CGC urban transport – 2015 QGSO review

Introduction

The Commonwealth Grants Commission (CGC) Report on State Revenue Sharing Relativities, 2015 Review (the Review) included a new urban transport infrastructure assessment and a new methodology for urban transport net expenses assessment.

Analysis undertaken by the Queensland Government Statistician's Office (QGSO) within Queensland Treasury and Trade suggests that the Review's urban transport assessments require further research before they meet the CGC's terms of reference criteria of 'robust quality' and 'fitness for purpose'.

This analysis has identified a number of concerns with the urban transport assessments.

1. The Review has a fundamental problem in that it treats the Roads assessment independently of the Transport assessment. The conceptual case for public funding of urban transport services is based on the economic argument that the marginal social cost of each additional user of an urban road transport network exceeds the average cost they face. Public transport subsidies induce commuters to switch from private road vehicles towards public transport (rail, bus or ferry).
2. The Review proposed an urban transport assessment based on the population of urban areas, rather than the number of (including potential) users of public transport within an urban area, or the transport task (passenger-km of travel or intensity of public transport (vehicle-km of services per passenger-km of travel).
3. The proposed regression model used to estimate the urban transport assessment is based on the relationship between urban size and subsidy (net operating expenses) rather than the more policy-neutral variable of total operating cost.
4. The regression models proposed by the Review for urban transport assessments use weighted observations (weighted according to population) so that larger weights are given to urban centres with larger populations.

In each of these areas of concern, the Review has made judgements that are either not consistent with the Commission's sponsored consultancy reports or that are not robust to alternate, equally plausible, assumptions. For example, the CGC's sponsored consultancy on the econometric work[1] noted that the efficacy of weighting with population size, which gives more weight to the large cities, is a conceptual question depending upon the purpose and interpretation of the model. The analysis in this paper will demonstrate that the Review's population weights are not fit for purpose.

The Commission's latest position paper[2] acknowledges these concerns when it notes "*Given State concerns about the quality and policy neutrality of the data on urban transport infrastructure by city*…". However, the Commission's intended approach of simply relying on a population based model accentuates the problem of fitness for purpose. That is, the evidence presented in this analysis demonstrates that urban population (defined as the estimated resident population of an Urban Centre / Locality) is a poor proxy for the variable of interest which is the urban public transport task.

[1] '*Report on econometric work conducted by the CGC'*, Xiaodong Gong, IGPA, University of Canberra.
[2] '*2015 Review, Significant changes since the Draft Report*', Commission Position Paper CGC2014-04.

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Finally, in order to effectively replicate the existing CGC models, QGSO would need access to the states data available to the CGC. However, QGSO does not have these data and therefore to undertake this exercise QGSO has relied on data provided by the CGC in November 2013.

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Summary of the CGC Urban Transport models

The following discussion is not intended as a comprehensive summary of the CGC's urban transport (services and infrastructure) models[3]. Rather, this summary is provided as context for the discussion of the QGSO sensitivity analysis contained in the next section.

CGC Urban Transport Infrastructure model

The CGC's urban transport infrastructure model (as presented in '*2015 Review, Significant changes since the Draft Report*', Commission Position Paper CGC2014-04) is solely based on the square of the population of each urban centre above 20,000 persons in each state.

This simple model highlights two of the concerns noted in the introduction and fails the fitness for purpose criteria. This is relevant to the claim in the CGC Position Paper that the conceptual case has been established that larger cities require more assets per capita to deliver urban transport services. Further evidence on the robustness of this conceptual case is provided in the section below on the urban transport services model.

The Review has only sought to establish a relationship between asset value and the total population of an Urban Centre / Locality (UCL). The Review did not provide any statistical analysis to demonstrate that the population of a UCL was a statistically significant proxy for the urban public transport task.

Without the statistical evidence to support the use of the UCL proxy it is irrelevant whether or not the CGC has data that "…establish a broad relationship between asset values per capita and city size" because the purpose of the transport assessment is funding states to deliver an equal standard of transport services not funding based on city size.

The claim in the CGC Position Paper that the relationship is independent of the slope of the curve is only true if it is assumed every urban centre has the same coefficient.

As noted in the CGC's sponsored econometric consultancy[4], "…the choice of functional form (for the urban transport model) depends upon the assumption of the underlying relationship between the asset holding and the size of the cities." An implication of this point made by the consultant is that the CGC cannot rely on model results derived from applying a specific assumption as evidence that proves the validity of that choice of assumption.

Urban Transport Services model

The CGC's urban transport services model is based on the relationship between urban size and transport subsidy. The Report used regression analysis to estimate, for cities with a population greater than 20,000 persons, the relationship between per capita spending and the logarithm of population. City populations are defined using ABS UCLs contained within Significant Urban Areas.

Analysing the fitness for purpose of the CGC's model for the urban transport services assessment requires an understanding of the purpose of this particular assessment. Relating back to the conceptual principle of horizontal fiscal equalisation, the purpose could be described as states receiving funding such that each would have the fiscal capacity to provide urban transport services at the same standard.

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[3] Because the CGC released '*2015 Review, Significant changes since the Draft Report*', Commission Position Paper CGC2014-04 after the Review, this analysis discusses the infrastructure model in the Position Paper rather than the model presented in the Review.
[4] '*Report on econometric work conducted by the CGC'*, Xiaodong Gong, IGPA, University of Canberra.

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The Report states that the regression uses weighted observations (weighted according to population) so that larger weights are given to urban centres with larger populations. The Report claims that "*This gives the same weight in the regression to individuals, regardless of which urban centre they reside*." While weighting by UCL population may provide the statistical property of each individual having equal influence on the regression it does not meet the fitness for purpose criteria.

The conceptual case for public funding of urban transport services is based on the economic argument that the marginal social cost of each additional user of an urban road network exceeds the average cost they face (consisting of congestion related travel time, travel time variability and vehicle operating costs). Public transport subsidies induce commuters to switch from private road vehicles to public transport (trains, buses, ferries) thereby reducing the gap between the marginal and average cost.

For example, an additional thousand persons in Darwin represents approximately a 0.88% increase in public transport boardings but only a 0.02% increase in Sydney[5]. Therefore, for the purpose of receiving funding to maintain urban transport services at the same standard, the marginal user of public transport in Darwin imposes a higher marginal impact on the standard of transport services than the marginal user in Sydney.

This variation in marginal avoidable social cost of congestion demonstrates that the Review's weighted (by UCL population) regression is not fit for purpose as the weighting distorts the results away from achieving the assessment's purpose, as stated above. This highlights that the Review has a fundamental problem in that it treats the Roads assessment independently of the Transport assessment.

The Review claims that the proposed assessment (that is, one based on the relationship between urban size and subsidy) is valid because "*This is the same approach recommended by the consultants engaged in the last review*." However, the consultant's report[6] provides significant evidence to reject this approach as being fit for purpose.

The consultant's report identifies that a fit for purpose urban transport analysis should be based on the concept of average policy and average technical efficiency such that a state should not be compensated for:

- adopting low fares (i.e. adopting above average subsidies);
- providing above average public transport;
- providing above average quality of service; or
- using below average efficiency of service delivery.

The consultant's report commences with an analysis of the relationship between operating costs and population then shifts to an analysis of urban transport subsidy. The difference between the two concepts is the fares paid by passengers.

The consultant acknowledges that they have used operating subsidy rather than total operating cost for the analysis "…because the former is the focus of CGC." Their report states "It can be argued that total operating costs might be considered more appropriate because the level of fares is a policy choice of state governments…".

[5] This result includes accounting for Sydney having approximately 124.3 public transport boardings per capita whereas Darwin has only 15.6 boardings per capita.
[6] 2010 Review of State Government Subsidised Urban Public Transport Services: Consultant Advice, Institute for Sustainable Systems and Technologies, University of South Australia, April 2009.

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Therefore, using 'operating subsidy' as the dependant variable in the analysis appears to directly violate the principle of policy neutrality, and implies that a model based on operating subsidy is not fit for purpose.

Applying the consultant's recommended approach, using total operating costs rather than operating subsidies, demonstrates clear evidence of economies of scale in urban public transport. This is relevant to establishing the conceptual case that larger cities require more assets per unit of transport task (and therefore fiscal capacity) to deliver urban transport services.

Figure 1 Urban Transport Operating Costs (per passenger-km)

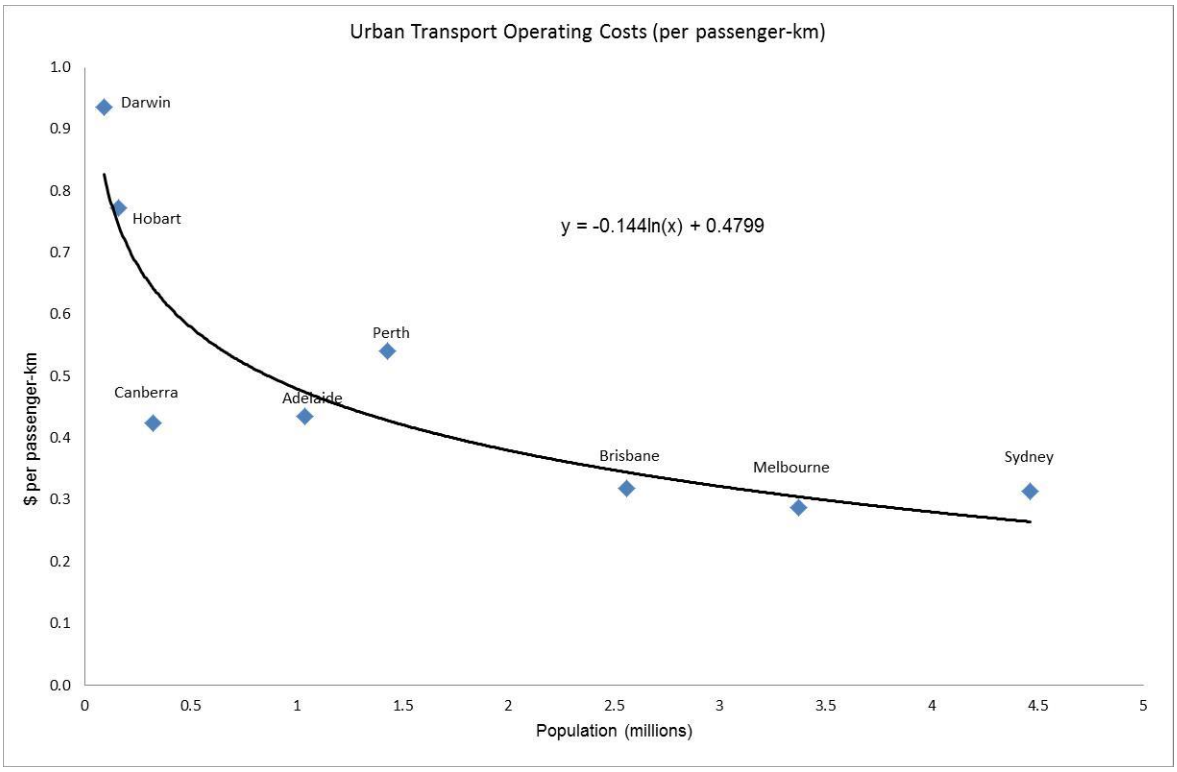

Figure 1 is based on the data for the capital cities as listed in Table B.7 page 58 of the consultant's report[7] and is similar to Figure 3.6 on page 17 of the consultant's report. Note that the data presented in Figure 1 are not adjusted for technical efficiency.

The consultant's report also documents that the "…*average cost of operating public transport in Sydney (expressed as a cost per passenger-km of travel) is 16% higher than in Melbourne when corrected for the difference in the passenger task performed. This may be broadly attributed to a difference in technical efficiency.*" This demonstrates the need for the Review to incorporate a technical efficiency adjustment for the model used for urban transport services.

Overall, this analysis demonstrates that rather than adopting the conceptual model and approach recommended by their consultant, the Review has used a model that is not fit for purpose as it is not based on the concepts of average transport task, average policy and average technical efficiency.

[7] 2010 Review of State Government Subsidised Urban Public Transport Services: Consultant Advice, Institute for Sustainable Systems and Technologies, University of South Australia, April 2009, page 16.

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QGSO Sensitivity Analysis of the CGC Urban Transport models

QGSO undertook three sensitivity analyses to assess the Review's urban transport services and infrastructure models[8] against the following criteria:

(i) Robustness;

(ii) Fit for purpose design.

Each sensitivity analysis changed one design variable of the existing CGC model and results were then analysed in terms of how the CGC model met both criteria. It is important to note the net change within Australia will be 0%. Therefore, where one state or territory may benefit from one scenario, another will be disadvantaged.

In order to effectively replicate the existing CGC model, QGSO would need access to all data available to the CGC. However, as QGSO does not have these data to undertake this exercise, data previously provided by the CGC has been used to derive each state and territories assessed share of GST distributions relating to urban transport.

The reported minimum values for scenarios one and two have been derived for each state and territory using the minimum assessed share across all model iterations. Likewise, the maximum values for scenarios one and two have been derived for each state and territory using the maximum assessed share across all model iterations. Therefore, both the minimum and maximum shares for all state and territories do not need to add to 100%.

The data used in each of the three sensitivity analyses has been taken from the spreadsheet '*Consolidated regression data for States - Nov 2013*' provided by the CGC. The regression models use significant urban areas (with a population over 20,000 persons) and their operating expenditure (total of GGS and PNFC) and estimated resident population for 2010-11.

The three sensitivity analyses can be summarised as:

- The first sensitivity analysis observed the impact on each state and territory's assessed share when using a different geographical region to what is currently used in the model;
- The second sensitivity analysis made small variations to each urban centres' expenditure (that could plausibly occur from year to year) and the impact that had on each state and territory's share; and
- The third sensitivity analysis looked at changing the regression model and what impact that had on each state and territory's share.

[8] All three sensitivity analyses apply to the CGC's urban transport services model, however only the first sensitivity analysis is applicable to the urban transport infrastructure model.

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Sensitivity analysis 1: Geographical changes

The existing CGC model for urban transport services utilises the pre-defined ABS geography of urban centres. This sensitivity analysis looks at the impact of changing from an 'off the shelf' ABS geography to a more customised geography, fit for the purpose of urban transport analysis. As noted in the previous section, a fit for purpose model would have used transport task not the Review's UCL population proxy.

A customised geography has been derived by defining place of work 'destination hubs'. These hubs have been defined where the working population of a statistical area level 2 (SA2)[9] meets a specific population threshold. The geographical transport 'origin' region was then defined by SA2s where the number of people travelling to work at the destination hub was above another population threshold. The resultant transport region may or may not be contiguous. By varying the destination and origin thresholds, the impact and sensitivity associated with the geographical definition was observed.

For this sensitivity analysis, origin thresholds between 25 and 1,000 employed persons and destination thresholds between 100 and 7,400 employed persons were taken. A total of 2,960 combinations were analysed and for each combination, the state and territory shares were calculated. Results that were not statistically significant were removed, as were results where the origin threshold was larger than the destination threshold. The maximum and minimum share[10] for each state and territory is detailed in Table 1.

Table 1 shows Victoria and Queensland have a greater absolute variability when changing the geographical definition. However, less populous states and territories have a much higher relative variation such as the Northern Territory.

By varying the geographical definition, a large range in state and territory shares are observed. Since the absolute and relative differences are not small and uniform, this demonstrates that the existing CGC model is not robust.

Table 1: Share of assessed operating expenditure for varying geographies, 2011

State/territory	Assessed expenditure share		Difference	
	Minimum	Maximum	Absolute (a)	Relative (b)
	— per cent —		percentage points	per cent
New South Wales	33.5	35.3	1.8	5.3
Victoria	28.8	32.1	3.4	11.1
Queensland	13.2	16.5	3.3	22.3
South Australia	6.6	7.7	1.1	14.8
Western Australia	10.1	12.3	2.2	19.8
Tasmania	0.6	1.0	0.3	41.4
Northern Territory	0.1	0.2	0.2	118.1
Australian Capital Territory	0.7	1.5	0.8	68.8

(a) Difference between maximum and minimum share.
(b) The absolute difference relative to the mid-point of the maximum and minimum.

[9] Defined under the 2011 Australian Bureau of Statistics, Australian Statistical Geography Standard (ASGS).
[10] This analysis uses an unweighted model, for the reasons outlined in the summary of models section, in contrast to weighted model used by the Review.

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Sensitivity analysis 2: Operating Expenditure changes

It is to be expected that state and territory expenditure will vary[11]. This sensitivity analysis has been designed to understand the impact that volatility in expenditure will have on the state and territory shares of assessed expenditure. To develop a range of state and territory shares, a constant population was used with varying expenditure. New expenditures were derived by randomly varying the initial expenditure for each state and territory by up to 10% and the assessed state and territory shares were derived.

This sensitivity analysis model has remained consistent with the existing CGC modelling and has used a log-linear regression, weighted by population. Based on these results, the weighted regression, under certain expenditure scenarios, leads to the Northern Territory (and more specifically a number of smaller urban centres) having a negative assessed expenditure (or at best an assessed expenditure of $0).

Table 2 shows the results of 3,000 randomly simulated models, each with up to a maximum of 10% variation in expenditure from each state and territory's actual expenditure. The minimum and maximum values have been taken as each state and territory's maximum and minimum share across the 3,000 variations. The three most populous states have a greater absolute variability when small changes are made to expenditure values. However, less populous states and territories, such as the Northern Territory and Tasmania, have a much higher relative variation.

This sensitivity analysis shows a small change in expenditure values can have a large impact on state and territory shares, even to the extent that some urban centres are assessed with a negative expenditure. Therefore, as the absolute and relative differences are not small and uniform, the existing CGC model is not robust. Furthermore, as discussed in the previous section, the Review's use of net operating expenditure (subsidies) is not policy-neutral and therefore the Review's model is not fit for purpose.

Table 2: Share of assessed operating expenditure for varying expenditures, 2011

State/territory	Assessed expenditure share		Difference	
	Minimum	Maximum	Absolute (a)	Relative (b)
	— per cent —		percentage points	per cent
New South Wales	35.1	35.8	0.7	2.0
Victoria	30.9	32.0	1.1	3.6
Queensland	14.6	15.2	0.7	4.6
South Australia	5.9	6.3	0.4	5.8
Western Australia	10.8	11.0	0.2	1.7
Tasmania	0.1	0.3	0.2	108.2
Northern Territory	0.0	0.1	0.1	200.0
Australian Capital Territory	0.9	1.2	0.3	30.8

(a) Difference between maximum and minimum share.
(b) The absolute difference relative to the mid-point of the maximum and minimum.

[11] The variability in state and territory expenditure is highlighted in the recent *CGC 2015 Review Significant changes since the draft report*. Table 6 of this report details the assessed investment for Australia as changing from $7.307 billion in 2010–11 to $3.565 billion in 2011–12 (more than a 50% variation for Australia and up to 75% variation in some state and territories).

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Sensitivity analysis 3: Model changes

The CGC currently models per capita expenditure using a weighted log-linear model regressed on population. The third sensitivity analysis investigates the possibility of another statistically significant model. Sensitivity analysis three moves away from a model that is dependent upon population counts and eliminates the need to use UCL populations as a proxy for transport expenditure.

The alternative model in this sensitivity analysis investigates the relationship between expenditure and total passenger distance travelled (referred to as passenger kilometres). As noted previously, the regression model uses data for all significant urban areas with a population over 20,000 persons and their operating expenditure for 2010-11.

Initially the dependent variable (expenditure) was regressed against passenger kilometres, using a simple linear regression. Whilst the model was statistically significant, the plot of residuals verse predicted values were increasing in variability. This was primarily due to Sydney's expenditure being an outlier but also indicated the need for a transformation on the variables.

Both expenditure and passenger kilometres were transformed using the log function and were remodelled. Plots of the linear model and the residuals verse predicted values can be seen in figures 2 and 3.

Figure 2: Log of expenditure modelled against log of passenger kilometres, 2011

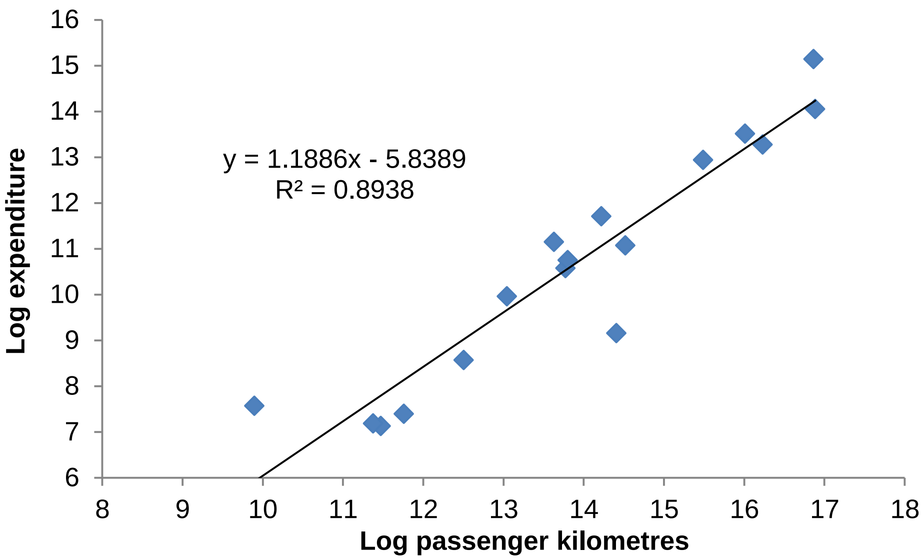

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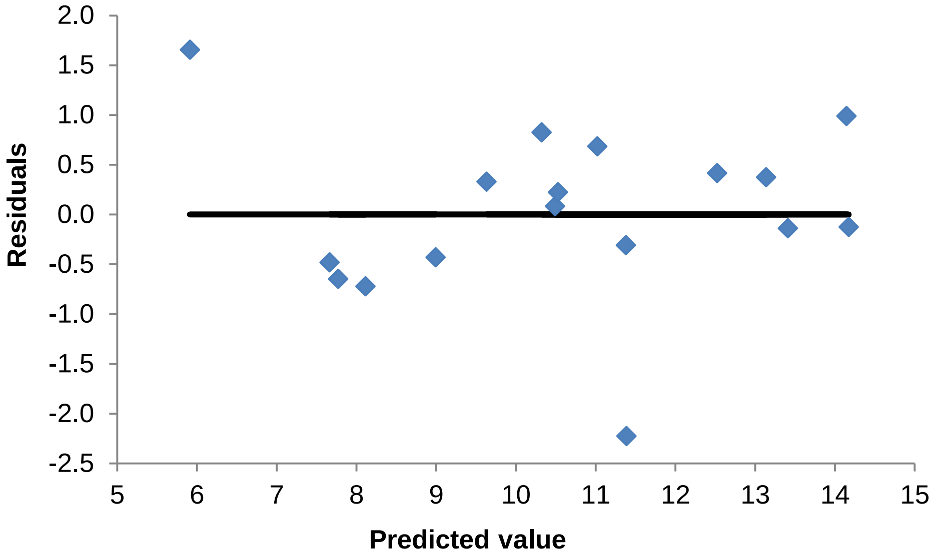
Figure 3: Residual values verse predicted values, 2011



The log transformation shows the residuals are much more randomly distributed and therefore indicates a much better model than was initially fitted. The share of assessed expenditure for each state and territory as a result of this model can be seen in Table 3. Table 3 shows New South Wales has the greater absolute variability (compared to the existing CGC model) when implementing an alternative model.

This sensitivity analysis shows that whilst the existing CGC model may be statistically significant, another model is equally (if not more) statistically significant. Therefore, the existing CGC model is not as robust as it should be. The Commission should undertake more research to determine whether there are statistical models with greater validity and robustness.

Table 3: Share of assessed expenditure for alternate model, 2011

State/territory	Assessed expenditure share		Difference	
	Original model (a)	Alternate model (b)	Absolute (c)	Relative (d)
	— per cent —		percentage points	per cent
New South Wales	34.2	32.7	1.5	4.3
Victoria	29.6	31.0	1.4	4.9
Queensland	16.0	16.7	0.7	4.4
South Australia	6.6	5.9	0.8	11.4
Western Australia	11.3	11.3	0.0	0.1
Tasmania	0.5	0.8	0.3	47.2
Northern Territory	0.3	0.3	0.1	21.4
Australian Capital Territory	1.5	1.3	0.2	14.7

(a) Derived from modelling per capita expenditure (dependent) verse log population (independent).
(b) Derived from modelling log expenditure (dependent) verse log passenger kilometres.
(c) Absolute difference between maximum and minimum share.
(d) The absolute difference relative to the original model.

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Conclusion

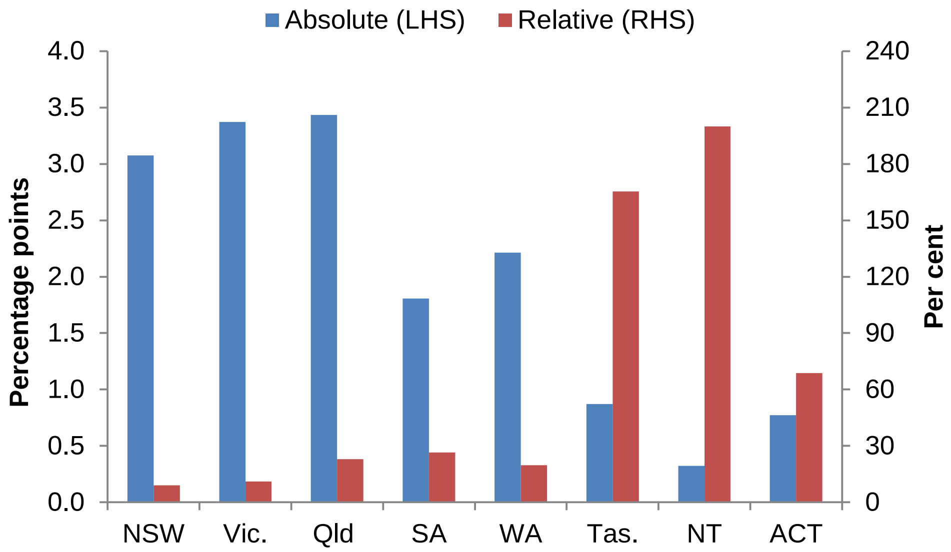
Based on the three different sensitivity analyses, state and territory shares of assessed expenditure can vary markedly.

Figure 3 shows the variability (in both absolute and relative terms) of the results between the three sensitivity analyses. The absolute variability has been derived for each state and territory by taking the maximum share from the three sensitivity analyses and subtracting the minimum share from the three sensitivity analyses.

The relative variability is the absolute percentage point difference (between the maximum and minimum), expressed as a percentage of the mid-point between the maximum and minimum derived values.

Overall, Queensland had the largest absolute variability in its share of assessed expenditure, followed by Victoria and New South Wales. The Northern Territory had the largest relative variability in its share of assessed expenditure, followed by Tasmania.

Figure 3: Summarised variability of share of assessed expenditure across the sensitivity analysis



Overall, the three sensitivity analyses have highlighted the conceptual case for the existing CGC urban transport model to be weak. The sensitivity analyses have revealed major problems surrounding the robustness of the existing CGC model and its fitness for purpose. It also raises concerns about the non-policy neutrality of the urban transport subsidy (net operating expenditure) data.

Based on this analysis, it would seem prudent that, for their final report, the Commission review their existing urban transport models with the aim of deriving models that are more robust and fit for purpose. This research would need to include analysing the link between urban road and public transport assessments.

If this research could not be completed within the timeframe of the 2015 Review this analysis supports the argument that the Commission should remove the urban transport subsidy assessment altogether, or at a minimum, impose a discount of 75% for both the urban transport services and infrastructure assessments.

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