

CH2404 Process Economics

Unit – III

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Sensitivity Analysis

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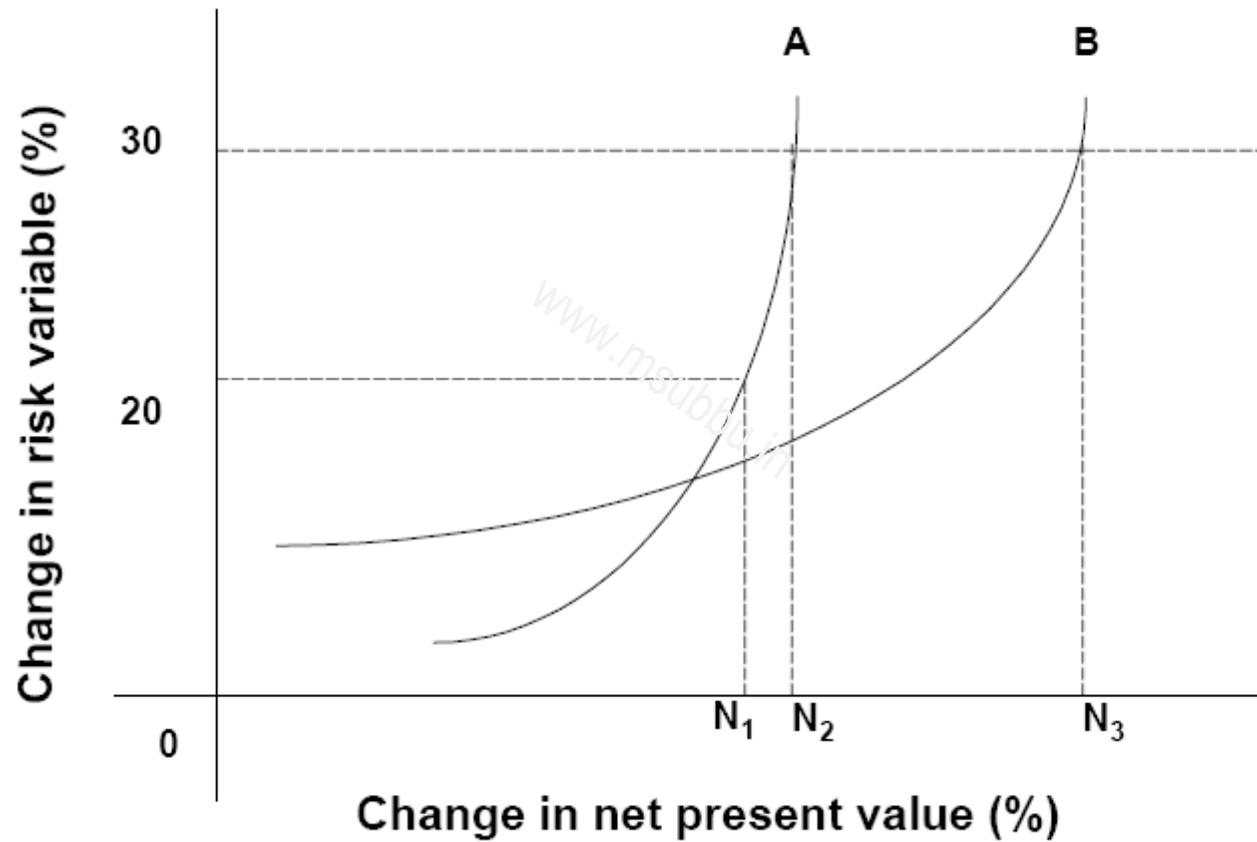
Introduction

- ***Sensitivity analysis*** is concerned with the extent of change in a cost analysis resulting from variations in one or more elements of a cost study. It shows the influence of possible changes of significant variables upon profitability.
- From this analysis, those variables that have a critical effect are identified. Especially important are those variables that might alter a decision when only small changes occur.
- The ordinary practice is to make a number of computations of profitability, varying each significant cost element over the most likely range of values. A visual aid, e.g., a graph, depicts the most sensitive variables in a cost study.

Single Factor Sensitivity Analysis

Single factor sensitivity analysis involves holding all cost factors except one constant while varying the remaining cost factor through a range of percentage changes. The effect of cost factor changes on the measure of worth is observed, to determine whether the alternative remains attractive under the evaluated changes and to determine which cost factor effects the measure of worth the most.

Figure 7.6.1: Sensitivity of net present value to a benefit variable

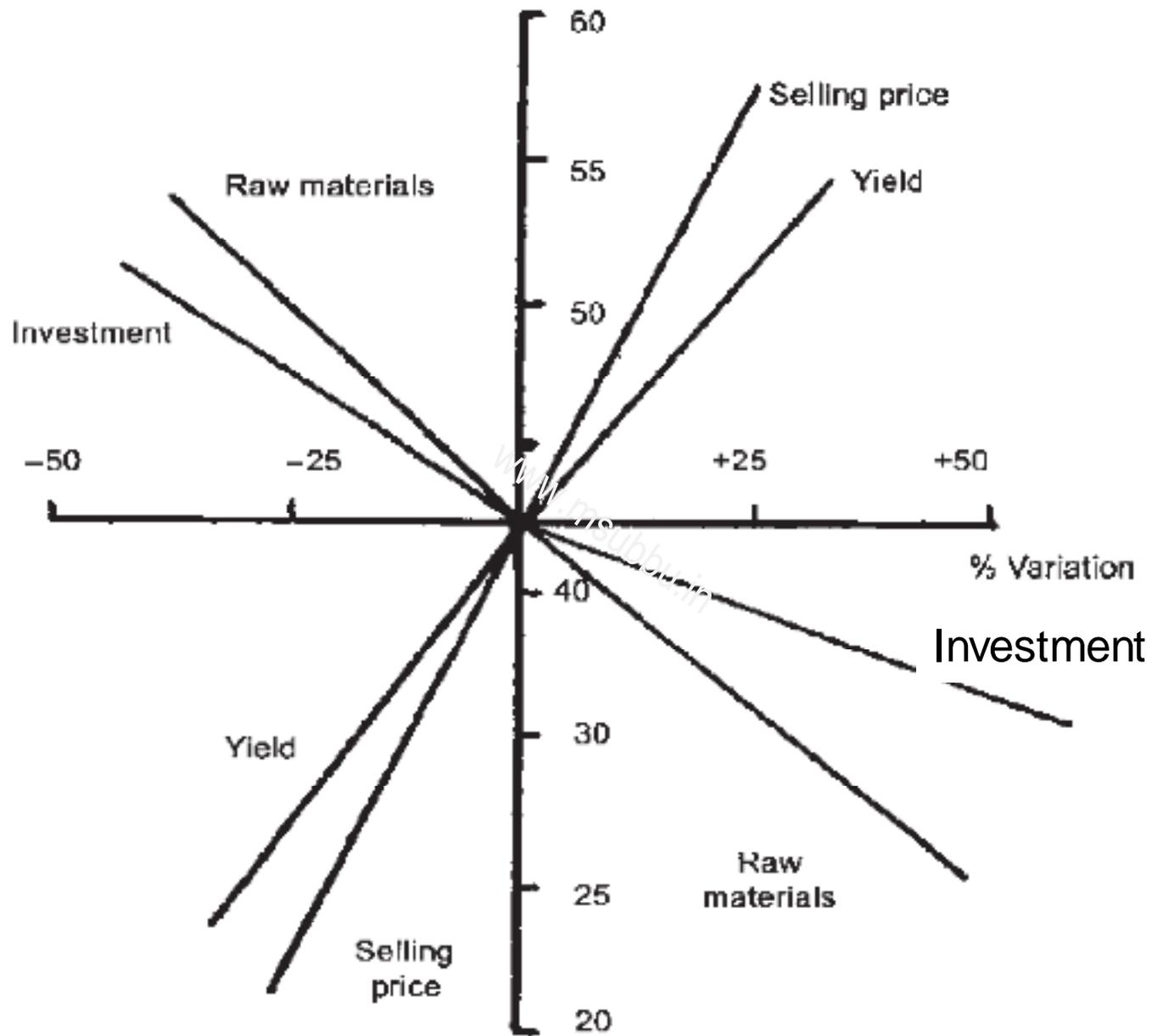


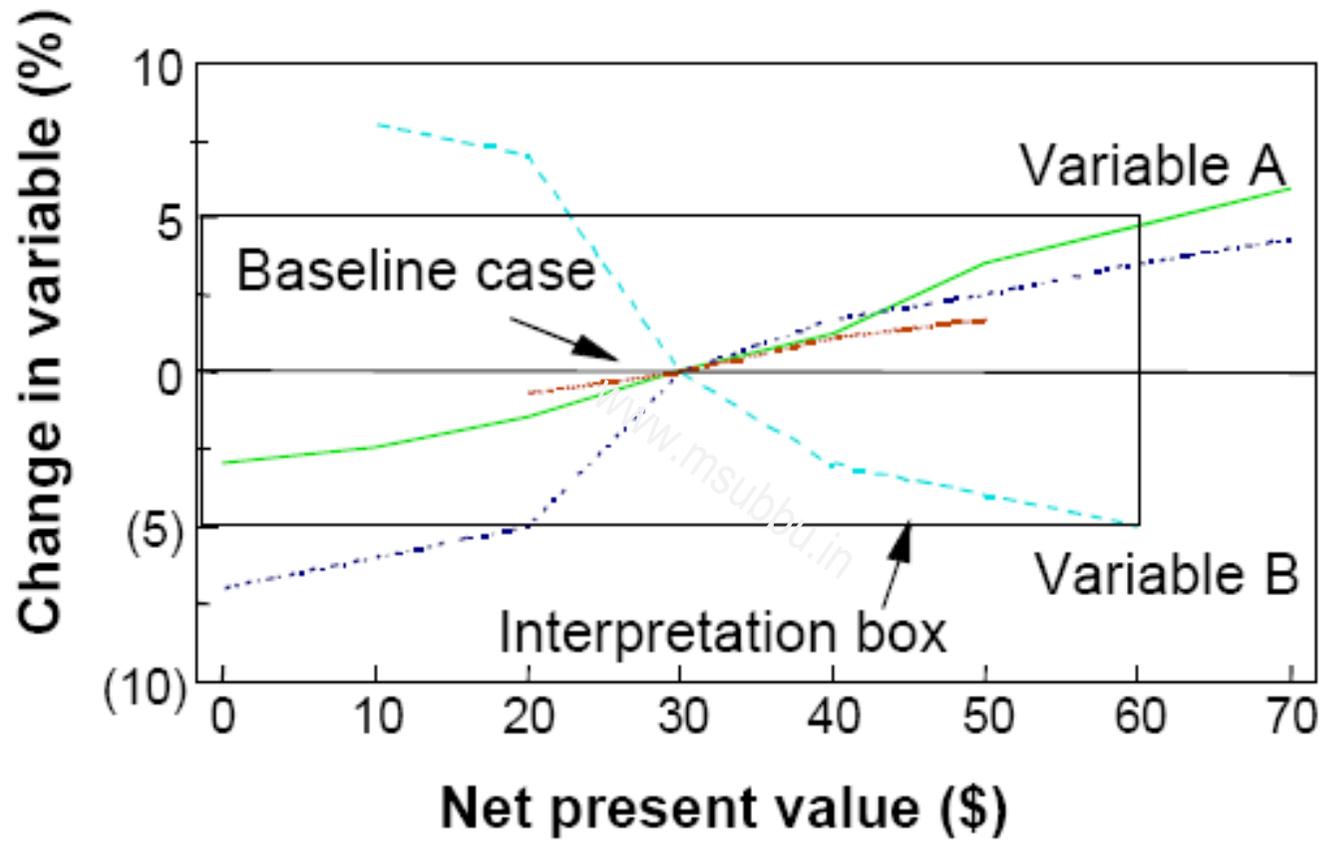
An example of gross sensitivity of the NPV to input variables

Variable	Change in NPV in response to a 10% change in the variable
Insurance costs	15%
Operating costs	21%
Machine price	7%
Usage rate	19%

The Strauss Plot

- Richard Strauss developed a method for plotting the results of a sensitivity analysis in which the ordinate is the measure of profitability and the abscissa is the change in a variable greater or less than the base case.
- Where the abscissa crosses the ordinate is the base case value of the return, net present worth, net annual worth, etc. This plot is also known as the "spider" plot due to its shape.





Example Problem

Conduct a sensitivity analysis for the cash flow data as shown below. The sensitivity analysis should explore the sensitivity of present worth to changes in annual revenue over the range -10% to +10%. Interest rate applicable is 8%

Initial investment = \$1000

Cash flow = \$600 per year at the end of each year
project life = 4 years.

$$\text{Net present worth of the project} = -1000 + 600/(1+0.08) + 600/(1+0.08)^2 + 600/(1+0.08)^3 + 600/(1+0.08)^4 = -1000 + 555.6 + 514.4 + 476.3 + 441.0 = \$\mathbf{987.3}$$

The sensitivity of present worth to changes in annual revenue over the range – 10% to +10%:

- Annual revenue for -10% change = $600 - 0.1 \times 600 = \$540$
- Annual revenue for +10% change = $600 + 0.1 \times 600 = \$660$

Present worth for -10% change in annual revenue:

$$= -1000 + 540/(1+0.08) + 540/(1+0.08)^2 + 540/(1+0.08)^3 + 540/(1+0.08)^4 = -1000 + 500 + 463.0 + 428.7 + 396.9 = \mathbf{\$788.6}$$

Present worth for +10% change in annual revenue:

$$= -1000 + 600/(1+0.08) + 660/(1+0.08)^2 + 660/(1+0.08)^3 + 660/(1+0.08)^4 = -1000 + 611.1 + 565.8 + 523.9 + 485.1 = \mathbf{\$1185.9}$$

The sensitivity of PW to changes in annual revenue over the range – 10% to +10% is +\$397.3 (from \$788.6 to \$1185.9).

The sensitivity of present worth to changes in initial cost over the range - 10% to +10%.

- Annual revenue for -10% change = $100 - 0.1 \times 1000 = \900
- Initial cost for +10% change = $1000 + 0.1 \times 1000 = \1100

Present worth for -10% change in annual revenue:

$$= -900 + 600/(1+0.08) + 600/(1+0.08)^2 + 600/(1+0.08)^3 + 600/(1+0.08)^4 = -1000 + 555.6 + 514.4 + 476.3 + 441.0 = \$\mathbf{1087.3}$$

Present worth for +10% change in annual revenue:

$$= -1100 + 600/(1+0.08) + 600/(1+0.08)^2 + 600/(1+0.08)^3 + 600/(1+0.08)^4 = -1000 + 555.6 + 514.4 + 476.3 + 441.0 = \$\mathbf{887.3}$$

The sensitivity of PW to changes in initial cost over the range - 10% to +10% is $-\$200$ (from $\$1087.3$ to $\$887.3$).



The sensitivity of present worth to changes in interest rate over the range – 10% to +10%.

- Interest rate for -10% change = $0.08 - 0.1 \times 0.08 = 0.072$
- Interest rate for +10% change = $0.08 + 0.1 \times 0.08 = 0.088$

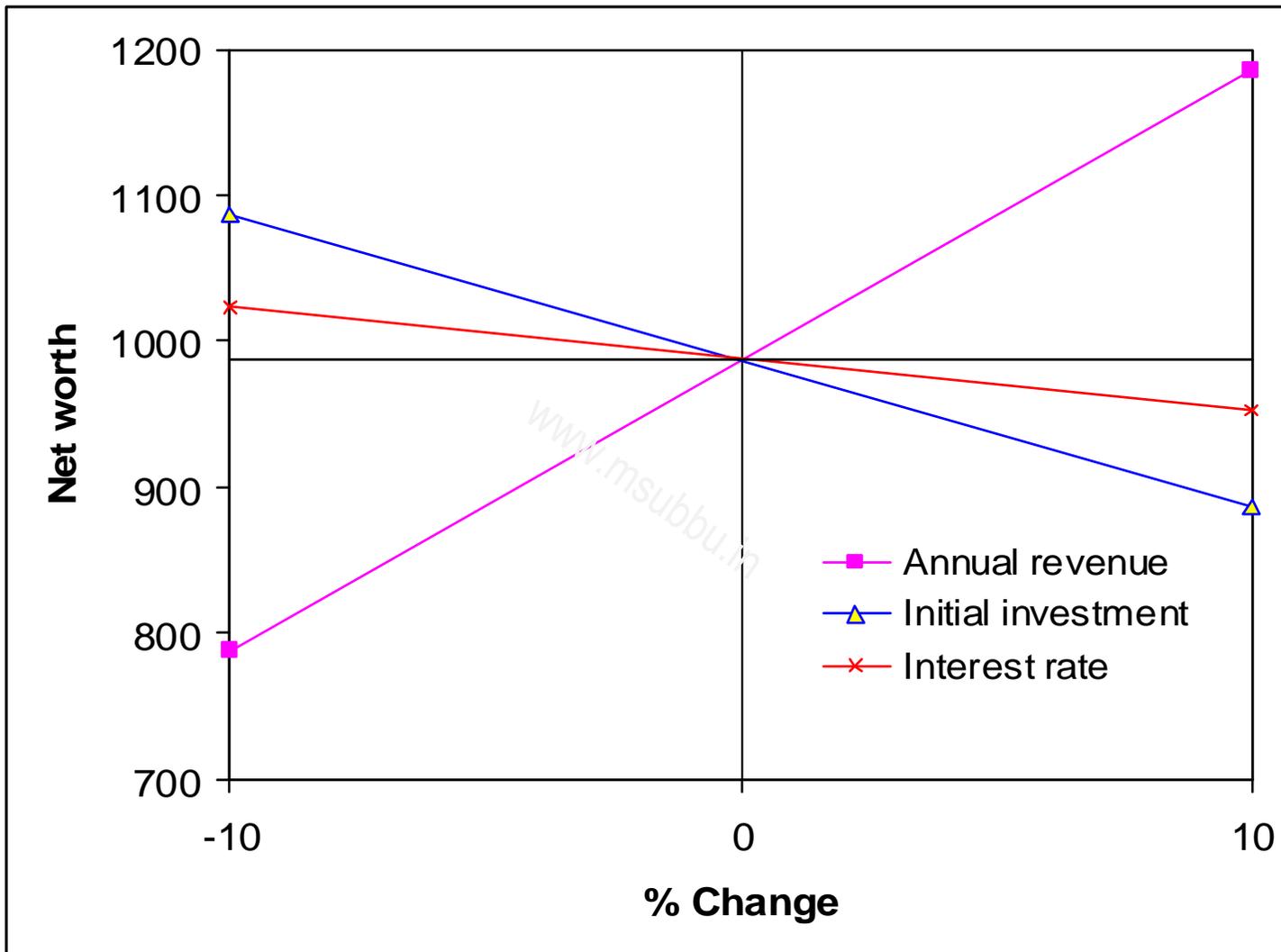
Present worth for -10% change in interest rate:

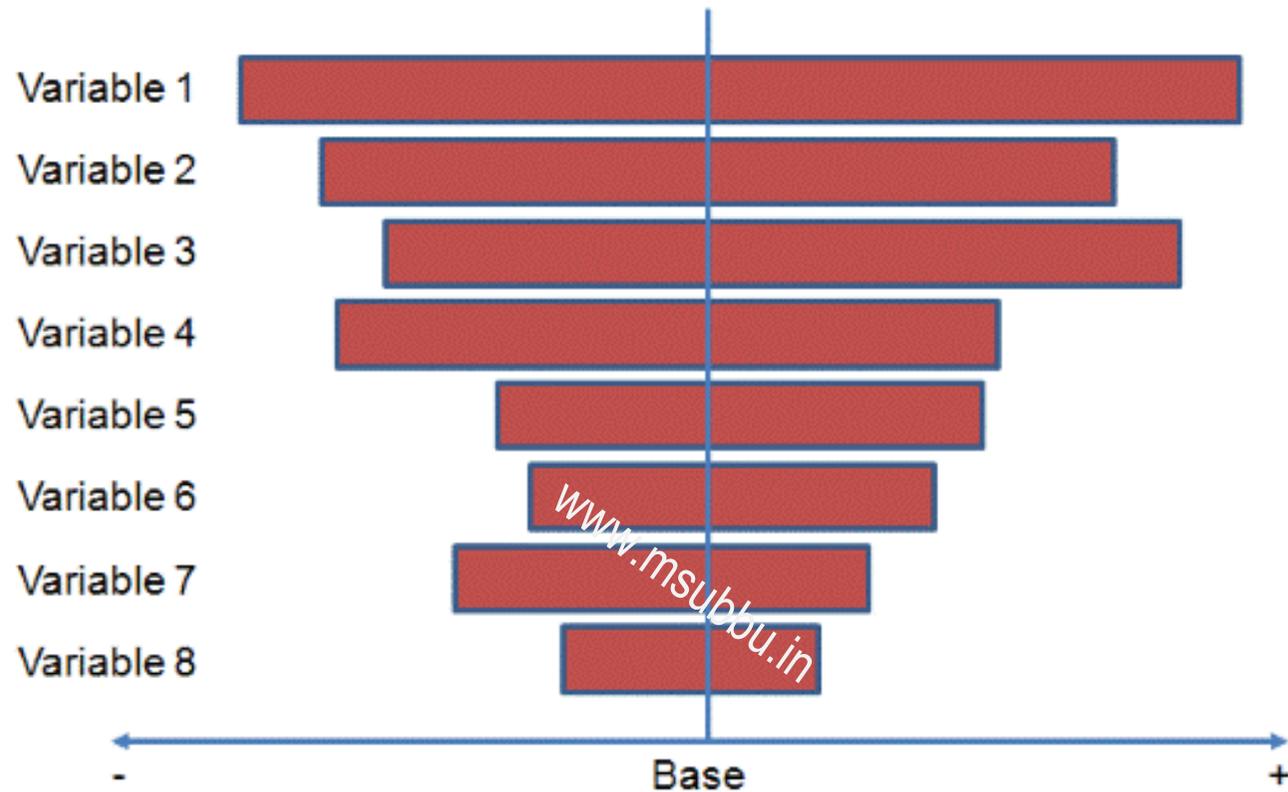
$$= -1000 + 600/(1+0.072) + 600/(1+0.072)^2 + 600/(1+0.072)^3 + 600/(1+0.072)^4 = -1000 + 559.7 + 522.1 + 487.0 + 454.3 = \mathbf{\$1023.1}$$

Present worth for +10% change in interest rate:

$$= -1000 + 600/(1+0.088) + 600/(1+0.088)^2 + 600/(1+0.088)^3 + 600/(1+0.088)^4 = -1000 + 551.5 + 506.9 + 465.9 + 428.2 = \mathbf{\$952.5}$$

The sensitivity of PW to changes in initial cost over the range – 10% to +10% is $-\$70.6$ (from $\$1023.1$ to $\$952.5$).



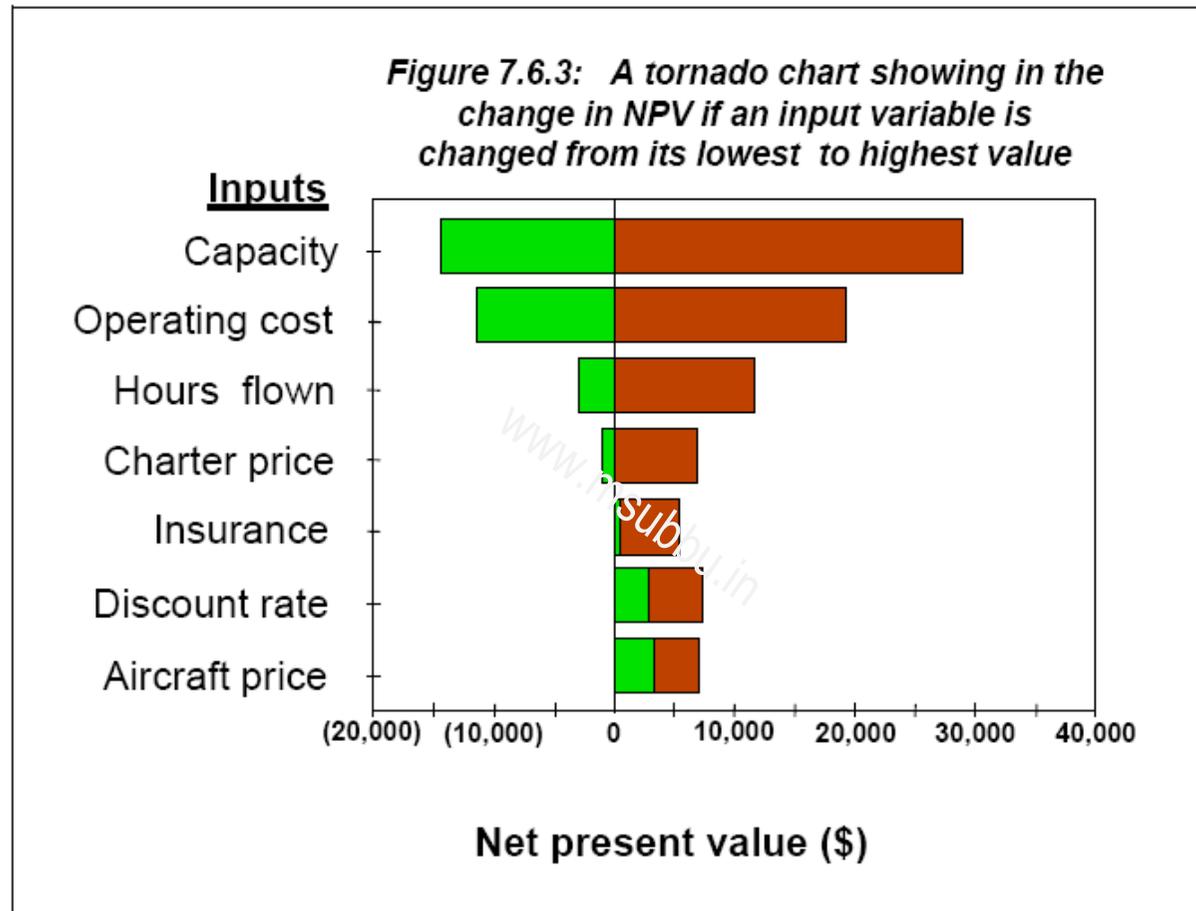


Tornado charts are bar charts that reflect how much impact varying an input has on a particular output, providing both a ranking and a measure of magnitude of the impact, sometimes given in absolute terms and sometimes in percentage terms.

As you can see above, a base line is drawn for a selected output (the vertical line in this graphic) which corresponds to all inputs set at their 'base' settings, i.e., with no sensitivities incorporated. The variables are ranked so that the input that causes the most variation in the chosen output is shown first, the assumption that causes the second greatest movement is ranked second, and so on.

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Tornado chart



The length of each bar is a measure how much the variable can influence the NPV. The shading within the bar changes at the NPV, which corresponds, to the deterministic value of the variable.

Tornado charts give us another quick picture of relative sensitivity. Each bar in the tornado chart shows the range of the NPV when each variable is allowed to change (one at a time) from its highest to its lowest value. You can see from a quick glance at the shape of Figure 7.6.3, (which has variables arranged in descending order of influence from top to bottom), why it is called a tornado chart.

Two-variable sensitivity analysis

Table 7.5.1: Influence of combinations of two input variables on net present value

Discount Rate	Usage rate				
	500	475	450	425	400
0.10	\$16,814	\$12,987	\$9,161	\$5,335	\$1,509
0.11	\$14,923	\$11,200	\$7,476	\$3,753	\$29
0.12	\$13,082	\$9,459	\$5,835	\$2,212	<i>(\$1,411)</i>
0.13	\$11,288	\$7,763	\$4,238	\$713	<i>(\$2,812)</i>
0.14	\$9,541	\$6,112	\$2,683	<i>(\$746)</i>	<i>(\$4,175)</i>
0.15	\$7,840	\$4,505	\$1,170	<i>(\$2,165)</i>	<i>(\$5,500)</i>
0.16	\$6,185	\$2,941	<i>(\$302)</i>	<i>(\$3,545)</i>	<i>(\$6,788)</i>
0.17	\$4,573	\$1,420	<i>(\$1,734)</i>	<i>(\$4,887)</i>	<i>(\$8,040)</i>
0.18	\$3,004	<i>(\$61)</i>	<i>(\$3,127)</i>	<i>(\$6,192)</i>	<i>(\$9,257)</i>
0.19	\$1,478	<i>(\$1,501)</i>	<i>(\$4,481)</i>	<i>(\$7,460)</i>	<i>(\$10,440)</i>

Benefit-Cost Analysis Guide

