4

10 Sensitivity testing

This section outlines the calculations used in sensitivity testing presented in the 'road case report' within CBA6. For further information on the 'road case report' see Section 4.6 of the *User Guide*. For further detail on the assumptions of sensitivity analysis, see Section 1.8.3 of the *Theoretical Guide*.

The standard sensitivity analysis in CBA6 recalculates BCR, NPV and FYRR subject to the following changes in inputs:

- capital costs ± 20%
- TTC ± 40%
- VOC ± 20%
- accident costs ±20%
- exclude private travel time costs.

Sensitivity testing shown in these sections is based on the following 'best estimate' assumptions:

- cost = $50 million
- capital costs = $40 million
- operating costs = $10 million
- benefits = $70 million
- TTC savings = $40 million
- private TTC savings = $1 million
- VOC savings = $20 million
- accident savings = $10 million
- first year benefits = $2 million
- discount rate = 4%.

Under these assumptions of benefits and costs the BCR is 1.4, the NPV is $20 million and the FYRR is 4%.

10.1 Net present value

There are a number of key project inputs that can influence the NPV when they are subjected to some variability. These inputs have been described in Section 10.1.1.

10.1.1 Changes in capital cost

Equation 87: Changes in capital cost (NPV)

$$NPV = \sum_{i=1}^{n} \frac{B_i - C_i \times (1 \pm \Delta B)}{(1+r)^i}$$

Where:

- NPV = net present value
- B_i = total discounted benefits
- C_i = total discounted costs
- ΔB = the percentage change in capital cost determined in the sensitivity analysis

Example: Changes in capital cost (NPV)

When the capital cost of a project, with discounted net benefits of $70 million and discounted net costs of $50 million, increases by 20%, the NPV is calculated as follows:

$$NPV = 70 - (40 \times 1.2) - 10$$

$$NPV = 70 - 58$$

$$NPV = \$12$$

Positive NPV indicates that despite the capital cost increase of 20% the project is still viable.

10.1.2 Changes in road user cost savings

The impact that changes in TTC, VOC and accident cost savings have on the NPV is shown by Equation 88.

Equation 88: Changes in benefits (NPV)

$$NPV = \sum_{i=1}^{n} \frac{(B_{ru} \times (1 \pm \Delta A) + B_{oi} - C_i}{(1+r)^i}$$

Where:

- B_{ru} = road user cost savings (TTC, VOC or Acc)
- ΔA = the percentage change in B_{ru} determined in the sensitivity analysis
- B_{oi} = benefits other than B_{ru}

Example: Changes in benefits (NPV)

If TTC increase by 40%, all other benefits and costs remain unchanged at $20 million for VOC benefits, $10 million for accident cost savings and $50 million for costs. The resulting NPV is:

$$NPV = (40 * 1.40) + (20 + 10) - 50$$

$$NPV = \$36\ million$$

The NPV has increased from $20 million under the normal scenario to $36 million when TTC savings are increased by 40%. This is an increase in NPV of 80% compared to the best estimate. In this example, the NPV is very sensitive to changes in TTC savings.

10.1.3 Excluding private travel time costs

The impact that removal of private TTC savings has on NPV is calculated by Equation 89.

Equation 89: Excluding private TTC (NPV)

$$NPV = \sum_{i=1}^{n} \frac{(B_i - PTTC_i - C_i)}{(1+r)^i}$$

Where:

- $PTTC_i$ = private travel time costs

Example: Excluding private TTC (NPV)

If a project has discounted net benefits of $70 million, the private TTC component of that net benefit is $1 million, and the net cost of the project is $50 million, then the NPV excluding private travel time is:

$$NPV = 70 - 1 - 50$$

$$NPV = \$19\ million$$

Given the small amount of private TTC savings as a proportion of total benefits in this case, the change in NPV is not very sensitive to percentage changes in private TTC savings.

10.2 Benefit-cost ratio

The derivation of BCR throughout the sensitivity analysis is shown in Sections 10.2.1 to 10.2.3.

10.2.1 Changes in capital cost

The impact of a change in capital cost on the BCR is given by Equation 90.

Equation 90: Changes in capital cost (BCR)

$$BCR = \sum_{i=1}^{n} \frac{B_i}{(1+r)^i} \Bigg/ \sum_{i=1}^{n} \frac{K_i \times (1 \pm \Delta B) + OC_i}{(1+r)^i}$$

Where:

- K_i = capital costs
- OC_i = net operating costs

Example: Changes in capital cost (BCR)

With a 20% increase in capital cost with discounted net benefits of $70 million, discounted net capital cost of $40 million, and a discounted net operating cost of $10 million, the BCR is:

$$BCR = 70/(40 \times 1.20) + 10$$

$$BCR = \frac{70}{58}$$

$$BCR = 1.21$$

In this example, the BCR has decreased from 1.4 to 1.21 demonstrating that the project is not economically viable if capital cost was to increase by 20%.

Note: The BCR must be greater than 1 to justify the investment.

10.2.2 Changes in road user cost savings

The impact of a change in road user cost savings on the BCR is given by Equation 91.

Equation 91: Changes in road user cost savings (BCR)

$$BCR = \sum_{i=1}^{n} \frac{B_{ru} \times (1 \pm \Delta A) + B_{oi}}{(1+r)^i} \Bigg/ \sum_{i=1}^{n} \frac{K_i + OC_i}{(1+r)^i}$$

Where:

- B_{ru} = road user cost savings (TTC, VOC or Acc)
- B_{oi} = benefits other than B_{ru}
- ΔA = percentage change in B_{ru} determined in the sensitivity analysis
- K_i = capital costs

- OC_i = operating costs

Example: Changes in road user cost savings (BCR)

Where TTC savings increase by 40%, discounted net investment costs are $50 million, VOC benefits are $20 million and crash costs are $10 million, the BCR is:

$$BCR = \big((40 \times 1.4) + (20 + 10)\big)/50$$

$$BCR = 1.72$$

The BCR of the project has changed from 1.4 to 1.72, an increase of 22% from the 'best estimate' as a result of a 40% increase in TTC savings.

10.2.3 Excluding private travel time costs

The removal of private TTC on the BCR is given by Equation 91.

Equation 92: Excluding private travel time costs (BCR)

$$BCR = \sum_{i=1}^{n} \frac{B_i - PTTC_i}{(1+r)^i} \Bigg/ \sum_{i=1}^{n} \frac{K_i + OC_i}{(1+r)^i}$$

Where:

- $PTTC_i$ = private travel time costs

Example: Excluding private travel time costs (BCR)

A project has discounted net benefits of $70 million, the private TTC component of that net benefit is $1 million, and the net cost of the project is $50 million. The BCR excluding private TTC is:

$$BCR = (70 - 1)/50$$

$$BCR = 1.38$$

The BCR is reduced by 0.02 as a result of the escalating private TTC.

Note: The change in BCR is relatively small given the low proportion of private TTC savings.

10.3 First year rate of return

The derivation of FYRR sensitivity analysis is calculated through Sections 10.3.1 to 10.3.3.

10.3.1 Changes in capital cost

A change in capital cost on FYRR is shown by Equation 93.

Equation 93: Changes in capital cost (FYRR)

$$FYRR = \frac{B_{t_f}}{(1+r)^{t_f}} \Bigg/ \sum_{t=1}^{t_{f-1}} \frac{C_i \times (1 \pm \Delta B)}{(1+r)^t}$$

Where:

- B_{tf} = total first year benefits
- ΔB = the percentage change in capital cost determined in the sensitivity analysis

Example: Changes in capital cost (FYRR)

A 20% increase in the capital costs of a project with discounted first year benefits of $2 million, discounted net capital cost of $40 million, and a discounted net operating cost of $10 million, produces an FYRR of:

$$FYRR = 2/(40 \times 1.2) + 10$$

$$FYRR = \frac{2}{58}$$

$$FYRR = 3.45\%$$

The 20% increase in capital cost lowers the FYRR from 4% to 3.45%.

10.3.2 Changes in road user cost savings

The impact that a change in road user cost savings has on FYRR is given by Equation 94.

Equation 94: Changes in benefits (FYRR)

$$FYRR = \frac{B_{RU_f} \times (1 \pm \Delta A) + B_{t0_f}}{(1+r)^{t_f}} \Bigg/ \sum_{t=1}^{t_{f-1}} \frac{C_i}{(1+r)^t}$$

Where:

- B_{ruf} = first year of road user cost savings
- ΔA = the percentage change in B_{ruf} determined in the sensitivity analysis
- B_{t0f} = benefits other than B_{ruf}

If first year TTC benefits increase by 40%, the FYRR becomes:

$$FYRR = (1 * 1.40) + (0.5 + 0.5)/50$$

$FYRR = 4.8\%$

A 40% increase in road user cost savings in the first year increases the FYRR from 4% to 4.8%.

10.3.3 Excluding private travel time costs

The impact that removal of private TTC has on the FYRR is given by Equation 95.

Equation 95: Excluding private travel time costs (FYRR)

$$FYRR = \frac{B_{t_f} - PTTC_{t_f}}{(1+r)^{t_f}} \Bigg/ \sum_{t=1}^{t_{f-1}} \frac{C_i}{(1+r)^t}$$

Where:

$PTTC_{tf}$ = first year private TTC savings

Example: Excluding private travel time costs (FYRR)

A given project has discounted first year net benefits of $2 million, a private TTC component of that net benefit of $0.1 million, and a net cost of $50 million. If private TTC savings are excluded the FYRR is:

$$FYRR = (2 - 0.1)/50$$

$$FYRR = 3.8\%$$

The removal of private TTC savings in the first year decreases the FYRR from 4% to 3.8%; this is below the cut off level at 4%.