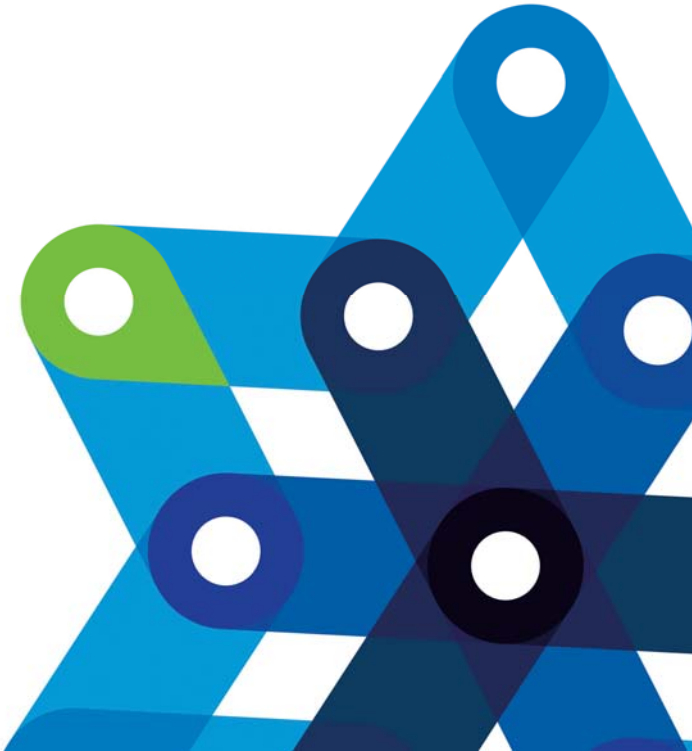
Government of **Western Australia**
Department of **Treasury**

Western Australia's Submission to the

Commonwealth Grants Commission's 2020 Methodology Review

Consultancy Report on Assessing Urban Transport

December 2018



Key Points

- The theoretical specification of the model is weak. In fact, there is no market model as such (i.e. based on equilibrium of demand and supply) and, by selecting multiple proxy variables, the final model specification is a long way from its theoretical underpinnings.
  - The consultants have suggested that passenger numbers are a good proxy for congestion costs, but we consider the supporting analysis to lack validity.
- The preferred model seems to have been selected for its 'goodness of fit' rather than conceptual merit.
  - This is a form of data mining.[1]
  - Looking at the consultants' other models, there is evidence that the preferred model is misspecified.
- All the consultants' variables are affected by policy. The CGC would need to make adjustments to remove the policy influences.
- There should be no expectation that per capita expenses should keep growing with city size (they may initially grow as train systems are put in place).
- Little conceptual or empirical evidence is presented to justify the consultants' view that infrastructure spending has the same profile as net operating expenses.
- Overall, public transport is difficult to model so an equal per capita (EPC) assessment of both urban transport net expenses and investment best reflects a policy neutral assessment of need.

This submission responds to the final Jacobs consultancy report on assessing urban transport, commissioned by the Commonwealth Grants Commission (CGC) for the 2020 Review.[2]

Although the report has a wide coverage of issues, we have concerns about its modelling specification, assumptions and conclusions. Our concerns are around four main issues:

- modelling specification;
- lack of policy neutrality;
- the assumption that costs per capita increase with population; and
- investment expenditures.

[1] Not in principle an illegitimate activity, but one that should be seen as a precursor to developing a robust model based on sound conceptual foundations.

[2] Jacobs (2018), *Urban Transport Consultancy Stage 2 Final Report,* Stage 2 Report to the Commonwealth Grants Commission, IA174500.

Modelling specification

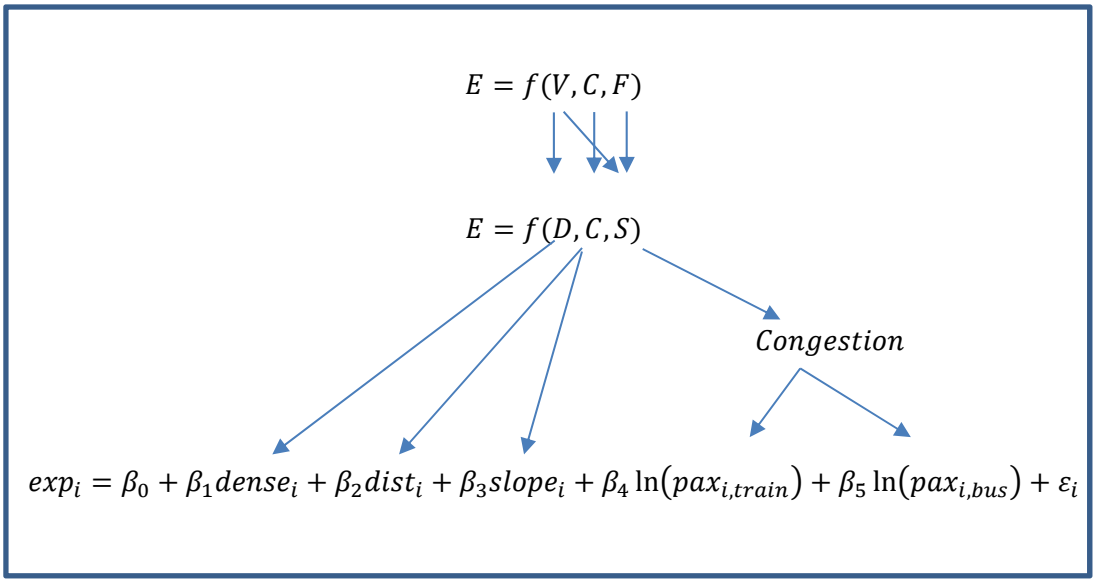
Theory issues

In a standard market analysis, an equilibrium condition is set where demand is equal to supply. This is similar to the approach the CGC used in the 1999 Review for urban transport,[3] where demand and supply functions were estimated and an equilibrium solution found. However, for this review, the consultants suggest that a demand and supply curve analysis is not viable due to a lack of data.[4]

The consultants' preferred theoretical specification for the public transport assessment is a single equation where net per capita expenses (E) are a function of service volume (V), factor prices (F) and city specifics (C). However, the consultants respecify the theoretical model with reference to a demand variable (D) to proxy volume and a supply variable (S) to proxy volume and factor prices, while retaining city specifics.

The consultants then identify a series of proxy variables. The demand variable is proxied by a density measure. The supply variable is proxied by congestion, which is further proxied by bus and train passengers. City specifics are identified by travel distance to work and a topography measure, which is proxied by mean slope of the land.

Figure 1: Theoretical superstructure



[3] Commonwealth Grants Commission (1999), *Commonwealth Grants Commission Report on General Revenue Grant Relativities 1999 Review. Working Papers*, ISBN (SET) 0642 389603.

[4] Jacobs (2018), *Urban Transport Consultancy Stage 2 Final Report,* Stage 2 Report to the Commonwealth Grants Commission, IA174500, page 7.

This layering of proxies means that the final specification is a long way from the theoretical starting point.

- Notably, bus and train passengers are proxies of a proxy of a proxy. They are used to proxy congestion, which is used to proxy a supply variable, and are ultimately used to proxy volume and factor prices.

The association of explanatory variables with demand, supply or city-specific characteristics is inexact.

- Density is said to be a demand variable, but equally will affect unit costs of supply (indeed, the CGC at one stage used density as a measure of total disability for urban transport).
- Distance to work is said to be a city-specific variable, but equally affects demand (i.e. the kilometre aspect of passenger-kilometres related to employment travel but not travel by school children or those not in the workforce).
- The consultants state: "Bus and train passenger counts are robust variables for supply or network related variables such as congestion or the cost of provision."[5]
  - However, bus and train passenger counts relate to quantity demanded. They do not capture excess supply.

The consultants' discussion of congestion and possible proxies for it (i.e. population, employment, public transport passengers) is problematic.

- The Bureau of Infrastructure, Transport and Regional Economics (BITRE) in the Department of Infrastructure and Regional Development calculate congestion costs as:

  > …the estimated deadweight losses (DWLs) associated with a particular congestion level – which, reiterating, give a measure of the costs of doing nothing about congestion or the avoidable costs of traffic congestion.[6]

- Therefore, congestion is considered a negative externality, which is by definition a market failure, requiring government policy. Congestion costs from a policy perspective measures social gains to be had if Marginal Social Costs are equalised to Marginal Social Benefits. Ultimately the consultants measured the social costs of not having a perfectly efficient and effective urban transport policy. Therefore, the indirect assumption is that the number of public transport passengers is a proxy of social gains associated with addressing policy flaws. This makes it unlikely that congestion is a policy neutral measure.

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5 ibid. page 1.

6 Department of Transport and Regional Services (2007), *Estimating Urban Traffic and Congestion Cost Trends for Australian Cities.* Working Paper No. 71.

- Nevertheless, the consultants suggest that population, employment by place of work and passenger numbers could all serve as proxies for per capita congestion because there is a good correlation in each case (at least with a non-linear fit). For example, the consultants say that "in a regression analysis, population will accurately depict the effects of congestion and vice versa."[7] It is correct that proxies need to have a two-way causal link to be proxies. However, it would be entirely implausible to assert such a link between congestion and population, or employment or passenger numbers. Indeed, if passenger numbers were sufficiently high, congestion could be low. The consultants are in effect assuming that a proxy simply has to trend in the same direction as the primary variable, which does not even require a one-way causal link.

- Finally, the consultants reject population as an explanatory variable on the basis that it "will test models in which population enters the regression as part of the dependent variable"[8] (i.e. expenditure per capita). However, expenditure per person is not intrinsically related to population and can therefore legitimately be regressed against population (or variants of it such as log (population)). The CGC's current analysis of urban transport regresses per capita spending against log (population), and this is not intrinsically wrong.

Modelling issues

The consultants say that:

> We tested a wide range of explanatory variables to identify those that produced the best statistical fit.…[9]

This is a form of data mining.

It means that measures of R^2 or statistical significance or bias across States don't have the significance that they might have if there were a firm conceptual underpinning. If you pick a model on the basis of how it performs, you are by definition biasing the usual tests of the model's integrity.

Even so, with a weak theoretical specification, testing for statistical significance is an important component of the assessment of any model. Hence it is difficult to understand the following comment by the consultants.

> With regards to the statistical significance of variables, we would recommend placing less weight on p-values relative to other model and/or variable selection indicators.[10]

It is also unclear why the consultants have used explanatory variables that are highly correlated, and why the consultants do not think this leads to multicollinearity problems.

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7 Jacobs (2018), *Urban Transport Consultancy Stage 2 Final Report,* Stage 2 Report to the Commonwealth Grants Commission, IA174500, page 27.

8 ibid., page 27.

9 ibid., page 1.

10 ibid., page 48.

We consider that the consultants have not demonstrated the superiority of its model 1b over the alternative models 2b, 3b, 4b and 5a/b.[11]

- The alternative models are not as well documented as model 1b.
- The plots of variance across States (where provided) provide incomplete information.
- Model 1b uses passenger numbers as an explanatory variable, which is likely to be more policy influenced than the alternative variables used in the other models (employment, SEIFA).
- Only model 4b tests for the significance of rail systems, which is likely to be an important explanatory variable. (The model also includes dummy variables for ferry and tram systems, but as these systems are in limited use, the quantification of their impact through regression analysis is likely to capture issues unrelated to ferries and trams.)

The explanatory power of the consultants' model across significant urban areas (SUAs) ranging from tens of thousands to millions of people is unclear. The public transport systems for small communities bear little resemblance to the systems serving the larger cities. It is unclear that the estimated coefficients would look similar if the model were estimated only for small SUAs or medium SUAs or large SUAs.

Urban rail services are distinctly different from urban bus services. For example, the operation of bus services is significantly more flexible than rail services. Bus routes, volumes and frequency could easily be adjusted to changing circumstances. On the other hand, the inflexible nature of rail services requires significantly more focus on urban planning and development. As well, bus services in conjunction with rail services need to be carefully designed to optimise the use of the combined public transport system, including through the use of feeder services.

This suggests a two model approach that splits the cities with urban rail services from the rest of the SUAs.[12] As there are only five SUAs with developed urban rail systems (excluding those with feeder lines from other SUAs), there is not enough data to do other than an equal per capita (EPC) assessment among these SUAs. A simplified consultant-type analysis for the smaller SUAs could be considered, with a minimal number of city-specific adjustments.

Based on pervasive policy impacts and the wide range of unobservable city specifics, the pragmatic approach would be an EPC assessment across all public transport, as we argued in our submission on the draft assessment papers.

[11] Models 1a, 2a, 3a and 4a lack plausibility.

[12] See page 8 of this submission for further discussion on the appropriateness of the consultants' model.

Lack of policy neutrality

The CGC indicates that policy neutrality:

> aims to ensure that State policy choices have minimal direct influence on HFE assessments and conversely, that HFE has minimal direct influence on State policy choices.[13]

As explained in our previous submissions we consider that policy neutrality needs much greater emphasis. This is because policy neutrality is critical to proving that the 'same effort' requirement of HFE is being achieved.

The consultants' treatment of policy issues is clear. As explained at the December 2018 telepresence meeting on transport, the consultants consider that it is up to the CGC to make any necessary policy adjustments.

The position taken in the consultants' report is that:

> In our opinion, policy neutrality and a reliable model can only be ensured following a two-step modelling process.
>
> 1) Estimate a model that includes variables accounting for **both** policy-related and policy neutral cost drivers.
>
> 2) Use this model to adjust the expenditure observations to policy neutral levels by removing the effect of policy variables on expenditure. Funds can then be allocated based on the relationships of these standardised expenditure levels.[14]

The consultants' report uses an illustrative example to show the dangers of not taking into account policy differences, but thereafter ignores the issue. Without applying the two-step approach, the consultants' report then declares:

> As the model captures all key relevant (theoretical) drivers, its forecasts can be considered a relevant benchmark for appropriate expenses under each SUA's specific attributes. Hence, it can be applied to derive a policy neutral benchmark per capita expense level for all SUAs.[15]

Therefore this equation (the consultants' preferred model 1b) has no adjustments for policy neutrality:

$$exp_i = \beta_0 + \beta_1 dense_i + \beta_2 dist_i + \beta_3 slope_i + \beta_4 \ln(pax_{i,train}) + \beta_5 \ln(pax_{i,bus}) + \varepsilon_i$$

[13] Commonwealth Grants Commission (2017), *The Principle of HFE and its Implementation*, Commission Position Paper CGC 2017-21, page 19.

[14] Jacobs (2018), *Urban Transport Consultancy Stage 2 Final Report,* Stage 2 Report to the Commonwealth Grants Commission, IA174500, pages 9-11.

[15] ibid. page 2.

Table 1: Policy drivers of selected variables

Variables	Directly policy influenced	Indirectly policy influenced
• Density • Distance travelled • Slope		• Town planning • Infill development • Availability of public transport • Building restrictions
• Train passengers • Bus passengers • Net expenditure	• Price of tickets • Availability of services • Reliability of services • Quality of services • Operational efficiency • System design (choice of routes, modal connections, modal composition, trip frequencies)	
• Per capita expenses	• All of the above	• All of the above

- Western Australia considers that all the variables in the model are either directly or indirectly influenced by policy.
- Our presentation to the CGC on 2 August 2018 highlighted that efficiency can vary significantly across States, in terms of both input costs (e.g. staffing of trains) and system design (e.g. choice of routes, siting of stations and modal connectivity).
- The only policy neutral assessment for Public Transport would be an EPC assessment.
- Adopting a policy-centred rather cost-centred assessment in this area (e.g. "big cities choose to spend more on public transport than small cities") would have ramifications across many other CGC assessments, such as utility subsidies, economic development and mining revenues.

Increasing cost per capita as population increases

The consultants expect an increasing cost per capita in the provision of public transport services:

> The estimates in the [preferred] model follow intuition as the results suggest that net expenses per person:
>
> - increase with urban density (representing demand);
> - increase with the distance to work (representing network complexity);
> - increase with mean land slope (depicting topographical complexity); and
> - increase with train and bus passengers.[16]

Actually, the model is not particularly supportive of the consultants' intuition, as the coefficient for bus passengers is well below significance level and the strongly significant coefficient for train passengers may simply reflect the lack of a train dummy variable. Model 4b provides some evidence that this is the case.[17] On page 5 we suggested that it was more conceptually appropriate to analyse public transport through two distinct models, one for SUAs with buses and possibly train feeder routes, and another for SUAs with internal rail systems.

Regardless of the details of model structure, as the population grows, it could be expected that bus and train passenger kilometres grow more than proportionally, increasing net expenses per person if unit costs and fare recovery per passenger kilometre don't change. However, we can also expect economies of scale decreasing net expense per person. Which is the dominating force?

Notably the CGC's 1999 Review, based on a supply-demand analysis, concluded that New South Wales' urban transport costs were below average. Economies of scale dominated the increasing use.

The consultants' analytical framework reflects economies of scale, graphically illustrating a downward sloping long-run average cost curve.[18] This explanation is consistent with standard economic theory and indicative of a natural monopoly. The consultants also acknowledge studies supporting economies of scale across both bus and rail transport.

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16 ibid. pages 2, 50, 97, 100, 104.

17 Model 4b uses employment rather than passenger numbers as an explanatory variable (well below significance level) and a train dummy variable which is apparently significant (although not being marked as such) even though one could expect the significance to be diluted by the confounding influence of the tram and ferry dummy variables in Model 4b, and also diluted by the possibly non-optimal specification of the train dummy variable (SUAs with only feeder rail from other SUAs have a different cost experience and are best not classed as train SUAs).

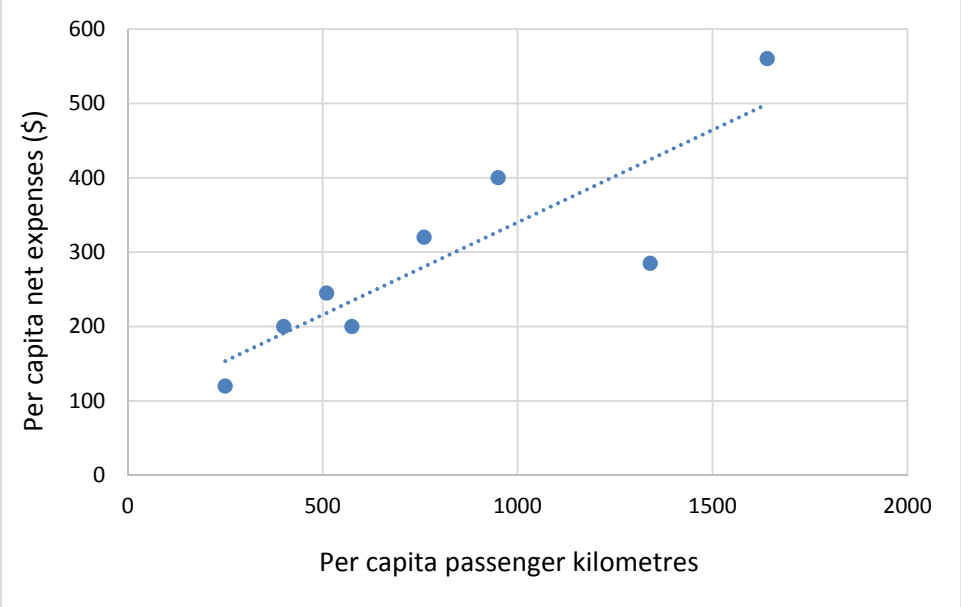
18 ibid. page 5.

> Based on these insights one would expect to at least see economies of scale across both key modes in a wider sense: The associated coefficients do not necessarily have to be negative – this would imply lower cost per capita or passenger – but could just show slowing growth for additional passengers.[19]

Economies of scale are not explicitly considered in the rest of the study. Rather, economies of scale are implicitly embedded in the coefficients of explanatory variables for modelling per capita expenses, and act as a counterforce by reducing the values of these coefficients and hence reducing increases in net per capita expenditure with increasing urban size.

The fact that there are embedded economies of scale can be extracted from the consultants' analysis of spending versus passenger kilometres shown in Figure 2.

Figure 2: Reconstructed net expenses *versus* transport task by capital city, per capita average of 2009-10 to 2011-12



Source: Reconstructed from the consultants' report.[20]

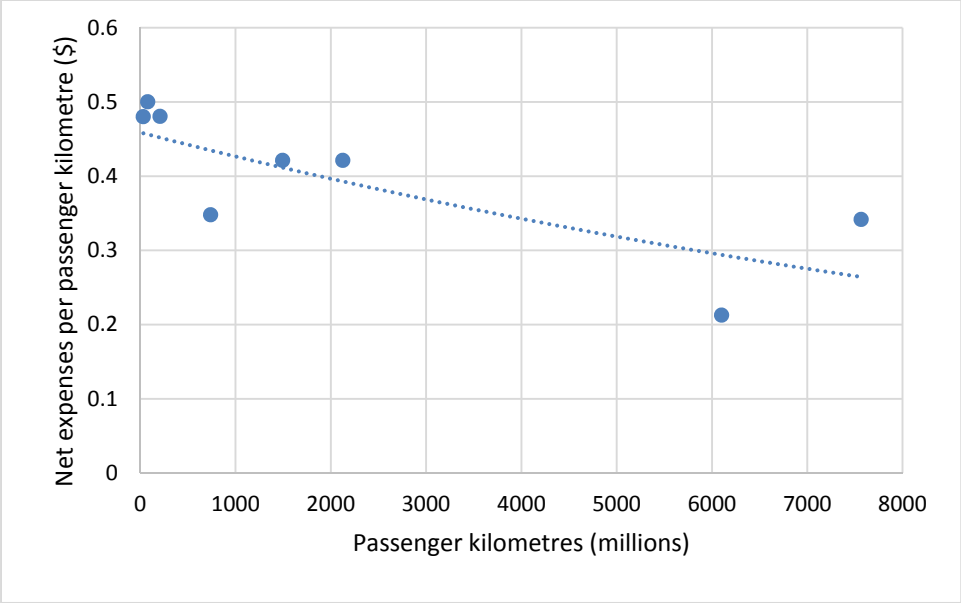
Using the data points from the above graph together with population numbers one can derive the embedded economies of scale illustrated in Figure 3. However, an important qualification is that the observed level of economies of scale may be affected by policy influences discussed above, and may understate the underlying influence of economies of scale.

This figure can be compared with the somewhat stronger economies of scale derived by the CGC in the 1999 Review shown in Figure 4.

[19] ibid. page 8.

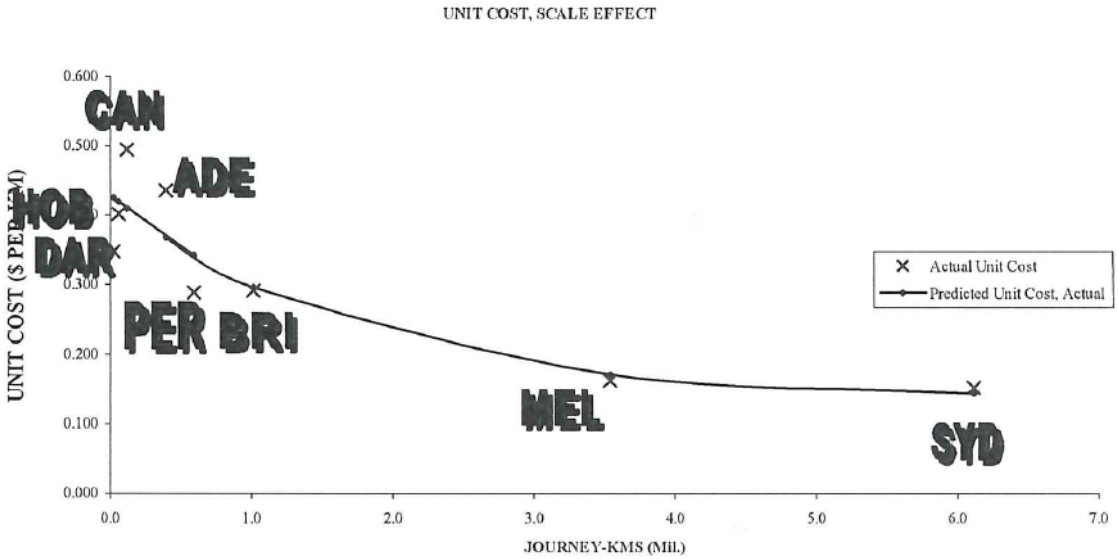
[20] ibid. page 24.

Figure 3: Embedded economies of scale: passenger kilometre cost with population



Source: Western Australian Department of Treasury.

Figure 4: Economies of scale, 1999 Review



Source: CGC.[21]

[21] Commonwealth Grants Commission (1999), *Commonwealth Grants Commission Report on General Revenue Grant Relativities 1999 Review. Working Papers*, ISBN(SET) 0642 389603.

Overall, it appears that there should be no *a priori* expectation that per capita expenses should keep growing with city size (they may initially grow as train systems are put in place). Careful analysis, teasing out the impact of policy, is required to settle the issue, but the required data is unlikely to be available.

Investment expenditures

The consultants argue that the recurrent expenditure model should be used to estimate investment expenditures. They argue that for a system in 'equilibrium' there is a close correlation between recurrent expenditure and investment needs. Although the model is presented as a long-run model, little conceptual or empirical evidence is presented.

- The North American data quoted by the consultants for a stable relationship between operating and capital costs may simply reflect financing practice rather than drivers of need (so the system capacity and quality may be a balancing item and the financing practice may not be sustainable in the long run). The (presumably) aggregated data may also mask differences between systems.
- The consultants argue that the 19 available data points for investment in Australian SUAs (9 from Western Australia) may not be sufficient to model investment robustly. But, they plot the 19 investment data points against operating expenses to build a case for their recommendation and accept those results as reliable. The high 0.98 correlation coefficient may reflect one outlier.[22]
- The consultants assume that quality improvements lead to higher unit costs (for example air conditioning, timetable reliability, etc.). However, even though the total cost might increase, cost per passenger might decrease if more passengers use the service.

We doubt that analysis of Australian investment data would reveal much about long-run public transport investment needs. Expansion of capacity takes time, is lumpy (smooth marginal adjustments are not practical) and precedes recurrent expenditure. For example, the current METRONET program, started in 2018, is being progressively implemented and won't be fully commissioned (and fully reflect recurrent costs) until the period beyond the forward estimates.

The timing and nature of investment is strongly influenced by political factors, competing demands, economic cycles and funding availability.

[22] It is characteristic of ordinary least squares estimation that a single outlier can be the difference between a high and low correlation coefficient.

Other factors affecting investment demand include:

- the need for smaller cities to rapidly develop the quality of their public transport infrastructure (shifting modal composition to rail and increasing public transport utilisation), which needs to be balanced against the pressures in larger cities from growth-induced increased utilisation of a relatively mature network;[23]
- public transport in large cities should take some pressure off the road network; and
- public transport in large cities can more fully utilise running stock, due to less 'dead running' and the broadening of peak utilisation periods.

Overall, we believe that an EPC assessment of urban transport investment best reflects a policy neutral assessment of need.

[23] Victoria's recent $50 billion proposal for a new underground circle around Melbourne would represent a higher level of connectivity than Perth has.