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Transport Cost Benefit Analysis: Are the criticisms valid in practice?

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Abstract

The wide-spread use of Cost Benefit Analysis (CBA) to appraise transport investments is accompanied by a growing level of criticism of the methodology. This is difficult to reconcile with the fact that CBA has been used in Australia since the early 1970s and that, since then, there have been significant developments in its application. This paper investigates whether some of the common criticisms of CBA are valid in practice. Firstly, it identifies and explains the main criticisms. The validity of these criticisms is then assessed by observing whether they are due to shortcomings in the CBA methodology or stem from poor practice. Finally, the paper draws some conclusions.

1. Introduction

Australian practitioners have access to around twenty CBA guidelines published by the Australian and various State Government departments. However, the large number of guidelines belies the observation by Douglas and Brooker (2013) that "*transport project appraisal in Australia centred on Cost Benefit Analysis dates back to the 1960s. From tentative beginnings, through a period of relative stability in the 1980s and 90s, the core approach has largely remained unchanged.*" Despite the longevity and consistency of the CBA approach, and the abundance of guidance, including on some significant methodological developments, the level of criticism of CBA is increasing.[1] Criticism can be a catalyst for methodological development. However, BTE (1999) reflects that "*Furphies about benefit–cost analysis have a way of enduring. Various economists — Herbert Mohring, Mitchell Harwitz and E.J. Mishan, to name a few — have made admirable attempts to dispel them…The problem is partly that many furphies are self-serving.*" Section 2 of this paper reviews the common criticisms of CBA and then investigates their validity by assessing whether they are due to a departure from or a shortcoming in CBA best practice. Section 3 provides some conclusions.

2. Some of the common criticisms of CBA

2.1. Transport CBA routinely excludes disbenefits

Critics argue that CBA's failure to incentivise the inclusion of disbenefits is a major shortcoming. For example, in discussing the concept of '*innovation bias*', Denham and Dodson (2018) observe that, while the number of estimated benefits included in CBA is increasing over time, "*there seems to be no similar rush to innovations that increase costs*." The key risk here is that omitting disbenefits will skew the economic viability and/or ranking of a project. Despite these criticisms, best practice CBA requires that all material benefits/disbenefits are quantified

[1] The range of criticism which relates to procedural and institutional issues (e.g., perceived over-reliance on the Benefit Cost Ratio (BCR) and optimism bias) is not covered in this paper. For coverage of these issues, the reader is referred to Denham and Dodson (2018), who reflect that "*the recent history of infrastructure development in Australia indicates that the rational, technocratic and objective decision -making principles of CBA, have been subjugated to political imperatives, indicating the problems are not in techniques and methodologies, but in the decision-making process.*"

and where possible monetised.[2] [3] This is evidenced in recently released guidance by Transport for NSW (TfNSW) which requires analysts to quantify and monetise construction phase disruption costs (TfNSW 2023a). [4] The omission of disbenefits therefore marks a departure from, rather than a deficiency in, best practice CBA. There is also a temptation to think, given the long list of potential disbenefits, that CBA systematically overestimates the net benefits of projects. However, TfNSW (2023a) guards against this by explaining that "*The assessment of construction disruption cost should be strategic, proportionate to the size of expected disruption….*" This paradigm should be extended to all potential disbenefits as many will fall away or have minimal impact when their effects are contextualised.

The most frequently cited criticism is CBA's failure to account adequately for the negative effects of induced traffic (mainly in the context of road appraisals). Department of Transport (1994) provides a detailed definition of and differentiates induced *traffic* from induced *demand,* in the context of *fixed* and *variable* trip matrix modelling approaches. Starting in a fixed trip matrix setting, Department of Transport (1994) identifies changes in route, changes in the time of travel, changes in mode and changes in vehicle occupancy[5] as possible sources of induced traffic. However, according to Department of Transport (1994), these responses don't *induce* demand because they are made by people already committed to undertaking a given trip. In a fully variable trip matrix context, changes in trip frequency, origin *and* destination are accommodated, as is *generated* demand, where there is a net increase in trips between an origin-destination (OD) pair. The interest here recognises that, while induced traffic generally accounts for a small proportion of total network traffic, it can have a large effect on traffic flow on specific links or ODs. Department of Transport (1994) supports this by observing that "*the economic value of a scheme can be overestimated by even a small amount of induced traffic*." The potential materiality of the impact is shown in Department of Treasury and Finance (2015) economic appraisal of the Western Distributor where the omission of induced demand increases the total present value (PV) benefit by around 30% (excluding wider economic benefits (WEBs)).

Furthermore, most narratives refer to induced demand as being generally a negative phenomenon. However, to the extent to which transport is a derived demand, improvements in road capacity, which allow additional trip making, will increase net private benefit. Therefore, road appraisals based on fixed trip matrix approaches forego the net private benefits of induced demand. Elaurant, Wang and Currie (2017) state the common view that "*congestion reduction benefits from increased road capacity are likely to be short term and quickly absorbed by induced traffic*". While this may occur, it is not unusual for the congestion relief provided in the short term (net of the impacts of induced traffic and/or demand), to be significant enough to more than offset the whole-of-life cost of the project. Secondly, many road projects are aimed at encouraging traffic re-assignment to provide relief on other parts of the network (which may be unsuited to carrying high traffic volumes, including heavy vehicles). Highway assignment models will implicitly weigh any reduction in generalised trip cost (GTC) savings with traffic re-assignment against the longer-lived benefits of a more efficient distribution of traffic across the network. Critics also point to the absence of the induced traffic response of mode shift in road appraisals as a major shortcoming. However, there are few operational models with a mode choice module that can adequately represent the physical characteristics of a road network and

[2] See Vine and Frost (2022) for a long-list of typical disbenefits.

[3] There are many examples of appraisals which appropriately include disruption costs such as Railcorp (2010).

[4] While the requirements in TfNSW (2023a) focus on construction phase disruption costs, it marks an important change by standardising the requirement to include disbenefits in CBA.

[5] For example, a car passenger decides to become a car driver.

that are capable of modelling complex traffic operations within congested road corridors.[6] Constraints to modelling capabilities are often the greatest obstacle to capturing induced traffic and/or demand. Finally, the effort involved in capturing induced traffic and/or demand can be wasted if these trips are valued incorrectly. The marked differences in the impacts of induced traffic/demand on project viability indicates that the valuation approach is not consistent. For example, City of Sydney (2016) observes that the total transport benefits of the Westconnex project only falls by 2.9% when induced demand is included compared with the similar Western Distributor business case in Melbourne where the transport benefits fall by 30%.

Another disbenefit which is often raised includes negative impacts on amenity and/or biodiversity. However, all Australian jurisdictions have comprehensive statutory planning frameworks which govern the identification, assessment and management (e.g., through design refinements) of potential biodiversity, heritage, amenity and natural resource impacts.[7] It would be extremely unlikely for a transport project to proceed to construction with negative environmental/biodiversity effects of a size that would skew an appraisal and hence, warrant estimation of environmental disbenefits.

The omission of construction phase delays can also potentially skew decision making, particularly where night works are not feasible and even in the case where attempts are made to mitigate disruption risk using traffic management (Vine and Frost 2022). While there is merit in assessing the materiality of construction phase impacts, the tempering effects of traffic management, construction staging and the opportunity for behaviour change e.g., re-routing, should be factored into the analysis.

Finally, critics focus a lot of attention on the potential impacts of transport projects on local businesses.[8] Notwithstanding the methodological risks of transferred value, some critics point to the negative effects of projects such as bypasses as having the potential to significantly damage local economies.[9] However, this ignores that a key objective of many road projects, which involve establishing a new route (e.g. bypasses), is to remove through traffic from town centres.[10] In many circumstances this through traffic can diminish the amenity of local streets and thereby significantly reduce traffic flow, pedestrian safety and amenity. This in turn acts as a disincentive for the local community and tourists to access and spend time at local retail, community and tourist attractions. Therefore, positive effects of removing through traffic should be considered along with any disbenefits. Turning to construction impacts in dense urban settings, the CBD and South East Light Rail (CSELR) in Sydney is held up as an example of a transport project which has significant impacts on local businesses. Without diminishing the financial and emotional costs incurred by individual businesses and residents and, confining ourselves to an economic perspective, any upfront disruption costs with projects such as CSELR must be balanced against the economic benefits of (future) *higher value land uses* enabled by such projects (DITRDC, 2022).

2.2. Consumer surplus in transport CBA is not a valid measure of welfare

It is ironic that the role and importance of CBA is largely justified by the need to evaluate alternative approaches to correcting market distortions, including market failures (N. Douglas,

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[6] Moreover, introducing a public transport mode option may be impractical or the corridor does not currently feature a viable public transport mode alternative.

[7] For example, in NSW, Preliminary Environmental Assessments (PEA), Reviews of Environmental Factors (REF) and Environmental Impact Statements (EIS) require a methodical assessment of project impacts (depending on stage) and make specific recommendations on the need to eliminate or mitigate a range of risks as part of the project design process.

[8] During both the construction and operating phases of the project.

[9] While net impacts of bypasses will be location specific, Roads and Maritime Services (2012) finds that impacts on gross annual turnover are relatively small, businesses tend to adjust to account for reduced through traffic and the duration of impacts are generally short-term.

[10] Often comprising a high proportion of articulated vehicles.

personal communication, April 2023). Notwithstanding the importance of CBA in this regard, Harberger (1971) notes that "*I encounter with considerable regularity colleagues who are skeptical of consumer surplus on one or more of several alleged grounds*". The points of contention regarding this central tenet of CBA include: (i) constant marginal utility of income does not hold; (ii) changes in income distribution are not considered; (iii) general equilibrium effects are ignored; (iv) large changes in price/quantity are not accommodated; and (v) revealed preference analysis renders consumer surplus obsolete.

Our paper focuses on the criticism that CBA omits general equilibrium impacts as they relate to major transport outcomes. The partial equilibrium framework which underpins CBA means that the change in welfare with a new transport project is measured with respect to changes in directly affected sectors *and* that these sectors are treated independently of the rest of the economy (Robson, Wijayaratna and Dixit, 2017). The authors further observe that "*significant transport projects can impact demand and supply in other markets, and therefore the transport market should not be treated as independent from the rest of the economy...*". However, application of CBA assumes that all affected markets are complete and perfectly competitive and that industries exhibit constant returns to scale. Under these assumptions, the GTC will reflect the value of transport to the user and hence, the change in consumer surplus with a transport improvement will be a true measure of the ultimate economic impacts of expanded production, wages and employment (ITF 2016a).[11] However, ITF (2016a) also explains that "*When, as is often the case, the theoretical assumptions underpinning standard CBA don't fully apply, the equivalence between direct benefits and final economic impacts breaks down*."

Vickerman (2007) points to the relevance of 'geography' in the context of market distortions as one of the most significant issues for transport appraisal. Specifically, the Department for Transport (2019) and DITRDC (2023) explain that the externality from density of economic activity gives rise to the largest WEB, agglomeration. The relevant analytic framework, referred to as `new economic geography', focuses on the spill-over effects of changes in GTC which increase the 'effective density' of economic activity in affected zones. This occurs through an increase in the proximity of businesses within an existing economic cluster (static agglomeration) or an increase in the size of the economic cluster as businesses relocate to the area with improved transport connectivity (dynamic agglomeration) (DITRDC, 2023). ITF (2016b) refers to numerous studies which demonstrate that economic density has a positive impact on productivity and that clustering is dependent on effective transport systems.

This framework also covers 'land use' benefits in CBA.[12] Liew, Baker and Crane (2018) explain that there is a movement away from the traditional 'predict and provide'[13] approach to infrastructure planning to one which integrates transport and land use to 'shape' the urban form and, in doing so, addresses some of the imperfections in the land market including land rationing, imperfect competition and coordination failure (Department for Transport, 2019). This re-orientation also means that there is now a need to move beyond simply accounting for induced traffic/demand and consider *variable land use* inputs to transport modelling. DITRDC (2022) defines land use change as '*changes in the level of population, employment, or developed floor space within an area, and in the spatial distribution across areas*.' While many guidelines suggest that land use benefit methodologies are still developing in Australia, most have landed on an agreed typology. Importantly, DITRDC (2022), presenting the findings of Smith *et al* (2015), suggests that it is large scale, mass transit projects that are (most) likely to create land-

[11] This is the basis of BTE (1999) observation that "*BCAs tend to measure indirect benefits obliquely, inferring their magnitudes from transport outcomes*."

[12] DITRDC (2022) provides a full list of potential land use benefits.

[13] This approach involves forecasting future demand and building the transport infrastructure to meet that demand.

use change.[14] The study findings show that bus rapid transit projects increase land values by 9.7%, light rail by 9.5% and heavy rail by 6.9%. The importance of capturing the land use benefits of large public transport projects is reinforced by the current situation where, while the cost of rail projects (particularly for 'tunnel solutions') have increased exponentially, project benefits have only increased in line with inflation (Douglas and Brooker, 2013). Despite their potential importance, critics question why WEBs and land use benefits are often omitted from CBA.

Most of the criticisms relating to the omission of WEBs and land use benefits, however, stop at identifying the theoretical impacts of departures from perfect competition without commenting on the relevance or materiality of their effects on CBA results. Most guidance, such as Department for Transport (2019) and DITRDC (2023), requires the analyst to develop a 'narrative' to justify the inclusion of WEBs. However, the expectations of the narrative differ widely, with the latter stating that the decision to include WEBs "*...for particular transport initiatives is a matter for judgement by proponents"*. Moreover, the specific guidance on making this judgement does not require the analyst to demonstrate that there are market distortions and whether including WEBs, considering the potential distortion, will lead to a positive or negative effect on net benefit.

This important context, given by the Department for Transport (1999), concludes that WEBs may be either positive or negative, depending on the relationship between prices and marginal social costs in the relevant markets. This becomes more problematic where multiple markets are affected and the starting relationship between price and marginal social costs across these markets varies. In these cases, Department for Transport (1999) finds no evidence, of the combined effect, to infer the relationship between prices and full social marginal costs. Further to the direction of the impact of WEBs, there is also the issue of materiality. BTE (1999) steps through several theoretical scenarios involving monopoly and oligopoly structures in transport 'using' and 'producing' sectors only to conclude that the actual benefits of improved competition with a transport project is largely tempered by the already stiff competition in many sectors of the Australian economy and the existence of safeguards against limits to competition where this is a risk. HM Treasury (2006) provides further context by explaining that "*where transport connections already exist in mature economies, the contribution that transport improvements at the margin can make to competition, and therefore productivity, is difficult to measure*".

Moreover, correcting for the externality which gives rise to agglomeration is not straightforward. [15] Douglas and O'Keefe (2016) step through some of the practical risks with estimating agglomeration including that: the productivity of some industries does not increase with proximity; increased proximity may reduce prices and output in existing clusters where competition for output is already keen; difficulty in *observing* the source of productivity effects and hence, its attribution to the transport improvement; errors associated with transferring input data (e.g. agglomeration elasticities) estimated for other jurisdictions; and displacement of economic activity with dynamic agglomeration is not given due consideration. Importantly, in relation to static agglomeration, the most estimated type of agglomeration, Abelson (2019) also observes that there is minimal evidence that lower GTC *alone* increases productivity because transport improvements usually create few new business trips. Moving to dynamic agglomeration and on to a broader set of 'land use' benefits, another constraint is attributing land use change to a single project. For example, ITF (2016a) explains that "*A single transport*

[14] See DITRDC (2022) for a list of conditions where land use changes can be expected.

[15] The potentially amorphous nature of agglomeration benefits is highlighted in Douglas and O'Keefe (2016) which suggests that the only driver of agglomeration benefits, which are external to user benefits, are described in Marshall (1890) as intellectual 'spill-overs' whereby "*the mysteries of the trade become no mystery, but are, as it were, in the air*".

project is unlikely to be sufficient to unlock transformative change, its value depending on complementary transport improvements, land-use planning changes, and perhaps even wider demographic changes". ITF (2016b) observes that this challenge is heightened by the need to forecast land use outcomes when coordinated actions among actors are required. Other constraints relate to modelling and valuation of land use change. ITF (2016b) explains that modelling, such as land use transport interaction (LUTI) modelling, is expensive, complex and produces predictions which have not been extensively tested.

Despite the qualifications and uncertainty surrounding land use benefits and WEBs, they feature prominently in the CBAs of many major transport projects. Table 1 shows that in some cases, these benefits relegate conventional transport benefits to minor contributor status.

Table 1: Proportion of total benefits accounted for by benefit types

Project	Land use	WEBs	Transport
[1]Sydney Metro – Western Sydney Airport (Metro Rail)	59%	9%	32%
[2]Capital Metro (light rail) Stage 1	39%	20%	41%
[3]Capital Metro (light rail) Stage 2a +2b	33%	38%	29%
[4]Gold Coast Light Rail: Stage 3A	49%	22%	29%
[5]Sydney Metro City & Southwest (Metro Rail)	4%	47%	48%
[6]METRONET: Yanchep Rail Extension (Heavy Rail)	-	31%	69%
[7]Melbourne Metro (Heavy Rail)	-	39%	61%
[8]Western Harbour Tunnel (Road)	6%	11%	83%
[9]Sydney Metro West (Metro Rail)	20%	20%	60%
[10]Sydney Gateway (Road)	-	21%	79%

Source:
[1]https://www.infrastructureaustralia.gov.au/projects/sydney-metro-western-sydney-airport
[2]Capital Metro Agency 2014, Capital Metro Full Business Case, prepared by Ernst and Young, Canberra.
[3]ACT Audit Office 2021, Canberra Light Rail Stage 2A: Economic Analysis – Report No. 8 / 2021, ACT Auditor General's Report, Canberra.
[4]https://www.infrastructureaustralia.gov.au/sites/default/files/2019-09/business_case_evaluation_summary_-_gold_coast_light_rail_stage_3a.pdf
[5]https://www.infrastructureaustralia.gov.au/sites/default/files/2021-03/SMWSA%20Evaluation%20Summary.pdf
[6]https://www.infrastructureaustralia.gov.au/sites/default/files/2019-06/Project-Evaluation-Summary-METRONET-YRE_0.pdf
[7]https://www.infrastructureaustralia.gov.au/sites/default/files/2019-06/Melbourne_Metro_Project_Evaluation_v2_0.pdf
[8]Infrastructure NSW 2020, *Final Business Case Summary Western Harbour Tunnel,* Infrastructure NSW, Sydney.
[9]Infrastructure NSW 2020, *Final Business Case Evaluation Summary Sydney Metro West,* Infrastructure NSW, Sydney.
[10]Infrastructure NSW 2019*, Final Business Case Summary Sydney Gateway, Infrastructure NSW,* Sydney.

These shortcomings are not new or in themselves a sufficient rebuttal of the criticism that CBA omits WEBs and land use benefits under certain circumstances. The conservative approach adopted in Infrastructure Australia (2021) whereby WEBs should only be reported 'below the line' is understandable given these shortcomings. However, this conservative approach is incompatible with the potentially large value of these benefits, particularly given the mounting criticism of the perceived bias of CBA against large, 'city shaping' transit projects.

2.3. High discount rates used in transport CBA skew appraisal outcomes

The discount rate reflects the return the community expects for deferring consumption. Therefore, a higher discount rate means that the community places a greater emphasis on near-term benefits (and costs). Given the difference in appetites for deferring consumption, it is not surprising that the discount rate is the subject of much criticism. This concern is valid given compounding discount rates can have a dramatic effect on the PV of future costs and benefits.[16] Yet despite these concerns, Grattan Institute (2018) explains *"that almost all Australian jurisdictions have opted, since at least 1989, to use a discount rate of 7 per cent for most transport and other infrastructure projects, irrespective of project risk and real interest rates."* [17]

Wang and Ellis (2021) explain that there are several models which can be used to estimate a discount rate for CBA. However, the favoured approach across Australian jurisdictions is the social opportunity cost of capital (SOC), which is commonly implemented using the Capital Asset Pricing Model (CAPM). The key time dependent variables in this model are the risk-free rate (proxied by the10-year Commonwealth bond yield) and an equity risk premium which captures systematic risk attributable to economy-wide fluctuations. Grattan Institute (2018) and Elauarnt, Wang and Currie (2017) echo the arguments made by many critics that it is difficult to reconcile a 7% discount rate and the risk-free rate over the most recent 10-year period. [18] Critics also argue that the falls in yield should lead to a commensurate reduction in the discount rate.[19] [20] A high discount rate means that benefits occurring later in the evaluation period will make a relatively small contribution to total PV benefits. Critics therefore argue that a higher discount rate will favour projects which generate significant benefits in the near term such as increases in road capacity.

There are however several contextual issues which should be considered alongside the assertion that high discount rates favour certain projects over others. The first issue is temporal. Wang and Ellis (2021)[21] note that, given the time variable nature of economic inputs to discount rate models, results must rely on predicted future values. Therefore, the authors estimate theoretical discount rates for different time periods: short (5 years); medium (15 years); 'evaluation' (30 years); and long (40 years) terms. It is unsurprising to find that the theoretical discount rate estimated using the CAPM model is nearly 8% when viewed over a typical project evaluation period of 30 years. It is only the short-term (5 years) estimate which produces an appreciably lower discount rate at 2.8%. Interestingly, the medium-term estimate, at 4.5% is approaching the central case estimate of 5% recently recommended by NSW Treasury (2023). The cyclical nature of economic indicators, coupled with the time and cost involved in frequently changing the discount rate, means that viewing the discount rate through short or medium-term perspectives is not practical.

Secondly, Grattan Institute (2018) raise concerns that a relatively high discount rate "*prompts decision makers to prefer projects with near-term benefits over those with benefits that extend long into the future*". This statement oversimplifies the typical transport project cashflow in practice. All projects should produce benefits that extend into the long term. It is more likely that this comment relates to cashflows where the benefits are 'back ended'. There are however few transport projects which will give rise to a one-off benefit or step change in benefit profile, of a sufficient magnitude and, so far into the future, that a change in discount rate would make a significant difference to its economic viability. Potentially large, non-marginal benefits, such

[16] For example, the PV of $1 in Year 10, using a discount rate of 4% is $0.68 compared with only $0.39 using a discount rate of 10%.

[17] At the time of writing, NSW Treasury released its latest *NSW Government Guide to Cost-Benefit Analysis* which now recommends a central case discount rate of 5%.

[18] See Reserve Bank of Australia 2023, F2.1 Capital Market Yields –Government Bonds; accessed 6 February 2023.

[19] Reinforcing the deflationary effects of falls in the risk-free rate, Grattan Institute (2018) observe that adopting a single discount rate for all transport projects implies the same level of systematic risk. This, the authors explain, conflicts with guidance and analysis which shows that most public sector initiatives and regulated assets will have lower market risk than projects undertaken by the private or commercial sector.

[20] The observed falls are more significant since 1989 when analysts started using the benchmark 7% discount rate.

[21] It is interesting that despite estimating theoretical discount rates using the three major models, and hence, having an opportunity to deep dive into the workings of each, Wang and Ellis (2021) still "*do not take a position whether the current discount rates adopted in the infrastructure business cases and economic appraisals are high or low"* because "*no one can really predict the future thus it is reasonable to say that the debate on discount rate can never be settled*".

as higher value land uses, are still likely to occur within a reasonable elapsed time from project opening. Another scenario which may give rise to back ended benefits is a step-change in transport demand (and hence, benefits) generated by new employment or residential developments coming online later in the evaluation period. While both these scenarios are possible and would benefit from a reduction in the discount rate, so would projects which face more immediate pressure/opportunity from land use change. Furthermore, this criticism usually focuses on the benefit side. Reducing the discount rate will also increase the upfront construction costs. Therefore, the net impact of reducing the discount rate will be a combination of the timing, profile and relative size of the benefits and costs. Lastly, the issue of 'long-lived' benefits often refers to environmental and/or sustainability benefits. However, this issue largely falls away within the context of transport CBA to the extent to which these externalities, if positive, are marginal in nature and hence, a function of the demand which prevails from project opening.

There are also limiting factors to the criticism regarding high discount rates. Firstly, a scenario where a CBA is commenced, such that there is an unreasonably long elapsed period between the base year and project opening, is extremely unusual. Even with projects such as CSELR, which involve significant construction periods (even including construction delays), there is only around eight years between the base year of the initial CBA and the project opening in 2019/20 (Audit Office of NSW, 2016). Another limiting factor is the recommended evaluation period. For example, TfNSW (2023a) recommends that "*By default, all infrastructure projects should be evaluated for 30 years starting from the date of open to traffic or public transport operation*". Even benefits occurring towards the end of this evaluation period are considered short to medium term compared with the long economic lives of many transport assets let alone transformational environmental, social or land use benefits.

Finally, much of the criticism relating to discount rates is viewed through the lens of examples such as that presented in Grattan Institute (2018) which captures the impact of changing the discount rate on the appraisal results of four markedly different projects: Canberra Light Rail, Murray Basin Rail, Melbourne Metro and Inland Freight Rail. While the analysis is mathematically interesting (because each project is likely to have a significantly different cashflow profile), the comparison is of limited practical relevance because options in a CBA are tailored to address a particular 'problem'. Therefore, it is unlikely that a CBA will feature a light rail project as a viable alternative to a freight rail project and vice versa.

2.4. Transport CBA favours road over public and active transport projects

2.4.1. The role of travel time savings is over-emphasised

Some critics question the validity of travel time savings as a benefit. Metz (2008) argues that changes in travel time with a road project are conserved rather than saved because travellers are motivated by improved accessibility (in the long run). Therefore, instead of using their time savings to undertake other activities, travellers will try to access more distant destinations within their travel budget. Presenting data on average travel time per person per year (1970-2010) from the UK National Travel Survey (NTS), Metz (2008) observes that average travel time holds constant across populations and overtime.

Another convention in Australian CBA which attracts attention is that a constant unit value of travel time is applied regardless of the size of the time saving. Mackie *et al* (2001) shows that the value of travel time savings is made up of two effects – the benefit of a release of time for all other activities and the benefit from a reduction in the disutility of travel. Focusing on the first effect, critics argue that beneficiaries cannot make use of minor time savings due to schedule rigidities and, in some cases, time savings are so small that they are unperceived and hence, have a zero-resource value. Hickman and Dean (2017) argue that the aggregation of these "tiny increments" of time savings is difficult to justify, citing that some countries (e.g., Germany, at the time of writing) discount travel time savings below a certain threshold. The outworking of this approach is that the rates of return from urban road investment (where small travel time savings are enjoyed by many road users) are overestimated (Bureau of Transport Economics, 1982). This characteristic of CBA is described by Hickman and Dean (2017) as *consequentialism*, i.e., CBA prioritises projects that affect large numbers of people. Douglas and Brooker (2013) refer to one of the key challenges of consequentialism in the context of cycling, namely the low base mode share. Pre-pandemic census data from 2011 and 2016 suggest that 3% of commuters in Sydney cycle to work, compared with 22% who arrive by car.[22] CBA finds it difficult to justify investment in modes where even large benefits can only be extrapolated across a small number of beneficiaries.[23]

Mackie *et al* (2018) responds to the criticism of the validity of travel time savings. The authors explain that, while Metz's (2008) argument that time can't formally be saved, holds, the practical outcome is that the beneficiary transfers the time saved between uses of different value. It follows then that whether people choose to use (some or all of) the change in travel time to travel to/from a different location does not undermine the concept of travel time savings as a proxy for the value of enhanced accessibility. Nash (2010) reinforces this by observing that "*if users choose to devote time savings to more travel, they must get benefits at least as great as if they had devoted the time savings to other activities…*". Metz (2008) suggests that there are still problems with this approach, pointing to the increased external costs of induced traffic such as additional congestion, crash costs and environmental costs. However, notwithstanding modelling limitations, these factors are accounted for in a properly applied CBA under either fixed or variable matrix scenarios.

There are also numerous counter arguments to the criticism of small travel time savings. Nash (2010) suggests that small time savings can be aggregated with other time savings and losses over the long run to produce a saving which is larger than the initial impact and Mackie (2001) argues that most travellers' timetables can be re-scheduled over time to make use of smaller time savings. From the perspective of benefit perception, BTE (1999) suggests that common (yet dangerous) driving habits (such as weaving between lanes and speeding) are employed to simply save a few minutes or even seconds from a trip. Mackie *et al* (2001) takes up a similar theme by observing that "*society justifies safety schemes on the basis of changes in small probabilities of accidents which may well go unperceived by users – but no-one argues that the benefits are therefore not real.*"

Criticisms regarding the over-reliance on travel time savings are also rarely balanced by mentions of value of time issues which can favour public transport projects. DITRDC (2021) presents the common view that public transport users have, on average, lower incomes than car users, which lead to lower behavioural values of in-vehicle time (IVT). TfNSW (2023b) explains that an 'equity' value of (non-work) time (which is consistent across modes and users) is used in CBA to avoid creating a bias against lower income people using public transport. However, this introduces a potential scenario where the CBA could justify a public transport project based on benefits for which users are not willing to pay (WTP).[24] For example, Douglas

[22] https://www.theguardian.com/australia-news/2022/oct/30/cycling-wars-resume-in-australias-biggest-cities-but-is-it-a-bikelash-or-just-nimbyism; accessed 6 March 2023.

[23] Particularly if the cycling project leads to any disbenefits (e.g., because of re-allocation of road space) to existing modes.

[24] Nash (2010) is often quoted in this context observing that using an equity value of travel time "*might have been reasonable at a time when appraisal was mainly applied to road schemes which were paid for by the government but gave time savings to users, but now that appraisal is often applied to schemes which trade-off time savings against money cost (e.g. whether to replace buses with higher priced light rail services, whether to reduce road congestion by means of road pricing), it may be highly misleading. It would be quite possible for the*

(2019) shows that for Wellington, the average annual income for rail commuters, car drivers and car passengers is $72,000, $57,000 and $49,000, respectively. Douglas (2019) is supported by the Bureau of Infrastructure, Transport and Regional Economics (BITRE) (2019) which estimates that the weekly personal income in Australia in 2016 for public transport users ($1,503) is higher than for users of private vehicles ($1,261), active travel ($1,265) or other modes ($1,224). Based on these data, Douglas (2019) argues that investment in rail is regressive since rail commuters have higher incomes than car users and conflicts with the accepted view that rail investment requires support for equity reasons. Finally, even though the GTC of public transport modes includes both IVT and (various) out-of-vehicle (OVT) elements, Hickman and Dean (2017) assert that time savings in public transport appraisals are significantly smaller than those of highway projects. Holding aside the issue of demand, these broad statements mask the fact that public transport improvements can impact several GTC elements (including OVT elements[25]) and hence, result in material change in total GTC. Importantly, travellers' perception of time spent in OVT environments is higher than the equivalent IVT. Therefore, savings in OVT make a greater marginal contribution to the reduction in GTC compared with an equivalent reduction in IVT (DITRDC, 2021). This is despite the findings of a workshop of experts in 1997 which recommends that 'private' travel time in Australia by all modes (car, rail, bus, walking and cycling etc. – including OVT elements) should be valued at 40% of average hourly earnings (Douglas and Legaspi, 2018).

2.4.2. Road benefits are more easily quantified and monetised

Critics argue that the problems of consequentialism increase for modes which don't compete on travel time savings. For example, changes in the behaviour of people who ride or walk for exercise or leisure are unlikely to be motivated by time savings (DITRDC, 2016). In the case of some critics, the focus on time savings is only the beginning. They suggest that the prevalence of social, health and wellbeing, land use and environmental objectives of public transport projects means that there is a higher likelihood that a greater number of benefits will go unquantified with CBA. Despite concerns of omitted benefits, the same critics, such as Hickman and Dean (2017), remain highly skeptical of non-market valuation techniques used to attribute monetary values for non-traded goods and services. Focussing on the value of statistical life, the authors suggest that "*Placing a value on human life or other such impacts is highly contentious – there is no price which anyone would contemplate selling their own life. Such practice is morally unacceptable to many, and even invites ridicule*".

These approaches however are long established and inform a range of parameter values from values of statistical life[26] and injury (Roads and Traffic Authority, 2008) through to public transport quality attributes (DITRDC, 2021). There are also recent applications of CBA which capture the health and education benefits associated with transport projects (Jollow and Kulkarni, 2021) and benefits of reducing social exclusion with improved mobility (Stanley *et al*, 2022). Applications of land use benefits and WEBs are also now commonplace and yield material benefits as shown earlier in Table 1.

Again, however, these criticisms rarely mention issues which may serve to underestimate the benefits of road projects. One of the major issues is the treatment of latent[27] and incomplete demand[28]. This issue arises because operational models, which are now routinely used to

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appraisal to conclude that the scheme was desirable on the basis of a standard value of time, when according to the actual values of the users it was not (or vice versa)".

[25] Including, in some cases, the quality of public transport infrastructure such as stops and stations.

[26] Schelling (1968) provides an early exploration of the value of life including the differentiation of 'identified lives' and 'statistical life' and analysis of the benefits of WTP measures over the human capital approach.

[27] Vehicles cannot enter the network during the modelled period due to capacity constraints.

[28] Vehicles cannot reach their destination during the modelled period due to capacity constraints.

forecast traffic behaviour in congested road corridors, are capacity constrained, but often source their traffic growth assumptions from unconstrained strategic models. Stevens and Wang (2019) observe that "*a mismatch from strategic demand modelling and simulation model has been frequently observed on roads servicing high demand areas*". In other words, there are travellers who are prepared to travel at the prevailing (unconstrained) GTC but cannot do so due to artificial capacity constraints. Stevens and Wang (2019) steps through several workarounds to shoehorn the unconstrained traffic demand into a constrained demand model and produce realistic results. However, none of these approaches directly addresses the economic cost of constraining the demand for travel, even at what will presumably be a higher base case GTC estimated by an operational model. The value of this travel will be lost because, unlike suppressed demand, these travellers are willing to travel in the base case, and hence are not 'induced' with the project case. The under-estimation associated with latent demand is compounded by the appraisal convention to cap benefits from the final forecast year to "*limit the benefits as volumes approach capacity*" (Stevens and Wang, 2019). This convention is conservative and implies that the operational model over-estimates the deterioration of the corridor with the base case and/or does not adequately capture induced traffic, particularly re-assignment. While there may be a case for the former, this is largely limited by the capacity constraints of the operational model and returns us to the issue of latent and incomplete demand. Secondly, re-assignment is routinely captured in all models and hence, cannot be a valid reason for this convention. Finally, modelling complexity and cost increases materially when model structures are expanded to include periods outside the weekday peaks and/or additional demand segments or trip purposes. This limits the analyst's ability to accurately forecast benefits of road projects which, for example, target tourist traffic during holiday periods.

2.4.3. It is difficult to achieve and value mode shift to public transport

Some critics suggest that the relative attractiveness of public transport is challenged by the fact that, unlike car trips, the IVT of public transport users comprises only one element of the GTC. Only public transport customers must consider a range of OVT components such as wait time, walk time and an interchange penalty. Importantly, TfNSW (2023b) shows that these components attract weightings which result in the perceived OVT exceeding the equivalent IVT. Further considerations compared with the car mode include the proximity of stops/stations/wharves to users' place of residence and destination, stopping patterns, frequency, operating hours, route and travel speeds. Therefore, public transport projects generally need to produce significant reductions in GTC to encourage mode shift from car. Tsai (2017) observes further that even when mode shift does occur, the benefit to the new users is valued at half that enjoyed by those who used the public transport mode prior to its improvement (continuing users). This convention is referred to as the 'Rule-of-Half' (ROH). [29] Therefore, a key requirement of the ROH is that the GTC of the mode with the base case is defined. This introduces a complexity when evaluating 'new' modes as the base case GTC is undefined and the ROH fails.

However, the change in logsum cost is an alternative measure of consumer surplus which is used in public transport appraisals (e.g., CSLER). The logsum cost measure is based on the combined utility of all mode choices available between an OD, across all ODs in a network (TfNSW, 2013). The modal choices faced by users are defined by a model's modal structure or 'mode choice tree'. The composite cost calculated at the 'top of the tree' is an aggregate across all motorised mode choices. As we move down the tree, the mode choices are broken down until we reach the bottom of the tree where users face a choice between access mode (e.g., park and ride, kiss and ride, bus or walk access) or, even in some cases, station choice.

[29] ROH provides an acceptable approximation when trip demand is linear and the change in GTC is marginal.

In most circumstances, the monetised change in logsum cost should be the same as the benefit estimate calculated using the ROH. Moreover, the change in logsum cost should be the same regardless of the level of the mode choice tree at which it is calculated. However, previous experience shows that the change in logsum cost can be greater when calculated at the top of the mode choice tree. In addition to this discrepancy, the value calculated at the top of the tree masks the proportion of benefits accounted for by previous car trips and hence, can attract criticism as being ‘black box’ in nature. However, a major counter to the criticism that ROH limits the viability of public transport projects, and one that goes largely unmentioned, is that with a logit mode choice model, increasing the number of choices faced by the user (compared with the base case) will always increase the change in logsum cost. A typical example of how the change in logsum cost can be over-estimated is where users are provided with multiple station choices (rather than the least cost public transport links by either walk access or by car access) (N. Douglas, personal communication, May 2013).

3. Conclusions

The main purpose of this paper is to introduce some balance to the increasing criticism aimed at CBA. None of the counter points presented in this paper are new or particularly technical. Yet they are rarely mentioned, even in passing, to balance out the criticisms of CBA. For example, there is no mention of Elaurant, Wang and Currie (2017) which reviews nineteen funded urban road and mass transit projects in Australia and concludes that “*We do not find evidence for a systemic bias in the assessment methodology for Australasian urban road or mass transit projects*.” The findings of Percy and Harton (2009), which analyses eighty-two project appraisals across different modes in Auckland and shows “*that new and improved road infrastructure projects do not have significantly higher benefit/cost ratios than other categories of project*” and “*no one category of project has a clear advantage over other categories in terms of the level of benefit per unit cost*” are similarly absent. Potential publication bias may also extend to criticisms relating to specific aspects of CBA. For example, while many critics cite the results of Grattan Institute (2018) to justify lowering discount rates, few relay the authors’ observation that a reduction in the discount rate “*will also make the economics of all transport projects look better*”. It is impossible to underplay the importance of inputs to CBA, such as the discount rate. Therefore, it is potentially moot to argue that critics should focus on the quality of inputs, rather than the CBA approach itself. Critics also often neglect to mention that any appraisal technique, which seeks to justify future transport investments, will have to use some or all the inputs used by CBA and hence, will attract the same criticisms. The increasing and in most cases unbalanced criticism of CBA therefore runs the higher risk identified by Laird and Venables (2017) that “*ultimately the marginalisation of CBA can result in politicised decision-making and potentially bad decisions*.”

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