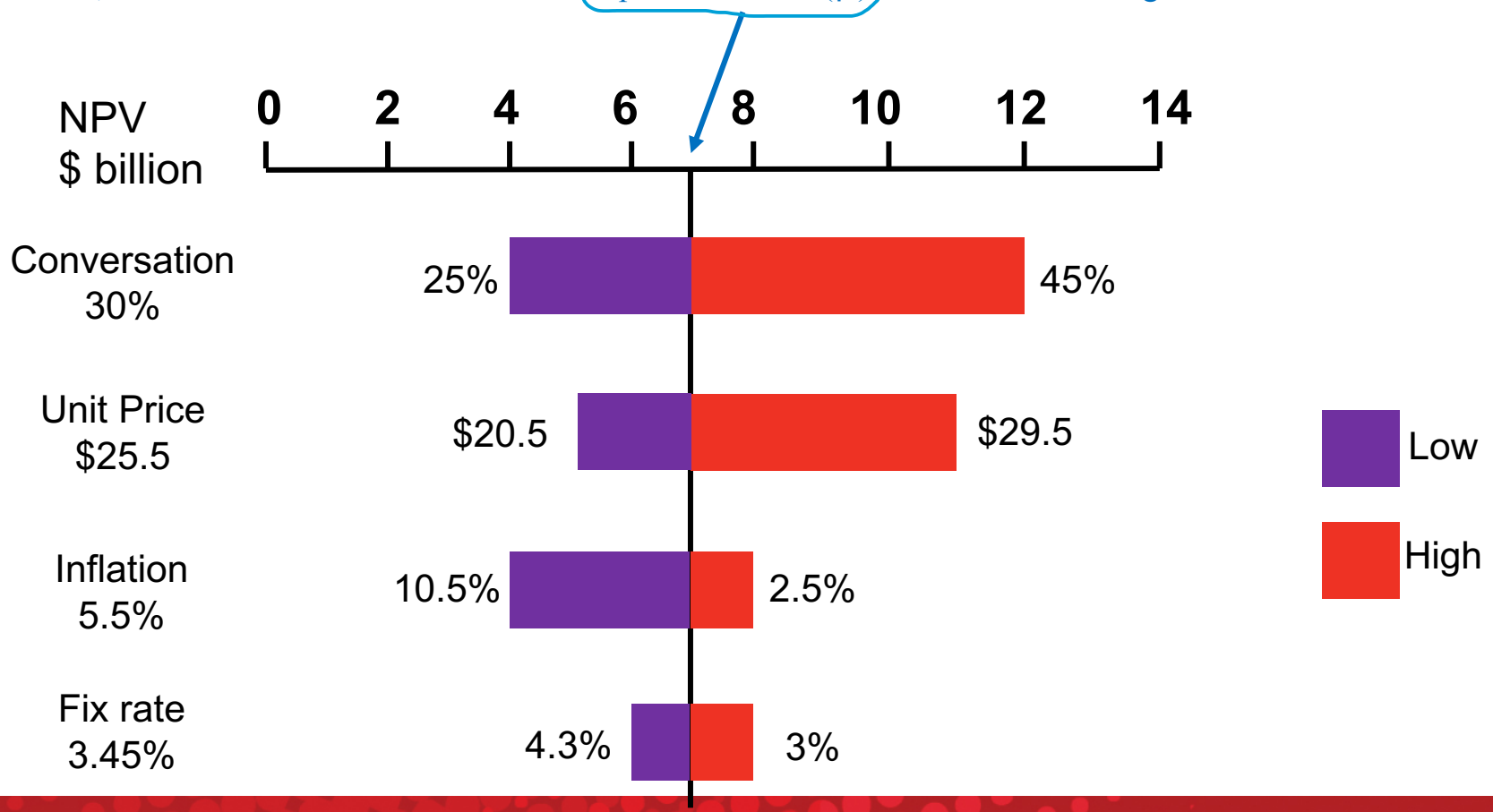


Sensitivity Analysis using Tornado Diagram

Sensitivity analysis on NPV

In statistics, we need to consider a concept named 'Confidence Interval (CI)', which means the chance the Population Mean falls between two endpoints. This is extremely important in Examining Product Quality via Sampling (a statistical concept of using the Sample Mean to reflect the Population Mean).

If CI=90%, it means there is a 90% chance the Population Mean (μ) will fall into the range.



Interval Estimates of the Mean

The interval estimate is the form favored by statisticians because it provides some acknowledgement of the error inherent in the sampling process.

Confidence Interval Estimates

In addition to reporting the point estimate for μ , we must provide information that indicates the accuracy of the estimate

i.e. a confidence interval for μ

A confidence interval estimates for a parameter consists of numbers obtained from a point estimate together with a percentage specifying how confident we are that the parameter lies in the interval.

The percentage is called the confidence interval.

Confidence Intervals

A random sample of size *n* is to be taken from a population with mean μ and standard deviation σ . Assume that the population is normally distributed or the sample size is large ($n \geq 30$).

Determine the probability that the interval

$$\bar{x} - 2\frac{\sigma}{\sqrt{n}} \quad \text{to} \quad \bar{x} + 2\frac{\sigma}{\sqrt{n}}$$

will contain the population mean μ , and interpret the result in terms of percentages.

Confidence Intervals

Using Table D, the probability is approximately 0.9544 that an observed value of $\bar{x}$ is within 2 standard deviations to either side of the mean.

$$P(\mu_{\bar{x}} - 2\sigma_{\bar{x}} < \bar{x} < \mu_{\bar{x}} + 2\sigma_{\bar{x}}) = 0.9544$$

since $\mu_{\bar{x}} = \mu$ **and** $\sigma_{\bar{x}} = \sigma/\sqrt{n}$ **we can rewrite this equation**

$$P(\mu - 2\frac{\sigma}{\sqrt{n}} < \bar{x} < \mu + 2\frac{\sigma}{\sqrt{n}}) = 0.9544$$

This can be rewritten as

$$P(\bar{x} - 2\frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + 2\frac{\sigma}{\sqrt{n}}) = 0.9544$$

Confidence Intervals

The probability is 0.9544 that the interval from

$$\bar{x} - 2\frac{\sigma}{\sqrt{n}} \text{ to } \bar{x} + 2\frac{\sigma}{\sqrt{n}}$$ **will contain** μ .

If we take a large number of random samples of size *n*, then approximately 95.44% of the samples obtained will have the property that the interval with endpoints

$$\bar{x} \pm 2\frac{\sigma}{\sqrt{n}}$$

contains the population mean μ .

Expected Monetary Value (EMV)

- The method considers the probability of each possible outcome and determines the average value of all outcomes
- To determine the EMV, follow the below steps:
    1. Identify the scenarios that could occur
    2. Determine the probability of each scenario
    3. Determine the monetary value associated with each outcome
    4. Multiply the probability times the monetary value of each outcome
    5. Sum the outcomes to get the expected monetary value of the risk or decision

Expected Monetary Value (EMV)-Examples

Software company is analysing whether they are going to develop software in-house or purchase?

To develop software:

Risk Event Alternative	Probability	Cost	Expected Monetary Value (EMV)
Keep staff	50%	$172,000	$86,000
Lose staff	50%	$208,000	$104,000
Expected Monetary Value	$190,000		

To purchase software:

Risk Event Alternative	Probability	Cost	Expected Value
Little customization	60%	$152,000	$91,200
Much customization	40%	$188,000	$75,200
Expected Monetary Value	$166,400		

Based on the analysis, Company will decide to purchase software

Here is another example.

Ice Cream Shop: if successful EMV would be $100

Which one should you choose?

Assuming that:

1. no initial costs; and
2. 50% chance success for both options.

Juice bar: if successful EMV would be $ 90

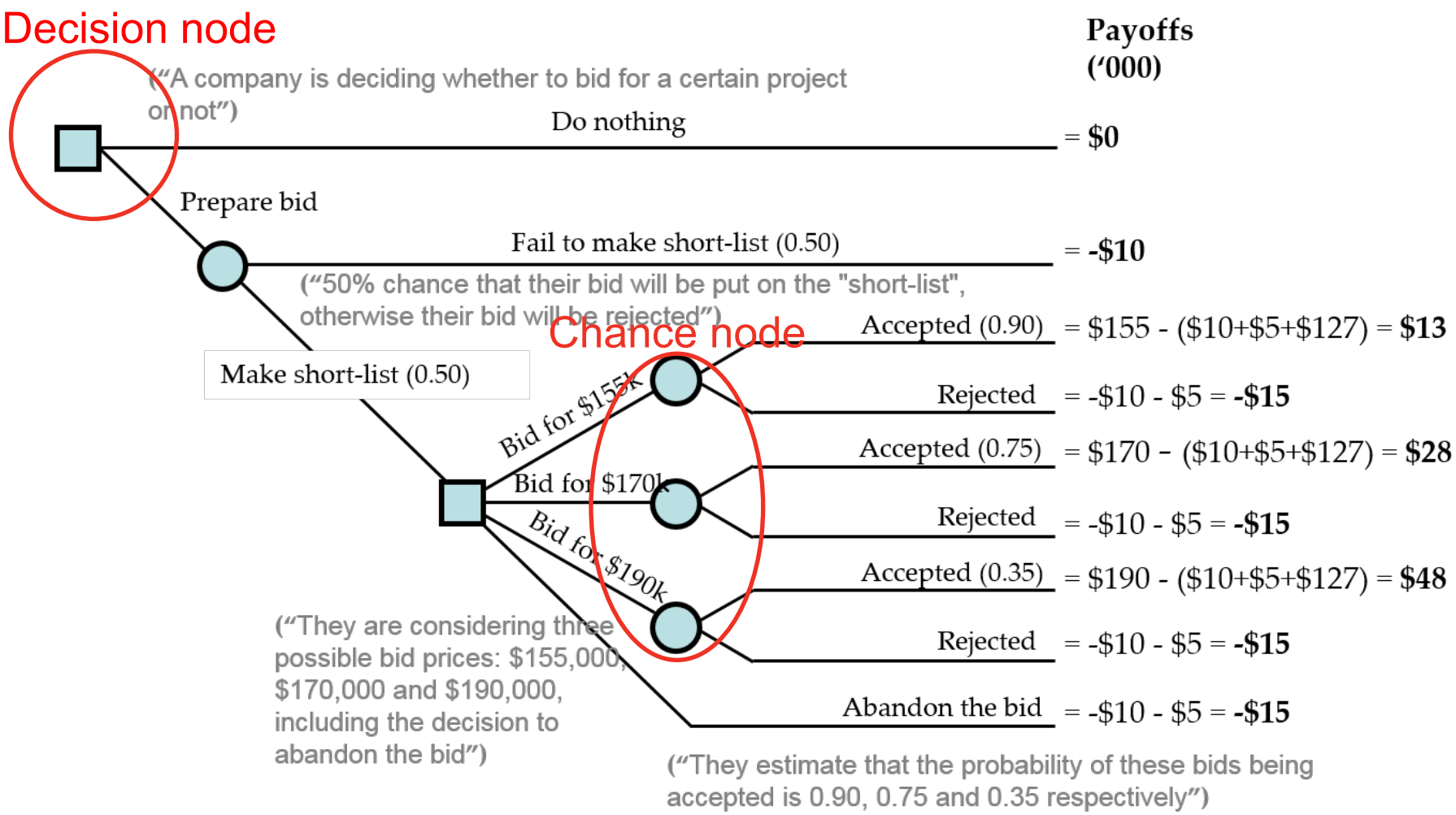
In practice, we could combine Decision Tree Analysis to help us make informed decisions - let us look at this case

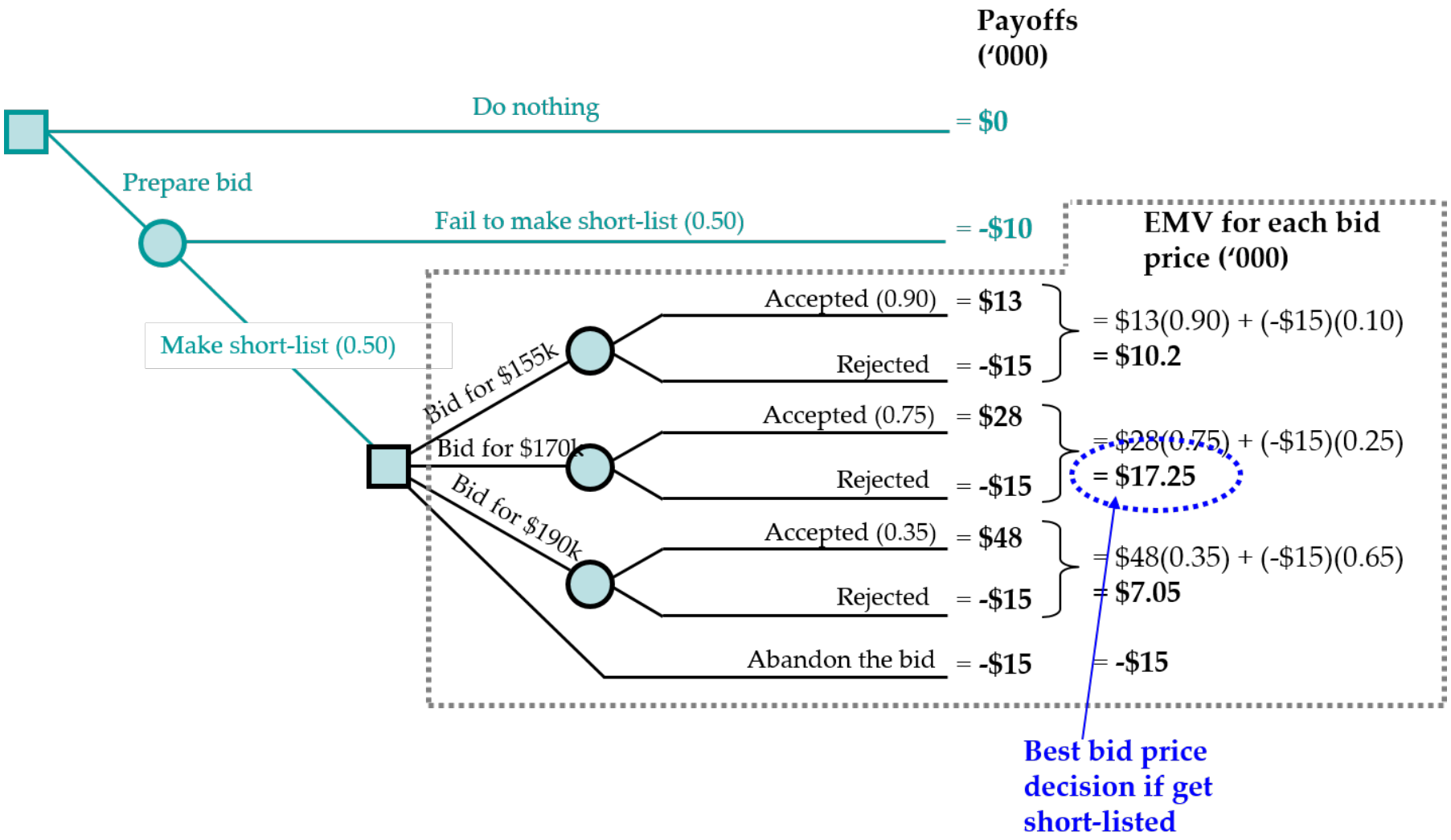
A company is deciding whether to bid for a certain project or not. They estimate that merely preparing the bid will cost $10,000. If their company bid then they estimate that there is a 50% chance that their bid will be put on the "short-list", otherwise their bid will be rejected.

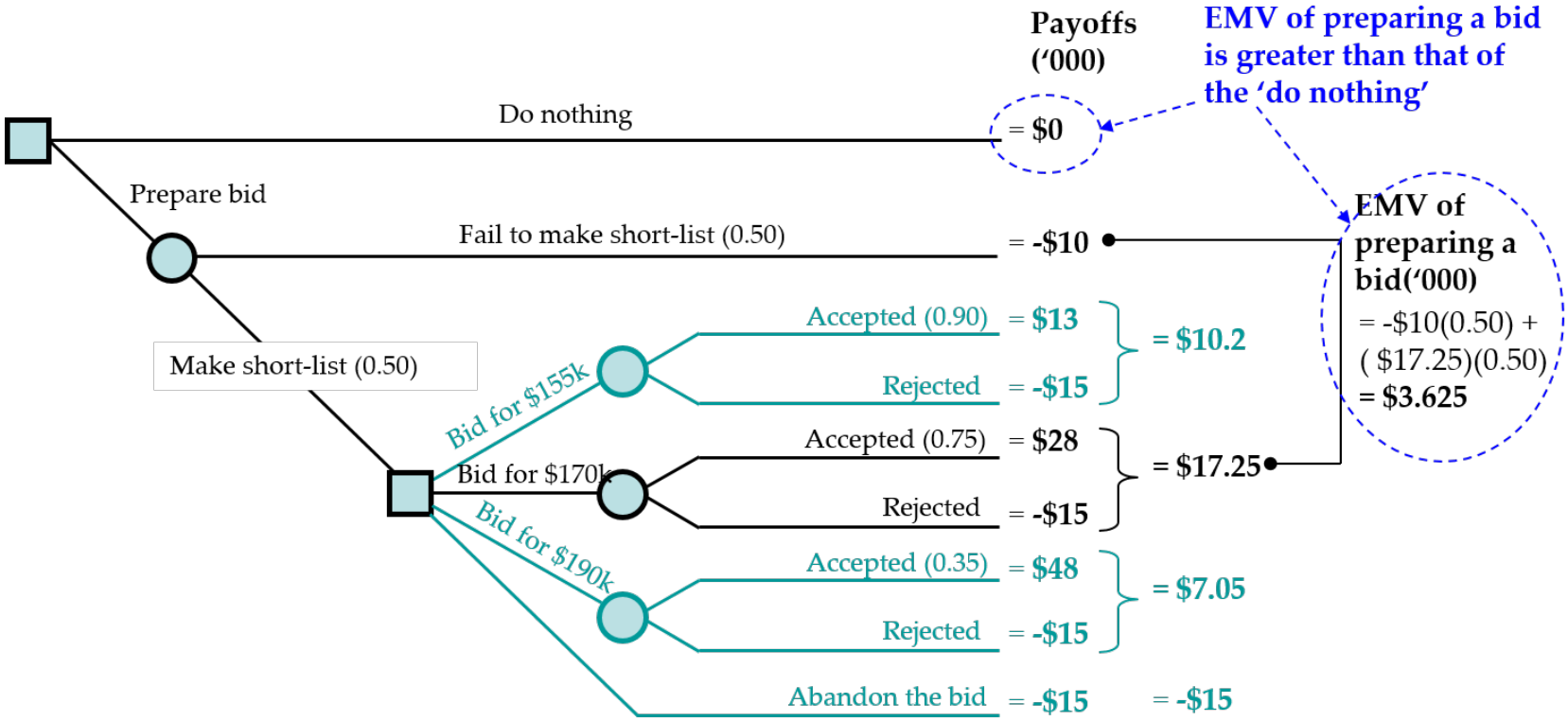
Once "short-listed" the company will have to supply further detailed information (entailing costs estimated at $5,000). After this stage their bid will either be accepted or rejected.

They are considering three possible bid prices, namely $155,000, $170,000 and $190,000, including the decision to abandon the bid. They estimate that the probability of these bids being accepted (once they have been short-listed) is 0.90, 0.75 and 0.35 respectively. The company estimate that the labour and material costs associated with the contract are $127,000.

What should the company do and what is the expected monetary value of your suggested course of action?


Decision node
("A company is deciding whether to bid for a certain project or not")
Payoffs ('000)
Do nothing
= $0
Prepare bid
Fail to make short-list (0.50)
= -$10
("50% chance that their bid will be put on the "short-list", otherwise their bid will be rejected")
Chance node
Make short-list (0.50)
Bid for $155k
Accepted (0.90)
= $155 - ($10+$5+$127) = $13
Rejected
= -$10 - $5 = -$15
Bid for $170k
Accepted (0.75)
= $170 - ($10+$5+$127) = $28
Rejected
= -$10 - $5 = -$15
Bid for $190k
Accepted (0.35)
= $190 - ($10+$5+$127) = $48
Rejected
= -$10 - $5 = -$15
Abandon the bid
= -$10 - $5 = -$15
("They are considering three possible bid prices: $155,000, $170,000 and $190,000, including the decision to abandon the bid")
("They estimate that the probability of these bids being accepted is 0.90, 0.75 and 0.35 respectively")


Payoffs ('000)
Do nothing
= $0
Prepare bid
Fail to make short-list (0.50)
= -$10
EMV for each bid price ('000)
Make short-list (0.50)
Bid for $155k
Accepted (0.90)
= $13
Rejected
= -$15
= $13(0.90) + (-$15)(0.10)
= $10.2
Bid for $170k
Accepted (0.75)
= $28
Rejected
= -$15
= $28(0.75) + (-$15)(0.25)
= $17.25
Bid for $190k
Accepted (0.35)
= $48
Rejected
= -$15
= $48(0.35) + (-$15)(0.65)
= $7.05
Abandon the bid
= -$15
= -$15
Best bid price decision if get short-listed



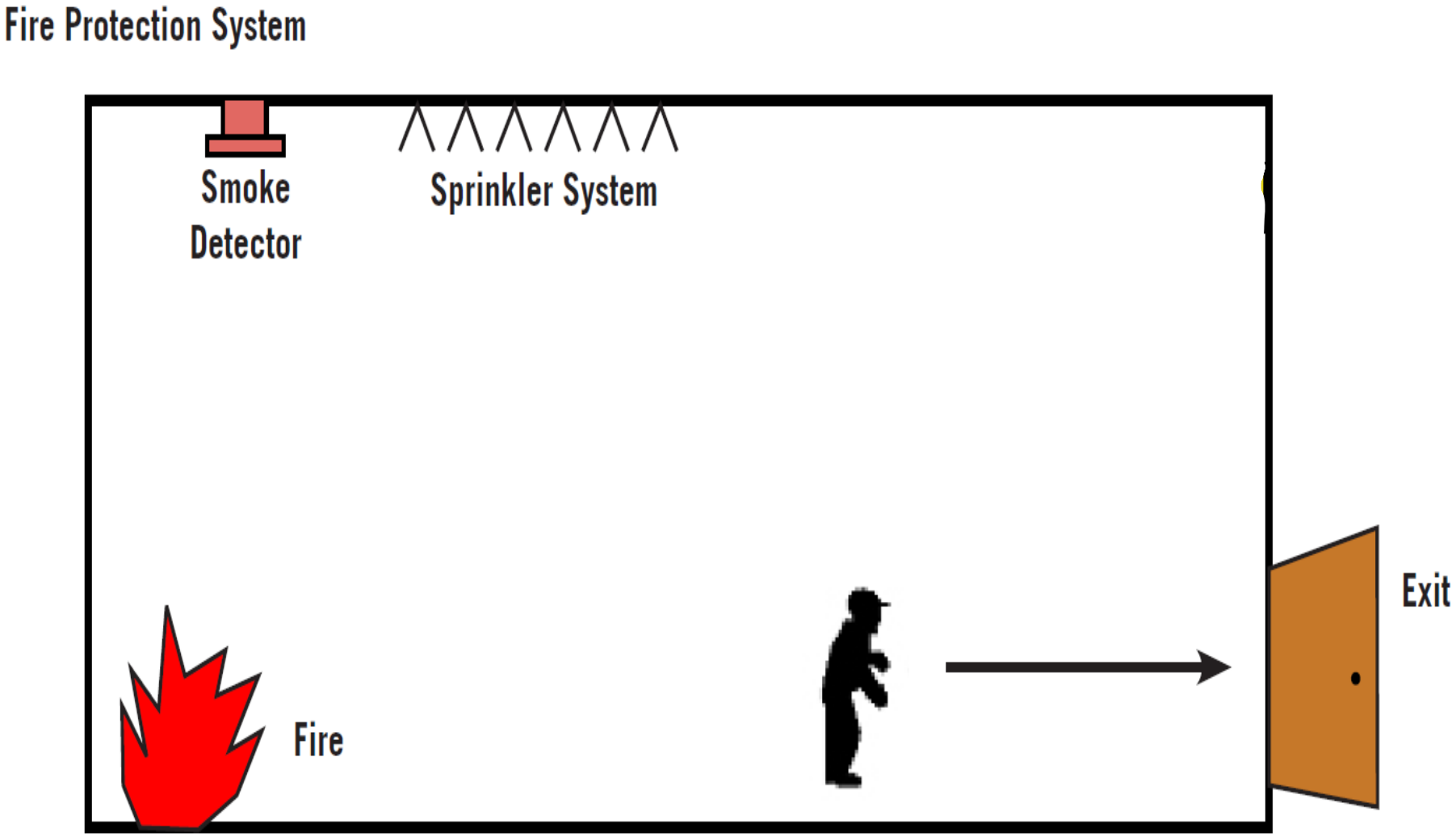
∴ It is recommended that the company should prepare a bid, and, if get short listed, should bid for $170,000.

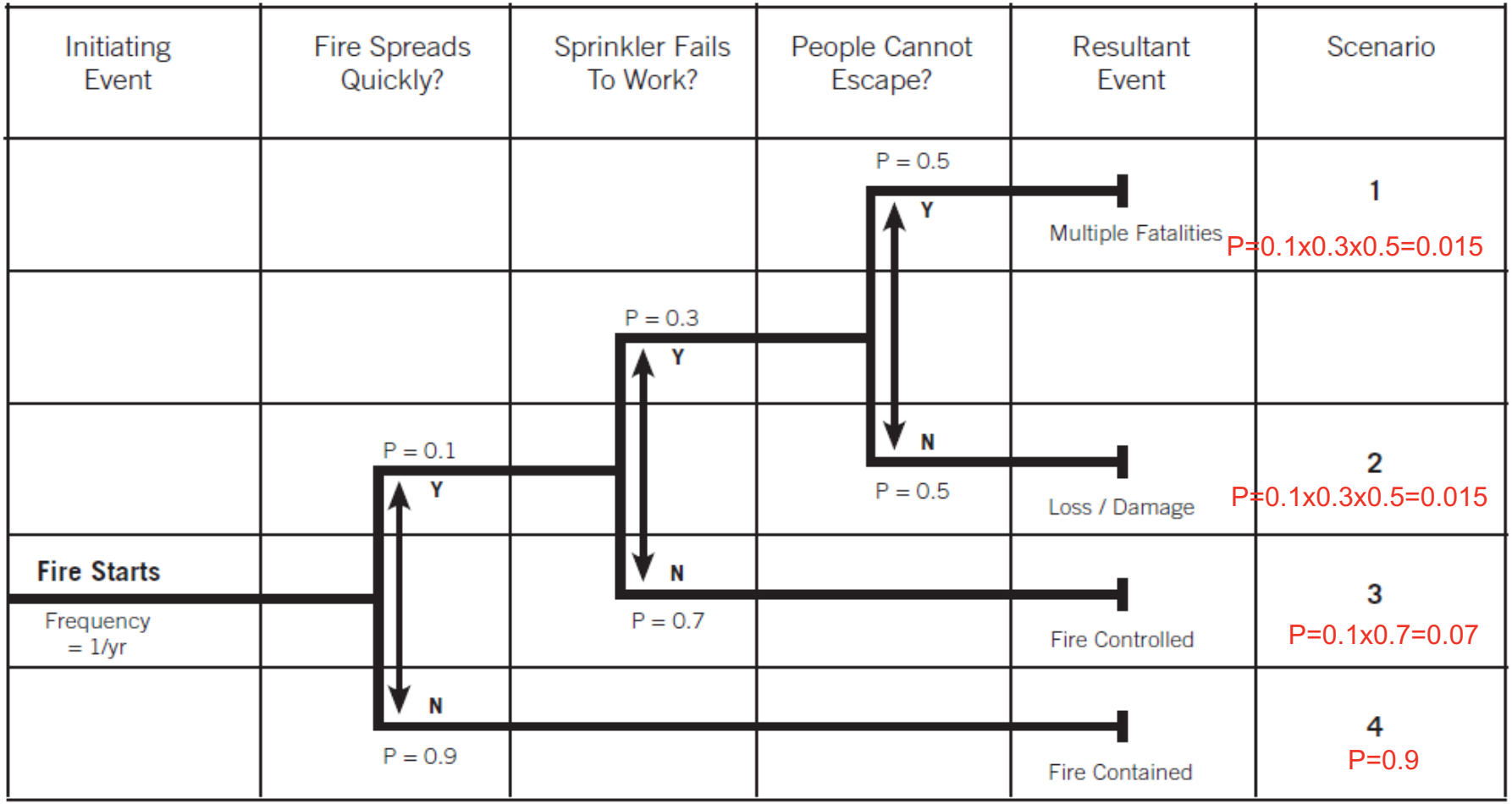
Event Tree Analysis

- **Purpose:** speculating (forwards) possible outcomes and probabilities of an initiating event (assuming the event has not happened yet)

- The process involves:
  - Identifying an initiating event of interest.
  - Identifying the consequent events followed by the impact of the initiating event
  - Constructing the event tree
  - Describing the resulting accident event sequences

Event Tree Analysis-Examples




Initiating Event
Fire Spreads Quickly?
Sprinkler Fails To Work?
People Cannot Escape?
Resultant Event
Scenario
Fire Starts
Frequency = 1/yr
P = 0.1
Y
N
P = 0.9
P = 0.3
Y
N
P = 0.7
P = 0.5
Y
N
P = 0.5
Multiple Fatalities
Loss / Damage
Fire Controlled
Fire Contained
1
P=0.1x0.3x0.5=0.015
2
P=0.1x0.3x0.5=0.015
3
P=0.1x0.7=0.07
4
P=0.9

Fault Tree Analysis (opposite to ETA)

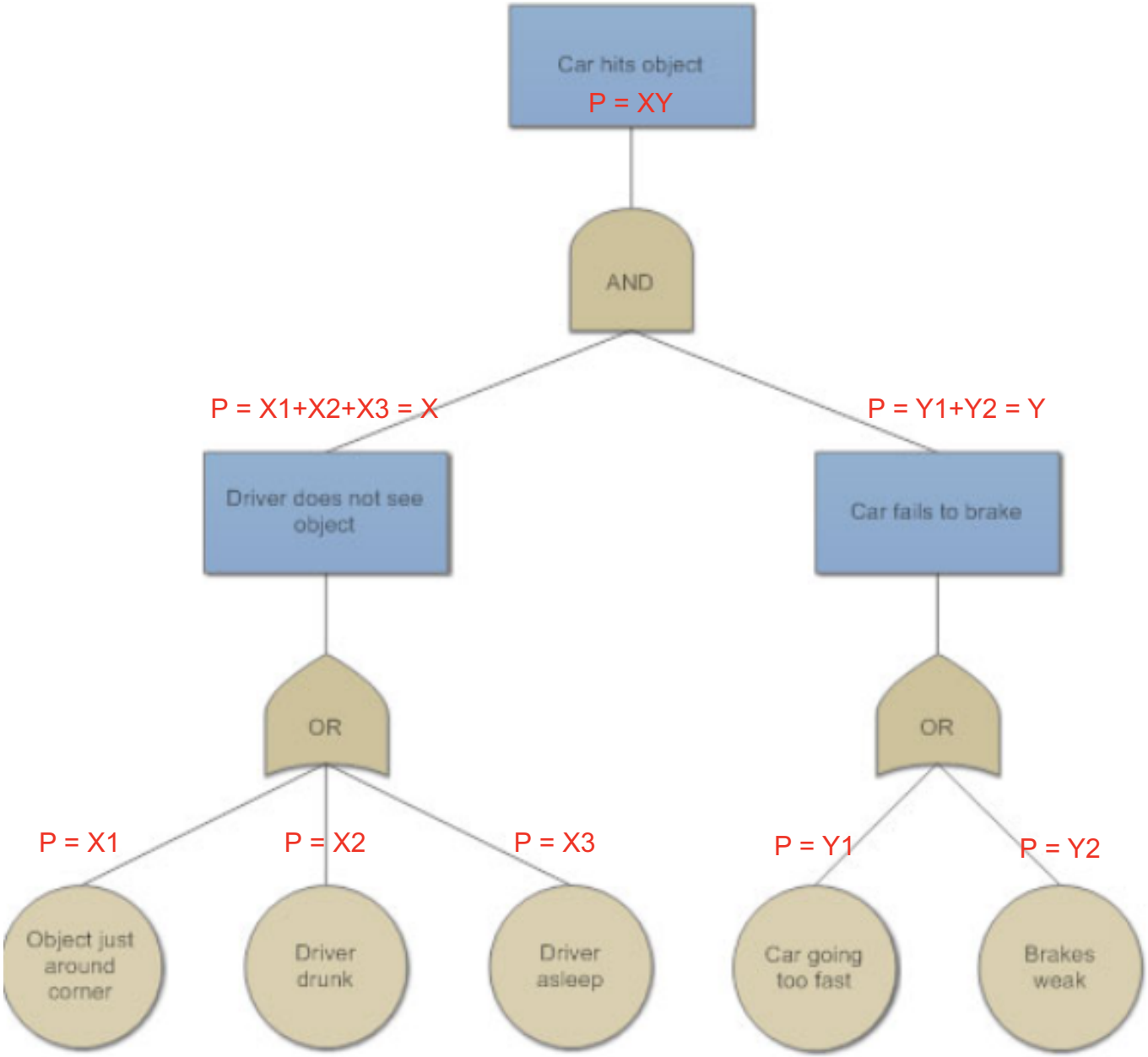
- **Purpose:** deducing (backwards) possible reasons and probabilities that lead to an outcome (already happened)

- FTA process involves:
  - An undesired event is defined
  - The event is resolved into its immediate causes
  - This resolution of events continues until basic causes are identified
  - A logical diagram called a fault tree is constructed showing the logical event relationships

OR gate – the above output event occurs if **either** of the input lower level events occur

AND gate – the above output event occurs if **all** of the input lower level events occur

Car hitting an object


Car hits object
P = XY
AND
P = X1+X2+X3 = X
P = Y1+Y2 = Y
Driver does not see object
Car fails to brake
OR
OR
P = X1
P = X2
P = X3
P = Y1
P = Y2
Object just around corner
Driver drunk
Driver asleep
Car going too fast
Brakes weak

A production plant is earning a gross profit of $110k per year and has some earnings saved up for expansion. The plant's current overhead $50k per year. The company has the choice of putting up a new plant in either a far-away city or a nearby town.

If the company decides to establish a far-away plant, there is a 37% chance that the economy in the far-away city does well, a 29% chance the economy remains the same, and a 34% chance the economy does bad. If the far away city's economy does well, there is a 71% chance the plant will earn a huge profit of $400k and a 29% chance it will earn a gross profit of $207k. If that city's economy stays the same, the plan will probably earn a gross profit of $85k. If that city's economy goes bad, the plant will probably earn a gross profit of $25k.

Or, if the company decides to set up a nearby plant there are equal probabilities that the economy will do well, stay the same or be bad. If the economy does well, the new plant's gross profit will be 70% higher than the current production plant. If the economy stays the same, there is a 62% chance that the gross profit will increase to $166k and 38% chance it will increase to $156k. If the economy does badly, the smaller plant's gross profit will only be 50% of the current production plant.

The overhead of the new plant in the far-away city is $30k per year, and in the nearby town is 40% of the current production plant.

Using Decision Tree Analysis, evaluate the most profitable production plant option?!

Solution

Economics-based project appraisal

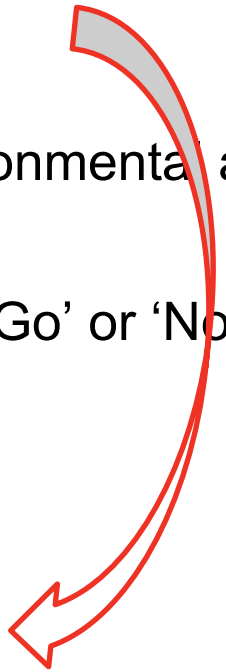
How to appraise the feasibility of a project? We should consider to:

Assess the **financial aspects (economics perspectives**.

&

Assess the environmental and social aspects **(non-economics perspectives)**

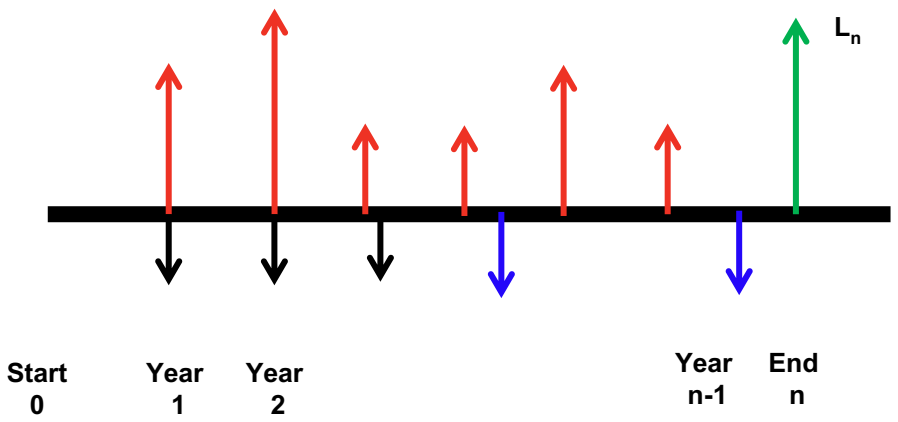
Before deciding ‘Go’ or ‘No go’



Does a dollar today have the same value tomorrow?

FINANCIAL STUFF!!!	
Costs	**Benefits**
loan/mortgage (A)	Profit made from sale, rental, or other services (B)
operation cost (O)*	Salvage or residual value (L_n)
maintenance cost (M)*	

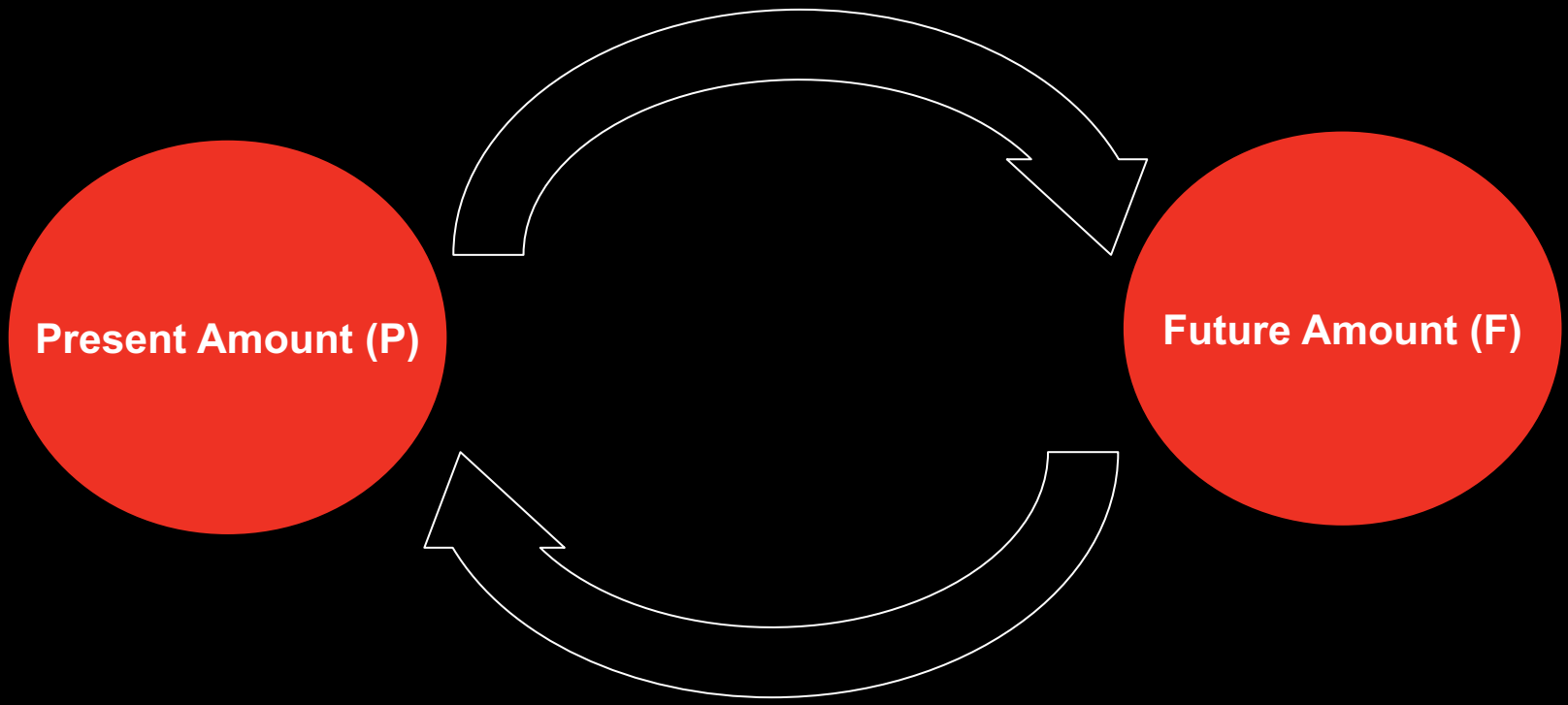
A Typical Cash Flow



Cash Flows-Compounding & Discounting

$$F = P(1 + i)^n$$

i= interest rate



Cash Flows-Major Formulas

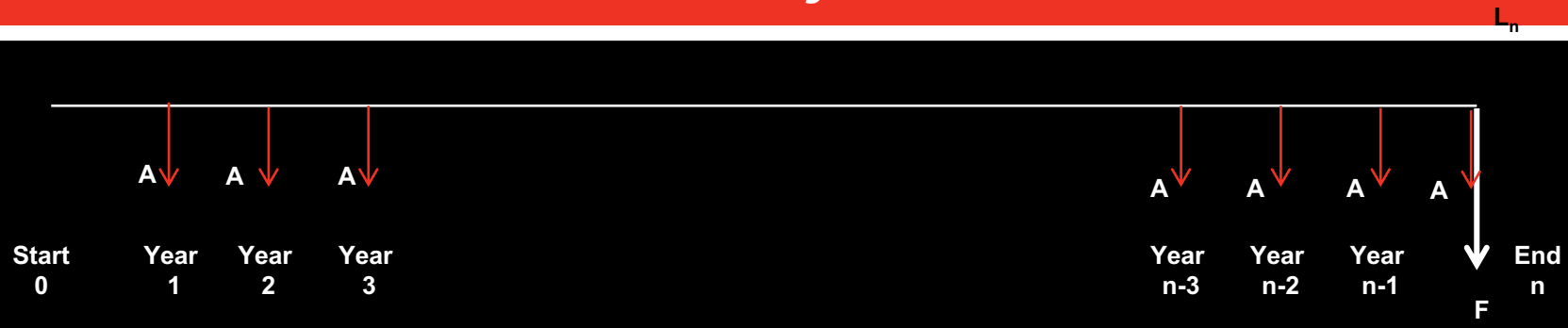
$$F = P(1+i)^n$$

Compound Factor = $(1+i)^n$

$$P = F/(1+i)^n$$

Present Value Factor/ Discount Factor = $1/(1+i)^n$

Cash Flows-Major Formulas



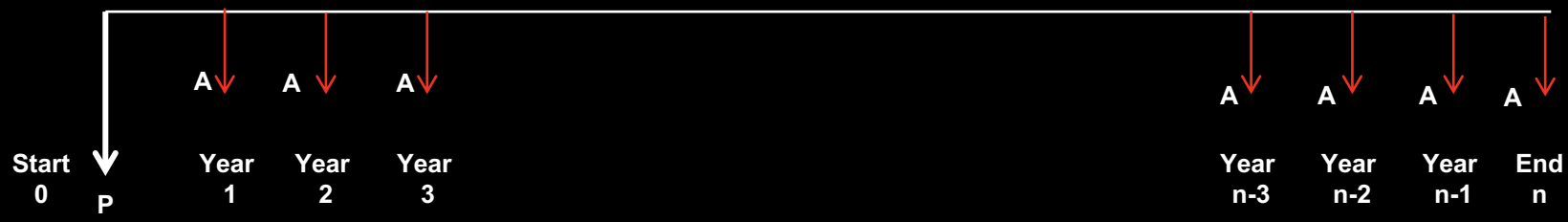
$$F = A[(1+i)^n - 1]/i$$

Compound Factor for an Annuity

$$A = F\frac{i}{(1+i)^n - 1}$$

Sinking Fund Deposit Factor

Cash Flows - Major Formulas



$$P = A\,[(1+i)^n - 1]/i\,(1+i)^n$$

Present Value Factor for a consistent Annuity. P is the sum of annuities to the present day!

$$A = P * i(1+i)^n/[(1+i)^n - 1]$$

Capital Recovery Factor

Besides, other financial metrics can also help the investor to further consider the project feasibility:

1. Benefit-Cost Ratio (BCR)
2. Net Present Value (NPV), similar to EVM and PV.
3. Payback Period (PB)
4. Internal Rate of Return (IRR)

- $BCR = \frac{Present\ Value\ of\ Annual\ Benefits}{Present\ Value\ of\ Annual\ Costs}$
- $BCR \geq 1$ is an indication that the project is financially viable and can be continued for further consideration of implementation
- BCR can be misleading if projects differ significantly in size, for example, if proposal A has a PV of benefits of 200 and PV of costs of 100, it has a NPV of 100 and a BCR of 2. If the alternative proposal, B, has a PV of benefits of 600 and costs of 400, it has a smaller BCR (1.5) but a larger NPV (200). It would be more efficient to choose proposal B.

Example: two alternative designs have been put forward for the construction of a new desalination plant in Victoria. It has been decided to adopt the **benefit cost ratio** as the method and upon its values to decide the successful project. Given that the economic life of the desalination plant is set at 25 years and the interest rate set at 10%. Also, the information in the table below can be used to decide which option should be adopted. The cost of the water to the public will be the same irrespective of which design is chosen (Assume 1.50$/ ML).

	Design I	Design II
Initial Cost	$25,000,000	$10,000,000
Annual Costs (Operation and Maintenance)	$100,000	$100,000
Annual Production (ML)	2,500,000	1,000,000

Solution (which function are we gonna use?)

Net Present Value (NPV)

- The NPV is the sum of the present values of the net benefits minus the costs associated with the project
- A positive NPV indicates that the benefits will exceed costs over the lifetime of the project
- When comparing projects, the highest NPV will be selected
- Discount rate is crucial to the project
- Not good for comparing projects of different lifetimes

$$NPV = -I_0 + (B-C)PVF_{i,n} + L_n/(1+i)^n$$

Where:

I_0 – Initial capital investment

B – annual net benefits

C – annual net costs

$PVF_{i,n}$ – present value factor = $[(1+i)^n - 1]/i(1+i)^n$

L_n – liquidation yield (residual value)

i – discount rate

n – number of years

Example

Two alternative designs have been put forward for the construction of a new retail park near Geelong.

In option 1 the survey work will cost of $1,000,000, the purchase of the required land will cost $50 million and the construction will cost a further $150 million. Operating and maintenance costs will be $20 million a year. The retail park is expected to have 5 million customers a year, each person expected to spend in $10. At the end of the operational period the land will have a re-sale value of $4 million

In the second alternative the construction cost will be $250 million and the land purchase $60 million. The survey cost will be the same as for alternative 1. Operating costs will be $25 million per year with salary costs at 20% of operation costs. The expected income from customers is expected to be $100 million but the site will have no resale value.

Both alternatives will have a design life of 50 years and discount rate of 7.5% has been selected as appropriate for the project.

Based on NPV, determine which option should be selected?

Solution

PayBack (PB) Period

$$PB = \frac{\text{Initial Cost}}{\text{Annual Cash Inflow (Net Benefit)}} = \frac{I_0}{(B-C)}$$

- The time required to pay back the investment in the project
- Payback period does not take into account the change in value of money with time
- Favours projects which generate high benefits in early years compared to projects which give substantial benefits in later years

Example

Planning team of a construction company is considering two design options for a community market building. One involves the use of timber, the other uses structural steel. Using following data, choose the better option on the basis of Pay Back Period?

(Assume discount rate is 10%)

	Timber	Steel
Initial Cost	**$80000**	**$120000**
Annual Operation and Maintenance Cost	**$12000**	**$8000**
Annual Benefit	**$25000**	**$20000**

Solution

Internal Rate of Return (IRR)

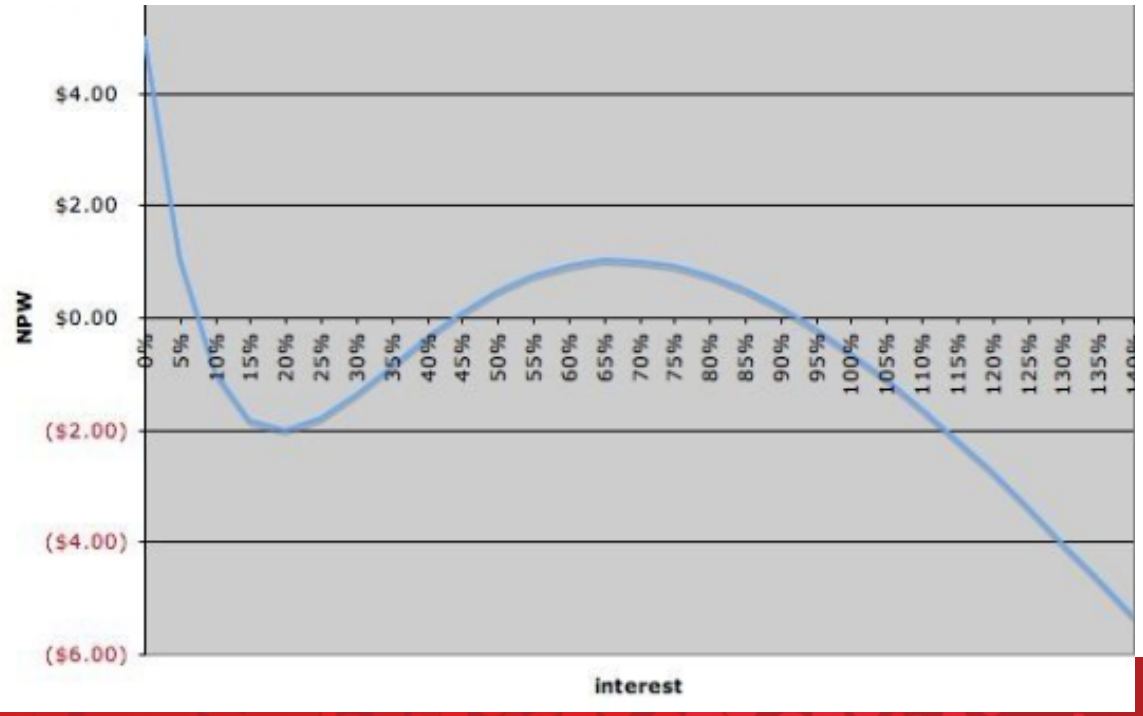
- **The IRR is the discount rate at which NPV = 0. See below:**

$$NPV = -I_0 + (B\text{-}C)PVF_{i,n} + L_n/(1+i)^n$$

***When NPV=0, i becomes the IRR*

- When the IRR exceeds a predetermined rate then the project is considered economically desirable (our common sense on Interest Rate is that **the bigger the interest rate the better the return on investment).**
- Compared with NPV, IRR can be misleading, especially when the difference of I_0 in different projects is large – *Refer to Pg35 where "the bigger IRR the smaller NPV".*
- NPV would be more reliable.

- If a project has multiple cash inflows and outflows in the future, there will be multiple IRRs. For example, an investment option I_0=100, 1st year cash inflow =200, 3rd year cash outflow = 100, I = 10%; given NPV = NPV_1 + NPV_2 + NPV_3 = -100 + 200/(1+IRR) +(-100)/$(1+IRR)^2$ = 0, this function becomes a quadratic function (if more years, then cubic function, quartic function or higher degrees) (see below), IRR will have 3 values.
- That is why NPV is more reliable!!



Example

A manufacturing company has decided to evaluate the construction of the proposed new production line. If the IRR is less than 10%, company may not continue with the proposed project. Based on the information below, determine if the project should be allowed to proceed?

Land Purchase	**$2,500,000**
Construction	**$7,500,000**
Operational Costs per annum	**$250,000**
Net benefits per annum	**$1,000,000**
Service Life	**20 years**
Residual Value	**$2,000,000**

Solution