FORECASTING THE BENEFITS FROM INTEGRATING CYCLING AND PUBLIC TRANSPORT

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ABSTRACT

This paper outlines research conducted to forecast the likely demand for better integration of cycling and public transport in New Zealand (Cycle-PT). Cycle-PT takes the form of secure bicycle storage at points on public transport routes and/or the carriage of bicycles on buses, trains and ferries.

A forecast model has been developed that is suitable for New Zealand practitioners to forecast the use of Cycle-PT initiatives and assess using NZTA's economic evaluation framework, the likely scale of benefits that will occur. Included in these benefits is an estimate of the PT patronage increases and the mode-shift that would occur from the private car to both cycling and public transport.

The research has identified that the benefit to cost ratio for implementing Cycle-PT initiatives in major centres in New Zealand would in each case be above 1 and would be particularly high in the larger centres of Auckland and Wellington. The benefit to cost ratios for Cycle-PT implementation increases further where only Bike-on-Board initiatives are considered.

The model presented in this paper is suitable for guiding the planning and funding of Cycle-PT scheme implementation in New Zealand.

1 INTRODUCTION

The more cycling is integrated with public transport services, the easier it becomes for people to combine cycling and public transport on a single trip. This in turn increases the use of both cycling as a mode of travel as well as increasing patronage on public transport.

Common means of better integrating cycling and public transport are allowing the carriage of bicycles on public transport (bus, rail, ferry), and/or providing secure bicycle storage at points on public transport routes. In this paper this is referred to as 'Cycle-PT'.

Currently the implementation of Cycle-PT in New Zealand is poor with only sporadic examples of Cycle-PT across the country and no examples of network-wide implementation.

The research outlined in this paper has assessed international experience in providing Cycle-PT and based on this has developed a model for the New Zealand context to forecast demand for Cycle-PT and evaluate the economics of Cycle-PT initiatives.

When a forecast of demand for Cycle-PT on public transport routes is available, the New Zealand Transport Agency's Economic Evaluation framework can be used to estimate the economic benefits of implementing Cycle-PT. This paper concludes with an estimation of the benefit to cost ratios for network-wide adoption of Cycle-PT in some of the larger urban areas in New Zealand.

2 FORECASTING DEMAND FOR CYCLE-PT

2.1 Review of International Literature

The literature identified two primary methods of cycle and public transport integration:

- Bike and Ride (BaR): This is where a cyclist uses a bike to reach the public transport facilities and then parks the bike there.
- Bike on Board (BoB): This is where a cyclist uses a bike to reach the public transport facilities and then carries the bike onto the public transport service. The bike can then be used at the latter end of the service to reach the final destination.

Some other key findings from the search of international literature on Cycle-PT were:

- The economics of Cycle-PT initiatives appear to be positive and there are successful operations continuing internationally.
- Previous research had not been able to develop an overarching process to forecast cycle locker usage nor forecast the split of preference for using secure cycle storage when bikes on PT was also available.
- The provision of Cycle-PT integration increases the effective catchment area for public transport and will lead to increased PT patronage.
- While Cycle-PT occurs in various parts of the world, North American research and bicycle characteristics may be best suited for forecasting Cycle-PT demand in New Zealand due to similar transport networks, car ownership rates and modal splits.

2.2 Increase in Public Transport Catchment with Cycle-PT

Research and surveys in a number of countries have found that the time required to reach public transport is a dominant factor in public perception of public transport as a viable mode choice. One of the key benefits of Cycle-PT is the ability to increase patronage on existing PT services due to the increased catchment area (number of people) with the opportunity to cycle to public transport rather than walk. Research on catchment areas in Canada[1], UK[2], UK[3], USA[4], Scotland[5], China[6], and Australia[7] shows the ratios between walking catchment and cycling catchment are of a similar scale: typically patrons are prepared to spend 10 minutes walking (800 metres at 1.3 m/sec) or 10 minutes cycling (3.2 km assuming 4 times the walking speed).

Considering the increased distance of travel by integrating cycling and public transport, the public transport catchment area could potentially increase more than 10 fold over walking and use of GIS on the particular geography in Auckland and Wellington confirmed this.

While it is clear that the catchment for public transport routes will increase when Cycle-PT is introduced, there was insufficient information available on the number of potential PT patrons outside the walking catchment who would be attracted to cycling to PT. To collect this information in would require a substantial survey effort.

For this reason, the research focussed on using only long-term observed Cycle-PT rates from relevant urban contexts, PT catchment densities, PT mode share and where data was available on long-term Cycle-PT mode share as a proportion of total PT patronage.

International experience suggests that initial patronage from trials / pilots is sensitive to short-term factors and for this reason data from local pilots in New Zealand has not been used in developing the models.

2.3 Using North American Cycle-PT Data

Although some level of bike and bus integration is common throughout Europe, it is a relatively new development in North America. Federal legislative changes starting in the early 1990s provided specific bicycle funding collected through petrol usage tax to local and state government authorities for the purposes of implementing cycle facilities and BoB programmes.[8] The success of BoB programmes has meant that, since 1991, more than 80 operators across the United States have adopted a BoB programme, with more than 15.5 million BOB trips per year.[9]

This in turn has led to a body of research that is valuable in a New Zealand context, as it describes the results of cycle planning in highly motorised cities with historically low cycle mode share and cycling facilities.

The following table identifies the percentage of total PT patronage that is BoB across a range of North American transit authorities, with **Table 1** showing bus Cycle-PT and **Table 2** showing light rail and train Cycle-PT.

Table 1: Mode Share for BoB Cycle-PT in North America (Bus Only)

No. of Transit Authorities with data	Range of Annual Patronage	Average % of Patronage that is BoB	Maximum % of Patronage that is BoB	Some similar cities in New Zealand
22	Less than 4 million	**1%**	**5%**	Tauranga, Dunedin, Hamilton
19	6 to 20 million	**1%**	**4%**	Christchurch
11	30 to 60 million	**1%**	**2%**	Wellington, Auckland
10	60 to 350 million	0.5%	0.8%	-

The percentage of BoB patronage as a percentage of total patronage is a steady 1% over the range of annual patronage that is relevant to New Zealand. The most attractive systems in North America attract no more than 4% to 5% of patronage as BoB. The BoB percentages tend to reduce as bus patronage increases but at patronage levels many times greater than any region in New Zealand.

For commuter rail, Wellington and Auckland are the only relevant regions in New Zealand. **Table 2** identifies the BoB mode share from the North American data.

Table 2: Mode Share for BoB Cycle-PT in North America (rail only)

No. of Transit Authorities with data	Range of Annual Patronage	Average % of Patronage that is BoB	Maximum % of Patronage that is BoB	Some similar Cities in New Zealand
6	Less than 10 million	**3%**	**6%**	Wellington, Auckland
11	10 to 250 million	**<0.1%**	**0.5%**	-

Based on this analysis of North American data, the percentage share for BoB shown in the following **Table 3** is considered appropriate for the New Zealand context. The operation of bus as rapid transit (BRT) on separated facilities such as Auckland's Northern Busway will be more similar to train/ferry than to bus due to the characteristics of demand for public transport not subject to on-road congestion and less overlapping of catchments of each station.

Table 3: Bike on Board Percentages relevant to New Zealand

Mode	Average Bike on Board %	Typical Range of Bike on Board%	Relevant Cities
Bus	**1%**	**0.5% - 3%**	All
Train, Ferry	**3%**	**1.5% - 6%**	Wellington, Auckland

2.4 Developing the Demand Forecast Models

We developed two equations to forecast demand for Cycle-PT which can be used in tandem to develop a Cycle-PT implementation plan for a public transport system:

Macro Model Equation: Assesses the entire system at a macro level by general demand equations for number of Cycle-PT users and lockers per system.

Micro Model Equation: A simplified equation that provides Cycle-PT user and locker demand estimates for individual routes, stops, and stations.

2.5 Macro-Model (Network / Entire-Route)

The **macro model** provides system-wide or entire-route forecasts of the number of BoB and BaR users[1] and the amount of secure bicycle storage to provide for BaR patrons. The model uses North American data of observed BoB Cycle-PT as a percentage of total PT patronage, and assumes that this includes those who without BoB would either drive / be passengers in cars, or alternatively use non-car-driver modes (PT, cycling, walking).

The model then assumes that the introduction of secure storage would induce further demand for Cycle-PT BaR from predominantly previously car-based trips, and there would also be minimal mode-shift from cycling or non-BoB PT trips.

The total Cycle-PT patronage with BaR is then in excess of the originally observed Cycle-PT% where only BoB was provided. This total Cycle-PT can then be disaggregated into BoB and BaR components.

From our assessment of the international literature and a result of a number of failed hypotheses, we developed the following formula to explain the factors contributing to Cycle-PT demand.

A dominant issue in the research on Cycle-PT is the lack of data on the contributing factors to Cycle-PT demand. In order to make use of the limited number of data points and provide for sensitivity to the possible range of input variables, our calculations for demand are based on an estimate of the mean and standard deviation for each variable.

This model has been implemented in Microsoft Excel where four variables are used for three PT modes (bus, rail, and ferry) with the three Cycle-PT scenarios. The four variables are shown in the by the orange boxes in **Figure 1,** shown in **Equation 1** and listed in **Table 4**.

The factors are then described in turn.

Table 4: System Wide Model Variables

Variable	Description
Mode	Select mode: Bus, Rail, or Ferry
Scenario	Select Provision: BoB Only, BaR Only, or BoB & BaR
(1) Cycle-PT	Range of Usage Rates (mode and facility dependent)
(2) StorInducedPT	Demand for PT due to the presence of bicycle storage
(3) BoBModeShift	Demand for PT due to the ability for bikes on board
(4) StorageBaRDemand	Demand for Storage Units. Expressed as a percentage of total Cycle-PT users.

[1] A Cycle-PT user is defined as a person who makes two Cycle-PT trip ends per day.

Equation 1: Macro Model Equation for Cycle-PT Demand

CyclePT = *Existing PT Patronage (x) Cycle-PT Rate (x) BoBModeShift_induced (x) StorInducedPT (x) StorageBaRDemand*

The process is summarised in **Figure 1** below.

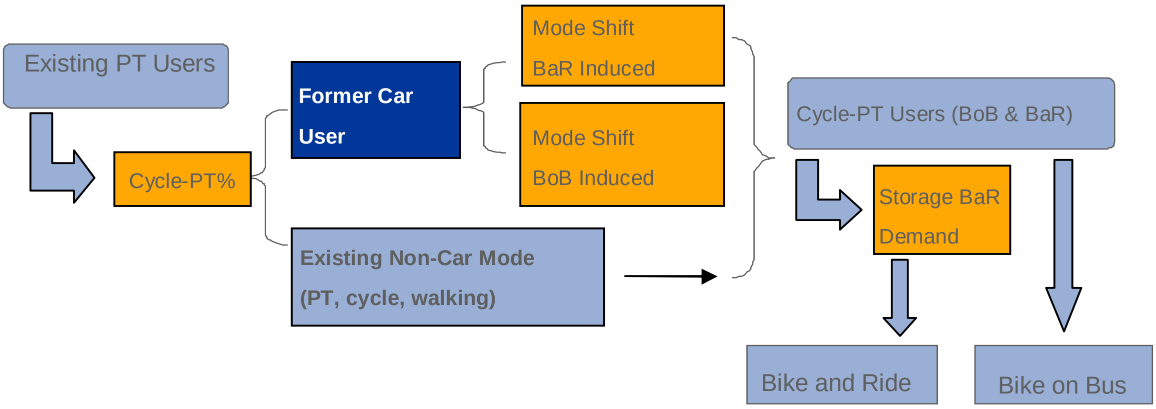


Figure 1 – Macro Model Form

Variable 1: Cycle-PT

The variable provides an observed ratio of Cycle-PT users to total PT patronage. This figure typically does not include any BaR users. Based on analysis of the range of US data, appropriate observed rates of Cycle-PT as a proportion of total PT patronage for PT systems with similar patronage to New Zealand's were calculated. These are shown in **Table 5** below, which is based on the observed rates shown previously.

Table 5: Forecast Range of Cycle-PT Users by PT Mode for PT Systems similar to NZ

PT Mode	Low	Average	Maximum
Bus	0.5%	1.2%	5%
Rail & Ferry	1.5%	3%	6%

The range and distribution of the Cycle-PT demand shows the degree of variation that exists within the observed North American data. The pattern however shows that most systems do obtain at least the low rate with the majority of the systems working around the average value. However, as the long tail in the figure shows, several bus systems see higher Cycle-PT rates. The observed Cycle-PT rates were translated into a log-normal distribution and used throughout the analysis in the Monte-Carlo simultation.

Variable 2: StorInducedPT

This variable captures the effect of placing secure storage facilities in an area. As it pertains to PT, simply the provision of secure storage will induce certain users to use the storage unit and then use PT. These users are never observed as BoB in typical studies since they would have parked their bicycle before boarding in all cases. Users explained by this variable will increase net Cycle-PT users above the observed rates of **Variable 1: Cycle-PT**.

The value was derived as part of the initial research (1992 National Bicycling and Walking Study) conducted in the United States before a national effort to improve walking and cycling programmes. The likely value is about 4% with a range extending from a low of 1% to a high of 12%. The range of this variable is taken into account by a log-normal distribution.

Variable 3: BoBModeShift

A significant source for many of the quotes on BoB usage is the Center for Transit Research at the University of South Florida. The report states that approximately 25% of riders started riding transit because of Bikes on Bus programmes. The authors state that this number may be artificially low because even sporadic PT users were defined as previous PT users, where most often mode choice surveys designate the most frequently used mode as the primary mode.

A study by Denver Regional Transportation District in 1999 found that of the 2,300 daily users of bus mounted cycle racks, 50% of riders surveyed said they were new riders to public transport and 27% said they would be sitting in a single occupancy vehicle if they did not have the option to put their bike on the bus.[10]

Pinellas Suncoast Transit Agency (PSTA) indicated that in a 1999 survey of their Bike on Bus riders 70% were single occupant drivers or carpool riders before using the BoB program.

A 1992 study in Vancouver, Canada, found that 30% of users at Vancouver's bike lockers at a commuter rail station had not previously used public transport to commute.[11] The converse is that 70% of BaR users were also previously PT users.

There is difficulty in comparing data and differing or unclear definitions of a 'previous PT user'. For this reason there is a large range in the variable with the likely value being 50% of Cycle-PT users are new to PT, with a range from a low of 25% to a high of 70%.

This variable captures the effect of induced PT riders switching from other modes due to the presence of Cycle-PT (Bike on Board and Bike and Ride) options.

Variable 4: StorageBaRDemand

The variable forecasts the percentage of Cycle-PT patrons using secure storage in their Cycle-PT trip. This includes both riders who may use storage at the front end of the PT trip and those that may prefer to store their cycle at end of their PT trip.

BaR demand is forecast as a percentage of total Cycle-PT users. As the attractiveness of storage increases, a reduction in BoB may be observed. The BoB predicted within this study represents those trips that do not use any secure storage provided at the stations.

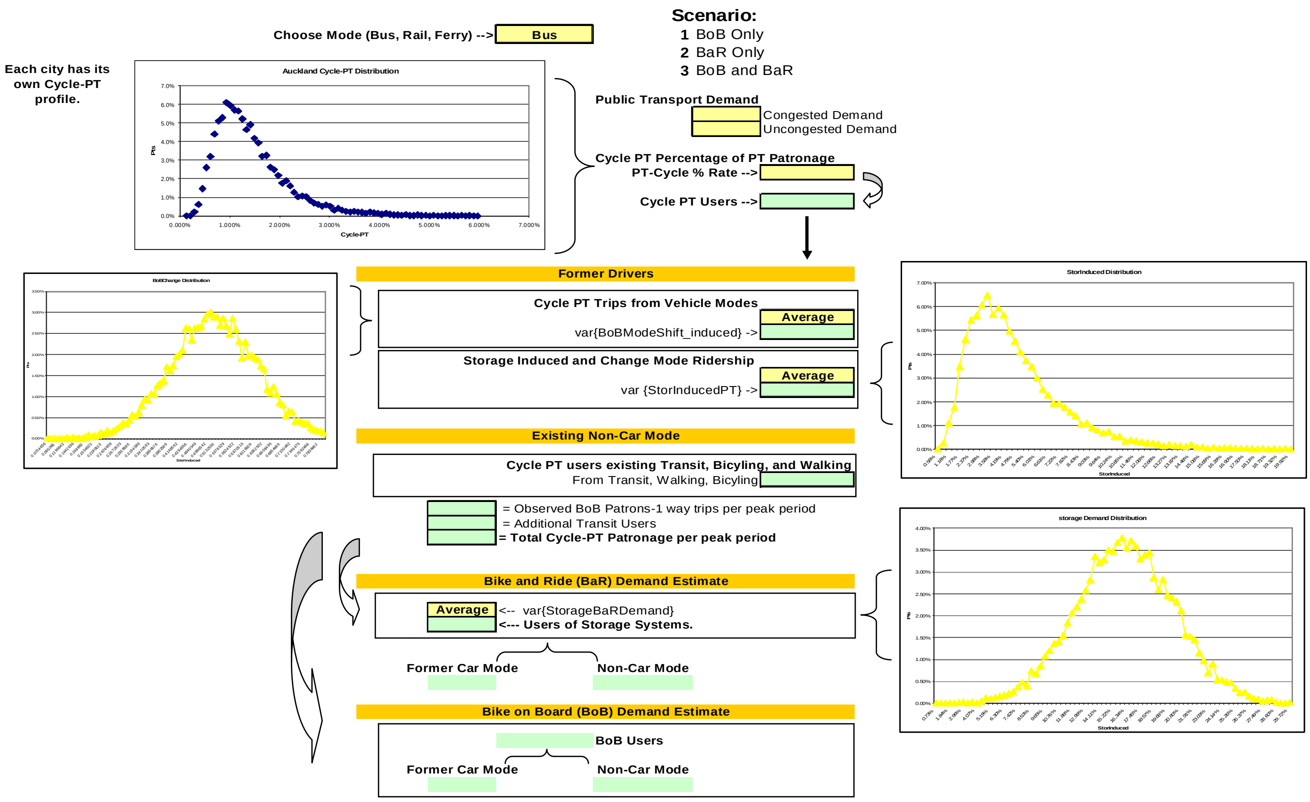
There was little information available on the demand for storage based on patronage figures. Based on our research, the expected value of Bike and Riders is 16% of total Cycle-PT users[12] which does not include the additional induced users shifting to Cycle-PT described by **Variable 2: StorInducedPT**. This value is from one study of observed storage demand and surveys of storage users in the greater Seattle, Washington area developed by the Puget Sound Regional Council[12]. Without better data, it is assumed that the upper and lower quartiles of demand would be 8% and 24%.

Figure 2 shows a flow chart for the Macro Model with the variable distributions used in the Monte-Carlo simulation. A Monte Carlo simulation[2] was developed to create a range of potential values and a 95th percentile confidence interval for the Cycle-PT demands. The distributions of the four variables were based on the values obtained from the international literature review.

The flow chart demonstrates the steps used in the assessment of the BoB and the BaR and the estimation of those users shifting from car modes to Cycle-PT. The process provides the distribution pattern of the four variables involved in the demand assessment of Cycle-PT. The variables are all multiplied by the existing overall PT patronage to obtain estimates of Cycle-PT users, Bike on Board users, Bike and Ride users, and those users shifting from private cars.

The Monte-Carlo simulation carried through the analysis equation for Cycle-PT but accounted for the unique distribution of the variables included in the analysis. In this manner the study attempted to reflect the range and likely values of Cycle-PT based on the range of conditions amongst New Zealand cities.

Figure 2: System Wide Cycle-PT Demand Model



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2 Monte Carlo simulation based on 10,000 iterations of the ranges of variables described above. Cycle-PT and StorInducedPT based on Log-Normal distributions, BoBModeShift, and StorageBaRDemand based on normal distributions.

2.6 Micro Model: Cycle-PT Demand at Individual Stops / Stations

This model is useful for determining the Cycle-PT capacity required in various parts of the network / on the PT route and hence also how many secure storage lockers could be provided at points on the network.

The macro model includes assessment of the entire system, however the placement of individual lockers and which routes may receive prioritisation for racks comes down to an individual route by route analysis.

The demand for Cycle-PT at a micro level comes from the following sources:

- Those who are in the **increase in catchment size** from people outside walking catchment being able to ride a bicycle to PT service (BaR or BoB).
- Those currently **within walking catchment** for whom their destination was outside walking distance from the end of the PT journey (BoB).
- Those for whom typically **already cycle the full journey**, but want to take PT instead with their bicycle (BoB).

The sum of these three demands will equate to the BoB plus BaR patronage.

The research methodology assumes that the Cycle-PT% patronage rates are indicative of catchment effects for different types of PT services (e.g. local bus, rail) and therefore the micro model could make use of existing data on PT patronage that boarded or alighted at a particular stop.

> ***CyclePT at a point on Route or at a Terminus*** *= Existing PT Patronage Alighting and/or Boarding (x) Cycle-PT Rate*

Table 6 shows how the variation in Cycle-PT rate (using the Monte-Carlo simulation) by each mode varies by the size and mode of the existing PT patronage. This table also contains the information necessary for estimating Cycle-PT demand for a route or a station.

Accounting for secure storage locker space uses the estimated Cycle-PT patrons for the route or station and finds the amount of storage necessary based on the StorageBaRDemand variable described in Section 2.5.

The BaR numbers shown in **Table 6** should be multiplied by a peak demand factor of 1.3 to account for higher patronage that will occur on peak days. This 1.3 factor is based on North American commuter data which suggests on average a male cycle commuter will make 6.7 trips on average per week.

Table 7 shows the supply and demand range of secure locker facilities for a variety of stations for different modes.

Table 6: Example Forecast Demand Ranges for Cycle-PT for typical PT Service Routes

	Boardings per Period	Range	Median	Average	Standard Deviation	95 Percentile Confidence Interval High	Low
Local Bus							
Cycle-PT in AM Peak = Existing PT Patrons x 1.2%							
Cycle-PT (BoB & BaR)	100	7.7	**1.2**	1.4	0.7	2.7	0.5
BaR	100	1.4	**0.2**	0.2	0.1	0.5	0.1
Cycle-PT (BoB & BaR)	500	37.7	**6.0**	7.0	3.7	13.7	2.6
BaR	500	9.0	**1.0**	1.1	0.7	2.4	0.4
BRT, Rail, Ferry							
Cycle-PT in AM Peak = Existing PT Patrons x 3%							
Cycle-PT (BoB & BaR)	100	14.7	**3.1**	3.4	1.5	6.1	1.6
BaR	100	3.3	**0.6**	0.7	0.3	1.3	0.3
Cycle-PT (BoB & BaR)	500	73.6	**15.7**	17.2	7.3	30.0	8.0
BaR	500	16.4	**3.0**	3.4	1.7	6.6	1.4
Cycle-PT (BoB & BaR)	1000	147.1	**31.3**	34.3	14.7	61.4	16.0
BaR	1000	32.7	**6.1**	6.8	3.4	13.3	2.8
Cycle-PT (BoB & BaR)	2000	294.3	**62.6**	68.6	29.4	123.0	32.0
BaR	2000	65.4	**12.2**	13.6	6.8	27.0	5.5

Table 7: Example Secure Locker Demand and for typical PT Service Routes

Mode (Cycle-PT Rate)		One-direction Boardings	Cycle-PT Users	Storage Demand (BaR Demand) Low (8%)	Average (16%)	High (24%)	Storage Locker Supply (BaR Supply) Low (8%)	Average (16%)	High (24%)
Local Bus (1.2%)	Local/City Bus	50	0.6	0	0	0	0	0	0
		100	1.2	0	0	0	0	0	0
		300	3.6	0	1	1	0	1	1
		500	6	0	1	1	1	1	2
BRT (3%)	Express or Limited Access Bus						0	0	0
		500	15	1	2	4	2	3	5
		1000	30	2	5	7	3	6	9
		2000	60	5	10	14	6	13	19
Rail (3%)	Local Light Rail or Heavy Rail						0	0	0
		1000	30	2	5	7	3	6	9
		2000	60	5	10	14	6	13	19
		4000	120	10	19	29	13	25	37
Ferry (3%)	Regional Ferry Station						0	0	0
		1000	30	2	5	7	3	6	9
		3000	90	7	14	22	9	19	28
		5000	150	12	24	36	16	31	47

Practitioners need to use this model in association with the macro model to avoid any double-counting of secure storage demand within the system. For example, if a walking PT user is counted at more than one point (station / terminal / stop) on the route (e.g. both where they board and where they alight the service), then the micro model will forecast Cycle-PT BaR usage for that user at each point, double-counting storage demand.

At locations where the required supply of BaR lockers is less than 2, there will be extreme variability in locker requirements as day-to-day demand may rise to 3 or 4, for example. Where there is only a small numerical requirement for BaR lockers at a location, then there are two possible courses of action: a minimum of 2 lockers at any location; group lockers at one location for demand from a number of stops (with a minimum of 2 lockers at any point).

To avoid double counting by the micro model, only boarding patrons should be considered.

Literature research from the United States indicated that 61 percent of BoB users cycle more than one mile to access transit but 80 percent travel less than one mile after getting off transit. This data suggests that secure bicycle storage would be the most effective at the origin of their PT trip.

But if secure storage is being provided at the end of the PT trip (i.e. there also needs to be BoB) then alighting passenger numbers can be used at that end of PT trip. However as the micro model calculates users (who make 2 trips per day) double counting will occur if more than one direction of PT is used for calculation.

It could be expected that if lockers are allocated using the micro model that the route / system-wide number will be higher than the macro model, due to effects of rounding up locker demand number at each point.

3 APPLICATION OF THE FORECAST MODELS TO NEW ZEALAND

3.1 Forecasting Cycle-PT Demand in New Zealand Centres

The macro model developed has been used to determine both the existing demand for Cycle-PT in New Zealand's larger centres, as well as the potential should a Cycle-PT implementation operate at higher than typical levels because of local context, for example higher existing cycle mode share / high quality cycling infrastructure.

Table 8 shows that there is current demand for approximately 1.5 million Cycle-PT trips per annum in New Zealand.

This is based on existing patronage levels – where there is forecast high growth in PT patronage in a region, then Cycle-PT is forecast to rise at a similar rate.

As patronage rises from the large investment in Auckland's passenger rail system in the coming decade, then there is likely considerable upside in the Cycle-PT demand for the Auckland region above the 660,000 annual trips forecast.

Table 8: Annual Cycle-PT Trip Demand based on approximate annual patronage per region

Location	Mode	Current PT Patronage (approximate per annum)	Annual Cycle-PT Trip Demand	
			Likely	Stretch Goal
Auckland	Bus	45 million	479,000	1,350,000
Auckland	Train & Ferry	7 million	422,000	520,000
Wellington	Bus	25 million	253,000	750,000
Wellington	Train & Ferry	10 million	534,000	684,000
Tauranga	Bus	0.5 million	13,000	15,000
Dunedin	Bus	2 million	22,000	60,000
Christchurch	Bus	15 million	161,000	450,000
Hamilton	Bus	2 million	20,000	60,000
		Total	1.9 million	3.9 million

3.2 Economic Evaluation of Cycle-PT

The information produced by the forecast models has been used to perform an economic evaluation to assess a benefit to cost ratio using the New Zealand Transport Agency's Economic Evaluation Manual procedures.

Six urban areas within New Zealand were assessed for their potential to integrate Cycle-PT into their existing public transport service. This involved identifying the cost of fitting out the public transport vehicles, training, and ongoing operating costs.

For every area, the benefit to cost ratio exceeded 1; more so for the cities with higher congestion.

Table 9 identifies the forecast economics of the introduction of Cycle-PT in New Zealand for the different implementation scenarios. Scenario 1 being Bike on Board only, Scenario 2 being Bike and Ride Only, and Scenario 3 being Bike on Board and Bike and Ride.

Note that when comparing with the table of Cycle-PT trips above, a Cycle-PT user is defined as a person who makes **two** Cycle-PT trips per day.

In the three areas of relatively lower patronage (Hamilton, Tauranga and Dunedin), the model predicts to the seemingly accurate level of a dozen or so people who will use Cycle-PT. The reality is that in these situations local conditions on particular routes could alter the forecast demand by a large percentage. The Monte Carlo simulation illustrated this for the Dunedin scenario where the 95th percentile figures for both BoB and BaR were more than double the averages shown.

Table 9: Demand and Economics of the Introduction of Cycle-PT into New Zealand (Bikes on Board & Bike and Ride)

	Auckland	Wellington	Christchurch	Hamilton	Tauranga	Dunedin
Scenario 1: Bike on Board Only						
Daily Cycle-PT Trips	2,224	1,218	745	89	58	99
Daily Cycle-PT Trips from cars	1,469	580	369	44	17	49
Secure Locker Supply	-	-	-	-	-	-
Benefit to Cost Ratio	6.1	4.5	3.5	2.3	3.4	3.5
Scenario 2: Bike and Ride Only						
Daily Cycle-PT Trips	582	307	195	23	15	26
Daily Cycle-PT Trips from cars	133	70	45	5	3	6
Secure Locker Supply	378	200	127	15	10	17
Benefit to Cost Ratio	N/A	N/A	N/A	N/A	N/A	N/A
Scenario 3: Bike on Board & Bike and Ride						
Daily Cycle-PT Trips	2,939	1,550	985	118	76	131
Daily Cycle-PT Trips from cars	1,536	810	516	61	40	68
Secure Locker Supply	378	200	127	17	10	22
Benefit to Cost Ratio	3.0	2.8	2.2	1.2	1.3	1.6

The economic analysis indicates that either Cycle-PT option would produce favourable results in any of the six regions and result in funding projects where benefits exceeded costs.

4 CONCLUSIONS

Cycle-PT can provide additional transport modal choice and flexibility in the utilisation of existing public transport. By providing additional means and methods can realise an increase in public transport patronage and can encourage an increase in non-car travel. It also provides options for cyclists who at times may wish to use PT for part of their journey.

The provision of cycle racks on-board PT or secure storage at the stations can increase overall public transport patronage and provide an overall benefit in the local region by reducing congestion, improving health of patrons, and reducing environmental impact of transport.

North American data provides observed rates of Cycle-PT utilisation and the ranges of variables to estimate the sources of Cycle-PT demand. The research described in this paper provides a unique overview of the variables to determine the demand for Cycle-PT, including an estimate the shift from private cars, the demand for secure lockers, as well as the assessment of economic benefits using the standard New Zealand project evaluation process found in the Economic Evaluation Manual (EEM).

An estimation process using the range within factors in a Monte-Carlo simulation has produced demand equation which can provide New Zealand practitioners a likely value and range potential values for the planning, economic and funding assessments.

The economic benefits of Cycle-PT as assessed for New Zealand regions using the procedures outlined in the EEM indicate a positive economic return for the introduction of a combined bike on board and bike and ride system. The economic returns from a Bike on Board system alone are higher and particularly high in the Auckland region.

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