Auckland Transport

Auckland's Cost of Congestion

White Paper Appendix - 2024

Appendix 1. Traffic, Externality, and Macroeconomic Modelling

This Appendix provides technical detail to support *The Cost of Congestion White Paper*. It does not provide any additional results or findings, but instead sets out the foundation for micro and macroeconomic modelling, supporting the transparency of analysis. The Appendix is primarily intended for traffic modellers, policy advisors, and other analysts interested in detailed methodology information. Information is split into three sections:

1. **Transport Modelling**: Assessing congestion impacts required forecasting potential user responses to changes in the Auckland transport network at a regional level. The Auckland Forecasting Centre (AFC) conducted this input into our analysis using its Macro Strategic Model (MSM).

2. **Externality Modelling**: Building on MSM outputs, as well as published appraisal guidance, to estimate a total monetised cost of congestion. Externality modelling reflects the societal costs and benefits generated from differing transport outcomes. These costs and benefits largely reflect non-market impacts, and the trade-offs associated with them.

3. **Macroeconomics Analysis:** Elucidation of the Computable General Equilibrium (CGE) model that underpins macroeconomic benefits, quantified within the Report. It focusses on underlying principles, source data, and key features. The section concludes with a short discussion of New Zealand Treasury guidance, and implications for the appropriate treatment of CGE results.

We note that a full explanation of underlying models, for example the MSM process, is not practical to canvass within this appendix. Weblinks and references are provided throughout each section to indicate where such information can be found.

1. Transport Modelling

As described above, this first step involves assessing congestion impacts by forecasting potential user responses to changes in the Auckland transport network at a regional level. The Auckland Forecasting Centre (AFC) provided this input into our analysis using its Macro Strategic Model (MSM), as well as contributing the explanatory material below.

Overview of MSM model

The MSM is a four-stage multimodal transport model that estimates travel demands based on a given spatial land use projection and supporting transport networks as key inputs. MSM (previously called the Auckland Regional Transport model (ART3)) was initially developed and calibrated in 2006. Following a significant refresh undertaken in 2016, forecasting now occurs from the 2016 base year to the year 2051.

Key features of the MSM model are listed below.

Sensitivity to Regional Growth Scenarios:

- Accounts for demographic and employment shifts
- Incorporates location and density changes, as shown in the Auckland Council land use model

Impact of Transport Infrastructure:

- Evaluates possible outcomes of significant regional transport projects

Congestion Effects:

- Analyses how congestion influences trip generation

Trip Distribution Changes:

- Considers alterations in the distribution and redistribution of trips

Mode Shift:

- Assesses changes in transport modes, including motorised, walking, and cycling

Route and Travel Timing Changes:

- Examines modifications in travel routes and timing of trips

The MSM model allows for the investigation and evaluation of the following regional policies and issues:

- The addition of major transport infrastructure, including major public transport infrastructure and plans
- The management and expansion of the region's public transport system
- The allocation of investment capital between competing transport investments
- Taxation or charging policies aimed at specific parts of the transport system
- Non-pricing demand management measures
- Policies to reduce the energy consumption of the region
- Policies to reduce emissions of pollutants
- Policies to improve the health and safety transport system users

MSM Trip Purposes

- Home-based work (HBW)
- Home-based education (HBE)
- Home-based shopping (HBSh)
- Home-based other (HBO)
- Employers' business (EB)
- Non-home-based other (NHBO)

Modes

- Light vehicles (called cars); persons in cars, that is, car driver and car passenger combined, in the demand models, converted into vehicles prior to assignment
- Passenger transport: all PT modes combined in the demand models and assignment is used to split PT demands into bus and rail/ferry
- Active modes; walk and cycle combined; trip productions only
- Medium and heavy vehicles combined (called HCVs)

Modelled Periods

- The model represents an average working weekday
- Trip ends and distribution-mode split are 24-hour models, and
- 24-hour demands are split into 5 periods by the time-of-day choice model:
  - AM peak: 7 am to 9am
  - Interpeak: 9am to 3pm
  - School peak: 3pm to 4pm
  - PM peak: 4pm to 6pm
  - Off-peak: 6pm to 7am

Assignment of trips within the model occurs in three time periods: AM peak, Interpeak and PM peak.

MSM Structure and operations

The MSM modelling process is consistent for both the base year, 2016, and future year forecasts. A modelled scenario (land use and network) is set up for the AM, IP and PM periods as a first step of running the model. The overall process for running the model is shown in Error! Reference source not found. **1**:

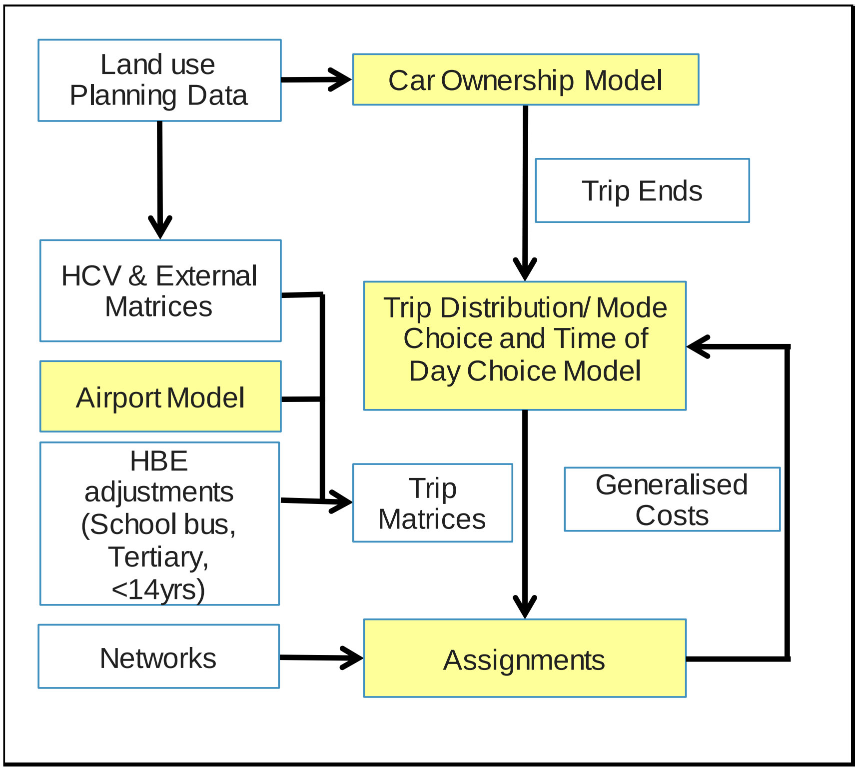

Figure 1: MSM flow chart

Land Use Planning data
The land use planning data from Auckland Council is imported into the modelling system (MSM). This data includes the number of persons categorised by person type and household type, as well as the number of households by type, employment figures by category, and educational enrolment statistics for primary, secondary, and tertiary institutions.

Car Ownership
Population data is input into the car ownership model to determine person type, household type and household car ownership levels which can range from. 0, 1, 2, 3 or more cars per household.

Trip Ends
The data on employment, households, and educational enrolment, along with the person data from the car ownership model, are utilised in the trip end models to determine the number of home-based (**HB**) person trips by purpose, excluding heavy commercial vehicles (**HCV**s).

Trip productions are calculated for all modes, with active modes being categorised from which mechanised mode productions are derived.

Trip attractions are only accounted for mechanised modes. Adjustments for future changes in working-from-home proportions related to non-pricing Travel Demand Management (**TDM**) are made at this stage.

Home-based education (**HBE**) trip ends are generated for all individuals except those under 14 years of age. The data for this age group is used in the HBE distribution-mode split (**DMS**) and time-of-day (**ToD**) choice models.

Non-home-based (**NHB**) attractions (including employers'-business trips and non-home-based origin trips) are estimated based on home-based trip ends and are evaluated for mechanised modes (car, public transport) after the home-based distribution-mode split and time-of-day models are completed.

Distribution-mode split (DMS) and Time-of-Day Choice (ToD)
The mechanised home-based trip productions and attractions are input into the distribution-mode split model and Time of Day choice models.

The distribution-mode split, and time-of-day analysis is conducted separately for each home-based (HB) purpose, resulting in origin-destination (OD) trips categorised by purpose, mode, and time of day. Adjustments are made to account for the effects of future Transportation Demand Management (TDM) non-pricing strategies.

Trips made by individuals using cars are then converted into vehicle counts.

The Non-Home-Based (NHB) distribution-mode split and time-of day models are also run separately for each purpose (such as employers'-business and non-home-based origin trips) and mode (car and public transport) to generate non-home-based origin destination trips categorised by time of day.

HCV Matrices
The AM, IP and PM 2016 HCV matrices are imported into MSM from the Auckland Dynamic Traffic Assignment (DTA model).

In forecasting process, the future synthetic trip ends are compared to the 2016 trip ends using a ratio. Additionally, growth is accounted for based on the forecasted GDP per capita growth.

External Matrices
The external trip matrices for the AM, IP, and PM periods from 2006, along with the observed counts from 2016, are imported into MSM.

The change in trip counts between 2006 and 2016 is allocated to each of the three sectors based on the 2006 distribution. Within each sector, the distribution is further adjusted according to changes in land use by zone.

In the forecasting process, the 2016 observed counts are adjusted by the input growth rates, and then the same allocation process is applied.

Airport Trips
The airport model is utilised to calculate the number of trips to and from the airport related to flights. The daily total for 2016 is adjusted using growth rates for future forecasting. These trips are then distributed according to the number of households and employment figures in different zones, and subsequently divided by transportation mode and time of day.

Networks
The MSM consists of 596 internal zones, two airport zones, and five external zones.

The network generally includes all roads down to major collector roads, with minor collector roads included as necessary to support the zoning system. Period-specific Lane coding represents various traffic configurations, such as clearways, tidal lanes, and bus lanes.

Two types of volume delay functions are defined to capture travel time and delay for mid-block links and intersection approaches.

The public transport (PT) network encompasses rail and ferry links, bus-only links, car access links, and pedestrian walk links. PT services, which include bus, rail, and ferry options, are represented along with their vehicle types, considering both seated and standing capacities.

Rail and ferry travel times are based on scheduled timetables, while bus in-vehicle travel times are calculated using vehicle travel times and infrastructure-specific speed assumptions. Dwell times for buses are determined based on distance.

Assignments and Generalised Costs
Vehicle assignments are conducted over three periods, focusing on the required costs.

Public transport (PT) assignments are carried out over four periods, including the Off-Peak (OP) period.

Four purposes are considered for PT:

- Home-Based Work (HBW)
- Home-Based Education (HBE)
- External Business (EB), and
- Other

Generalised costs are calculated for each mode, period, and purpose. These costs consider different values of time, operating costs, and fares.

For private vehicles, there are three purposes:

- HBW
- EB, and
- Other

While for public transport, there are four purposes:

- HBW
- HBE
- EB, and
- Other

Included in the car costs are:

- Travel time
- Vehicle operating costs

- Parking costs for HBW (long-term) and Other (short term)
- Walk time for CBD-destined trips for HBW and Other and
- Any tolls or pricing

Included in the PT costs are:

- Travel time
- Access time (walk, car access)
- Wait time (function of service headway)
- Transfer
- Fare
- PT crowding

MSM recent applications

- To inform policy – Vehicle Kilometres Travel reduction, Time of Use Charging
- To inform strategy – RLTP, RPTP, Auckland Plan, Future Development Strategy
- Assess Additional Harbour Crossing/ Auckland Light Rail
- Rapid Transit Networks (Northwestern)
- Rail Programme Business Case, Level Crossing Assessment

Transport Modelling to calculate additional delay

A scenario for 2026 was created, incorporating all transport projects expected to be completed by that year, including the City Rail Link (CRL), and was modelled using the MSM (Macro Strategic Model). This approach provided estimates of annual vehicle kilometres and total travel time on the road network projected for 2026, based on anticipated transport investments.

Importantly, the MSM model considers land use population and employment projections for 2026, along with assumptions about transport investments, to estimate travel patterns and behaviours. These estimates are utilised to assess network performance, including levels of congestion on the road network and public transport usage, among other factors.

To facilitate the externality modelling in step 3, the efficient throughput time of road links that meet the Level of Service (LoS) criteria of D and above was calculated.

For further details, please refer to the Technical Note ATAP Headline KPI – per capita annual delay. This methodology was also employed in the study by Wallis and Lupton (2013).

The outputs produced by the MSM are presented in vehicle kilometres travelled (VKTs) and vehicle minutes. The current version of the MSM also estimates road vehicle emissions, in alignment with Waka Kotahi tools, allowing for an integrated analysis of the regional emissions profile under various scenarios.

2. Externality modelling

This chapter describes the process of measuring and quantifying the direct costs of congestion to Aucklanders. The approach makes use of the best available evidence to estimate time savings, then communicate those impacts in dollar terms. We note that the methodology is consistent with previous New Zealand studies on the topic, specifically NZIER (2017) and Wallis and Lupton (2013). The key difference is the application of contemporary traffic modelling data, as well as the latest appraisal guidance published by the NZ Transport Agency (NZTA).

Externalities are defined broadly, for the purposes of this document. The term seeks to capture direct impacts on the wellbeing of individuals, primarily consisting of time and frustration that can be attributed to road users being stuck in traffic. It is used to describe 'bottom-up' effects on individual utility (the subject of this chapter) and distinguish them from 'top-down' macroeconomic outcomes (the subject of chapter 3). Separating the costs of congestion into 'internalised' vs. 'third party' effects, as would be necessary to meet an academic definition of an externality, is outside the scope of the study.

Conceptually, the externality modelling process is straightforward. As set out in the diagram below, it involves four steps: Establishing an appropriate baseline scenario for Auckland's road network, defining a 'no congestion' counterfactual state, monetising impacts, then estimating effects across Auckland based on congested trip volumes. Each of these steps reflects best-practice New Zealand guidance, including NZTA's Monetised Benefits and Costs Manual (MBCM).

Figure 2: High-level Externality Modelling Methodology

1. Baseline Scenario

This process is based on the Auckland MSM, as described in the chapter above. Two parameters of the traffic modelling were tailored to support analysis of the cost of congestion in Auckland, so are highlighted below.

First, the choice of time period has the potential to influence the accuracy and relevance of analysis. Auckland Transport publications, at time of writing, have highlighted the potential for City Rail Link (CRL) to have substantial impacts on Auckland traffic patterns in the year 2026, suggesting that a scenario prior to this point will have limited applicability. In addition, we understand 2026 is a common year for MSM analysis, having been applied to several recent programme assessments in Auckland. For these reasons, 2026 was selected as the basis for externality and macroeconomic modelling.

Second, the baseline scenario is heavily influenced by assumptions about the pathway for network investment. A dramatic increase in infrastructure spending, for example, would lead to very different travel patterns across Auckland roads. With relevance and consistency in mind, a scenario aligned to MBCM guidance was applied: Changes to the network over the next two years are limited to committed and funded transport activities only. This takes account of CRL, as described above, without the need to judge the likelihood of future investment plans.

Note that baseline scenario modelling, via the MSM, also produces distributional data about the volume of congested trips across Auckland. This information includes journey purpose, time of day, origin-destination matrices, and vehicle type. Distributional data is used as a proxy to estimate the proportion of congestion costs across Auckland trip types, including the allocation of monetised cost. However, it does not form part of the total annual cost calculation.

2. Defining a counterfactual

This requires identifying a hypothetic state in which Auckland's road network does not experience traffic congestion, permitting differences from the baseline scenario to be quantified. Calculating a 'no congestion' state whilst maintaining the same MSM model run ensures that assumptions and parameters are consistent, such externality modelling can focus on marginal effects.

We define congestion using technical metrics of service quality, consistent with previous New Zealand studies on the subject. Within ATAP definitions, Levels of Service (LoS) range from A (Free-flow conditions with unimpeded manoeuvrability), through to F (Extremely low speeds caused by intersection congestion). Translating these metrics into more accessible terms, Wallis and Lupton (2013)[1] define LoS D as 'maximum flow', in contrast to 'at capacity' (LoS E) or 'free flow' (LoS A). We consider LoS D performance to be an appropriate proxy for 'congestion free' for the purposes of the White Paper, as it represents a world in which network usage is optimised (NZIER, 2017).[2]

With congestion clearly defined, the next step is adjusting baseline scenario performance. This involves four steps (Auckland Forecasting Centre Technical Note, 2016):

i. Identify links that have assigned traffic volumes greater than capacity (i.e., with performance that does not meet the LoS D standard.
ii. For these links, modify the 'volumes' variable, such that the capacity of these links permits efficient throughput. The original volume delay formulations are retained.
iii. Calculate the total vehicle minutes for links identified in step i using the travel times in the baseline scenario (congested) and step (ii) (efficient throughput), multiplied by the traffic volumes on the links.
iv. Perform steps (i) – (iii) for the AM, IP and PM peak periods.

This results in two outputs for the Auckland road network: Total annual vehicle hours, and total annual vehicle hours under efficient throughput. Based on LoS D, the difference between the two outputs is 29 million hours for the year 2026.

3. Monetising impacts

The two outputs described above are converted into monetised values using the MBCM. This document represents best practice transport-sector economic appraisal in New Zealand.

Core cost of congestion monetisation calculations are based on Table 16 of the MBCM: Composite values of travel time, plus maximum increments for congestion, for different road categories and different time periods. The following assumptions and parameters were applied:

- Baseline MSM scenario modelling (vehicle person hours) was used to estimate the proportion of congested hours by time. Data was not adjusted by period length (e.g. interpeak), as this would result in higher monetised values, and we considered a more simple and conservative approach to be preferable.
- Urban arterial values are used for each of the three time periods in scope (morning commuter peak, daytime inter-peak, and afternoon commuter peak). "Urban other" was not applied because this category only offers a single 'weekday' value.
- The full congestion increment is applied, reflecting the 29 million figure consists of congested hours only.
- Consistent with MBCM guidance, the 'base date' for inflation adjustments reflects the year in which analysis is prepared (2024), as opposed to the analysis period (2026).
- NZTA update factors are applied to convert 2021 dollars to 2023, then an additional 2% is added to estimate 2024 results (consistent with standard CPI uplift assumptions).
- This results in a per hour monetised cost of $66.87, on average, in 2024 dollars (including the congestion increment).

[1] https://www.nzta.govt.nz/assets/resources/research/reports/489/docs/489.pdf

[2] https://www.nzier.org.nz/hubfs/Public%20Publications/Client%20reports/nzier_report_on_auckland_benefits_of_decongestion.pdf

This results in a total annual cost figure of $1,942.8 million for the year 2026. No discounting or other adjustments are made to this figure, beyond the process described above.

The counterfactual process, described above, does not allow for direct estimates of wider cost savings, for example emissions reduction benefits and vehicle operating costs. These wider savings are therefore calculated as a sensitivity test only, using the ‘order of magnitude’ assessment described in Wallis and Lupton (2013). This consists of vehicle operating costs (VOC) equal to 6% of travel time, then greenhouse gas emissions equivalent to 0.5% of travel time, totalling $126m for the year 2026. We note that this approach results in a conservative estimate, as the inclusion of safety and health impacts could increase the figure.

4. Estimating distribution

An important element of the White Paper is understanding how the costs of congestion in Auckland impact different users of the transport system. As described above, the MSM baseline scenario provides distributional data about the volume of congested trips across Auckland split by journey purpose, time of day, origin-destination matrices, and vehicle type.

MSM data is used as a proxy to estimate the proportion of congestion costs across Auckland trip types, including the allocation of monetised cost. We note that the number of congested trips is one of several possible metrics that could be used for this allocation, and an alternative methodology would lead to different results.

Throughout the White Paper, the total cost of congestion expected in 2026 (29 million hours, or $1.9 billion) is illustrated through a number of different lenses, including:

- Time of day
- Journey purpose
- Vehicle type
- Origin-destination (including board areas facing high levels of socioeconomic deprivation).

3. Macroeconomic Analysis

Overview of economic impact assessment

Computable General Equilibrium (CGE) models are a class of economic model developed originally out of Input Output (IO) models providing a causal, network wide, and theory driven framework for the assessment of a range of policy, project, and economic conditions.

As suggested in the name, CGE models provide an equilibrium representation (where capacity equals demand) of international and national economies in a chosen base year, including explicit treatment of (for example) primary factor markets, inter-industry purchases, and international trade flows. It is this initial equilibrium position which forms the starting point for a sequence of future projections of possible economic states, and it is by comparing these future pathways against each other that we can assess the impact of different policy choices on macroeconomic indicators such as GDP and employment.

As noted by Dixon in the Handbook of Computable General Equilibrium Modelling:

> *"CGE models are used in almost every part of the world to generate insights into the effects of policies and other shocks in the areas of trade, taxation, public expenditure, social security, demography, immigration, technology, labour markets, environment, resources, infrastructure and major-project expenditures, natural and man-made disasters, and financial crises. CGE modelling is the only practical way of quantifying these effects on industries, occupations, regions, and socioeconomic groups."*

The CGE model for this White Paper was produced by EY. The primary data source for EYGEM model is the GTAP database, produced by Purdue University. The GTAP database is the most detailed, comprehensive, and widely used database of its type in the world, used by over 700 researchers worldwide. The database contains information on inter industry flows, trade, taxes, and behavioural variables.

In this section we will describe the EY General Equilibrium Model (EYGEM), including a description of the economic foundations of the EYGEM model, the national accounting framework, and behavioural assumptions and the key features and structural underpinnings of the EY version of a global CGE model.

Overview of the EYGEM model

The EYGEM model is a member of the Global Trade Analysis Project (GTAP) / Global Trade and Environmental Model (GTEM) family of CGE models which have a long history in the public and private sectors to assess the economic impact of projects and policies. As with most modelling frameworks it is natural to think about the model in terms of the data and structural components.

As with all CGE models, EYGEM is based on an underlying input-output or social accounting matrix, which is a standard representation of the national accounting frameworks applied by central statistical agencies globally and forms the basis for calculating well known macroeconomic variables such as gross domestic product. This foundational data describes how economies are linked through production, consumption, trade, and investment flows.

Overlaying this system of national accounts are a set of standard behavioural structures that simulate real world decision making and are validated by established academic literature, providing the basis for forecasting responses to policy changes. For policy analysis, this incorporation of behavioural structures provides an advantage over traditional econometric approaches, particularly where historical examples or analogues of the policy being evaluated is not well represented in historical data (for example climate change policy).

The below points highlight the key features of the EYGEM model, ahead of a discussion of the economic theory underpinning the model:

- Direct linkages between industries and countries through purchases and sales of each other's goods and services.
- Inter industry linkages through purchases and sales of each other's goods and services.
- International linkages through the imports and exports of goods and services.

- Capacity constraints in primary factor markets, representing the finite availability of capital, labour, land and the natural resource (this is not accounted for in IO models).
- Behavioural mechanisms such as the responses to price changes.

Key features and structure underpinnings of EYGEM

1. **Income**

The model contains a "regional consumer" that receives all income from factor payments (labour, capital, land, and natural resources), taxes, and net foreign income from borrowing (lending).

Income is allocated across household consumption, government consumption, and savings so as to maximise a Cobb-Douglas utility function.

2. **Consumption**

Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.

Government consumption for composite goods, and goods from different sources (domestic, imported, and interstate), is determined by maximising utility via a Cobb-Douglas utility function.

3. **Production**

Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.

Producers are cost minimisers, and in doing so choose between domestic, imported and interstate intermediate inputs via a CRESH production function.

The supply of labour is positively influenced by movements in the real wage rate governed by an elasticity of supply. A labour supply elasticity of 0.15 is uniformly adopted for this analysis.

4. **Investment**

All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.

Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return.

Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions and minimises costs by choosing between domestic and imported sources for these goods via a CRESH production function.

5. **Prices**

Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other New Zealand regions (interregional exports).

For internationally traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But in relative terms imported goods from different regions are treated as closer substitutes than domestically produced goods and imported composites.

CGE Application

Manuals published by the New Zealand Treasury provide a clear indication of the appropriate uses for CGE modelling, in contrast to traditional cost-benefit analysis, or CBA (and by extension, externality assessment in the body of the 2024 Report). Treasury guidance specifies that:[3]

> *"Economic Impact Analysis (EIA) differs from CBA in that it measures the economic impact of a project, that is to say the activity generated, rather than the net benefit created. Because it measures the activity generated, it treats costs as a benefit… In contrast, a CBA would treat the expenditure on labour as a cost, recognising the fact that the labour is prevented from carrying out some other activity, i.e., recognising its 'opportunity cost'….*
>
> *EIA can provide useful contextual information for decision-makers, but it is not suitable as a tool for measuring the balance of costs and benefits of a decision to society."*

CGE modelling offers insights to those interested in risks and opportunities to the wider New Zealand economy, including implications for productivity, competitiveness, and export-led growth. In our view, macroeconomic results are likely to offer value in the context of top-down economic performance, for example considering the relative contribution of different New Zealand industries to GDP.

[3] https://www.treasury.govt.nz/sites/default/files/2015-07/cba-guide-jul15.pdf

Appendix 2. Limitations and Caveats

Limitations and caveats:

- Our findings are highly dependent on MSM outputs, and thus, any limitation of their transport modelling will naturally flow into our computed results. This includes any underlying assumptions made about the state of congestion in Auckland, movement preferences, road demand, the technical definition of congestion applied, etc.

- The cost of congestion is estimated using a counterfactual scenario for the year 2026, based on externality and output differentials. An alternative time period and / or set of infrastructure assumptions would lead to different results. This section highlights the key assumptions underpinning Report estimates, including inputs and parameters that rely on historic data.

- All dollar values are reported in 2024 terms, reflecting MBCM update factors to 2023, then a 2% adjustment to 2024. Monetisation factors are based on the MBCM v1.7.
- The study does not account for dynamic behavioural change as a result of the counterfactual analysis, beyond the traffic modelling process described in sections 1-2. Alternative results could be expected if an agent-based, micro-simulation, or otherwise dynamic framework for estimating future impacts was applied.
- The distribution of 2026 cost is based on volumes of congested trips, provided by the MSM. This does not account for trip length, variance in occupancy rates, differences in monetised value by journey purpose, or other potential adjustments.
- Congestion costs only include time delays and exclude any benefits of increased travel time reliability. Extending the analysis to consider such uncertainty would likely increase the estimated cost of congestion.
- We have assumed proportional values for Vehicle Operating Cost and emission impacts, as per prior studies. These values are included for sensitivity analysis purposes only, as direct estimates are not available via the counterfactual process.

- Our approach to CGE modelling is described in Appendix 1, including economic foundations, the national accounting framework, and behavioural assumptions.

Appendix 3. Comparison with the "Benefits from Auckland road decongestion" by NZIER

This section compares the intent, purpose, and analytical differences between the White Paper (the EY report) and the NZIER "*Benefits from Auckland road decongestion*" 2017 report (the NZIER report). On a foundational level, both these reports set out to achieve similar things: define the impacts associated with congestion in Auckland for a specific year. The differences in input data, assumptions, scope, and model parameters nevertheless results in each report producing distinct results.

The rest of this section describes differences between the two reports through high-level categories: Contemporary context, tonality, and technical analysis. Where reasonable, we detail and compare the quantitative results from the EY report to the NZIER report.

Contemporary context

Prior to discussing any of the analytical or presentational differences between the two reports, it is important to consider the outside influences that played a role in shaping each piece of analysis.

The NZIER report was written in August 2017, commissioned by a collection of road proponents[4] to set up potential future analysis that better defines the impacts associated with decongestion. The surrounding political environment was not unfavourable for such analysis, and the report itself was considered as a stand-alone piece, rather than something that fits into a larger programme.

This contrasts with the EY report, which is being delivered as part of a wider Time of Use programme for Auckland Transport (AT), in which they investigate the potential for implementing a time of use charging policy for Auckland. The EY report does not aim to prove the benefit of a time of use charging proposition, but merely outline and updated view of the congestion problem in Auckland.

Additionally, we cannot ignore the fact that the EY report comes after the NZIER report. This naturally results in there being similarities, both in terms of the problems that Auckland faces with regards to congestion, as well as methodological implementation. Specifically, it should be noted that both reports do rely on transport modelling from AT, which has naturally evolved over time.

Therefore, while the internal technical methodology looks similar, the narrative surrounding those results has drastically changed over time. Indeed, while the political economy in 2017 may have been relatively unfavourable towards the idea of implementing a congestion charge, the current environment is particularly volatile. Specifically, the clash between central and local government views, and their respective level of control behind policymaking that affects Auckland has led to further emphasis being placed on the robustness of analysis for estimating the impact that congestion has on Auckland, and ensuring that it is communicated in a way that remains accessible for a wide range of individuals.

Tonality

When detailing the surrounding context behind the reports, we noted that the EY report is fundamentally designed for a wider audience, when compared to the NZIER report. This has naturally resulted in different styles of written communication. Indeed, when it comes to both the surrounding context, impacts associated with congestion, as well as technical detail, the external influence on tone becomes more apparent.

This does not suggest that one tone is better than the other, but rather, points to the reality of these two reports being designed for two differing purposes. Simply put, given that the audience for the EY report is wider (and thus, will hold a more general view of the world), the report must maintain a level of accessibility for individuals who do not specialise in transport economics. This translates to a report that holds a more fluid, narrative driven tone, particularly in relevance to technical detail. The has resulted in the EY report

[4] EMA, Auckland International Airport Ltd, Infrastructure NZ, Ports of Auckland Ltd and the National Road Carriers Association.

holding a more "reality-driven" narrative, in which the economic impacts have been expressed in ideas and forms that the average Aucklander could relate to.[5]

Technical analysis

The underlying technical analysis that informs both reports remains similar. Both use outputs from a Computable General Equilibrium (CGE) model to inform their conclusions regarding the economic impact of congestion, and complement that analysis by using NZ Transport Agency best practice social impact evaluation guidance to investigate further effects.

Given that the overarching methodology remains consistent, we now detail the changes that lead to differing results between the two reports. We separate this into dedicated CGE and social impact (or externality) sections, for ease of understanding.

Computable General Equilibrium modelling

Both the EY and NZIER reports use outputs from CGE modelling to inform their conclusions. While the CGE methodology holds between the two reports, the underlying model is different[6]. Therefore, even when using the exact same empirical inputs, and the exact same shock, it is likely that the two models would output differing states of the world.

Regardless, there is still merit in stating the methodological differences between the two reports. First, we consider the differences in the economic shock that is inputted into the model.[7] The NZIER report replicates a prior study,[8] and examines the flow-on impacts arising from the travel time reductions that would occur when the entire road network operates at capacity, and free-flow. The EY report in comparison only looks at the network operating at capacity, reflecting the fact that a free-flow network is both unrealistic and inefficient in terms of asset usage. The core difference is the underlying input: the estimated movements that are expected to occur, and thus, the expected time savings.

Whereas the NZIER report used outputs from Auckland Transport's ART model,[9] the EY analysis used outputs from Auckland Forecasting Centre's Macro-Strategic Model (MSM). This involves a forecast for the year 2026, including committed and funded infrastructure programmes in Auckland such as CRL.

One critical difference in computation is the fact that NZIER only considers the AM peak implications, and extrapolates that for both Interpeak and PM peak periods. This is less of a methodological criticism of NZIER, but rather, a limitation that occurred due to ART modelling constraints. AFC inputs for the EY report does not suffer the same restrictions, and thus, fewer layers of extrapolation were required.

From here, monetisation of such time savings follows very similar processes between the NZIER and EY reports. One important note is that the Economic Evaluation Manual (EEM) used by NZIER was rendered obsolete with the release of the Monetised Benefits and Costs Manual (MBCM) by NZTA. Once again, that is not a direct criticism of prior work, but rather, reflecting the fact that economic impact valuations used for the most recent report is more representative of present day, simply due to the fact that effect parameters were updated.

[5] This differential is perhaps most explicitly seen in the "defining congestion" sections in both reports. Whereas the NZIER report opens the section by noting that they "…adopt the engineering measure of congestion…", the EY report opens with a brief paragraph which aims to set the scene "Being stuck in traffic is a common experience…".

[6] Differences between the EY CGE model (EYGEM) and the NZIER CGE model are challenging to quantify due to the secrecy / intellectual property considerations involved in development of each model. It is likely that the differences lie within behavioural considerations (i.e., how do consumers / businesses / countries react when facing some type of economic shock), alongside the methods for the ways that the shock flows through the aggregate model.

[7] Appendix 2 provides more detail around how a CGE model operates, but in short, one observes some "base state" of the world, implements a "shock" (some economic event that affects behaviour), and then evaluates the state of the world after (i.e., ex post the shock).

[8] Wallis and Lupton (2013).

[9] It is noted in their report that results were uplifted to 2016 from a base 2013 state.

From here, the monetised inputs are inserted into each of the respective models, which then output total impact on the country / Auckland region. We present aggregated results from the two reports below:

Parameter	EY results (2024)	NZIER results (2017)
Auckland GDP impacts (annual)	$707 million	$488m - $842m
Employment impacts (annual)	1,200 job years	1,500 to 2,300 job years

To summarise, the differences in results stem from:

- Different underlying input models (for transport modelling)
- Annualisation / extrapolation differences (AM peak extrapolation versus results for each time period)
- Updated effect parameters (EEM to MBCM)
- Idiosyncrasies of CGE models

It is likely that the EY results present a more current view regarding the impact that congestion currently has in Auckland. That is not to discredit prior analysis, with the NZIER results likely being the most accurate representation of congestion impacts at the point in time in which the analysis was performed.

Social impact modelling

Comparing the social impact modelling methodologies between the two reports is an interesting proposition, as the EY computations for non-travel time social benefits uses the same proportions as the NZIER analysis.

Additionally, the core differentials were noted in the CGE section, in which we highlight the differences in input. These inputs flow into calculating social impacts, and thus, it remains that while the NZIER report required extrapolation of AM peak volumes for other time periods, the EY report simply obtained transport modelling outputs for all three periods. Due to this increase in granularity, we obtain a more representative value for the additional vehicle hours, and thus, the application of these assumed proportions would intuitively, be closer to the true impact.

The percentages used for calculation are:

Effect	Percentage of	Percentage value
Vehicle Operating Costs (VOC)	Time costs	6%
GHG emissions	VOC	8%

We also present EY outputs compared with NZIER results:

Effect	EY results (2024) - Annual	NZIER results (2017) - Annual
Additional Time costs	$1,943m	$437m - $655m
Vehicle Operating Costs (VOC)	$117m	$24.5m - $36.8m
GHG emissions	$9.3m	$2.0m - $2.9m

Overall the difference between the EY and NZIER reports show an increase in the social impact effects, driven by changing opportunity cost values, with largely similar macro-economic impacts.