11 Effects of intermediate outputs

This section outlines the key relationships between intermediate outputs such as road roughness and speed, and the outputs of VOC and TTC.

Table 43: Input and output relationships

Input	Intermediary output	Output
Speed/roughness	Fuel	VOC
	Tyres	VOC
	Oil	VOC
	Interest and depreciation	VOC
	Repairs and maintenance	VOC
	Travel time	TTC

This analysis will examine the effects of changes in the intermediate outputs such as speed and roughness on the final outputs.

11.1 Vehicle operating costs

Table 44 shows the effects of a change in operating speed and current roughness on the outputs. This comparison differs with vehicle types, however it provides a general guide as to trends of output change, holding all other inputs constant.

Importantly, this example compares changes to a 'base case' as described in the examples throughout Section 4 i.e. a single B-Double travelling at 64.49 km/h on a curvy flat road with a VCR of 0.049.

As illustrated by Table 44, changes made in the intermediate outputs of speed and roughness have a significant effect on VOC in CBA6. When these costs are combined over multiple vehicle types and lengthy sections of motorway, their impacts become large in monetary terms.

Table 44: Sensitivity testing of VOC components in respect to changes in intermediate outputs (B-doubles)

Outputs (c/km)	Base case	Intermediate output change			
		Change in speed		Change in roughness	
	64.49km/h/ 120NRM	40km/h	85km/h	30NRM	200NRM
Fuel	95.72	113.04	95.42	81.26	99.42
Oil	1.71	1.60	1.80	1.71	1.71
Tyres	49.58	47.00	52.60	49.58	49.58
Repairs and maintenance	24.93	24.93	24.93	20.60	29.87
Interest and depreciation	54.42	58.04	52.99	54.42	54.42
Total VOC unit cost	226.36	244.61	227.74	207.57	235.00

There are two important points to be noted from this comparison.

1 Table 44 illustrates trends in the calculation of fuel costs with regard to changes in roughness and speed. Fuel consumption and speed do not have a linear relationship. Moreover, fuel consumption reaches an efficiency frontier, when a marginal increase in speed produces an increase in fuel consumption. This trend is illustrated by Figure 12.

2 Fuel costs are sensitive to changes in road roughness. This point is based on the fuel consumption roughness adjustment (Equation 21) which becomes a proportionately larger adjustment as roughness increases (all other things being equal). Oil costs however, are only affected by speed and not by roughness. This is a result of Equation 25, which is derived solely on changes in speed. Similarly, the results in Table 44 show that interest and depreciation and tyre costs are based solely on changes in speed. This is a result of the net interest and depreciation equation (Equation 37), which includes operating speed to derive the final cost. However, changes in operating speed in the interest and depreciation calculation have a relatively small influence on the final unit VOC. The impact of changes in speed on tyre costs are greater and are a result of the roughness adjustment and the basic tyre wear equation (Equation 27).

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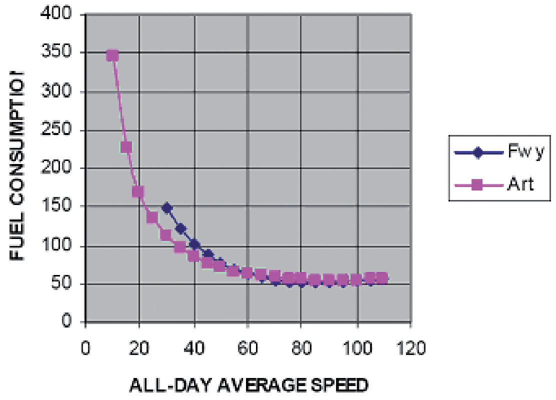
It is important to note that changes in roughness do not affect tyre wear or tyre costs. The inclusion of a 'roughness adjustment' based on speed is the result of the assumption that lower operating speeds should reflect rough surface conditions.

Figure 12: Fuel consumption (B-Double)



11.2 Travel time

The impact of speed on travel time is intuitive. The following calculation shows TTC for the road user.

Equation 96: Trip time

$$TripTime(VT) = \frac{SecLength}{OS(VT)}$$

As calculated in Section 5, trip time (hours) is then applied to vehicle cost per hour, which is reflective of the driver's time (for private vehicles), business costs and freight carried (commercial vehicles where appropriate).

Changes in road roughness have no effect on TTC, unless the vehicle's operating speed is also affected by the change in roughness. TTC are based purely on changes in operating speed.

Example: Trip time

A section length of a rural road remains constant at 5 km and a B-Double is travelling at 85 km/h. The time it takes for the B-Double to complete its journey is:

$$TripTime(VT) = \frac{5}{85} = 0.059hrs$$

Applying this trip time to the hourly time unit rate for a B-Double ($48.40 from Table 23) yields TTC of $2.86. Assuming that the B-Double travels the same section length at a speed of 45 km/h, TTC increase to $5.38. When operating speed decreases by 53%, TTC increase by 88%. There is an inverse relationship between the change in speed and the change in TTC.

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