Deconstructing the New Zealand Transport Agency Economic Evaluation Manual:

Bringing the best research on transportation and its economic benefit into the applied New Zealand context.

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Abstract

This paper explores the New Zealand Transport Agency Economic Evaluation Manual from the perspective of best practices in international literature. Drawing upon research from the international community and policy-focused bodies like the OECD, the paper seeks to improve the NZTA EEM's quality by employing hedonic and revealed-preference methods to create a more accurate tool to derive the value of certain transport investments. The paper finds that the value of time in New Zealand is far too low, the discount regime improperly reflects the nature of such investments, cycling benefits are undervalued, and property values are not accounted for as well as they could be. The paper then applies these findings to the recently-completed Public Transport Spine Study in Wellington, New Zealand to illustrate the importance of accurate economic evaluation of transport investments.

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Chapter I. Introduction

In modern political decision making cost-benefit analysis is the most common, most powerful, and most important tool employed to determine whether or not a public project should be executed. The cost-benefit methodology currently in use in New Zealand is in need of a review, particularly in the transport area. The transport methods stand out as having areas that need better research behind them if the best evidence is to reach the hands of decision makers. Whether it is fundamental issues that span disciplines like the discount rate, critical elements of transportation analysis like the value of time, or unique changes relative to individual transportation modes like cycling and driving, there are many issues that currently prevent cost benefit analysis in New Zealand from providing the best possible evidence.

Characteristic of these shortcomings is the Public Transport Spine Study recently released for Wellington, New Zealand: an ordinary case where a cost-benefit analysis was produced to analyze an engineering study according to the methods of the New Zealand Transport Agency Economic Evaluation Manual (NZTA EEM). This case illustrates what these issues can lead to – undervalued benefits, costs and dissonant values between modes. Despite this, the study contributes to the study of Wellington's transport context – particularly relative to the costs of construction and the engineering challenges faced by each mode. However, the conclusions of the report have important implications for Wellington's public transport infrastructure, and those conclusions are built upon faulty foundations.

This paper examines 3 aspects of cost-benefit analysis. Firstly, the NZTA EEM is dissected relative to six challenges this paper perceives: discounting practice, value of time determination, cycling safety and health benefits, employing land values as a confirming value of benefits, excluding private automobile ownership costs from initial benefit calculations, and neglecting to determine the value of the community severance effect. This paper compares current methods in each of these categories to international best practice in order to determine what the difference between current practice and best practice may be. This results in a package of best practice methods that will then be applied later in the paper.

The second part of this paper explains these issues in the context of the Public Transport Spine Study. This requires a two-step process. In order to be sure of this paper's conclusions, the Spine Study must be scrutinized if it is to serve as the foundation for conclusions. This is particularly true given that the study evaluates modal choices not currently extant to study within a New Zealand context, and so conclusions about cost-benefit inputs must be scrutinized much the same way this paper examines the methodology used to create cost-benefit outputs. This paper restricts analysis to travel times anticipated given future projected car growth and ridership projections per mode. This is because these two factors are by far the most important for determining overall benefits of a given option; even more important in some ways than the cost benefit analysis methodology applied to them.

Finally, the third portion takes the inputs, and then runs through the cost-benefit analysis practice put forth in each of the relevant areas, in order to provide an analysis of four separate possible scenarios:

1. The existing benefits and costs determined by the Spine Study
2. The benefits and costs determined using Spine Study travel times and ridership data given corrected costs.
3. The benefits and costs determined using corrected travel times and ridership data, as well as corrected costs.
4. The benefits and costs determined using corrected travel times and ridership data, as well as corrected costs presuming a flyover and 2nd Mount Victoria Tunnel are not constructed.

Through the analysis of these four scenarios this paper can determine to what degree existing cost-benefit analysis is a problem and where corrections to that problem may be sought soonest.

This paper seeks to reduce the degree of error in New Zealand cost-benefit analysis, particularly for the transport sector. In this vein, the paper seeks better information for decision makers, better projects getting funded, better options for ratepayers, and better long-term outcomes for the country.

Chapter II. Existing New Zealand Context, Recent Research, and Optimal CBA Methods

Transport investment decisions lean heavily on cost-benefit analysis to determine their viability. In turn, these analyses depend heavily on the parameters employed to evaluate them. The paper identifies six areas where current New Zealand methodology does not conform with international literature: discounting; the value of time; cycling benefit calculation; property uplift; automobile ownership costs; and community severance. Each one deserves close attention, and improving the methodology used to calculate these components of cost-benefit analyses would improve the evidence provided to decisionmakers and ideally improve outcome attainment for transport investments. This improvement will result in better internalizing externalities and helping to seek a more balanced, realistic version of cost-benefit analysis. In doing so, these changes strike a compromise between the myriad needs of decisionmakers while attempting to remove political considerations from cost-benefit analysis whenever possible, replacing it with sound methods founded in international literature that can then be viewed through a political lens. The following explores each of the six areas with an eye towards the existing New Zealand context, pitting it alongside the best literature in the area.

Section 2.01 The Discount Rate

Discounting practice is easily described. It is a tool used to represent the value of a future dollar in today's terms. The methods used to achieve this conflict are primarily divided into two camps. One originates in the private sector, financially-oriented discounting, and primarily uses market rates of interest with a risk premium to discount future values. The second, social discounting, attempts to discount at the rate of preferred consumption, rather than the rate of private interest, to reflect the concept's psychological underpinnings.

Discounting is a relatively recent concept in government, though it dates from far before in the investment world. After making an appearance in government analyses in the 1970s, the 1980s saw discounting rise to prominence (Sáez & Requena, 2007), revolutionizing the practice of cost-benefit investment analysis by incorporating the practical challenges imposed by the cost of capital and the inherent individualistic desire to consume now rather than later. This has resulted in a modern status quo where CBA influences every government investment in the developed world to an extent that the OECD notes "The discount rate is normally the most crucial factor in whether medium to long-term projects pass a cost-benefit analysis" (2007, p. 5). Given this fact, both the why and how of discounting need be examined when looking at medium-term investments, among which transportation fits quite well.

Various writers propose different explanations for discounting as a practice. Some see it employed to represent the quantifiable chance that the population intended to enjoy it will not be there, or the investment will not be there to serve them, due to some manner of catastrophe (Feldstein, 1964; Rambaud & Torrecillas, 2005). Others see the social time preference to consume now rather than later as the primary focus (De Rus & Nombela, 2007; Feldstein, 1964; Hope, 2008; OECD, 2007; Rambaud & Torrecillas, 2005), while still more, including New Zealand, see the defining point of view as market rates of return layered upon the cost of capital (Boardman, Moore, & Vining, 2010; Lally, 2012; New Zealand Transport Agency, 2010; OECD, 2007; Rambaud & Torrecillas, 2005). At a fundamental level, there is compelling reason behind each of these options. For the purpose of transport investment, the existing literature's point of view on discount rate boils down to a few practical options:

- Using a fixed discount rate based upon the cost of capital and market return.
- Using a low, fixed discount rate that reflects respect for future generations' needs.
- Using declining discount rates that track the long-term social perception of value.
- Refusing to discount at all, based on the responsibility to future generations.

The current New Zealand Treasury guidance on transport investment discounting is six percent – just reviewed in July 2013 – due primarily to the logic of the first option above (New Zealand Transport Agency, 2010). Market return on investment is considered and strong arguments may be put forth that the cost of capital alone justifies the use of this method in government evaluation (Lally, 2012). One of the key elements to consider, however, is the broad base of literature that recognizes such discount rates fail to perform adequately both in public and private arenas. This literature ranges from that dealing with forestry (Hepburn & Koundouri, 2007; OECD, 2007), to that dealing with broader ecological issues (Hepburn, Koundouri, Panopoulou, & Pantelidis, 2009; Hope, 2008; Rambaud & Torrecillas, 2005) and generalized public investment (OECD, 2007; Rambaud & Torrecillas, 2005; Sáez & Requena, 2007). The key factor these works acknowledge is that such discount rates as envisioned currently do not take into account several important issues.

Getting to the source of these issues begins with uncertainty and aggregate preferences. Gollier (2002b) details that discount rates as currently employed don't account for the uncertainty surrounding future growth, and thus "…the discount rate to be used for long-lasting investments should be a decreasing function of their duration. This is due to the negative effect of accumulating the per period growth risk in the long run" (p. 163). Further research of his bolsters this position with models that deal with other areas of discounting theory. He models the interaction of wealth effects and precautionary action (Gollier, 2002b) and aggregate time preferences given non-heterogeneous rates of impatience among a population (Gollier & Zeckhauser, 2005) which separately lead to the same conclusion that fixed discount rates do not accurately reflect social time preference. These combined models lead from different avenues to the same conclusion that declining discount rates should be employed by any agency evaluating an investment. The conclusion that discount rates should be declining no matter what the rate is to begin with has an outsized influence on the outcome of cost-benefit analysis, particularly in the long term. Rambaud (2005), OECD (2007), Hepburn (2007 & 2009), Boardman (2010), and Azfar (1999) all note these issues with a constant market-focused discount rate.

Weitzman (1998) further highlights the problems with the existing regime by pointing out practically that, "the logic of exponential discounting forces us to say that what we might otherwise conceptualize as monumental events 'do not much matter' when they occur in future centuries or millennia… Yet almost no one really feels this way about the distant future"(p. 201). His modeling both adds further ammunition to the conclusions posed by Gollier, and provides an additional conclusion that certainty-equivalent social discount rates are the most appropriate rates to employ when looking at the distant future. By modelling future uncertainty about growth rates, Weitzman shows that, in fact, future growth rate uncertainty need also be accounted for when factoring risk into a cost-benefit analysis. Project risk is offset, or more than offset, by the fundamental risk of growth rate uncertainty. His modeling leads to the conclusion that the least limiting discount factor should be employed for any given evaluation (Weitzman, 1998). The least limiting discount factor is the lowest one, particularly as you get further into the future. As a result, he finds that the lowest discount factor possible, and thus discount rate possible, need be employed. In the near future, the lowest possible discount rate is the certainty-equivalent discount rate. In the distant future, it is more likely to be some diminished portion of that rate.

In sum, the discount rate currently employed by the NZTA EEM under option one is denying society a proper picture, and in turn possibly introducing a cost by selecting projects that are not optimal among projects being evaluated. This is particularly true in the transport space, where investments tend to be long lived.

The second option, a low long-term discount rate as proposed in the Stern Review (Stern, 2006) for environmental purposes, offers value for intergenerational purposes. In particular when applied to investments or impacts that aren't necessarily consumption-driven, and that will be felt long after the existing generation has passed, this method has high potential utility. That said, it is particularly unsuited to the evaluation of near-term government action due to its neglect of short-term project risk. This flaw is markedly similar to the existing regime's flaw, but with the opposite outcome. It is because of these opposed strengths and weaknesses that some literature notes the possibility of applying different discount rates to different impacts (Rambaud & Torrecillas, 2005) – for example discounting environmental impacts less than financial revenues. These possibilities are posed, and summarily declined due to the possibility of lending overwhelming effect to certain categories in evaluation. Sáez & Requena (2007) offer a particularly illuminating taxonomy of discounting regimes and the relative merits of each.

Based on the understanding that a change is warranted due to these shortcomings, it is important to note that it is easy to eliminate the fourth discounting option – not discounting at all. As mentioned previously, the risk of the project or the population served being impacted by catastrophe, thus preventing the future use of any good, should set a baseline minimum for discounting. That minimum is quite low, and it resembles closely the second option.

The combination of these strengths and weaknesses of options one, two, and four suggest that option three, a declining fixed (or hyperbolic) discount rate that applies to all government investments equally, is the optimal discounting scheme to employ (Azfar, 1999; Gollier & Zeckhauser, 2005; Gollier, 2002a, 2002b; OECD, 2007; Rambaud & Torrecillas, 2005; Sáez & Requena, 2007; Weitzman, 1998). Schemes based on this concept have already been adopted by the United Kingdom and France, with the United States scheme bearing a remarkable resemblance (Her Majesty's Treasury, 2013; OECD, 2007; Rambaud & Torrecillas, 2005). A number of countries bear similar resemblance when noting the differential discount rates employed in different areas of government. The United States highlights this policy, with financially-oriented (Office of Management and Budget) government departments tending towards higher rates, and environmentally- or infrastructure-oriented (Environmental Protection Agency/Department Of Transportation) government departments tending towards lower rates (OECD, 2007; Rambaud & Torrecillas, 2005). This ultimately is linked to the United States' downward-sloping yield curve. While employing differential rates, these countries would be better served by a unified declining discounting scheme that was employed across the whole of government, whether hyperbolic or fixed, but declining.

Due to this growing global consensus, and the state of affairs in New Zealand, adopting a similar program would yield benefits for the capability of NZTA and other New Zealand entities evaluating future projects, including transport investments. This is a revision already adopted in several OECD countries, highlighted by France and the UK. Below is the framework of their discounting schemes, set side by side with a pair of smoothed versions to combine the best of both in creating one for New Zealand.

Table II-1 Existing International & Proposed NZ Discounting Schemes

Year of Project	UK	France	NZ Social	NZ Compromise

0 – 30	3.5%	4%	3%	4%
31 – 75	3%	2%	2%	2.5%
76 – 125	2.5%	2%	1.5%	2.25%
126 – 200	2%	2%	1%	2%
201 – 300	1.5%	2%	1%	1.5%
301 –	1%	2%	1%	1%

This discounting scheme strikes a balance between the two existing discounting schemes, acknowledging lower annual growth rates per capita in New Zealand (Institute for Health Metrics and Evaluation, 2013) compared to both the United Kingdom and France, and smoothing together the existing schemes. This scheme offers advantages for reasons detailed above, but also because the focus shifts to the longer term as long-term interest rates reduce. This removes the focus on shorter-term analysis which can be more variable as it is affected by fluctuating interest rates, and shifts it to the long-term growth of the economy. This social discounting regime may be challenged either due to institutional inertia or pre-existing notions of the political implications of such a discounting regime. This paper does not concern itself with political issues, but does propose that a compromise discounting regime such as proposed above might provide a middle ground for social discounting and market rate discounting to settle upon. This regime uses short-term certainty-equivalent rates in the 30 year timespan and smoothed decline over time. This compromise reflects the different environment and solidifying consensus that declining CBA is appropriate. For the purposes of our evaluation, this paper uses the social discounting schemes.

The above scheme yields two technical challenges that would need to be addressed by the EEM as well. Firstly, the period of evaluation should be extended beyond 10-30 years, to a minimum of 50 for any project – and ideally 100. Pragmatically, using the existing discount rate negates the value of any such evaluation – but this scheme would require closer attention to long-term trends.

Secondly, due to the detachment of market rates and the social discount rate, it would be necessary to discount payments against project financing as well. Currently, that is not necessary because certainty in financing payments implies the interest rate and discount rate are the same due to the market basis, and therefore discounting nets out in the original value of the financing. This would not be the case if the discount rate and market rates are detached in the manner described, and thus requires such evaluation on a project level.

It is worthy of note that costs should be discounted based on when the resource cost is incurred. It also serves a second purpose of ensuring interest rates are accounted for in an environment where the discount rate is detached from the market rate of interest. In this way, payments account for existing market interest rates, yet reflect the overall net present value of the financing payment's impact. This distribution of impact better reflects the potential for benefits, while implying that separate and severable all-of-government considerations but be evaluated for how much debt is tolerable outside of the cost benefit analysis process.

Section 2.02 The Value of Time

The value of time for cost-benefit analysis is explained relatively easily. It is used to calculate the "cost" of a given trip in more than financial terms. This means, effectively, that a higher value of time equates to a more troublesome commute. This is why modes with co-benefits (public transport, which allows working and reading, or cycling which has health benefits) tend to have a lower value of time than driving, which is perceived to be the most problematic mode.

Quantifying the value of time (absolute time saved) and reliability (reduced variability) is one of the oldest challenges for cost benefit analysis when analyzing transportation investments. This is not just because valuing time is difficult due to its non-economic nature, but also because times vary based upon both work purpose and travel mode. O'Fallon & Wallis (2012) examine the reasons behind this and the existing attitudes in New Zealand. Their research includes such insights as walking time is valued more as leisure, even when commuting, while driving is valued more like work. The NZTA distinguished between 9 separate values of time for different modal choices and 3 separate types of travel for analysis (New Zealand Transport Agency, 2010) until July 2013, when it removed the modal choice distinctions. The variance in value between modes employed matched well with international literature. The values themselves for the three types of travel (during work hours, to and from work, and leisure/optional travel) on the other hand do not, except for leisure travel. Current New Zealand numbers indicate roughly $22/hour for travel during work hours, around $7.50/hour for commuting to and from work or leisure time travel (New Zealand Transport Agency, 2010). This section explores the commuting value of time because the number of trips taken for commuting purposes dwarfs the number of trips taken during work hours.

Various theoretical studies have posited that the value of time is in fact quite low, particularly in situations where "within-route" times are in consideration (Hopkinson & Wardman, 1996). The evidence base for this is highlighted by studies built upon willingness-to-pay foundations such as Calfee & Winston (1998), who find through stated preference methods the value of time to be in the vicinity of USD$4/hr. Within a New Zealand context, a stated preference study of Auckland drivers found the value of time between $7.54 and $20.7 per hour depending on travel conditions (Hensher, 2001). This is not too far distant from the New Zealand EEM value of time of NZ$7.40/hr determined using similar stated preference methods.

On the other hand, studies using revealed preference following toll payments to try and value these aspects tend to show much higher values of time, along with an even more noticeable increase in value of reliability as measured by reduced variance in travel times from day to day (Brownstone & Small, 2005; Lam & Small, 2001). Women in particular find reliability 40% more valuable than time (Brownstone & Small, 2005). Keep in mind that reliability is calculated as the variability in travel time, which by and large is much smaller than overall commute time. As a result, the value of a single minute of variability is far higher, but the magnitude of the overall effect of reliability on a commuter's cost structure for commuting is much lower.

The literature dissects the values relative to the prevailing wage and gross wage rate, leading to the conclusion that the value of travel time itself varies between 20% and 100% of the prevailing wage, depending on congestion, with the strongest argument being for 72% and above when attempting to divine an average for a congested zone (Boardman et al., 2010; Lam & Small, 2001; Litman, 2013a). It is notable that O'Fallon & Wallis (2012) quote a conference paper as disproving the link between prevailing wage and travel time value. However, later work by the same author has in fact proved the link(Jara-Diaz & Guevara, 2003). In addition, the bulk of research indicates such a link does exist, and in fact wage-based tools are employed by the United States Department of Transportation, Canada and much of Europe. Given the large body of work supporting it and the mixed body of work from that author, the O'Fallon & Wallis, (2012) assertion must be disregarded.

With a prevailing wage of NZD$31.90 and choosing 72% as a point to use, Wellington resembles closely the data Lam & Small's (2001) optimized model used as input data, though Lam and Small used US Dollars. Their sample indicated a prevailing wage of USD$31.69. This indicates a value of time, both for Lam and Small and for Wellington, in the vicinity of $22.87. Despite the different currencies, the values are for practical purposes the same. This high value is supported by recent research at the New Zealand Institute for the Study of Competition and Regulation using hedonic price models that indicated a value for each minute of travel time to the central city of around NZD$40/hr spread out temporally over the span of ownership for a house (Pettit, Daglish, Saglam, De Roiste, & Law, 2013; Wannan, 2013). [1]

The value of reliability then layers upon this at 66% of the value of time for men, and 140% the value of time for women (Brownstone & Small, 2005; Lam & Small, 2001). Rather than conducting gender sampling an evaluation can instead use 100% of the value of time to calculate the value of reliability for cost-benefit analysis purposes.

Employing these values as baseline, there are three major influencers needing consideration for the value of time indicated in the literature:

- Purpose of travel – non-optional travel like commuting is burdensome and time is valued higher when computing costs than for optional driving. (Handy, Weston, & Mokhtarian, 2005; Litman, 2007)
- Mode of travel – commuters pay substantially more to avoid driving than to avoid other modes, which implies that they find driving more expensive, or other modes offer more co-benefits. (Elvik, 2000; Litman, 2007, 2009; Russell, 2012)

[1] This research indicated a home value increase of NZD$6700 for each minute of public transport travel time closer to Cuba Mall a home was. When accounting for estimated number of commuting minutes per year this amounts to around NZD$0.67 per minute value of time, or NZD$40.20 per hour.

- Reliability of travel – consistency of schedule, minimization of wait times and congestion. (Handy et al., 2005; Lam & Small, 2001; Litman, 2009; Russell et al., 2011)

The EEM adequately categorizes different modal choices and purposes of travel, with three categories of purpose (work, commute and other) and 10 categories of modal choice (driver and passenger for car/motorcycle, light freight, heavy freight, seated or standing bus, pedestrian and cyclist). As of July 2013, it has now eliminated the modal differences, however, introducing a new wrinkle to the EEM's challenges. Even aside from this, the EEM's problems in its treatment of travel time are still noticable.

Incongruous differentials between purpose and modal split are difficult to justify in light of the existing literature. Particularly glaring is the differential between the roughly equal during work hours travel time values (which match closely with the value this paper determined above for commuting values) and the travel time values for getting to and from work, which are roughly equivalent to the values used to represent "all other" travel modes (New Zealand Transport Agency, 2010). This does not conform with the findings of Handy (2005), Russell (2011,2012), Lam (2001), Litman (2009), or De Rus (2007). Though none of these specify a value of time for non-commute purposes, the consensus is clear that the value of time for commuting purposes is roughly equivalent to the values NZTA EEM specifies for at-work travel.

Possible explanations for this incongruity are a presumed differential based on time being paid or business savings being prioritized in evaluations. However, rather than devaluing accurate measures of travel time's value for commuting, the value for at-work travel should be increased above the commute baseline. As such, values for at-work should roughly equate to the value of time plus some representation of the cost to business for having their employees idled during that time, while commute time value should sync up with the above-determined value of time. The easiest way to represent this would be to add the prevailing wage atop the isolated commute costs. Optional travel can be valued at less than commute levels, but the current EEM level conforms with research that indicates lower values of time for costing optional travel. Further research is needed to determine both numbers for during work hours commute time and leisure travel. This is particularly true of leisure travel. With leisure travel it is possible per the work done by Handy (2005) that additional optional travel time may actually add value to an individual's enjoyment, rather than being solely viewed as a cost, providing wide-ranging possibilities for values.

An additional issue with the EEM is that the way it calculates congestion and bottleneck penalties. These calculations use a value far below even the travel time numbers denoted in the optional travel section of time values, roughly NZD$4 per veh/hr (New Zealand Transport Agency, 2010). It neglects the possibility of multiple passengers and establishes that value of time in congestion is worth far less than when travelling at speed. This disagrees both with stylized facts that driver frustration due to congestion would incur a higher cost than actually travelling towards the destination, and with stylized facts that regardless of whether travelling at speed or waiting in traffic, the commuter's time is worth the same. Additionally, congestion value calculations focus on an incredibly complex section devoted to determining exactly how to quantify the vehicle hours of congestion caused by intersections, exceeding roadway capacity, and bottlenecks in general. This method generates an artificially low value of congestion costs. This should be abandoned in favor of valuing congestion equally to travel time and doing so on a per-person rather than per-vehicle basis. Such an evaluation would create an underestimate as well, as frustration induces a perceived cost. However, it would be much more accurate to reality than the existing system.

Layered atop this is the reality that reliability of transport is viewed, on average, as equally or more important to the value of travel time itself (Brownstone & Small, 2005; Lam & Small, 2001). This is particularly true of women (Lam & Small, 2001), who have a slight population advantage over men in New Zealand and elsewhere, thus raising the value of reliability (World Bank, 2013). That said, reliability accounts for roughly one third the service quality variance compared to travel time value representing about two thirds of the variance value (Brownstone & Small, 2005) when comparing express lanes to standard traffic patterns. To clarify, given a comparison between any two route choices, any differences between them in value of travel quality would be apportioned by the above ratio. This ratio may not hold when compared to the more regimented schedules of a train system, wherein reliability is highest, but it provides a useful indicator of what that higher value of reliability equates to in car-to-car comparisons or bus-to-train comparisons, at least. The higher value for time value and the higher multiple implied by the literature combine to raise the value of reliability using the EEM formulas by at least 50%.

There is one existing issue with the EEM formulas, which rely heavily on capacity and other engineering statistics, in that the formulas don't explicitly demand that population increases and development changes be taken into account for future years. For example, due to the widely-acknowledged concept of induced demand lane expansions inspire development further down a given highway, usually inspiring in the medium term a higher capacity overuse than existed before (Goodwin, 1996). This should be accounted for in long-term analyses. Note that this is true of train systems as well, but no meaningful intraurban rail systems exist in Wellington (or even New Zealand) to introduce such an issue.

Finally, the EEM also neglects to present different values for time when cycling or using any public or active transport mode. Cycling and public transport offer co-benefits in terms of health, decreased need of gym fees, productivity benefits, increased leisure reading time and other benefits detailed in Hopkinson & Wardman (1996), Russell (2012), Russell et al. (2011), and Sælensminde (2004). What this amounts to is a lower value of time for costing purposes when using public transport, and lower overall costs when cycling or walking, roughly half that used when travelling by car. This is represented in the older EEM as time is worth NZD$7.40 when commuting by car, and only NZD$4.80 by public transport (New Zealand Transport Agency, 2010). However, this was revised in July 2013 to equal out in spite of the literature's evidence to the contrary. The evaluation of this modal difference is beyond the scope of this paper, however it is a ripe topic for further primary research in New Zealand. For the purposes of our corrected costs, due to the research consensus on this matter this paper encourages further research to determine the value of the benefits accrued on a per hour basis for active and public transport, as well as psychosocial benefits for car travel, to then apply against this value of time. This paper operates as if the status quo of unequal travel times is accurate – using a 64% multiplier (4.80 divided by 7.40) to acknowledging that public and active transport travel time is less of a nuisance than driving travel time.

Section 2.03 Treatment of Cycling Benefits

Carrying on from this challenge, cycling, as noted previously, has co-benefits in the health area. Valuation of these benefits is typically done on a per-km basis to conceptualize both the dangers of cycling in certain contexts (a cost), and the value of the health benefits accrued (a benefit). These are notably flawed in the New Zealand Transport Agency's EEM.

Cycling trips have experienced a massive decline in New Zealand over recent decades, and evidence suggests this to be a result of transport policies that fail to adequately account for the needs of cyclists (Jakob, Craig, & Fisher, 2006). The 2010 EEM makes strides to rectify this, but is hamstrung by several issues that distort the value of cycling in the eyes of evaluators. Currently, the methods focus too heavily on travel time, and neglect that safety is more important to cyclists than any other consideration (de Geus, De Bourdeaudhuij, Jannes, & Meeusen, 2007; Hopkinson & Wardman, 1996; Sælensminde, 2004). As a result, cost-benefit analyses of active transport undervalue the total social benefit available to society if planners create cycling routes that are both safe and fast, rather than just fast. Having already discussed the challenges implicit in the evaluation of the value of time when cycling, it is necessary to look at other aspects of the EEM's treatment of cycling.

The absence of risk reduction from benefit consideration when investing in cycling-friendly infrastructure is a prominent, and surprising, oversight considering the overall vulnerability of cyclists compared to other commuters and the research prioritizing safety (New Zealand Transport Agency, 2010). This is particularly strange in view of the fact that the only other project type that does not consider risk reduction is land use and parking investments, and the EEM lays out the point that "cycling and walking improvements should specifically address safety and personal security issues" (New Zealand Transport Agency, 2010).

Higher road speed and proximity to traffic or parking alongside roads (due to the danger of opening doors) leads presumably to higher feelings of insecurity, which should be accounted for in the methodology. Measuring safety perception in the EEM is captured separately by willingness-to-pay methodology to capture all benefits. Currently, willingness-to-pay assigns a value of $1.30 per km for health benefits and $.05 per km for improved safety (New Zealand Transport Agency, 2010), which does not comport with research indicating that security is more important than any other consideration to cyclists (de Geus et al., 2007; Sælensminde, 2004).

Safety and risk reduction (security) is prioritized by cyclists above all other considerations, and its value can be as much as the value of travel time – implying that it is perceived as a requirement rather than an option to employ cycling as a commute mode (Elvik, 2000; Hopkinson & Wardman, 1996; Sælensminde, 2004). Despite this lesser value, it is important to get this particular aspect of evaluation correct considering the top-of-mind nature in the mode choice decision. To represent this, Sælensminde (2004) notes that Nordic literature indicates a value of NOK 2/km (NZD$.44/km). This paper cannot access this literature as there is no English translation. However, based upon the research that indicates insecurity is even more important than the marginal travel time cost of cycling, it would seem that this value is somewhat conservative, and thus sensible to employ for low-speed areas until research on the value of insecurity can be conducted more extensively in New Zealand.

Another alternative is to set the value of time ($22.87) equal to the value of insecurity, dividing by the travel speed of commuter cyclists (14km/hr) yielding a somewhat higher value of insecurity of NZD$1.63/km. This likely sets a fair upper bound for the value of insecurity. That said, given the context where insecurity is perceived to be the most prominent impediment to cycling according to international research, it is likely that this value would be more productive to employ to accurately represent the psychosocial and perceptual benefits of safety. Numbers closer to the upper bound should be adopted for high-speed areas (over 30km/h speed limit) and closer to the lower bound for low-speed areas (15km/hr and below).

We can draw the conclusion that the EEM either neglects to separate out improved security, or fails to apply adequate value to the issue. Some would indicate this is the responsibility of the WTP surveys, which has some validity. The health benefits are positive externalities, and though they have higher economic value, they are intrinsically valued less by cyclists when they make the cycling decision. This is because these benefits are accrued primarily to the government-funded healthcare system as a positive externality, while the individual benefit represents very little of that excepting intangible costs like quality of life. Because of this, the values generated by WTP stated preference methodology for transport purposes are brought into question. The issue with the EEM's treatment of cycling extends into the calculation of health benefits. The EEM poses:

"Walking and cycling can have significant health benefits through increased exercise levels. However, this could be offset by an increased exposure to pollutants if the activity involves sharing road space" (p. 2-30).

However, research shows that it is not cyclists who endure the highest levels of pollutant exposure, but in fact motorists and diesel bus passengers who experience the pollutants in an extended fashion (Kingham, Shrestha, Longley, & Salmond, 2011). Contrasting this, electric light rail is the only mode that is superior to cycling in terms of total pollutant exposure, though cyclists do experience higher peak intensities for extremely brief moments. The value of health benefits at $1.30 per km presumably includes a penalty for pollution exposure, but it is unknown to what extent. To compare, the World Health Organization HEAT (Health Economic Assessment Tool) indicates that an appropriate value for cycling per km would be $3.5/km using updated values of a statistical life from NZIER (2010) (World Health Organization / Europe, 2013). Given the lack of transparency for the prior number and the global applicability of the HEAT tool, a value closer to the latter should be adopted.

In sum, numerous changes are needed to reflect current literature in the way cycling is treated for cost-benefit analysis in New Zealand. The changes are summarized in Table II-2.

Table II-2 Proposed Changes to Cycling Benefits

Area of Change	Existing Value	New Value
Value of Insecurity/Safety	$.05/km	$.44/k, to $1.63/km
Value of health benefits	$1.30/km	$3.50/km

One thing is made clear. Whatever individual benefits are created by cycling are *currently* more than offset by any insecurity disbenefits that exist. This is particularly true if one notes that existing benefits in total can be more than offset by the best practice value for insecurity alone. By removing the value of insecurity from play using segregated cycleways, much more accurate data on the value of cycling's individual benefits could be generated, and it seems the government health system could accrue an abundance of potential health benefits were that the case.

Though these represent significant changes to bring the EEM up to the state of the art, for the purpose of later evaluating the Spine Study they have little effect excepting when cyclists transfer to public transport as their mode of choice. Because there are so few cyclists in Wellington, however, and the value of time benefits of switching to public transport may well outweigh the value of health benefits, this paper does not calculate this. That does not in any way minimize their importance when looking at cycling infrastructure in particular.

Section 2.04 Patterns of Development and Transport-Inspired Value

Patterns of development, and specifically property value influences, are inadequately handled in the EEM. It is well-known that transport influences property value. These value increase tend to "capitalize" the itemized benefits – in that they indicate what the sum of total individual benefits are worth to those who wish to use the transport. When they buy a house, or when they buy a business in the area what extra customer value they can expect. Currently, these are ignored as "double counting" in the EEM, but they offer the opportunity for good values to "check" that the benefits indicated by a cost-benefit analysis are sensible.

There are two major areas where the EEM neglects important aspects of transport development, and development patterns and land value changes are one of them. The second is private automobile costs. This paper first addresses development patterns. The EEM states that:

> “Certain external impacts of activities, such as increased land values, may arise because of the improved level of service and accessibility to nearby areas. These impacts shall be excluded from the evaluation because including them would be double counting” (New Zealand Transport Agency, 2010, p. 2-6).

While widely accepted, problems with this point of view have become evident in recent years. Improved level of service and accessibility are tangibly different from the value intrinsic to the improvement of the area surrounding a station. For example higher foot traffic surrounding stations drives superior business opportunities. The superior business opportunities thusly drive better businesses, which in turn promote easy shopping for local residents. But extending further, anything from the design of any installed vehicle or the attractiveness of stations can affect land values. While a certain percentage of capitalized land value certainly represents typified benefits, these typical benefits do not account for the full scope of benefits. Improved travel time and reliability, for example, represent only a small percentage (.000001%) of the capitalized benefits potential predicted in the Spine Study.

Practitioner workshops have noted this contradiction in recent years (Transportation Economics Center, 2010), providing evidence that:

> “While great care should be taken to avoid double counting, recent evidence indicates that part of the increase in land value may be more than just the capitalized value of the transportation and accessibility benefits. It may include option value accrued by non-users of the transportation facility” (p. 18).

The most convincing argument that including some form of capitalized land value is not double counting comes from literature that details the difference in hedonic price effects between modes of transport. Meta-analysis of commuter services price effects finds that all else being equal, bus rapid transit stations have no significant effect on land values, while rail stations cause highly significant increases based on proximity (Debrezion, Pels, & Rietveld, 2007). But what this means is that, in effect, rail modes have intrinsic value uplift based on characteristics not captured in cost-benefit analysis or the EEM.

It is important to ensure that, particularly in densely-populated areas where properties are packed in tightly, land-value changes are accurately captured as the influence could be enormous. Perhaps Lewis-Workman & Brod, (1997) said it best when they noted:

“The presence of transit contributes to the character and form of neighborhoods and creates opportunities whose value may not be fully captured by the intensity of use of the transit system” (p. 147).

It is that contribution to urban form that needs to be better captured in the EEM. To attribute the capitalized cost to benefits, it is important to state what attributes drive this value. When including choices like simplifying the car ownership decision, increasing option value, and allowing all valid transport decisions equal opportunity, the value is evident. Perhaps less evident are the minor differences in reliability and character, such as visual character, quality of ride, and spaciousness, that lend light rail additional value over other mode choices.

In either case, there is broad consensus that there is intrinsic value to development surrounding rail (Bartholomew & Ewing, 2011; Duncan, 2010; Frank, 2004; Huang, 1996; Ko, 2013). Property value uplift surrounding rail stations ranges from 2.61% increase per 250m closer to a station to up to 12% per 250m (Celik & Yankaya, 2006; Debrezion et al., 2007), but perhaps the most practicable value for corrective purposes is that within one quarter mile of any light rail station values are uplifted by 8.60% over properties outside a quarter mile, on average (Debrezion et al., 2007). 8.60% is also a highly conservative estimate, as it is based upon the 2.61% per 250m figure rather than 12% per 250m.[2]

As a result, applying this value in the EEM to any light rail station over and above the value of any Bus Rapid Transit station running on the same line seems sensible. It would be an appropriate way to handle the current exclusion of property value contribution to urban form and other factors which driven the economic difference. By using the most conservative figure this paper can both ensure that it is not overcorrecting based on a single aspect of analysis until similar research that accounts for all variables can be undertaken in New Zealand (or until light rail stations exist to analyze). If a light rail system's benefits already exceed Bus Rapid Transit benefits by more than this amount, no additions should be incorporated.

This is not to discount the worries about double counting. To then incorporate this value into the total benefit calculations, private travel benefits detailed elsewhere should be subtracted (or added, in the case of disbenefits) from the total calculated capitalized value. This determines if additional benefits or disbenefits are yet unaccounted for. It can also be used as a verification tool to ensure benefits are being captured and not excessively estimated. This would essentially render land value uplift as a "correction check" to ensure that benefits are being adequately analyzed.

This method is not perfect, of course. In situations where there are high value differentials between the stations immediately surrounding buildings and those that are around ¼ mile away (such as if a station were placed on Courtenay place) it is not perfectly precise. Alternatively, primary research could be done in New Zealand to establish appropriate values for each mode.

Section 2.05 Automobile Ownership Costs

Of the six issues this paper confronts, only one does not have extensive literature behind it. Existing cost-benefit analysis practice in the exploratory stages for the Economic Evaluation Manual leaves out an important component of transport – the fixed private costs of ownership for automobiles (New Zealand Transport Agency, 2010). This seems dissonant with the public transport options, wherein capital and operating costs are

[2] If data is available, you may also apply the 16.4% value uplift to commercial buildings and 4.8% value uplift to residential buildings predicted in the same study. This paper does both.

included, while variable costs alone are accounted for in the case of private vehicles in this initial stage.

When attempting to capture the true total cost, and more importantly the economic efficiency, of transport options, this oversight is deeply damaging to the accuracy of such initial analyses. Though these do not represent direct costs to the government, when attempting to capture the economic efficiency of transport options it is important to formally recognize the distributed transport spending that is occurring as a result of these planning decisions, even if it is induced by the project at a societal level rather than a project level.

Contrasting to the costs of parking, capital ownership and maintenance of private vehicles, another component should be captured- the positive psychosocial value (mental health value) of owning and using a car (Ellaway, Macintyre, Hiscock, & Kearns, 2003). Though these two values offset, capturing each individually increases the precision of cost-benefit analyses for the purpose of economic efficiency. Each dollar represented as cost that is not offset by psychosocial benefits is an opportunity cost to the rest of the economy – particularly discretionary goods.

To capture this, rather than turning to the literature, existing New Zealand data offers ample information about costing out ownership of a vehicle thanks to tax necessities. The Economic Evaluation Manual already calculates average car ownership costs on a per-km basis – pegged at 99.9 cents. Complimenting this, the Ministry of Transport calculates the average mileage driven per light vehicle at 12242km annually. As a result, each car owned incurs an average of $12,222 in costs to its owner for fixed and variable costs. This number captures the price of registration, licensing, road user charges, depreciation, petrol, and maintenance. Atop this is layered the EEM resource cost indicated for parking of $11.40 per trip. This includes both the cost to user of around $4 and the cost to society of providing those parks. Finally, adding atop the $.10 per km of environmental costs leads to a complete picture of the costs of private vehicle travel. Incorporating these are both important elements to include in any preliminary cost-benefit analyses, particularly when modal shifts drive changes in the level of car ownership.

It would be useful to include a psychosocial benefits calculation, but among the available literature no attempts have been made to quantify the value of this benefit. It has been left out exclusively due to this inadequacy and it is suggested that further research should be undertaken to quantify the differential between psych treatment costs and option value for car owners and non-car owners.

Section 2.06 The Community Severance (Barrier) Effect

The community severance effect is the value of how much more difficult a project makes it to get around the area the project is built. If a road is laid in between two friends' houses, or your house and work, a store, or a recreation area, this influences the perception of how easy the commute is, and leads to trips untaken, sales foregone, and social connections missed. Some countries have achieved costing of this issue, which New Zealand acknowledges in the EEM but has yet to cost out.

The EEM's cost-benefit analysis, specifically, lacks a methodology for capturing the value of the community severance effect. The EEM defines it and declares that it should be quantified, but fails to provide a methodology for converting the effect into dollar value outside of a limited scope.

The effect is defined in the EEM as "the dislocation and alienation a community feels as a result of roads which sever communities or hinder access. It includes the effect of traffic on security and mobility of people, particularly pedestrians and cyclists and the consequential effects on their movement patterns and interaction. (New Zealand Transport Agency, 2010). Additional definition is gleaned from the literature, which provides a more precise vision of the impacts implied – "The divisive effects of major roads result in fewer journeys on foot being made due to their increased duration or because of the poorer quality of the environment. [These are] considered 'real severance' and 'perceived or psychological severance,' respectively." (Mindell & Karlsen, 2012). Beyond this, Mindell & Karlsen (2012) provide a history of the origination of the concept and the overall impacts that follow on from the reduced trips – reduced social contacts, poorer matching between transport mode preference and actual mode, lower longevity, reduced support networks, fewer friendships, lower organizational membership. All of these add up to a vast interconnected network of effects that deal primarily with the construction of social networks and conceptualization of ideal life.

Currently, the EEM aims to quantify the effects of community severance simply through the additional travel times that arise based on the re-routing of pedestrian and cycling traffic. This portion of the effect should definitely be included in any analysis. However, this fails to capture the full psychosocial, health and commercial impacts of the introduction of community barriers, as it does not capture trips not taken, or perceptive effects on neighborhoods surrounding roads. Two options appear for evaluating the cost of severance that do not include further use of land capitalization.

Sælensminde (2004) provides us with an estimate of the value of the barrier effect at approximately the value of pollution (at Norwegian prices) or, more importantly for our purposes, twice the value of noise disbenefit. Noise approximates the level of traffic and is tied both to engineered capacity and policy outcomes of congestion. A value of $480 NZD/pers/db/year already illustrates how strong this could be of an effect. However, this rule of thumb is inadequate for our purposes. A more useful value is a Canadian value estimated at approximately $1000-1500 per affected person per year (Litman, 2012). Calculating "affected" individuals presents a challenge. Though this paper can model work trips and food shopping, hobby shopping, travel or simply visiting friends would be impossible to model accurately. As such, determined affected persons is inadequate.

Alternatively, Litman (2012) provides a collection of literature relating to the barrier effect, zeroing in on two countries that have data on per car km values of severance. These include Canadian and Norwegian estimates, with the Norwegian ones coming from the same author, and come in at 8.7 Canadian cents per mile (5.4 per km) and 4-7 cents USD per km in Norway (Rintoul, 1995; Sælensminde, 2004). This equates to a range of 4.95-8.65 New Zealand cents per km.

Neither method is inherently more justifiable, though both are quick to calculate as the required data is already generated through the evaluation process. However, the per car km method is more likely to represent value when modal shifts happen. It also better represents the fact that even if an investment is made that divides a community, car traffic must increase to increase the barrier effect. Presumably government builds roads to suit traffic demands, present and future. If this is the case, car kilometers driven likely represents the severance effect well. Using the Norwegian value of 5.4 cents per km remains at the conservative end of the 4.95-8.65 range, which is preferred. The severance effect can be calculated from there. Increased car kilometers results in a negative effect, while decreased car kilometers results in a positive net effect. [3]

Section 2.07 Summary

The changes in methods suggested above results in huge differences in the calculated values of both costs and benefits of various options, particularly in the case of changes to the discount rate. The end result is measured, objective cost-benefit analyses. That said, political considerations could drive the selection of parameters, as with any analysis tools.

As a result, the optimal solution for non-political advisory entities, whether consultants, agencies or ministries, is to calculate both the old numbers as a "traditional" option available to those political entities that prefer it and the new values can be employed as an updated method for those who desire the most up-to-date research. Thus the political entities are left to make decisions based on their preferred methodology while the integrity of the advisory entities is maintained.

For the purposes of the remainder of this paper, dealing with the Public Transport Spine Study, all but the treatment of cycling benefits is employed for analyzing the changes that occur as a result of using these updated methods.

Chapter III. Spine Study Input Analysis

In order to put these methods into practice, realistic input data must be fed into cost benefit calculations in ways that accurately represent the effects anticipated. Due to interest in analyzing the Wellington Public Transport Spine Study, the study presents a logical first place to seek such data. However, there are noticeable oversights in the Public Transport Spine Study that must be remedied in order to accurately represent the relative value of each change.

Section 3.01 The Travel Times

The Spine Study models travel times as being equivalent for Bus Rapid Transit and light rail at peak hours; distinctly unlikely given that the buses are expected to share traffic space through various portions of the route, particularly the most congested ones. It also notably neglects international research on ridership that indicates light rail would

[3] It is worthy of note that each active transport trip untaken represents a disbenefit to the tune of 76 cents per kilometer, but this is likely due to double counting benefits detailed earlier in the cycling benefit section and thus must be excluded from this line item.

have higher ridership than Bus Rapid Transit. Finally, it errs in including a rail tunnel that, from an engineering and policy perspective, is wholly unnecessary[4]. As such, a combination of adjusting the existing numbers in the Spine Study and employing outside sources for travel times and ridership must be employed to properly account for these errors.

Travel times from the railway station to Kilbirnie differ based on a variety of factors, including exposure to traffic and requisite number of services to serve existing ridership. The base travel times to Kilbirnie of 24 minutes for the normal bus option, 13 minutes for Bus Rapid Transit and light rail, excluding congestion delays (AECOM, 2013; Google, 2013), are provided by a combination of using existing times detailed in the study and applying travel speeds detailed by (Litman, 2013b) to the planned route.

In addition to distance covered, existing congestion at the basin reserve must be accounted for. Given the doubling of capacity expected from the second Mt. Victoria tunnel, and the construction of a potential flyover, this delay may fall. However, Kilbirnie and Newtown are projected to be high-growth areas for the city. The potential for induced traffic of up to 40% of existing traffic is high given the existing congestion (Goodwin, 1996), the existing Mt. Victoria tunnel being already over capacity (NZTA, 2012a), and congestion unmitigated expected to add 75% to travel times by 2021 (NZTA, 2012b). Congestion around the Basin is also driven by Adelaide road traffic (35,000 cars/day), which is expected to grow as well. Any congestion reduction achieved is likely to all but disappear by the end of any 30-year cost-benefit analysis, meaning the projects represent more of a band-aid than a long-term solution to the issue. The end result of this is the table below, with congestion times for each mode generated using methods in the Appendix:

Table III-1 Congestion Times Through the Basin Reserve

Congestion Times (minutes) through Basin - with SH1 flyover/duplicate tunnel			
Year	Bus (Base Case)	BRT	Light Rail
2013	10.25	10.25	10.25
2014	11.00	11.00	11.00
2015	11.75	11.75	11.75
2016	12.50	12.50	12.50
2017	13.25	13.25	13.25

[4] The tunnel through Mt. Victoria makes little sense because a perfectly viable route for the light rail would be going up Constable street. Constable street not only has more than enough space for a light rail (though GWRC wrongly claims homes would need to be demolished), but is graded specifically for rail due to the fact that it was initially a conduit for the prior tram network.

2018	14.00	14.00	14.00
2019	14.75	14.75	14.75
2020	15.50	15.50	15.50
2021 (Operational)	0.00	0.00	0.00
2022	0.00	0.00	0.00
2023	0.00	0.00	0.00
2024	0.00	0.00	0.00
2025	0.00	0.00	0.00
2026	0.00	0.00	0.00
2027	0.20	0.00	0.00
2028	1.11	0.34	0.00
2029	2.04	0.96	0.00
2030	2.61	1.33	0.00
2031	2.98	1.57	0.00
2032	3.35	1.82	0.00
2033	3.72	2.06	0.00
2034	4.09	2.31	0.00
2035	4.46	2.55	0.00
2036	4.83	2.80	0.00
2037	5.20	3.04	0.00
2038	5.57	3.29	0.00
2039	5.94	3.53	0.00
2040	6.31	3.77	0.00
2041	6.68	3.94	0.00
2042	7.05	4.19	0.00
2043	7.43	4.43	0.00

See Appendix A for assumptions and basis.

Construction delay influences are difficult to predict. As such, this paper neglects to model them. The doubling of capacity as the new Mount Victoria tunnel comes on line is modeled as reducing the delay substantially initially, with the delay returning to growth thereafter. The rail options are penalized at 33% of the congested time of the standard bus, as it does not share any right-of-way fully with other vehicles. Ridership increases that remove vehicles from the roadway reduce congestion for all vehicles, so congestion trends lower when ridership growth outpaces population growth and induced demand increases. Additionally, Bus Rapid Transit is penalized at 66% of the congestion time given that it does not have any light waiting times, but still encounters general traffic through the Mt. Victoria tunnel.

It is important to note that if the existing planned roading upgrades go forward alongside a light rail option, congestion times drop precipitously due to a massive supply of both car and public transport capacity (as reflected in the table above) given that rail cars can be run more frequently to accommodate ridership growth and the dual Mt. Victoria tunnels could accommodate nearly 40,000 cars a day. Additionally to these issues, travel time benefits accrued by non-users (other drivers) are also modeled through these congestion reductions.

Section 3.02 The Ridership

The existing ridership modeled for the options in the Spine Study is interesting in two ways. It relies on revealed preference models built for the Greater Wellington region (a region that includes no light rail) to model both bus and light rail options. On top of this, it models little in the way of modal shift in the base case, in spite of the fact that the councils collectively are aware of building congestion in the railway-to-airport corridor (AECOM, 2013; Wellington City Council, 2013), and population is expected to increase by 25% by 2041 (AECOM, 2013; United Nations, 2008). These two factors combined should lead to large increases, particularly given that Kilbirnie and Newtown are both high-growth areas.

Both of these issues lead to a degree of doubt in the findings, but when compared with existing reviews of multiple installations of this type of transport infrastructure, that doubt is well-founded. Particularly notable is the Spine Study finding that Bus Rapid Transit increases ridership by roughly 8%, while light rail does not increase ridership at all. This paper does not adjust Bus Rapid Transit ridership, though information released about BRT indicates that installations struggle to meet ridership targets (Henry, Litman, Authority, & Austin, 2006; Henry, 2012)[5].

[5] Here we meet an interesting conundrum. Given the shortcomings in the modeling of light rail, shown on the next page, the light rail numbers must be corrected. That said, it is likely that the GWRC is better at modelling BRT, given it's similarity to the existing context, than light rail. The question arises of whether or not to adjust the BRT numbers based on the international literature that suggests it would only raise ridership by 1-2% in

Tennyson (1989) shows, through a review of both existing modeling practice and existing installations of comparable bus and light rail systems, that light rail tends to exceed bus ridership by roughly 40%. In fact, he notes:

> *"Because transit use is a function of travel time, fare, frequency of service, population, and density, increased transit use can not be attributed to rail transit when these other factors are improved. When these service conditions are equal, it is evident that rail transit is likely to attract from 34 percent to 43 percent more riders than will equivalent bus service. The data do not provide explanations for this phenomenon, but other studies and reports suggest that the clearly identifiable rail route; delineated stops that are often protected; more stable, safer, and more comfortable vehicles; freedom from fumes and excessive noise; and more generous vehicle dimensions may all be factors."* (Tennyson, 1989, p. 6)

The Spine Study anticipates 25% population increase along the transport spine, while anticipating a Public Transport demand increase of a mere 3% (AECOM, 2013). This minimal increase is out of synch with realistic predictions of public transport mode share. Given the additional capacity of light rail and the preference of commuters to use light rail even over BRT options (which themselves would offer more ridership than traditional buses) this population increase should be modeled while maintaining most of existing mode shares.

Due to these combined issues, modeling the ridership of light rail as having an increase over bus would seem an appropriate solution to correct for this neglect. It would likely capture a great deal of the oversight in the area of modal shift, as well as capturing the differential between BRT and light rail that is qualitative in nature. For a short term basis, Henry et al. (2006) note that over a 7-year span, North American New Start light rail installations saw ridership increases of approximately 16%, which extrapolates out to about 68% increase over 30 years, while bus-only installations funded through the same program saw increases of around 1.7%. It is likely that this growth pace would not be sustained, however, because some of it represents early decisions to change residential choices to enable use of the light rail line. Tennyson (1989) provides numbers that indicate in the longest of terms the increase should be around 40%. As a result, using ridership numbers that increase by 14.3% in the first seven years, tapering off to around 40% total increase over bus options 30 years out, seems an adequate solution.

It is worth noting here that while these numbers seem large, there is massive unmet demand in parts of Wellington, including nearly 18% of Newtown residents (and even 22% of Churton Park residents further out) along the spine who would prefer to commute by public transport, but are not served adequately (Betanzo, 2013). Given this, 16% increase is not unrealistic over a short time. Given light rail's ability to attract riders and the compounding nature of these increases, over 30 years 40% is also not unreasonable. Applying this modifier is a "minimum" solution that solves a relatively simple oversight without excessively modifying of a GWRC model that likely is quite

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the first 7 years, or add a premium on to the international numbers suggested by the literature for light rail. In terms of taking a do-minimum approach, it would seem that the best option is to leave the numbers unadjusted for BRT. This may result in a slight overestimation of the value of BRT benefits.

good at predicting bus ridership. This yields a 2041 AM peak ridership number of 48,506.

Given the existing population of the mesh blocks in the catchment within 400m of the transport spine of 37269 (Statistics New Zealand, 2006a) and the predicted bus ridership of around 36000, the ridership of 48,506 in 2041 matches well on a mode share basis with population of 48,449 within 400m of the line. It is worthy of note here that the increase of ridership in proportion to the catchment population (in fact exceeding catchment population) is expected, given that Lyall Bay, Miramar, and northern suburbs are all served by the light rail via park and ride or trains, and their influence must be considered when comparing the ridership numbers to the catchment population.

Section 3.03 Properties Receiving Value Uplift

The properties that receive value uplift need to be determined. This is in order to value them and then apply the uplift in order to evaluate total benefits and marginal benefits between modes that are currently not represented. Any parcel within 400m of a station is flagged and the value is added to an aggregate number, which is then multiplied by the uplift percentage calculated in the Public Transport Spine Study for the base case and the numbers indicated by the growth patterns section for the improved case. The map of stations and parcels, with selected properties circled, is indicated below:

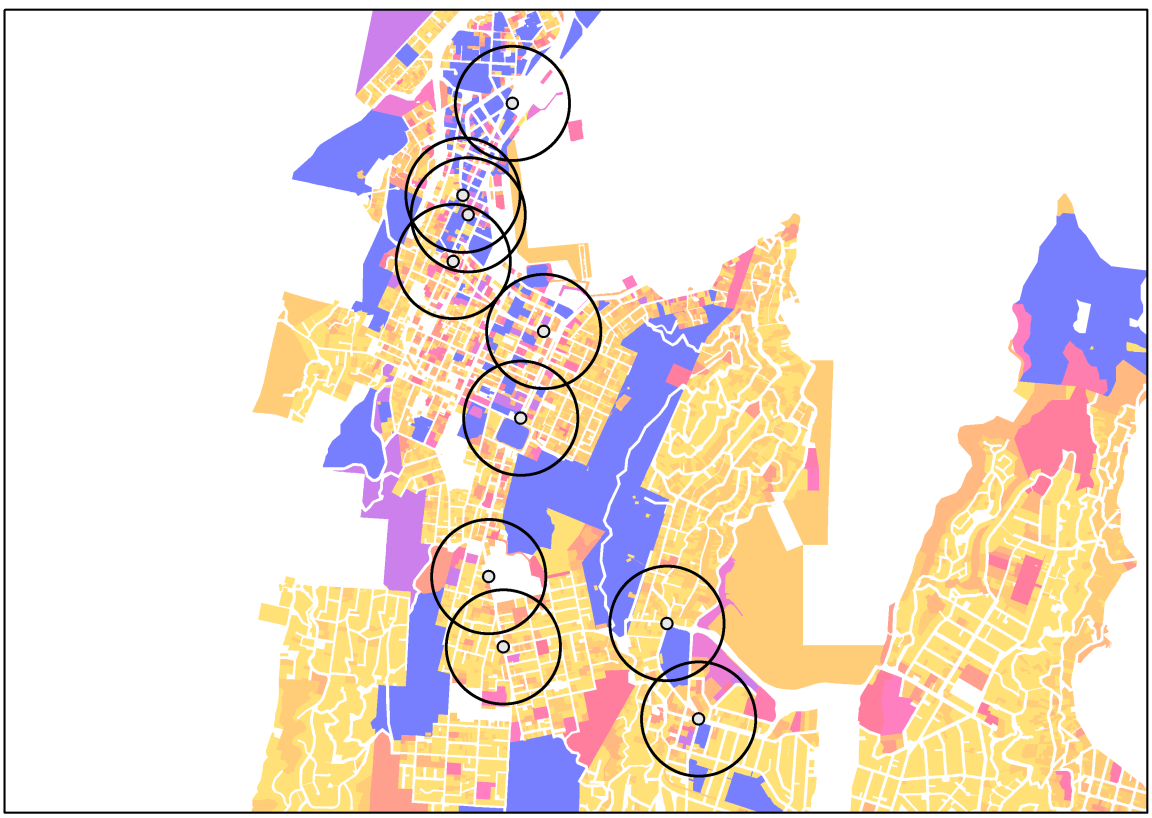

Figure 1 – Properties affected by Value Uplift

(Map courtesy Richard Law - Victoria University of Wellington School of Geography, Environment and Earth Sciences)

In order to remain accurate, only commercial and residential properties are added to this sum, as literature only exists to support uplift in those two categories of property. The total value of these properties in this area is $19.7 Billion.

Section 3.04 Difference in Car Kilometers Travelled

A necessity to understand the private vehicle ownership costs is understanding the difference in car kilometers travelled. The differences in demand between options must come from alternative travel modes, either active transport or car. About 27% of Wellingtonians commute by active transport (Greater Wellington Regional Council, 2011). Combined with the 20% who commute by public transport, modeling 50% of the shifts as car to light rail is not unreasonable. The reduction in car kilometers travelled, however, is likely to be dominated by shifts from those in Kilbirnie, Island Bay and additional commuters through the railway station. As such, given the distances between 5 and 6 kilometers of the total route, it is not inappropriate to project shifts at the average Wellington commute of 5km (Statistics New Zealand, 2006b). The New Zealand Household Travel Survey Data concurs with this amount, with an average in Wellington city of a 5.7km commute (Ministry Of Transport, 2013). It is important to account for the fact that many of these will involve some park and ride component to the trip – given that the terminus in Kilbirnie and the northern suburbs will be distant from a rider's home. As such, this paper will model the distance saved as 4km.

By multiplying the total number of mode shifts to BRT or light rail by the percentage of car shifts, and then again by the average commute distance, total car km saved per AM or PM commute is generated. Multiplying this by two, then by the annual average working days - 228 (OECD, 2013a, 2013b) yields the total annual car kilometers saved. This is then multiplied by the values in the Economic Evaluation Manual for operating costs to yield car ownership and environmental costs saved versus the base case. Additionally, it is used in the calculation for community severance.

Chapter IV. Methodology

Section 4.01 Congestion Times

First and foremost among the corrections must be the way congestion times are calculated. The literature behind this is detailed in the Input Analysis section, but the equations used to generate this are detailed here. The congestion calculations are themselves taken from the Economic Evaluation Manual.

To model congestion, we could model the entire start to finish congestion value for a line, but it would instead be more valuable to focus on the congestion choke points. The most prominent of these along the spine would be the Basin Reserve. Existing congestion is 9.5 minutes at the Basin Reserve when travelling into town in the AM versus a trip in the midday, and the 2021 congestion 16.25 minutes as predicted by the NZTA, which leaves a linear 45 second annual increase in travel time as the base case for analysis. This paper will take these data points, presume zero congestion elsewhere in the network for this limited study, and use congestion calculation methods dictated by the Economic Evaluation Manual to arrive at how the Basin influences travel times.

The existing number of vehicles per hour in the AM or PM peak is set at 4873 per Opus Consulting (2013a; 2013b) reports. This is then modeled against a capacity for the existing network of 4986 cars per hour, the 2021 throughput. Opus reports indicate that by that time most portions of critical Basin elements will be overcapacity, offering a low level of service. It is important to reiterate that this neglects capacity and congestion elsewhere in the network.

The base case number of cars through the Basin is then calculated based on population growth of approximately 1% per year, culminating with a 30% increase at 2043. A calculation is done for each potential mode that subtracts half the total new riders of a given mode from this number (as half of new riders come from cars) to yield the number of cars through the Basin in a given instance of modal shift.

Induced demand from road works, due to the already popular nature of that route into the city, is anticipated to scale from 0% to 40% over the ten years following construction of the SH1 improvements. Due to this, the induced demand increases by 4% each year following 2021, capping out in 2031. This is applied as a multiplier to 40% of the existing traffic representing one direction of Mt. Victoria tunnel traffic.

Following this, a 1400 car increase in capacity is expected from the construction of a second Mt. Victoria tunnel. This is due to existing traffic being around 1400 cars per hour, and Opus analysis indicating that the tunnel is already over capacity. It bears noting that in their modeling, Opus considers a second tunnel to add 1600 cars per hour of capacity. For our analysis purposes, however, the data on the existing tunnel is prioritized over projections about an as-yet constructed one.

Added atop this improvement, the diversion of 2/3 of traffic coming through the tunnel via the construction of a flyover is also projected. All of these are added together to yield a ratio that determines the total percentage of capacity utilized in the Basin reserve.

The final equation appears below:

Equation 1 – Use Ratio

$$\Omega = \frac{[\alpha + (\zeta \times \theta) - (\tau)]}{(\psi + 1400)}$$

Ω = *Use Ratio*
α = *Base Traffic* (*Vehicles/hr*)
θ = *Mt. Victoria Tunnel Traffic* (*Vehicles/hr*)
τ = *Flyover Traffic* (*Vehicles/hr*)
ζ = *Induced Demand* (*Percentage*)
ψ = *Base Traffic Capacity* (*Vehicles/hr*)

This output is then adjusted to determine the net congestion delay by subtracting .7 (representing the 70% of free capacity use indicated in the literature), then dividing the remainder by .3 (representing the portion of capacity that generates congestion) and multiplying by the existing congestion delay. This is represented by the below equation:

Equation 2 – Congestion Parameters

$$\Delta = \frac{\lambda \times ((\Omega - 0.7)}{0.3}$$

Δ = *Net Congestion Delay* (*Minutes*)
λ = *Base Delay* (*Base Delay*)
Ω = *Use Ratio*

The calculation is then executed on each modal option by using the appropriately adjusted base value of Traffic. For the version without the SH1 improvements, the modifications for the flyover and the second tunnel are excluded.

The only exception to these calculations is that individual congestion measures are capped at 20 minutes as that level of congestion would inspire modal shift to a massive degree presuming uncongested routes. This presumption implies that GWRC would step in with more buses through the Mt. Victoria bus tunnel. Additionally, many would divert around Oriental Bay and even, in convenient cases, up Happy Valley.

It is worthy of note that this is an exceedingly generous view on congestion due to the fact that the additional capacity in the Mt. Victoria Tunnel is evaluated as adding to the Basin's total capacity, when in reality bottlenecks will still exist within the Basin itself.

Section 4.02 Travel Time Savings

Firstly the travel times are generated for the base case by adding the speed of mode predicted in the Spine Study to the predicted congestion. These result in total travel time. For non-base case scenarios, the difference between the travel time of that mode and the base case is multiplied by the value of time to create time saved for public transport riders. The following equation is applied:

Equation 3 – Total Time Savings

$$\Sigma = (\chi - \beta_m) \times (\frac{\pi_{pt}}{60})$$

Σ = *Savings Per Rider* (*Minutes*)
χ = *Base Case Travel Time* (*Minutes*)
β_m = *Mode Travel Time* (*Minutes*)
π_{pt} = *Value of Time* (*Public Transport – Per Hour*)

The travel time savings per rider then must be applied to the number of existing bus riders and those transferring from other modes independently. This paper presumes existing bus riders have time savings represented by:

Equation 4 – Time Savings Per Rider

$$\delta = \Sigma \times \varphi$$

δ = *PT User Time Savings* (*Minutes*)
Σ = *Savings Per Rider* (*Minutes*)
φ = *Existing Ridership Plus Cannibalized Riders* (*People*)

The more challenging issue is travel time savings for new riders to the mode. Presumably some proportion of them are coming from cars, some coming from other public transport routes, and some coming from active transport. The challenge arises when trying to determine the value of travel time savings for active transport. Less research comparably has been done on travel times for preexisting reports. As a result, raw data must be used to source travel times for active transport.

Recent research indicates that 30 minutes or less is the ideal commute time for active modes. Presumably, those who already commute via active transport who have a 15 minute or less walking commute would not bother to pay for a trip on a public transport mode(Ministry Of Transport, 2013b). As a result, a roughly 22.5 minute travel time would represent the midpoint between the two, and a realistic estimation for the average travel time for those changing from active to public transport.

Combining the travel time savings determined and the active transport savings results in the below equation for travel time savings.

Equation 5 – Net Travel Time Savings

$$\left(\begin{array}{l} \left[((\sigma \times .5 \times .23) \times \beta_c \times \pi_{\square}) - ((\sigma \times .5 \times .23) \times \beta_m \times \pi_{\square})\right] + \\ \left[((\sigma \times .5 \times .27) \times \beta_c \times \pi_{\square}) - ((\sigma \times .5 \times .27) \times \beta_m \times \pi_{\square})\right] + \\ \left[((\sigma \times .1) \times \beta_{walk} \times \pi_{\square}) - ((\sigma \times .1) \times \beta_m \times \pi_{\square})\right] \end{array}\right) \times -2 \times 228 \times .5$$

σ = *New Ridership* (*People*)

β_c = *Car Travel Time* (*Minutes*)

β_{walk} = *Car Travel Time* (*Minutes*)

$\pi_{\square}$ = *Value of Time* (*Dollars/Hr*)

β_m = *Mode Travel Time* (*Minutes*)

This equation, combined with the prior equation, yields the total time savings value for any given Peak Period (23% of any morning's traffic) and the remaining uncongested time (27% of any morning's traffic), as well as all active transport users. The outputs of these equations are summed, then multiplied by 228 (the number of workdays) and again by -2 to represent two peak periods per day as well as the fact that a negative is positive in this case. The result is then halved to represent that most ridership is likely to travel only half the distance of the Spine on average. This calculation is then repeated for each year of the analysis.

Section 4.03 Automobile Ownership Costs

Unlike time savings and congestion, automobile ownership costs are easily calculated. As stated before, half of modal shifts are estimated to come from private automobiles. This number is likely conservative. These shifts are accompanied by estimates of the commute distance in vehicle (4km, 1km less than the regional average and 2km less than the spine length) saved. This is then multiplied by the cost of vehicle operation per kilometer and the cost of parking, both sourced from the Economic Evaluation Manual, is added atop this. This final number is multiplied by 2 commutes per day, multiplied by the number of workdays per year. The equation is seen below:

Equation 6 - Auto Ownership Savings

$$(\sigma \times .5) \times ((2 \times 4km \times \rho) + \gamma) \times 228$$

σ = *New Ridership* (*People*)

ρ = *Driving Cost per Kilometer* (*Dollars*)

γ = *Cost of Parking* (*Dollars*)

This yields total saved costs for a given year based on commuter switching to the given mode from the base case.

Section 4.04 Community Severance

As community severance is very similar to automobile ownership costs in that it is computed on a per-km basis, the equation is quite similar:

Equation 7 – Community Severance Costs(or Benefits)

$$(\sigma \times .5) \times (4km \times \rho) \times 228 \times 2$$

σ = *New Ridership (People)*

ρ = *Severance Cost per Kilometer (Dollars)*

It is notable that this new value is quite small compared to the cost of operating a vehicle (roughly 5%). Additional New Zealand research would be useful to determine if this conservative case is true in New Zealand, where pedestrians are relatively less prioritized than even the United States. In most states in the United States, pedestrians have the right-of-way for safety reasons, whereas in New Zealand, they are secondary to vehicles.

Chapter V. Aggregate Results

Section 5.01 Corrected Travel Times and International Costs

This section consists of the benefits given corrected values for costs based on this paper's review of literature, in addition to both corrected ridership and congestion analysis based on the same.

Table V-1 Costs and Benefits (in Millions) with Corrected Data and Values

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	212	1,792
Time Savings for Other Drivers	581	1,696
Cost of Auto Ownership Savings	27	402
Cost of Community Severance	.581	8.6
Total Benefits, Discounted	137	1,138
Total benefits, Including other drivers (Discounted)	426	1,967

Value of Property Uplift (in Millions of Dollars)

There are two types of property value uplift calculations indicated by the literature. One that applies to all property, and one that applies separately to commercial and residential property. They result in slightly different values. Both only apply to residential and commercial property within 400m of light rail installations, while values are not impacted (or even negatively impacted) by Bus Rapid Transit installations. We do not calculate the negative impact because the degree of impact is statistically insignificant.

Table V-2 Value of Property Uplift - Expected

Type of Property	8.6% for both Commercial and Residential Property	16.4% Commercial, 4.8% Residential
Commercial	1,696	2,361

Residential	223

Section 5.02 Corrected Travel Times and Current NZTA Costs

This section consists of the benefits given existing values for costs based on the NZTA Economic Evaluation Manual, in addition to corrected ridership and congestion analysis based on the literature. The only difference corrected here that spans both areas is to calculate congestion costs on a per individual basis, as that is part of the "corrected" travel times. This is the most glaring error in the existing EEM, and as such correcting it is not problematic.

Table V-3 Costs and Benefits (in Millions) with Corrected Data and Current Values

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	28	-157
Time Savings for Other Drivers	198	578
Cost of Auto Ownership Savings	27	402
Cost of Community Severance	.581	8.6
Total Benefits, Discounted	19	67
Total benefits, Including other drivers (Discounted)	70	210

Value of Property Uplift (in Millions of Dollars)

There are two types of property value uplift calculations indicated by the Spine Study. One that applies to all property in a Bus Rapid Transit environment, and one that applies in a light rail environment. They result in slightly different values.

Table V-4 Value of Property Uplift - Expected

Type of Property	20% - BRT	25% - LIGHT RAIL
Commercial	3,944	4,930

Section 5.03 Spine Study Travel Times and International Costs

This section consists of the benefits given corrected values for costs based on this paper's review of literature applied to the travel times given in the Spine Study.

Table V-5 Costs and Benefits (in Millions) with Current Data and Corrected Values

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	261	147
Time Savings for Other Drivers	n/a	n/a
Cost of Auto Ownership Savings	40	14
Cost of Community Severance	.871	.305
Total Benefits, Discounted	174	92

Value of Property Uplift (in Millions of Dollars)

There are two types of property value uplift calculations indicated by the literature. One that applies to all property, and one that applies separately to commercial and residential property. They result in slightly different values. Both only apply to residential and commercial property within 400m of light rail installations, while values are not impacted (or even negatively impacted) by Bus Rapid Transit installations. We do not calculate the negative impact because the degree of impact is statistically insignificant.

Table V-6 Value of Property Uplift - Expected

<table>
<tr><th>Type of Property</th><th>8.6% for both Commercial and Residential Property</th><th>16.4% Commercial, 4.8% Residential</th></tr>
<tr><td>Commercial</td><td rowspan="2">1,696</td><td>2,361</td></tr>
<tr><td>Residential</td><td>223</td></tr>
</table>

Section 5.04 Existing Analysis

The Existing Analysis indicated benefits of $95 million for BRT and benefits of $56 million for light rail. The value uplift predicted in the NZTA cost section matches the values in the Spine Study.

Table V-7 Costs and Benefits (in Millions) with Current Data and Values

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	n/a	n/a
Time Savings for Other Drivers	n/a	n/a
Cost of Auto Ownership Savings	n/a	n/a
Cost of Community Severance	n/a	n/a
Total Benefits, Discounted	95	56

Value of Property Uplift (in Millions of Dollars)

There are two types of property value uplift calculations indicated by the Spine Study. One that applies to all property in a Bus Rapid Transit environment, and one that applies in a light rail environment. They result in slightly different values.

Table V-8 Value of Property Uplift - Possible

Type of Property	20% - BRT	25% - LIGHT RAIL
Commercial **Residential**	3,944	4,930

Chapter VI. Discussion

These four (five including appendix C) different angles on the same project present a conclusive picture of one undeniable fact: the importance of assumptions used in to cost-benefit analysis cannot be overstated. These decisions have a vast influence on the type of projects recommended by cost-benefit ratios and the form they take.

This is highlighted by the differential in benefits between the option with NZTA-calculated costs and the one with corrected costs. However, perhaps a more interesting nuance is the difference between the options when major roading improvements are allocated funding along SH1. The tunnel duplication and flyover create benefits in a bus-driven environment, but in the case of light rail, they could be rendered needless since light rail would remove many drivers from the road (Appendix C). These benefits, analyzed in the current system, would likely be underestimated by more than half.

The reason for choosing light rail over BRT is quite simple. Building a BRT or light rail system, the flyover, and the second tunnel would lead to vast improvements in congestion times and substantial benefits to the tune of nearly NZD$426 million or NZD$1.5 Billion for light rail. That said, congestion times in a BRT environment return to a long, slow growth that return them to about half the congestion time of today by 2043. This may seem minimal, but in consideration of the alternative, it seems costly.

The attraction power of light rail actually outstrips population growth and can attract enough riders that congestion around the Basin Reserve declines steadily, and is eliminated completely by 2043. BRT still implies a congestion time of around 5 minutes around the flyover in 2043, while Light Rail reduces the congestion time to zero within 5-10 years of opening.

To indicate how this paper arrives at these conclusions, isolating each of the five changes to the EEM and the two changes to the Spine Study's modeling is important to illustrate where the major differences lie. This represents each change on its own merits and gives measure to their influence. This is also useful since it suggests how one could target corrective efforts for the future. To evaluate each, this paper uses the option where both costs are corrected, but the flyover and Mt. Victoria tunnel duplication are both constructed. That change itself is then isolated for evaluation.

Section 6.01 The Discount Rate

Using the discounting scheme developed for New Zealand based on the consensus among scholars and OECD countries increases the values of benefits by significant amounts compared to existing NZTA practice – even with their recent update. The values nearly double. The increase differs between modes based on the temporal spread of benefits, as might be expected. This is reminiscent of the OECD report that notes "The discount rate is normally the most crucial factor in whether medium to long-term projects pass a cost-benefit analysis" (2007, p. 6).

It is evident that a change in the discounting scheme has vast influence on transport decisionmaking, and decisionmaking throughout government if the guidance is applied on a whole-of-government rather than a departmental basis as the OECD suggests (OECD, 2007). Noting the challenges presented in financing projects and the general lack of benefits passed along to future users (who will pay those debts) due to existing discounting schemes, discounting adjustments may also recalibrate the social compact with the next generation, accurately reflecting that future generations may be willing to pay those debts, despite their increase in value, in exchange for similarly more substantive benefits.

Section 6.02 The Value of Time

Using the updated values of time indicated by the literature, the value of time creates significant changes in the benefits indicated. When correcting travel time value alone, the BRT benefits increase by 4 times, while light rail benefits both flip sign – going from negative to positive – and increase by 10 times. These are different due to the proportion of benefits coming from cars compared to other modes. This is the most eye-popping change, though when spread out over time it is somewhat less influential than the discount rate, as influences are heavily concentrated in the future due to population growth. The change of sign results from car to light rail transfers. Such transfers under the existing regime incurring a negative economic benefit – clearly unlikely to happen. Given the international literature on ridership having such a strong stance on the attractive power of rail, the differential values of travel time are justified in recognizing these values.

These changes have impact outside the transport space, with influences ranging from those on urban form to housing density and location of employment centers. As stated in the earlier section, substantial research in a few areas would be valuable. Defining the difference in travel time value for different modes is the first, and perhaps most important area. The NZTA recently discarded differential travel time values, but there is ample evidence that they should be different. By what degree they are different is where further research should be targeted. Additionally, determining the value of offsetting benefits for different modes like cycling and public transport (which serve to reduce the cost of travel time compared to that for driving) in the New Zealand context would be helpful. Additionally, more research would be useful into the psychosocial benefits of car ownership.

Section 6.03 Automobile Ownership Costs

Compared to the other categories, this is a more challenging area to evaluate. It is not a flaw in the existing manual's methods, but an important oversight to exclude from initial evaluations. Given the ease with which it can be calculated and that currently the cost of any alternative investment is considered, it makes sense to pit those new costs against existing costs to serve the same population. In the case of the Spine Study, excluding this element from the calculation of benefits leaves around 5% of the benefits out of the analysis for BRT, a number that balloons to around 20% of the benefits for light rail. To ensure an apples-to-apples comparison when looking at transport improvements, the cost savings related to vehicle operation on a private basis should be included and weighed against the alternative.

Ridership changes are heavily undervalued in initial analyses and, while not as influential as the discount rate or travel time, still contribute meaningfully when evaluating transport projects. It is particularly unfortunate that these are not calculated when relatively complex work has gone into calculating the precise value of car operation costs in the Economic Evaluation Manual.

Section 6.04 Community Severance Effect

The community severance effect in this analysis is not to be ignored, but it seems to be rendered relatively insignificant in comparison to the other overall influences when it comes to public transport. The $8.6 million community severance represents less than .5% of the total benefits in the case of light rail. In the case of BRT, the influence is so small as to be considered moot. This isn't to diminish the value of severance in general, but in the case of public transport projects that result in large modal shifts, such as the Spine Study, severance may not be a meaningful contributor to the costs and benefits. On the other hand, severance would likely be very significant in the case of new roading projects with high capacity. As a result, the finding is not that severance should be ignored by the EEM, but rather that it should take a backseat role in the case of public transport investments.

Severance is an area ripe for new research, particularly with the upcoming construction of large in Auckland transport projects. The impact of urban form, housing density, car throughput, and road width would all provide interesting fodder for academic research. Given the Auckland urban form, and the roads planned relatively near the center city, it seems the perfect situation to analyze severance effects and come up with precise values.

Section 6.05 Property Value Uplift

The property value uplift suggested by international review provides a solid checking value for urban rail projects to determine if existing analysis has done an adequate job of determining the benefits available. Though the total calculated benefits from the areas near light rail stations calculated in this study amount to roughly 58% of the total benefits projected to accrue for the system by land capitalization, the reality is that the itemized benefits we examine exclude many benefits – like those that accrue to businesses near stations as spending shifts from automotive operating costs to these shops. It also excludes basics like fares. Additionally, potentially new spending rather than just spending shifts are created due to increased time spent walking around these shops. Checking values when investing in light rail against these globally calculated capitalization values is good practice to determine whether or not analysis is relatively accurate, particularly when bringing modes as yet unseen to a country.

More important is the concurrence or lack thereof of property value uplift anticipated and calculated benefits. The clearest issue here is the disconnect between anticipated property value increase in the Spine Study and anticipated benefits calculation using current New Zealand methods. For either calculation method of property value, the new benefit methods are clearly more consistent with the capitalized land values.

Perhaps more importantly, the calculated benefits in the option with SH1 improvements match well with the 8% property value uplift method. Additionally, if accounting for the fact that they are individual accrual of benefits only – and exclude some benefits like retail sales – it is reasonable to posit that the missing benefits could make up the gap between the option and the more accurate property value analysis accounting for residential and commercial property.

Interestingly, the no improvements option far exceeds the projected property value increase, suggesting that with such an option it may be realistic to expect Wellington would be shifted into a category where far more in the way of property value increases occur. For example, Perth's recent installation of a northern railway saw property values increase as much as 41% (Newman, 2013). Such increases are not unrealistic when accounting for additional dwelling units per hectare that are possible surrounding such a route.

Section 6.06 Ridership and Congestion Times

An influential area in this analysis is the corrections to the Spine Study ridership and congestion times. Increasing the value by 30 times of the light rail benefits calls into question the inputs used for modeling the Spine Study ridership, given the international basis on which this paper has based it's analysis. The impact clearly can't be overstated, but the strong research indicating LRT will outperform BRT in almost any situation is hard to deny. With the inclusion of light rail, the city can expect that by 2043 there is virtually no congestion through the Basin Reserve.

Chapter VII. Conclusions

A trio of relatively minor changes to the Economic Evaluation Manual would result in better evaluation in separate cases. Cycling projects would have better isolation of health benefits and safety, new roads would better account for the severing of communities, and preliminary exploration of automobile ownership would additionally help create a more direct comparison between the operating costs to the economy of a public transport system versus private vehicles. But these changes are not even the most significant ones needed. The central figures in the EEM's flaws are those applied to the Spine Study in this paper's examination. The huge effects in question warrant addressing on an immediate basis.

It is evident from the magnitude of effect that a change in the discounting regime needs to be undertaken. Including evidence endorsed by the OECD and other OECD countries, standards in practice for more than a decade, is a logical step. New Zealand leadership deserves to be provided a scope of evidence that includes official OECD guidance and these best practices.

Transport decisions in particular are hamstrung by the existing regime, with results that are evident to the residents of the cities – with Auckland riddled with congestion and Wellington craving a proper public transport spine. Given the near doubling of benefits an appropriate discount rate indicates, even over the discount rate just adopted in July 2013, it is clear that New Zealand can't afford an oversight on best practices in this area any longer. Gollier's modelling that indicates declining discount rates are the weapon of choice for transport economists is compelling. Combined with the modeling by Weitzman indicating that the least limiting discount factor (leading to lower discount rates) should be used, this leads to the inexorable conclusion that the discount regime in New Zealand need adopt lower, certainty-equivalent discount rates (even lower than the rates adopted in the most recent July 2013 review) and that those rates should decline over the long term. That said, there is nothing preventing the inclusion of the older, financially focused discounting terms for the sake of those who prefer them. Balanced evidence that political entities can dissect on their own is not problematic for advice-oriented organizations.

Equally desperate is the need for accurate evaluation of the value of travel times. Sampling error and perceptual errors when evaluating what travel time is worth via survey is a well-known issue. So much so that in the Spine Study, they acknowledge perceptual errors and adjust times waiting for transfers to be more punitive. Revealed preference is the ideal method to determine the value of commuting travel time, and though the studies using it to determine such are limited, they are nonetheless valuable to consider. Stated preference is by far the easiest information to collect, as it can be sought by a broader cadre of researchers. That said, revealed preference is preferable for its accuracy, and this targets potential future research towards social scientists.

On the face of it, this is important in two ways. The first is that waiting time and congestion time should be costed out at the same price as travel time. Currently, congestion time vastly underrates the value of that commuter's time because not only is the value used far too low, but the value is applied on a per-vehicle rather than per-individual basis. These aspects combine to create an implication that congestion is effectively irrelevant, and spending money to alleviate it is unjustified. For this first issue, any commuter can tell you the opposite is the reality of the situation.

Perhaps more important is the effect on the nature of transport investments selected. The potential change in value indicates that in lieu of investments that increase road capacity (and thus induce demand, often making congestion worse further into the network, though the net number of road users increases), appropriate travel time analysis leads to more investments that manage demand, investments in alternate modes that are less capital-intense to the economy than private vehicles, and all-in-all produce benefits that are seen not just early on after the investment is made, but well into the distant future. Studies using revealed preference and urban tolls conducted in New Zealand could determine the value of travel time here to a precise level (and compliment the existing hedonic price research conducted in the Wellington region that concurs with the changed value), but for now the values relative to prevailing wage determined by the international literature can be employed in their stead to fix this pressing issue.

As with travel times, there is a lack of deep revealed preference or hedonic New Zealand research on the effect of rail development on home prices. Most rail in New Zealand dates from an era long before such research was conducted, and thus international research needs to be incorporated to create a verification method for explorations such as the Spine Study that include new modes. Urban rail in particular is under scrutiny in all three major New Zaland cities in a way that demands accurate analysis, and suggests that modelling should be important for potential bus and car options, but international research should be consulted to verify that the modelling is yielding results that make sense. Ample research exists to indicate that land value uplift is created when urban rail is installed, reflecting the total benefits created by such a system. By comparing the modeled benefits with a highly conservative anticipated increase in land value, this paper can ensure that these investments are analyzed with some sort of discipline in order to supply decision makers with the best possible evidence.

New Zealand has the capacity to produce the best evidence, and the research institutions that, in conjunction with government, have the capability to verify all of these aspects in the New Zealand context. Such changes do have broad implications, but they are largely ones that comport with recent research completed in New Zealand that indicates high value of time (Pettit et al., 2013) and research that indicates more people would like to take public transport (Betanzo, 2013). These studies combined with international research result in one overarching conclusion that requires change to New Zealand's analysis context. The reality is, taking all of these facts in sum, that New Zealand is currently lagging best practice by 5 or 10 years when it comes to transport analysis as a result of infrequent review. The changes in this paper would reduce most of the error in New Zealand cost-benefit analysis. This would yield better information for decision makers, better projects getting funded, better options for ratepayers, and better long-term outcomes for New Zealand.

International Implications

The implications for this analysis extend beyond the borders of New Zealand. It is common to see surprisingly low benefit-cost ratios for most forms of rail in cities that have major transportation challenges. If small cities like Wellington are economically viable for light rail, it calls into question the cost structures, routing, and Cost-Benefit Analysis tools employed in those cities. Of course, each city is unique and transport challenges are more varied the larger a city gets, but the economies of scale influencing the value of public transport is quite pronounced as a city gets larger.

Taking the analysis above as a best practice for the six areas defined would result in different conclusions in what the most economically efficient, most cost-effective, and thusly the first investments that should be made for a city of any size. Further research into each area, with a partiality for revealed preference data on value, and a preference for meta-analyses with issues like ridership and capital increase, should be pursued in any country that is interested in improving the economic efficiency of transport investment. Until such research is undertaken, the tools analyzed above provide guidance on adjustments based on prevailing wages, existing property values, and per-km values.

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APPENDIX

Appendix A – Congestion Times

In order to generate congestion times, a variety of issues need to be taken into account. Capacities, assumptions and information were derived from existing data from WCC, NZTA and GWRC to arrive at the following basis for analysis–

- Mt. Vic Tunnel is already overcapacity. (NZTA, 2012a)
- Around 4,821 cars per peak hour passed through the Basin in 2009. Currently, parts of the Basin (namely the Mt. Victoria Tunnel) are at capacity, while the entire system will reach capacity by 2021 – (Opus Consulting, 2013a; Wellington City Council, 2013).
- A 2nd Mt. Victoria tunnel would add around 1,400 cars per hour capacity in each direction, as the tunnel is already overcapacity (Opus assumes 1600 but contradicts itself in that way) (Opus Consulting, 2013a, 2013b).
- A 2nd Mt. Victoria tunnel would have the potential to induce demand over ten years up to 40% over and above existing demand for the tunnel portion of the trip (Goodwin, 1996).
- A flyover at the Basin would reduce demand for the Basin from the tunnel by around 1100 cars per hour up to its capacity of 3800 cars per hour. This presumption implies that the congestion wont appear downstream, but that is very unlikely (Opus Consulting, 2013b).
- Congestion in general does not occur until around 70% of a roadway's capacity is reached, scaling from there (New Zealand Transport Agency, 2010).
- Current congestion can be modeled as around 97% of the capacity of the roadways in the area (NZTA, 2012a, 2012b; Opus Consulting, 2013a, 2013b; Wellington City Council, 2013).
- Without improvement, Basin travel times will increase by around 75% by 2021 (NZTA, 2012b).
- Congestion is modeled assuming the flyover and 2nd Tunnel will be built.
- This is a conservative assessment for congestion because it does not account for the reality that even massively improving the basin individually, the roads on either side of this single point on the network will remain the same size from a capacity perspective. The likely net effect would be shifting the congestion downtown rather than solving the congestion issue. Opus consulting reports indicate this. Vivian Street is a notable place where the capacity will be exceeded before the Basin's completion. This is also conservative because it does not consider congestion outside of the Basin Reserve interchange – e.g. along Lambton Quay.

- Finally, congestion times never exceed 20 minutes. Such times would inspire massive modal shifts unlike any ever seen in Wellington before. It would like inspire more walking and cycling from further distance, more buses to be provided by Metlink, shifts in route to places like Happy Valley and Evans Bay Parade, more Scooter purchases, and other avenues that are not deemed as practical now.

Appendix B – Congestion Times without Flyover & 2nd Tunnel

In the main body, congestion times were generated presuming the construction of both the flyover and a 2nd Mount Victoria tunnel. Below are congestion times generated presuming neither are constructed:

Table A-0-1 Congestion Times without a Flyover or 2nd Tunnel

Congestion Times (minutes) through Basin - No SH1 Flyover/Duplicate Tunnel			
Year	Bus (Base Case)	BRT	LIGHT RAIL
2013	10.25	10.25	10.25
2014	11.00	11.00	11.00
2015	11.75	11.75	11.75
2016	12.50	12.50	12.50
2017	13.25	13.25	13.25
2018	14.00	14.00	14.00
2019	14.75	14.75	14.75
2020	15.50	15.50	15.50
2021 (Operational)	16.25	10.22	4.76
2022	17.00	10.80	4.45
2023	17.75	11.38	4.13
2024	18.50	11.95	3.82
2025	19.25	12.53	3.50
2026	20.00	13.11	3.19
2027	20.00	13.69	2.87
2028	20.00	14.26	2.69
2029	20.00	14.84	2.51
2030	20.00	15.42	2.33

2031	20.00	16.00	2.40
2032	20.00	16.57	2.24
2033	20.00	17.15	2.07
2034	20.00	17.73	1.91
2035	20.00	18.30	1.75
2036	20.00	18.88	1.59
2037	20.00	19.46	1.42
2038	20.00	20.00	1.26
2039	20.00	20.00	1.10
2040	20.00	20.00	0.93
2041	20.00	20.00	0.41
2042	20.00	20.00	0.23
2043	20.00	20.00	0.05

See Appendix A for assumptions and basis.

Appendix C – Costs and Benefits with No SH1 Improvements

This section consists of the benefits given corrected values for costs based on this paper's review of literature, in addition to both corrected ridership and congestion analysis based on the same. It also presumes the flyover and duplicate Mt. Victoria tunnel are not constructed. Confidence in these findings are somewhat lower and so they are left to the appendix.

Table A0-2 Costs and Benefits (in Millions) with Corrected Data/Values – No SH1 Improvements

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	203	3,347
Time Savings for Other Drivers	1,318	8,525
Cost of Auto Ownership Savings	27	402
Cost of Community Severance	.581	8.645
Total Benefits, Discounted	140	1,968
Total benefits, Including other drivers (Discounted)	1,097	6,867

Appendix D – Perturbation Analysis

Due to the various presumptions, based on literature, used to create this analysis, it is worthwhile to undertake a perturbation analysis of a few of the most critical components: Congestion Times, the Value of Time, and Ridership. In order to do so, this paper will reduce each assumption's added value by 20% and establish the kind of difference that would make to our optimized model's value.

Table A-0-3 Costs and Benefits (in Millions) - Perturbed Value of Time

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	152	1,415

Time Savings for Other Drivers	465	1,357
Cost of Auto Ownership Savings	27	402
Cost of Community Severance	.581	8.6
Total Benefits, Discounted	102	942
Total benefits, Including other drivers (Discounted)	334	1,605

The bottom line here is that a 20% reduction in the predicted value of time results in a 22% reduction in the value of BRT time savings, versus 18% reduction for light rail time savings. This indicates a strong effect on the overall outcome of this paper. That said this parameter can be accurately estimated due to the revealed preference nature of the data employed. It is based on both US and New Zealand data that extrapolate out the value of time from the actual behavior of commuters (in toll paying and house prices) rather than survey-based data that is subject to perceptual error. The precision of such revealed preference data is far better in the case of an issue like value of time.

Table A-0-4 Costs and Benefits (in Millions) - Perturbed Congestion

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	185	1,666
Time Savings for Other Drivers	465	1,357
Cost of Auto Ownership Savings	27	402
Cost of Community Severance	.581	8.6
Total Benefits, Discounted	122	1,075

Total benefits, Including other drivers (Discounted)	353	1,738

A 20% reduction in the congestion times predicted results in a 18% reduction in BRT benefits, and a 12% reduction in LRT benefits. This implies that modeling of congestion is a critical task, but slightly less important than travel time value. However – it is notable that existing Opus consulting reports on the Basin Reserve indicate that road's capacity will be exceeded by 2021 for all stages – and as such a second tunnel and flyover will not help without massive roading upgrades elsewhere in that area. As a result, these congestion times can be estimated accurately given the arterial it serves passes through that highly congested zone. Even so, estimates of congestion are likely underestimated due to the fact that the Basin is but one congested bottleneck along a series of them, and a series of them that will become bottlenecks, in the downtown.

Table A-0-5 Costs and Benefits (in Millions) - Perturbed Ridership Growth

Cost or Benefit Type	Bus Rapid Transit	Light Rail
Time Savings for Riders	190	1,297
Time Savings for Other Drivers	581	1,597
Cost of Auto Ownership Savings	27	285
Cost of Community Severance	.581	.6133
Total Benefits, Discounted	124	816
Total benefits, Including other drivers (Discounted)	413	1,596

A 20% reduction in the ridership growth rate predicted (applied only to light rail, as BRT numbers are not generated) results in a 19% reduction in the value of light rail benefits. This indicates that while the numbers are important to the analysis, the overall growth rate of light rail is about equal in importance to other areas. The high confidence gained from reviews of recent installations and long-term studies, aligned with long-term trends both nationally and internationally, combined with this minimal impact, lend this area a particular confidence. If any issue might compromise this ridership, it is form-related issues about the installation that drive an excess of transfers. This paper does not concern itself with these issues, though they would be easily solved by extension or modification of the plan.

Appendix E – Cost Structure When Discounted

As indicated in the discounting section of this literature review, any new declining and lower regime of discounting would need to include discounting payments made against financing instead of the resource costs of a project when incurred. This is to ensure that risk and financing cost is adequately accounted for within the payments structure of a cost-benefit analysis. For this payment, this paper uses a discount rate as stated above, and an interest rate of 5.9% for GWRC, or 4.27% for NZTA, from 10 year government bond rates reported by RBNZ.

The following costings presume bonds were issued in 2018, principal and interest are repayed throughout similar to a typical loan. The payment structure for a light rail installation using the costs indicated in the Spine Study is below (using 2018 as the base year for discounting):

Table A-0-6 10 Year Bond Cost Structure – Interest + Social Discounting Applied

Year	GWRC	(Millions of $)	NZTA	
Type	Undiscounted	Discounted	Undiscounted	Discounted
2018	$124.6	$121.0	$115.6	$112.2
2019	$124.6	$117.5	$115.6	$109.0
2020	$124.6	$114.0	$115.6	$105.8
2021	$124.6	$110.7	$115.6	$102.7
2022	$124.6	$107.5	$115.6	$99.7
2023	$124.6	$104.4	$115.6	$96.8
2024	$124.6	$101.3	$115.6	$94.0
2025	$124.6	$98.4	$115.6	$91.3
2026	$124.6	$95.5	$115.6	$88.6
2027	$124.6	$92.7	$115.6	$86.0
Total	$1,246.6	$1,063.4	$1,156.5	$986.5

Appendix F – Financial Recovery

On an annual basis the financial recoveries will actually be quite high for such a system. Seen below is a schedule of annual recoveries including farebox recovery presuming a monthly pass sold at $90 and rates generated by the scenarios indicated in the Spine Study assuming inflation of 3% and no increase in house prices in excess of this.

This neglects the additional tax from retail business increasing as well as the savings from interest servicing on roading projects. All numbers are in Millions.

Table A-0-7 Financial Recoveries and Costs

Year	Rates	Farebox	Total Financial Recovery	Costs
Type	Discounted	Discounted	Discounted	Discounted
2018				112.2
2019				109.0
2020				105.8
2021	7.3	25.7	33.1	102.7
2022	7.3	26.1	33.4	99.7
2023	7.3	26.5	33.7	96.8
2024	7.2	26.8	34.0	94.0
2025	7.2	27.1	34.3	91.3
2026	7.1	27.4	34.5	88.6
2027	7.0	27.7	34.7	86.0
2028	7.0	27.8	34.8	
2029	6.9	27.9	34.8	
2030	6.9	28.0	34.9	
2031	6.8	27.0	33.7	
2032	6.7	27.0	33.8	
2033	6.6	27.1	33.7	
2034	6.6	27.2	33.7	
2035	6.5	27.2	33.7	
2036	6.4	27.2	33.6	
2037	6.3	27.2	33.6	
2038	6.3	27.2	33.5	
2039	6.2	27.2	33.4	

2040	6.1	27.2	33.3	
2041	6.0	28.1	34.1	
2042	7.3	25.7	33.1	
2043	7.3	26.1	33.4	
Total			712.3	986.5

Appendix G - Realistic Cost Structures

There is one issue that overarches the evaluation of this light rail line. The costs proposed in the PTSS are grossly overestimated based on a combination of overspecification and poorly imagined routing. Routes based on best practice and highest economic efficiency would send a dual-track tram up Constable St, and redirect one lane of traffic through one of the neighborhoods adjoining the hospital at the expense of parking. This would yield two one-way car routes and a dual light rail track. Such a route would eliminate the need for an expensive tunnel and cut off 4km of track, savings of $540 million or more (AECOM, 2013). The PTSS costs are consistent with global evidence on a per-km basis. That said, the chosen routes severely damage their economic efficiency. For the purpose of the next section, this paper infers from prior evidence that the cost of an economically efficient system would be roughly $400 million.

Appendix H - Benefit-Cost Ratios

The Benefit-Cost Ratios for BRT in an environment with SH1 improvements increases to 2.05 with the employment of these tools. This is an assessment of the value of a BRT system built to international standards. The current one will struggle to meet even the bronze certification per the BRT Standard Version 1.0 (Institute for Transportation Development Policy, 2012).

From a fiscal perspective alone the light rail project, commencing in 2018 and operating from 2021 would have a Benefit-Cost Ratio of .75 even if restricted to these benefits. This is the worst imaginable situation for the light rail – restricting it to financial benefits only, using the minimal capital increase value, the highest cost, and ignoring potentially the most substantial benefits. Given the corrected benefits calculated early in this paper, using the higher cost structures and financial repayment estimates above, and doing a 30 year analysis the BCR grows to 2.85.

The benefits can also be analyzed against an economically efficient route costing $400 million. In such a situation the light rail BCR increases to 6.69.