WORKING PAPER

The Congestion Question

Could road pricing improve Auckland's traffic?

Workstream 3

Cost benefit analysis

January 2019

Working draft vB

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1 Cost-benefit analysis model overview

The cost-benefit analysis (CBA) model was built to assist in the evaluation of the five shortlisted congestion pricing options. The model calculates a dollar net present value (NPV) of the transport user benefits that arise from each option. The benefits assessed in the model are limited to:

- reduced travel time
- improved travel reliability
- lower vehicle operating costs
- environmental and health benefits from lower emissions.

The model does not attempt to quantify the full spectrum of economic benefits that would arise from reductions in network congestion such as increased economic productivity.

Note that revenues are excluded from the analysis as they are considered to be a transfer. In practical terms, as outlined in the revenue working paper, they would be used to offset operational costs in the first instance.

2 Model inputs

A range of inputs for the CBA model were used, listed below:

- Auckland Macro Strategic Model (MSM) outputs from the Auckland Forecasting Centre:
  - Total network statistics for the 2-hour morning peak period in the 2028 modelled year:
    - Travel time (split by trip purpose and by car-person/public transport user)
    - Travel time delay compared to efficient conditions in the 2 hour morning peak period
    - Total vehicle-kilometres travelled (vkt)
    - Average network speed
  - Daily emission totals (CO_2, NO_x and PM_{10})
  - Forecast population growth between 2016, 2028, 2038 and 2048 to use as a proxy for growth rates in benefits over time
- NZ Transport Agency's Economic Evaluation Manual (EEM, July 2018):
  - Values of time
  - Vehicle operating costs
  - Valuation of emissions
  - Update factors
- Costs (capital and operating) from D'Artagnan Consulting
- All costs and benefits are stated in 2018 dollars.

3 Assumptions

When developing the model, five overarching assumptions were included to calculate the benefits of each option. These assumptions are related to:

1. **Implementation period**

   The model assumes that implementation occurs over a two year period, with initial capital expenditure (capex) being split equally across the two years. After this period, the benefits start to be generated, and operating expenditure (opex) is incurred.

2. **Growth factor(s)**

   The growth factor is the rate at which benefits are assumed to grow during the evaluation period. As the modelling was only undertaken for a single future year (2028), growth from 2016 to 2028 and from 2028 into the future has been estimated using population totals from the MSM as a proxy.

3. **Periodic operating expenditure (capital renewal)**

   The periodic opex refers to the periodic reinvestment in replacement or renewal of the roadside infrastructure. This opex is assumed to be 30% of the initial capex for each option and is incurred every seven years (as advised by D'Artagnan).

4. **Discount rate**

   Benefits are discounted at 6%, which is the discount rate used in the EEM.

5. **Annualisation**

   Most of the MSM outputs are for the 2-hour morning peak period and these need to be converted to annual totals. The assumption is that congestion pricing would also apply in the afternoon peak period and is expected to only apply on weekdays. Therefore, an annualisation factor of 490 is applied to the benefits that are calculated from the morning peak outputs. This allows for two peak periods per day (assuming the morning and afternoon periods are approximately equal) and 245 weekdays per year (as per the EEM recommendation).

4 Benefit calculations

The benefits generated by each option are calculated for six categories:

- Travel time
- Travel time reliability
- Reduction in congested travel time
- Vehicle operating costs
- CO_2 emissions
- Other emissions.

4.1 Travel time

Travel time benefits are calculated by comparing the network travel time (by mode (car-person or public transport user) and by trip purpose) in the base case with the network travel time in each option. The MSM outputs are used to determine this difference and then it is multiplied by the value of time from the EEM (for the corresponding trip purpose (EEM Section A4.2)) to determine the travel time benefits generated by each option.

4.2 Travel time reliability

By reducing congestion, travel times will become more reliable (less variability) and there is an economic benefit associated with that as road users can be more confident that their journey times will fall into a smaller range. As the MSM is not a simulation model, and outputs are average values, they are not suitable for providing an estimate of reliability improvements. For the CBA model, we have used the Swedish assessment of their congestion pricing scheme to estimate the potential reliability improvements. The Swedish assessment had much more detailed information available and found that reliability improvements were equivalent to 16% of travel time savings and we have adopted this factor in our assessment.

4.3 Reduction in congested travel time

There is an incremental benefit for reducing travel time in congested conditions (denoted in the EEM as "CRV"), over and above the travel time savings outlined above. The MSM calculates the network travel time compared to efficient conditions, which we have used as a proxy for the amount of travel in congested conditions to which the CRV applies. This is reported across the network but is not split by trip purpose. We apportioned this total to each trip purpose using the overall network travel times that are split by trip purpose. These hours are then multiplied by the CRV value (EEM Section A4.2) to calculate the benefit in each option compared to the base case.

For public transport users, no CRV is applied, as we assume that the vast majority of public transport services travel along uncongested routes by 2028 (eg rail lines, bus lanes).

4.4 Vehicle operating costs

Vehicle operating costs are the average costs that road users incur in relation to the operation and maintenance of their vehicle. Across all options, these are assumed to be 28.1 cents per kilometre travelled using Table A5.7 in the EEM, based on an average 0% gradient across the network and an average network speed of 35km/h (from the MSM outputs). Total vehicle operating costs for each option are obtained by multiplying total vkt by the cost per kilometre. The benefit associated with each option is then the difference when compared to the total vehicle operating costs in the base case.

4.5 CO_2 emissions

Less congestion, and reduced travel times will reduce the amount of CO_2 that is emitted. This reduction is valued in the EEM as $65.68/tonne of CO_2 removed. The MSM provides total daily CO_2 emissions across the network. The difference between emissions in the base case and in the option is multiplied by the $65.68/tonne to calculate the benefit generated by the option.

4.6 Other emissions

Other emissions include vehicle emissions that occur in much lower quantities than CO2, but impose a more detrimental impact on the environment and therefore have higher costs per tonne emitted. These emissions include NOx and PM10. These are valued at $16,347 and $460,012 per tonne respectively. The benefit associated with their reduction is calculated in the same way as described above for CO2, as the MSM provides a total daily emission for each.

5 Costs

The costs associated with each option (provided by D'Artagnan) are split into three categories:

1. **Initial capital expenditure (capex)**

   These costs include all initial expenditure on infrastructure and implementation of the option.

2. **Annual operating expenditure (opex)**

   The annual opex refers to the ongoing costs that are required to keep the scheme running, such as system operations and maintenance, servicing (for both customers and equipment) etc. These are incurred each year once the scheme is operational.

3. **Periodic renewal costs (periodic opex)**

   The periodic opex refers to the expense that is occurred at certain intervals throughout the scheme's life to renew the necessary infrastructure. D'Artagnan have advised that this would be expected to occur every seven years and be approximately 30% of initial capital costs.

Note that the annual and periodic opex remain constant across the scheme's lifespan. They are not escalated or linked to the growth rates that are applied to the benefits.

The estimated costs associated with each of the shortlisted options are summarised in Table 1 below.

TABLE 1: CAPEX AND OPEX FOR EACH SHORTLIST OPTION ($M)

	City Centre Cordon	Isthmus Area	Strategic Corridors	Combination	Regional Network
Capex	46.0	198.0	185.0	207.0	579.0
Annual Opex	10.0	57.0	84.0	87.0	267.0
Periodic Opex	13.8	59.4	55.5	62.1	173.7

Source: D'Artagnan Consulting

6 Model outputs

The annual benefits for each option are detailed in Table 2 for the modelled year of 2028. Benefits have been calculated as described above, and as noted earlier, revenue is excluded from the analysis.

TABLE 2: ANNUAL BENEFITS ($M)

	City Centre Cordon	Isthmus Area	Strategic Corridors	Combination	Regional Network
Travel time	17.9	114.6	107.8	124.8	138.7
Increased reliability	3.1	20.6	17.9	20.9	23.1
Congested travel time	3.4	20.7	24.3	27.7	26.2
Vehicle operating costs	2.3	25.2	38.4	40.4	52.1
CO2 emissions	0.2	0.4	1.3	1.1	1.3
Other emissions	0.2	0.5	1.3	1.5	1.5
TOTAL	**27.2**	**182.1**	**191.0**	**216.4**	**243.1**

Source: MSM outputs, TCQ analysis

A 23-year evaluation period is used to calculate the scheme Net Present Value (NPV) and Benefit Cost Ratio (BCR). This period represents the initial two-year implementation period and two renewal cycles of the roadside infrastructure following the initial implementation. Sensitivity testing showed that extending the evaluation period had marginal impacts on the BCR.

The CBA summary is shown in Table 3.

TABLE 3: CBA SUMMARY FOR EACH OPTION

Option	PV Benefits ($m)	PV Costs ($m)	NPV ($m)	National BCR
City Centre Cordon	305.4	(181.6)	123.8	1.7
Isthmus Area	2,047.3	(936.4)	1,110.9	2.2
Strategic Corridors	2,147.6	(1,216.1)	931.5	1.8
Combination	2,433.2	(1,283.2)	1,150.1	1.9
Regional Network	2,733.7	(3,851.6)	(1,117.9)	0.7

Source: TCQ analysis

7 Limitations

The analysis outlined above is based on assessing the traditional transport benefits only. The actual economic benefits of the schemes would be higher when wider factors, such as wider economic benefits, labour supply impacts, improved productivity and liveability, (outside the scope of a traditional EEM assessment) are incorporated.

The analysis does not consider the impacts in other time periods where we expect some trips would shift to. For example, some trips from the morning peak may still occur, but are occurring earlier or later. This means that the total travel time and vehicle operating cost reductions reported may be being overstated.