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Economic benefits of park and ride

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Abstract

New Zealand transport decision-makers have been seeking better guidance on the rationale, appraisal methods and optimal investment conditions for park and ride. This research responds to this requirement with an economic and financial appraisal framework based on a cost-benefit analysis methodology, and a funding allocation framework that links funding contribution to the level of benefit received. Local transport models do not currently include park and ride as a modal option, so mode share is determined using diversion rates derived from market research, and the effect on road system performance is determined using an elasticity-based simplified modelling approach.

The appraisal framework has been tested by applying it to five case studies covering the expansion of existing rail and bus-based park and ride sites in Wellington and Auckland. The case studies demonstrate that increased park and ride provision produces high returns relative to most other types of investment that encourage modal shift to public transport in major urban areas, with estimated benefit-cost ratios in the range of 2 to 4.

1. Introduction

New Zealand transport decision-makers have been seeking better guidance on:

- the rationale for investment in park and ride (P&R) as a cost-effective and efficient means of improving state highway and local arterial road performance and/or reducing public transport subsidies;
- methods for the economic and financial appraisal of P&R investments; and
- the process and necessary conditions for optimal P&R investment decisions to be made.

This research, which was conducted through the New Zealand Transport Agency research programme in 2013-14, responds to this requirement with an economic and financial appraisal framework based on a cost-benefit analysis methodology, and a funding allocation framework that links funding contribution to the level of benefit received.

The research focus was on assessment of the case for individual P&R facilities using case studies, rather than on the development and assessment of an overall P&R programme for each region/corridor. A methodology was therefore developed for assessing the effects of investment in additional P&R spaces on demand and modal choice, and hence scheme capital and operating costs, benefits to public transport system users, benefits and costs to public transport operators, and decongestion benefits to road system users. A supporting spreadsheet-based tool provides a flexible and easy to use means for scenario testing.

This paper summarises the key considerations of the project and the findings of the case studies that were used to develop and demonstrate the methodology and provide performance estimates.

2. Background

Transport authorities may have many motivations for investing in the P&R option. However, the rationale for investment in P&R is usually based on one or more of the following objectives:

- to provide a lower-cost substitute for CBD parking, which can be expensive for authorities to provide and for users to access;
- to reduce peak demand on and help decongest major roading corridors, by providing an attractive alternative to driving 'all the way';
- to reduce personal vehicle travel and associated operating costs, fuel consumption and greenhouse gas emissions, by providing an attractive alternative to driving 'all the way'; and
- to improve the financial viability of public transport or support increased public transport service levels by increasing coverage and patronage.

P&R schemes must be carefully planned to ensure that they are appropriately implemented and maximise their potential for success (as with any public investment). Key considerations include:

- the geographical location of the P&R station, both in terms of the catchment that it can serve and the roading links that connect that catchment to the station;
- the quality of the facilities at the P&R station, particularly those that relate to car and personal security;
- the quality (e.g. reliability, frequency, travel time and condition) of the rapid transit link(s) between the P&R station and the city centre and/or other key destinations; and
- the cost, to the user, of the public transport alternative (including P&R charges) compared to the cost of driving 'all the way' and parking at the destination.

In New Zealand, formal P&R is a feature of the Wellington (rail) and Auckland (rail and busway) networks. There has been significant investment in the addition of new P&R locations and additional capacity and facilities at existing P&R locations over the last decade, and further P&R investment is planned. This is largely justified on the basis of reducing road congestion and extending public transport coverage and patronage.

3.1 Demand assessment

The initial step of this project was to find an appropriate way of assessing the potential mode shift impact of increased P&R provision. A review of transport modelling practices was carried out and found that the preferred international approach is to offer P&R as an option at the strategic level of transport models. Unfortunately, the current Wellington and Auckland regional transport models do not have this capability, and only offer P&R as a sub-mode level option, making them unsuitable for estimating the modal effects of changes in P&R availability.

A diversion rate approach was therefore used to identify the market response to the provision of additional P&R spaces, and in particular, the extent to which car drivers would switch from using car to travel to the CBD to using car to access P&R. The diversion rate can be defined as the proportion of PT trips associated with P&R improvements, which would otherwise have been made by car in the absence of such improvements.

The diversion rates in each city were determined from primary market research with current P&R users. A stated intention approach was used in Wellington, where the rapid transit system is well-established. There, existing P&R users travelling to the CBD from Waterloo and Petone railway stations were asked how they would respond to a reduction in the number of P&R spaces. This response was then 'inverted' and used to estimate Wellington users' likely response to an increase in the number of spaces.

A revealed preference approach was used in Auckland, where the rapid transit system has been significantly expanded in recent years. There, existing P&R users travelling to the CBD from Albany busway station were asked how they had changed their travel behaviour in response to a recent actual increase in P&R spaces.

The Wellington and Auckland diversion rates determined from the survey results are shown in Table 1. The respective diversion rates were applied to the relevant case studies in each city.

Table 1: Diversion rate per 100 users

Previous/next best mode	Wellington	Auckland
Car driver (to CBD)	12	34
Direct bus service (to CBD)	3	16
Feeder bus service	9	6
Park on street	41	33
Park at another station	16	6
Other	19	5
Total	100	100

These diversion rates are within the range of international experience with similar schemes. There is a distinct difference between the two cities, which may reflect that:

- direct bus services do not offer a competitive alternative at the Wellington sites, but do at the Auckland site; and
- the rapid transit system is well-established at the Wellington sites, but relatively new at the Auckland site.

The diversion rate approach was useful, but does have limitations. It had to be assumed that the rates surveyed for one site could be applied to other broadly similar sites, and the approach is probably only valid for relatively small increases in the number of spaces. It is also weak in terms of assessing likely diversion of P&R users between adjacent sites as a result of capacity changes, although the diversion rate surveys do provide some relevant evidence.

3. Economic appraisal

3.1 Appraisal framework

International literature on P&R scheme appraisal is not extensive. The project considered adapting the approach used by Jacobs (Jacobs Consulting 2011), which was considered useful and relevant. However, it was decided to develop a specific appraisal framework for the project, rather than adapt the Jacobs framework, to ensure that the recommended framework was fully applicable in the New Zealand situation.

The appraisal framework developed, which is based on cost benefit analysis principles, separates the financial impacts (costs) to public authorities from the economic impacts (benefits) to transport system users. The financial impacts are divided between three public authorities: the road authority, the public transport authority, and a notional P&R authority whose functions could belong to either of the other authorities in a ‘real world’ situation. The economic impacts are identified separately for three main transport user groups: road (car) users, public transport users and P&R users/mode switchers.

The main economic input parameters relate to the value of travel time savings, in particular commuter walking and waiting time, and average travel time savings for general traffic. The method also takes into account vehicle operating cost changes, greenhouse gas emission changes, and crash cost changes. Parameter values are consistent with those in the NZ Transport Agency Economic Evaluation Manual where applicable.

The Appendix details the components of the economic appraisal framework developed for this project. Sections 3.2, 3.3 and 3.4 discuss some of the key components of the framework.

3.2 P&R user impact

An increase in P&R capacity benefits existing P&R users, who benefit from greater availability of spaces, new P&R users who use the additional P&R spaces, and other P&R users, in particular on-street parkers who receive benefits (e.g. reduced walking times) even if they do not use the additional P&R spaces.

The number of potential new P&R users and the benefits to existing and new P&R users was calculated from the:

- the extent of on-street parking at a site;
- the benefits that on-street parkers enjoy in terms of reduced walking times; and
- the proportion of new P&R users that currently park on-street (as deduced from Table 1).

3.3 Public transport system impact

An increase in P&R capacity can be expected to result in increased patronage on peak period public transport rapid transit services, with people switching in part from car ‘all the way’ travel, and in part from other (non-rapid transit) public transport services.

The authorities can respond to this increased patronage in various ways, including:

- No response (i.e. the services would become more crowded with crowding disbenefits).
- Increase service capacity by increasing service frequencies (bus or train).
- Providing services in higher capacity units (e.g. longer buses, trains with more carriages).

For purposes of the case studies, the following response was assumed:

- bus service capacity and frequency would increase in direct proportion to any increase in demand (with additional costs falling on the operator, while users would benefit from the increased frequencies); and
- rail service capacity would increase in direct proportion to demand, but the additional capacity would be provided through longer trains (more carriages per train) rather

than through more frequent services (with no benefits or disbenefits to public transport users).

The number of new public transport users (as main mode or feeder mode) was estimated and used to calculate the effect on public transport operating costs, existing public transport user costs and public transport fare revenues.

3.4 Road system impact

An increase in P&R capacity can be expected to cause small changes in traffic volumes, due to the impact of mode switching. However, this decongestion impact can be challenging to measure.

The corridors assessed in this project (Waterloo/Petone to Wellington CBD and Albany to Auckland CBD) are covered by SATURN traffic assignment models, which represent traffic in units of vehicles (rather than people) and estimate route choice from a specified origin to a specified destination taking account of travel distances and travel times. Testing showed that there was a reasonably consistent relationship between the percentage of traffic removed and percentage change in average speed. This relationship was plausibly consistent with other research into generalised travel speed, and allowed the results to be expressed in terms of an elasticity of average % change in speed over the network with respect to average % change in vehicle km travelled in the network. Application to specific corridors gave elasticities of approximately 2.7 for Petone-Wellington CBD and 2.5 for Albany-Auckland CBD.

It was also found to be possible to replicate observed behaviour using mathematical models. This allowed a simplified modelling approach to be developed to calculate a site-specific travel time demand elasticity, based on the relationship between congested and free flow travel times, providing a very simple, but theoretically sound means of estimating the specific elasticity for any location. This relationship is:

Elasticity: $\varepsilon = 4 \cdot$(congested time – free flow time) /congested time.

The resulting elasticity could then be multiplied by the congested travel time to obtain the marginal congestion externality (i.e. the externality resulting from an increase or decrease in demand by one vehicle), based on the following relationship:

Marginal congestion externality: $E = \varepsilon$ * congested time

The results were used to estimate the elasticity for each of the park & ride case study sites, as shown in Table 2, and hence the congestion externality.

Table 2: Elasticity calculation

	Petone	Waterloo	Porirua	Albany	Constellation
Congested time (min)	21.6	25.2	20.9	50.9	46.1
Free flow time (min)	10.1	13.9	13.6	14.8	12.5
Elasticity	2.12	1.80	1.40	2.84	2.92

The elasticities calculated using the simplified modelling approach for Albany (2.8) and Petone (2.1) compare well with the elasticities identified from the traffic assignment model runs: 2.5 and 2.7 respectively. The relative sizes of the elasticities seem reasonable considering the known traffic conditions in each corridor.

4. Funding allocation framework

The literature shows that, internationally, P&R funding allocation is generally based on the objectives of the relevant investment fund. For example, the UK Department for Transport's 'Transport Investment Block' funding for small public transport projects, including P&R, is allocated using a 'needs based' assessment of six elements: deprivation, road safety, public transport, air quality, congestion and accessibility (Department for Transport 2012). These help justify investment from an individual organisation perspective, but do not help when looking where funding 'should' fall, e.g. based on where benefits fall. As noted in Allison et al (Allison et al. 2013), this is largely a political decision, although some guidelines can be provided and the concept 'that transport funding be equitable, that is, the distribution of costs and benefits should be considered fair and appropriate' (Litman 2013) is an important one.

The Queensland Government published 'Developing a Funding Framework' (Queensland Government 2013) is not specific to P&R or transport generally, but provides guidelines on quantifying and attributing costs and benefits for a multi-agency project. These are considered particularly relevant given the number of public authorities (with different policy goals/objects) involved in P&R investment in New Zealand. A key principle from this and other documents is that costs should be attributed across the various authorities on the basis of benefits accrued, which is the starting principle for the funding allocation framework below.

Although also not specific to P&R, the Auckland Council (2012) alternative funding discussion document identifies five criteria for assessing alternative funding sources - fairness, administrative efficiency, transparency, neutrality, capacity - that could be relevant for P&R.

Litman (2013) identified criteria for determining local funding sources for public transport projects and services (potential revenue, predictability and stability, equity analysis, travel impacts, strategic development objectives, public acceptability, ease of implementation, legal status). As Litman (2006) notes, funding allocation should be considered within the wider project appraisal approach.

The principles set out in these references provided a sound basis for the development of the funding allocation framework that guides the allocation of costs between the three authorities (i.e. the road authority, the public transport authority, and notional P&R authority). The key concept underlying this framework is that each party should contribute funding to worthwhile projects in the proportion to which they, and their users, benefit.

The recommended allocation of user benefits and costs is therefore as follows:

- P&R user benefits accrue to the P&R authority and new ridership benefits to the public transport authority;
- public transport existing user benefits accrue to the public transport authority;
- decongestion benefits (including operating and maintenance costs and deferral of capital expenditure) accrue to the road authority;
- road system externalities accrue to the road authority;
- infrastructure (capital) costs accrue to the P&R authority and public transport authority (assuming the road authority does not bear any direct/significant costs);
- operating and maintenance costs accrue to the P&R authority and public transport authority; and
- revenues from additional public transport users accrue to the public transport authority, while any user charges for P&R facilities accrue to the P&R authority and offset costs, although this will depend on the revenue collection mechanism.

The funding allocation framework was applied to the case studies to illustrate its application and implications in practical cases.

5. Case studies

5.1 Case study purpose and selection

The project undertook 'real world' case studies of investments in additional P&R capacity. These were used to provide a focus for the development, testing and fine-tuning of the appraisal methodology, demonstrate the methodology, and provide estimates of economic/financial performance and key performance drivers in each case.

Five case studies were selected from a long list of sixteen. The long list was identified with the help of practitioners in Wellington and Auckland, and covered a range of modes (bus/rail/ferry), different facilities located within the same catchment area, and varying distances from the CBD. Each long list site was then evaluated on its public transport service frequency, location relative to significant morning peak congestion, access (local road, arterial road, or State Highway), and size, and a short list of five preferred case study sites plus three reserve sites recommended to the Steering Group.

The five final case studies involved the provision of additional P&R spaces at existing sites on the Wellington and Auckland rapid transit networks. The schemes differed in terms of alternative public transport means of travel to the CBD, the length of time since establishment, the extent to which employment opportunities focus on the regional CBD, and the extent to which alternative P&R sites are readily available.

During the application of the evaluation framework, an issue arose relating to the size of the expansion to be assessed. Mode shift was calculated using diversion rates and the number of cars parked on-street in the vicinity of each site in the Base Case, which is valid when the number of cars parked on-street is less than or equal to the likely shift from on-street parking to P&R facilities (i.e. the input diversion rate). However, in some cases (Porirua, Petone and Albany), the larger P&R facilities in the Option provided more capacity for on-street parkers to relocate to than the estimated demand. This was addressed by reducing the additional P&R capacity to be provided and revising Option capacity.

Table 3 provides details of the chosen case study sites, and shows the planned and revised capacity changes.

Table 3: Case study sites

Site	Location	Base Case	Option	Mode	Development Plans	Suitable Traffic Model
Petone	Wellington	Current site (266)	Expansion (566) Revised to 441 [+175]	Train	Yes	Yes
Waterloo	Wellington	Current site (602)	Notional upgraded facility (702) [+100]	Train	No	Yes
Porirua	Wellington	Current site (452)	Expansion (761) Revised to 637 [+185]	Train	Yes	Yes

Albany	Auckland	Pre-2012 Expansion (550)	Current Site (1100) Revised to 990 [+440]	Busway	Yes	Yes
Constellation Drive (NEW)	Auckland	Current site (370)	Notional upgraded facility (470) [+100]	Busway	No	Yes

5.2 Case study economic/financial appraisal results

The case study economic/financial appraisal derived total costs and benefits[1] for each case study scheme, based on the specified number of additional spaces to be provided, and then converted these to values per additional space, to facilitate comparative analyses.

The case study appraisals were undertaken on an annualised basis, to circumvent the need for forecasting of future demand changes. The key economic performance measures derived were the net annualised value (annual equivalent of net present value) and benefit cost ratio (BCR). The benefit items were disaggregated into the three main transport user groups (i.e. road users, public transport users and P&R users/mode switchers).

Table 4 presents the results for each location on a per additional space basis. Several points should be noted when interpreting these results:

- All figures are provided on an annual basis (rather than a discounted cash flow basis over the scheme life). For this purpose, the capital costs involved in providing the additional spaces were annualised (at 6% pa real over an assumed 20 year life, and allowing for residual value for the land at the end of this period).
- BCR estimates are based on the NZ Transport Agency Economic Evaluation Manual definition of the government BCR (BCR_G), (i.e. with the BCR denominator representing the scheme costs to government). This approach was considered more appropriate for schemes such as this, which generate significant revenues to partially offset ongoing operations/maintenance costs.
- The net effects on PT operators (incremental cost less incremental fare revenues) are treated as a cost (i.e. included in the BCR denominator), on the basis it will be funded by the public sector (through regional council contracts), rather than as an operator benefit. This assumption affects the BCR results, but not the net annualised value for each scheme.

Table 4: Summary of case study results on a per additional space basis

	Dollars per annum /space				
	Petone	Waterloo	Porirua	Albany	Constellation
Benefits (pa)					
P&R users	1601	2005	2597	1138	1477
Public transport users	-88	-92	-124	-126	-153
Road Decongestion	451	478	313	4386	4108

[1] Using the economic appraisal framework specified in the appendix.

PT operator benefits	0	0	0	0	0
Total User Benefits	1963	2391	2786	5398	5432
Costs (pa)					
P&R capital	833	833	833	998	1120
P&R O&M	450	450	450	450	450
PT Operating (net)	-353	-353	-353	-36	97
Total Costs (annualised)	930	930	930	1412	1667
Summary					
Net annualised value	1033	1462	1856	3986	3765
BCR_G	2.1	2.6	3.0	3.8	3.3

Key findings on economic/financial performance for the 'typical' case study are summarised in Sections 5.2.1 to 5.2.3.

5.2.1. Costs

The largest cost item was the capital costs (land and construction) to provide the additional P&R spaces. In all cases these annualised capital costs were around $1,000 pa per space, corresponding to a total capital cost of around $15,000 per space. The second largest cost item was the P&R site operating and maintenance costs at $450 pa per space.

5.2.2. Benefits

Road decongestion accounted for the great majority (around 80%) of total benefits for the two Auckland case studies. In Wellington, the road decongestion benefits accounted for only 11% - 23% of the total benefits, with benefits to P&R users dominating (80% to 92%).

5.2.3. Overall economic performance

For each of the five case studies, the BCR_G results were substantially greater than 1.0. The two Auckland schemes (with the high decongestion benefits) had BCR_G estimates of about 3.8 (Albany) and 3.3 (Constellation). The three Wellington schemes, with much lower decongestion benefits, had BCR estimates between 2.1 and 3.0. These results were not very sensitive to plausible changes in input and methodology assumptions.

5.2.3. Impacts by transport agency

Allocating costs and benefits by agency, the majority of costs were incurred by the notional P&R authority, and the P&R users received economic benefits, which in most cases exceeded these costs. The net costs to the public transport authority (for providing additional services less additional fare revenues received) were relatively small, as were any benefits to existing public transport users (through service frequency changes). Road users were the major recipient of economic benefits (relating to decongestion), while the road authority did not incur significant costs.

6. Conclusion

The appraisal methodology developed and tested in the case studies was designed to provide the best possible estimates of the economic/financial performance of potential P&R schemes. Its strength is that it is supported by a transparent and flexible spreadsheet-based tool, which is relatively easy to use by the analyst, is very flexible (for 'what if' testing) and can be readily refined by the analyst as appropriate. The parameter values are consistent with NZ Transport Agency Economic Evaluation Manual parameter specifications.

A 'diversion rate' approach was used to estimate modal shifts based on market surveys of the 'next best alternative' means of travel by current P&R users. This approach has limitations – the assumption was made that diversion rates surveyed for one site can be applied to other, broadly similar, sites, and it is probably only valid for relatively small increases in the number of spaces. The methodology is also weak in terms of assessing likely diversion of P&R users between adjacent sites as a result of capacity changes, although the diversion rate surveys do provide some relevant evidence. This is one area where more work is required.

A simplified modelling approach was developed for estimating 'decongestion' benefits, which is corridor (and time-of-day) specific, simple to calculate and does not require separate transport model runs.

The case studies show that increasing P&R provision gives high returns relative to most other types of investment schemes that encourage modal shift to public transport in major urban areas, with best estimates of the BCR_G being in the range 2.1 to 3.8 (the full range of sensitivity tests undertaken widen this range to 1.7 to 4.3). These relatively high returns are not unexpected, given that P&R schemes are targeted at car owners and encourage mode switching at times and in situations where public transport offers an attractive alternative and decongestion benefits are likely to be maximised.

Appendix

This table and the following notes detail the components of the economic appraisal framework developed for this project.

PUBLIC COSTS (FINANCIAL)		Road Authority	Public Transport Authority	P&R Authority
Infrastructure (capital)				
	P&R site - land			*A
	P&R site – construction			*B
	Public transport – vehicles		*E	
Operating & Maintenance Costs				
	P&R site			*C
	Public transport – operations & maintenance		*F	
	Revenues			
	P&R charges			*D
	Public transport fare revenues		*G	
USER BENEFITS (ECONOMIC)		Other Road Traffic	Other Public Transport Users	P&R Users
P&R user benefits				
	New users – gen time (benefits)			*H
	New users – fares/ charges			*I
	New users – operating costs			*J
	Existing users – convenience			*K
Public transport existing users				
	Frequency benefits		*L	
Road system decongestion & externality				
	Decongestion benefits	*M		
	Vehicle op costs	*N		
	Crash costs	*O		
	Global environment costs	*P		
	Local environment costs	*Q		

Notes:

A. Value (opportunity cost) of land used for new facility, which may be included as a capital amount or as an annual (lease) charge.

B. Estimate of construction costs for new/expanded facility, including all overheads (planning design, consents, etc.), based on experience with similar facilities developed over recent years.

C. Estimate of annual operating and maintenance costs (incremental) associated with the new/expanded facility, based on experience with similar facilities.

D. Estimated (incremental) revenues from P&R charges (only relevant where a P&R charging regime is in place).

E. Allowance for the capital costs for additional peak vehicles required (to the extent that the scheme results in increased peak period peak direction PT patronage).

F. Additional PT operating costs associated with accommodating any additional peak period passengers.

G. Represents additional PT fare revenues (GST exclusive) associated with any additional PT passengers (including any changes in fare revenues on local services if significant).

H. Estimate of 'generalised journey time' benefits of new P&R users ('switchers').

I. Estimate of any PT fares/P&R charges paid by switchers to P&R (a transfer payment, with off-setting revenues under items D, G, rather than an economic cost or benefit).

J. Estimate of any vehicle operating cost savings for switchers from car to P&R.

K. Estimate of 'convenience' ('schedule delay') benefits to existing P&R users who can travel at their preferred time as a result of the increased P&R capacity.

L. Benefits to existing PT users from increased service frequencies if more frequent services provided in response to increased demand with the new/expanded facility.

M. Benefits to base/continuing road users resulting from reduced congestion (and reduced schedule delay) resulting from some car users switching to P&R.

N. Vehicle operating cost reductions for base/continuing road users as a result of the reduced congestion etc. (as item M).

O. Crash cost reductions (or increases) for base/continuing road users as a result of the reduced congestion etc. (as item M) (may also include a small component for bus users and operators that use the road system).

P. Reductions in greenhouse gas emissions associated with any reductions in road traffic volumes and decongestion impacts (as item M).

Q. Reductions in local environmental impacts associated with any reductions in road traffic volumes and decongestion impacts (as item M).

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