

Evaluation of Strategic Transport Packages

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Abstract:

There has been some concern and frustration with the lack of progress on the construction of strategic transport projects in New Zealand. This frustration arises from an apparent inability to implement Regional Land Transport Strategies. The lack of progress is primarily attributed to the funding mechanism not being linked to strategic outcomes and an inadequate level of funding. New Zealand Transport is developing further the strategic transport planning approach. Legislation has been passed which will require the development of a National Land Transport Strategy which will provide a framework for Regional Land Transport Strategies. Regional Land Transport Strategies are by nature and as a consequence of legislation multi objective. Regional Land Transport Strategies are required to determine the role of the full range of transport measures in an integrated way. The funding process currently used in New Zealand uses benefit-cost procedures to determine national priorities for funding. Benefit-cost analysis is by nature single objective, can only consider projects in isolation and currently does not treat all transport measures in a consistent way. This paper provides a framework to identify, review and evaluate strategic transport packages. A mechanism is provided to rationally prioritise projects and measures as elements of a strategic package within a Regional Land Transport Strategy. This methodology is applied to develop a package of measures for Wellington as a means of implementing the Wellington Regional Land Transport Strategy.

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Introduction

The poor links between the planning of the transport system and its funding is an area of major weakness in New Zealand. The problem has inhibited the implementation of soundly based transport strategies which is an issue of concern particularly for New Zealand's major urban areas.

This paper provides a rational methodology that can provide the vitally needed links between transport planning and funding. Using the techniques proposed, packages of transport projects and measures can be evaluated in a manner that is consistent with community endorsed strategies for transport. To that end this paper is a development of the work of Watson and Brennand (1996).

Current planning and funding structures

The process and organisational structures related to planning and funding of transport in New Zealand have evolved from about 1991 onwards. It is only the structures and processes that were in existence on 1 July 1996 that are commented on here.

The current planning and funding structures are the result of legislation, the Land Transport Act (1995), the Transit New Zealand Act (1995) and the Resource Management Act (1991) along with their various amendments. Those acts provide the framework set out in Figures 1 and 2.

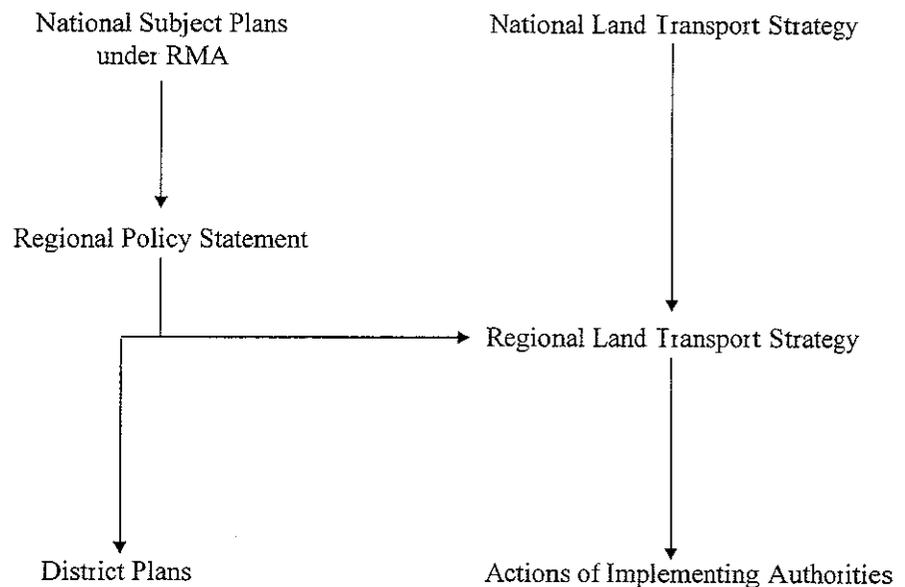


Figure 1 The New Zealand Transport Planning Structure

The relationship between each plan is that any lower one is not to be inconsistent with any immediately above. For example the Regional Land Transport Strategy cannot be inconsistent with the Regional Policy Statement and the National Land Transport Strategy. At this point there are no National Plans or Strategies although work has commenced on the development of a National Land Transport Strategy.

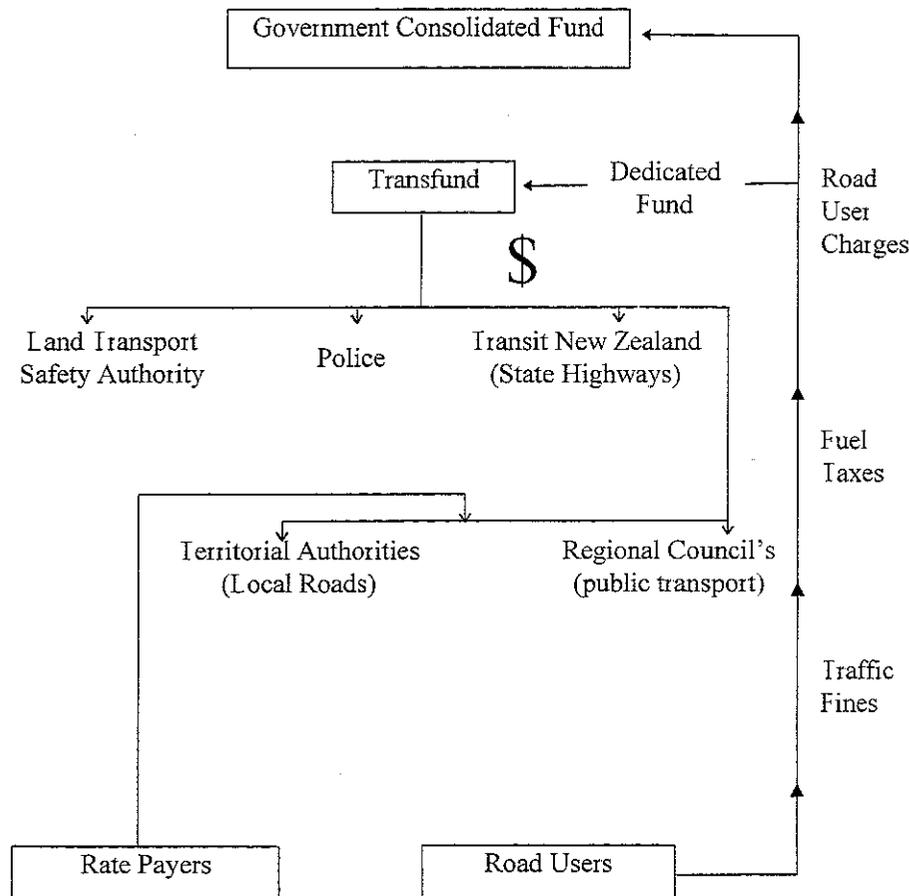


Figure 2 The New Zealand Transport Funding Structure

Money going to Transfund can be varied by Government by altering the proportion of fuel taxes. Once the money reaches Transfund it is dedicated to transport and can be spent

The Transfund administration is provided by Transit New Zealand. Since Transfund only existed from 1 July 1996 the procedures used by it are inherited from Transit New Zealand. Generally speaking therefore, the funding allocation process used by

Transfund is the same as that previously used by Transit New Zealand when it was the fund allocator. The method of project evaluation is the process of benefit cost analysis.

The primary benefits accounted for explicitly being road user time savings, fuel cost savings and accident savings. Other benefits are usually accounted for as externalities. Transfund therefore, allocates national funds on a nationally ranked project by project benefit cost system. The detail of the process will not be expanded on here, but is set out in the Project Evaluation Manual of Transfund New Zealand (1997). The manual includes specific rules for time, accidents, vehicle operating costs, discount rates and period over which benefits may be counted. Each of these are obviously open for debate. Currently these values favour low cost road based projects with immediate benefits, particularly accident savings.

The role of planning

The Land Transport Act requires that every Regional Land Transport Strategy:

- (a) Identify the future land transport needs of the region; and
- (b) Identify the most desirable means of responding to such needs in a safe and cost effective manner, having regard to the effect the transport system is likely to have on the environment; and
- (c) Identify an appropriate role for each land transport mode in the region including freight traffic, public passenger transport; and
- (d) State the best means of achieving the objectives referred to in paragraphs (b) and (c)

Clearly the intent of the Regional Land Transport Strategy is to provide an integrated approach to addressing the medium to long term transport needs of the region. The strategy is required to determine the most appropriate means of addressing those needs and includes all modes of transport having regard for safety, cost effectiveness and the impact that the transport system will have on the environment.

The funding system and its relationship to integrated strategic transport planning

Funding for transport usually comes from two sources. The Government through Transfund New Zealand funds State Highways. Local roads and passenger transport (services and infrastructure) are funded by local government. Passenger transport services also receives a contribution from the user through the fare box. Specific projects may receive a financial contribution from the private sector but this is not generally the rule. Local government investments may attract financial assistance from Central Government.

Funding from Central Government for State Highways or for financial assistance for local government investments is dependent on the project gaining a sufficiently high benefit-cost ratio when evaluated according to Transfund New Zealand's (previously Transit New Zealand) Project Evaluation Manual.

The planning and funding structures described earlier appear logical in themselves but lack one fundamental element. They are not linked except that all organisations involved with transport activities have to act in a way that is not inconsistent with any National or Regional Land Transport Strategy. The concept of planning before funding is therefore, often paid lip service with plans often being used as a basis for a veto on specific projects but rarely used to promote key projects. This difficulty has prompted at least the two largest regions in New Zealand to seek an alternative approach.

There have been a number of concerns expressed about the Project Evaluation Manual. These have been highlighted by a number of authors. Symonds Travers Morgan (May 1996) note that:

- there exists strategic factors that the Project Evaluation Manual does not include
- the project evaluation procedures are single objective and in general not compatible with soundly based Regional Land Transport Strategies that are multi objective by nature
- the project evaluation procedures use national average values that do not reflect regional values or regional priorities

BERL (1996) makes the following comments:

- that there exist fundamental inconsistencies between the Project Evaluation Manual and regional land transport strategies
- cost-benefit analysis has a short-term bias even though it is used to evaluate investment in assets with very long economic lives
- the Project Evaluation Manual methodology was at the forefront of international transport evaluation twenty years ago but can no longer be considered best practice
- the integrated strategic transport planning approach embodied in Regional Land Transport Strategies is largely consistent with New Zealand Government transport policy and overseas best practice in transport planning.

NZIER (1995) express the following concerns about the Project Evaluation Manual:

- that there is an absence of consistent inter-modal comparisons
- that there is inadequate consideration of the impact of an individual project on the wider network
- the length of the planning horizon used
- intangible effects are dealt with inadequately
- the use of national average values for benefits does not address regional variations or priorities
- the use of a high discount rate of 10% per annum causes a short-term bias, a rate of 5 to 7.5% per annum is recommended

Brennand (1996) also raises concerns with the Project Evaluation Manual methodology. These include:

- an inability to deal with regional economic and land use development issues
- an inability to take an integrated approach to transport planning

The character of a methodology to evaluate strategic transport packages

There are a number of characteristics that a methodology for evaluation of strategic transport packages requires.

Objectives led: Transport provision is not an end in itself. Transport is provided so that the community's wider objectives are met including economic and land use development objectives. MVA, Oscar Faber IPA and the Leeds Institute of Transport Studies (1994) comment that it is crucially important that decision makers are provided with the means to test various schemes or policies against the objectives which they are intended to achieve. In general there will be more than one objective which may require trade offs between objectives to be made. Implicit in a package being objectives led is that the valuation of the elements in the package will need to be consistent with the objectives.

Consistency between modes: Transport investment decisions should reflect the real merit of the proposal and should not be a function of biases within the evaluation procedures. The principle of evaluating transport proposals in a consistent manner independent of the mode being proposed is fundamental to the work of MVA et al (1994).

Integrated Approach: May (1996) stresses the importance of all major schemes being considered in the context of an overall strategy rather than in isolation. A balance between roads and public transport, major and minor schemes, physical and policy measures is required. The strategy must consider the full range of measures available including land use policies to achieve the overall objectives of the strategy.

The importance of synergy: May (1996) also expressed the importance of synergy in the development of transport packages. No one measure is likely to provide a solution to other transport problems of an area. Most have positive contributions to make to some objectives but may have adverse impacts on others; some may benefit one geographical area at the expense of another. For these reasons, a package of measures is likely to be more effective. One measure can offset the disadvantages of another or avoid the transfer of problems to another area; adding a second measure can reinforce the effect of the first.

Provides for intangible effects: As transport analysts frequently have a strong numerical emphasis, intangible effects are often overlooked or inadequately addressed. Intangible effects should be fully incorporated in the evaluation of a transport package.

Does not have a short term bias: New Zealand transport investment decisions have had a history of favouring short term incremental projects. Strategies must be developed to address medium to long term needs.

The proposed strategic transport package evaluation methodology

The following methodology builds on the "Package Approach" used in the United Kingdom which is described by May (1994)

The development of a vision for the region: This is a description of how the region is to look and function in the future, typically in 20 years time. The vision does not need to make an explicit reference to transport.

The development of broad objectives compatible with the vision: These may include objectives for economic development, environment, equity, accessibility, efficient use of resources and financial feasibility and land use development.

The development of specific objectives: Specific objectives are then developed from the broad objectives. The specific objectives should be written to include measurable targets.

Prioritisation of objectives for trade offs: Information is required about the relative importance of each of the specific objectives as it may not be possible to satisfy each of the objectives simultaneously. This may be obtained by a community survey so that if required a rational process can be developed for relaxing one or more of the specific objectives. Alternatively, the community could be asked to develop a preferred direction for transport strategy which subsumes this and the above steps.

The development of 'cartoon' strategies: A list of the possible policy measures can be drawn up. Potential strategies can be developed from combinations of the measures. Examples of 'cartoon' strategies include:

- free flow roading
- modest investment in roading
- high quality public transport
- modest public transport investment
- commuter traffic restraint

Testing the 'cartoon' strategies against the objectives: The 'cartoon' strategies are modelled and tested against the objectives including sensitivity tests for robustness. The outcomes are compared with a do minimum on a planning balance sheet and on a plot of net present value of benefits versus the present value of finance.

Categorising projects and measures: From the initial cartoon strategies and sensitivity tests the list of measures can be divided into three groups:

- those with clear benefits at low cost and should be included in any strategy
- those whose financial or environmental costs clearly exceed their benefits and should be excluded from any strategy
- the remaining measures

The preferred strategy can be developed by including all of the measures from the first category, none from the second category and different combinations from the third category provided they are mutually supportive.

Optimisation of the strategy The optimised strategy can be developed by formulating the problem as the solution of a mathematical programming problem. This in the simple case is a linear programming problem but will usually be non-linear. The various projects are defined in a generic way to allow multiple units of the project to be selected. A maximum number of the units is defined for each project. The objective function that is to be maximised is the net present value of benefits. The constraints are the specific objectives developed earlier plus the availability of finance. The availability of finance should include any revenue generated by measures such as tolls or parking charges. Synergy between measures can be incorporated by the appropriate writing of the mathematical expressions. The solution of the optimisation problem is obtained which satisfies the specific objectives or alternatively replicates the desired strategy. This may require some relaxation of one or more of the specific objectives if infeasible conditions are encountered.

Post optimal analysis It is important that the optimised solution is analysed. This may require sensitivity testing about the specific objectives. Even when infeasible solutions are obtained this provides some useful information about how realistic are the set of specific objectives. Once an optimal solution is obtained an examination of the shadow prices associated with each of the specific objectives provides some useful insights. A shadow price of zero shows that the particular specific objective is not binding and can be relaxed within bounds without effecting the optimal strategy. Where a shadow price is non-zero it indicates the worth of achieving the specific objective. The magnitude of the value should be examined to ensure that it is realistic. This may lead to a review of the specific objectives.

Prioritisation of measures Measures are prioritised to form a package by evaluating them individually using the shadow prices obtained from the optimisation process. This produces a package of measures which is consistent with the overall strategy.

Application of the approach to the Wellington Region

The vision for the region is central to the Regional Policy Statement which seeks to develop an economically, environmentally and socially sustainable region. Refer to Wellington Regional Council (1995). After the development of a vision the following objectives were developed:

Land use development The region should maintain its compact structure and enhance intensity about key modes. This was translated into a goal of ensuring that daily car vehicle kilometres remain less than 620,000 in the year 2011.

Environment There was a desire to ensure that fuel consumption in the region is maintained below acceptable levels and so the consequential local environmental pollutant levels are controlled. Carbon dioxide emissions were also a concern but as they are directly related to fuel consumption these issues were dealt with by requiring that daily year 2011 CO₂ emissions remain below 2090 tonnes.

Economic output A strong regional economy was an important attribute. An economic output for the region of at least \$28.3 billion per annum was desirable in year 2011.

Social A range of social factors such as safety, security, accessibility, mobility and severance were considered and ranked. The goal was that a small improvement in social attributes was required.

Financial Over the 15 years to 2011 it was estimated that up to \$750 million of public sector funding would be available.

Cartoon strategies

Six cartoon strategies were developed. They are summarised below:

Strategy 1 - Free flow roading

Aim Removing access problems by providing sufficient road capacity and reducing air pollution by providing more freely flowing traffic conditions. This strategy represents the realistic maximum amount of new road construction which is likely to be justifiable and affordable.

Capacity provision is designed to be consistent across the study area so as to remove major bottlenecks such as currently exist, for example, at Paremata on State Highway 1, Manor Park on State Highway 2 and at the Terrace Tunnel on the Wellington urban motorway. This strategy represents a logical limit to the development of the road system without a major change of scale. No attempt is made to contain demand for travel by private vehicle. Public transport subsidies are maintained to ensure a reasonable standard of service. Public Sector Cost : \$975 million over 15 years.

Strategy 2 - Improved roading (contained costs)

Aim To provide a solution to the worst congestion problems on the road network while containing costs. This strategy addressed the more pressing areas, but avoided major increases in capacity either where increases are not matched downstream, or where costs are particularly high. This strategy has more variations than the first, both

in content and total value. However, as it was the concept of partial expansion of the network that was being examined against other strategies, the detailed make up can be examined quite satisfactorily at a later stage if this strategy should be included for more detailed study. Like strategy 1, demand is unconstrained.

Trade-offs exist between roading and public transport as this strategy attempts to both contain costs, increase fare levels and reduce services. Public Sector Cost : \$600 million over 15 years

Strategy 3 - Mixed investment

Aim: To reduce traffic congestion where there are no public transport alternatives, by road building. To improve public transport while restraining car parking availability in Wellington City as a means of improving congestion and environmental impacts.

This strategy was based on containing spending, but used three means of dealing with problems. A modest road construction programme was intended to address the most pressing congestion areas and provide more capacity for movements not well served by public transport. Modest restraint policies would restrict car parking availability in Wellington City as a means of reducing traffic levels, and thereby congestion and pollution. An improved public transport system offered a better alternative for motorists and provided improvements for its users. Public Sector Cost : \$750 million over 15 years

Strategy 4 - Modern public transport system

Aim: High investment in public transport infrastructure to provide better service levels. This strategy used roading restraint and a strong emphasis on public transport. It allowed for higher investment levels in public transport to provide better service, although at relatively high fare levels. To reinforce the public transport attraction, private vehicle restraint was assumed through cordon charging in Wellington City. This could be through an electronic system charging motorists for driving into the CBD during peak periods. The major infrastructure investments considered were for light rapid transit (LRT), but this strategy could use other technologies, eg, bus ways (guided where necessary as with an O-bahn system). Public Sector Cost : \$375 million over 15 years with an additional \$15 million per annum obtained through cordon charging being used to assist funding the public transport improvements.

Strategy 5 - Low fares

Aim: To provide an attractive public transport system using current technologies. Strategy 5 provided a public transport system which was attractive by being cheap and frequent. It was based on the current technologies with logical improvements such as increased bus priority. Restraints are imposed via car parking limitations.

The strategy envisaged minimal road expansion with strong emphasis on public transport and parking restraint in Wellington City. This strategy assumed that a greater

proportion of growth in both employment and housing would be within Wellington City than for other themes. Public Sector Cost : \$825 million over 15 years.

Strategy 6 - Mixed investment (decentralised)

Aim: As for strategy 3, but with an emphasis on developing the sub-regional centres. These policies were supported by land use policies which direct development towards particular centres, thus reducing the need to travel to the Wellington City central business district (CBD) in particular. The centres used to develop this theme were the sub-regional centres (Hutt City, Upper Hutt and Porirua) and the district centres of Wainuiomata, Paraparaumu and Waikanae. Public Sector Cost : \$615 million over 15 years



Figure 3 The Wellington region

Strategy performance

Each of the strategies were modelled and assessed against the respective objectives. A summary of the performance of each of the strategies is presented in the following table

Table 1 Strategy performance against objectives

Strategy	1	2	3	4	5	6
Public Sector cost over 15 years (\$ million)	975	600	750	375	825	615
Present Value of finance (\$ million)	595	366	458	229	504	375
Net Present Value of benefits (\$ million)	-127	351	1010	1256	1682	532
Daily car veh-km	6736000	6414000	6225000	6143000	5925000	6332000
Daily CO ₂ emissions (tonne)	2272	2193	2086	2006	1935	2125
Regional Economic Output Forecast (\$ billion)	28.28	28.28	28.77	28.31	28.82	28.42
Social Impact Ranking	6	-2	2	0	2	2

Notes:

1. A discount rate of 7.5 per cent per annum was used.
2. Benefits were assessed over 25 years against a "do minimum" strategy that included only those projects that show clear benefits and should be included in any strategy.
3. Strategy 1 showed a net disbenefit. This is because the road improvements provided a strong incentive for users of other modes to switch to private transport thereby significantly increasing total vehicle kilometres and undermining travel time savings.
4. The social ranking indicates an improvement if positive and deterioration if negative.

Economic performance

The relative economic performance of the cartoon strategies is shown in Figure 4.

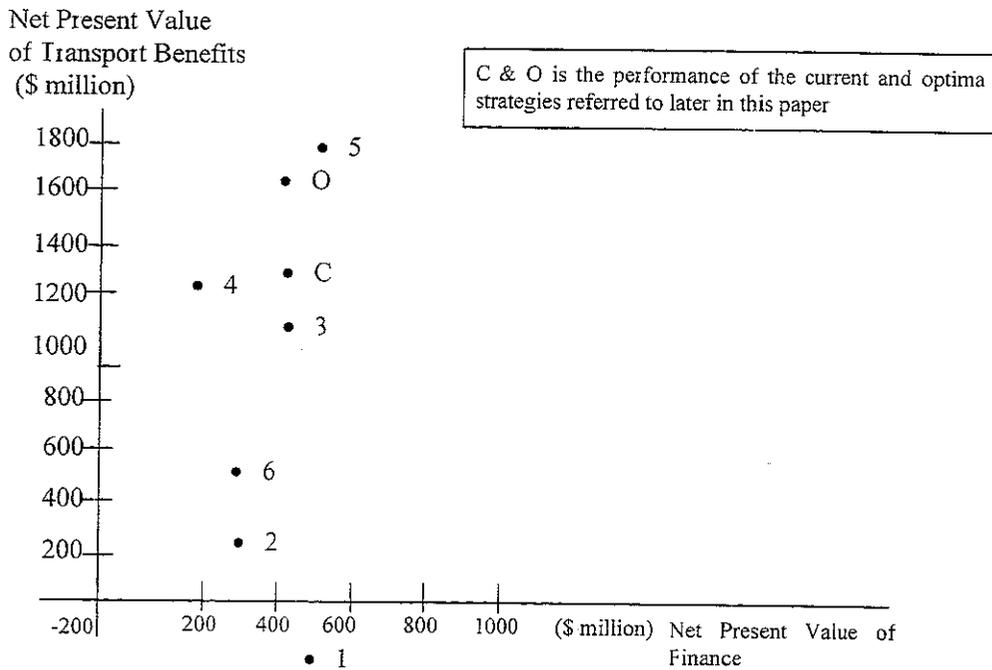


Figure 4 Economic and financial performance of the cartoon strategies

It is clear from the above diagram that in purely economic terms strategy 4 performs the best. Strategy 4 is partially self funding through the toll system and therefore has a lesser direct impact on public sector financial resources. Strategies 3 and 5 are also good performers in economic terms but have a greater demand for public sector funding.

Optimisation of the strategy

Optimisation of the strategy was achieved by formulating the problem as an optimisation problem. Essentially we sought to maximise transport benefits subject to:

- public sector expenditure over 15 years ≤ \$750 million
- year 15 daily car vehicle kilometres ≤ 6,200,000
- year 15 daily CO₂ emissions ≤ 2090 tonnes
- year 15 regional economic output ≥ \$28.3 billion
- year 15 social ranking ≥ 0.5

Solution of this problem was achieved by a strategy which is a mixture of cartoon strategies 4 and 5. Clearly this is a passenger transport strategy, focusing on low fares, passenger transport investment and car restraint.

The net present value of benefits was \$1645 million. In essence, this solution sacrificed some of the benefits achievable by adoption of cartoon strategy 4 to achieve its wider objectives. The economic performance of this strategy is shown as point O in Figure 4.

A sensitivity analysis provides some useful insights.

The shadow price for public sector investment was \$1.02/\$. This means that marginal economic benefits will accrue at a rate of \$1.02 for every extra dollar of public sector investment.

The shadow price of daily car vehicle kilometres was \$143/km. That is for every kilometre we relax the vehicle kilometre goal we are able to generate an extra \$143 of economic benefits over the evaluation period. The shadow price for CO₂ emissions was \$437,000 per tonne. That is we were prepared to trade off \$437,000 in economic benefits for every tonne of CO₂ not emitted. Clearly significant transport benefits have been traded off to achieve these objectives.

Economic output and the social impact ranking were not binding constraints. The tightening or relaxing of the goals of the various objectives had an impact on the optimum mix of the cartoon strategies. This is illustrated in Figure 5.

Despite the strong case for strategies that might include cartoon strategy 4, there was a reluctance to promote such an approach. Political nervousness with cordon tolls or economic instruments is not unique to Wellington. As a consequence the above analysis was repeated to determine an optimum strategy mix where cartoon strategy 4 was no longer an option.

- increasing regional economic output
- increasing transport benefits
- increasing social impact ranking
- decreasing car vehicle km
- decreasing CO₂ emissions



Figure 5 The impact of objectives on strategy mix per dollar of public sector investment in transport, with tolls

The optimum strategy was a mix of cartoon strategies 5 and 6. The net present value of the transport benefits achieved over the evaluation period was \$1310 million. This

strategy mix is shown as point C in Figure 4 and closely approximates the region's existing Regional Land Transport Strategy Refer to Wellington Regional Council (1996).

This strategy reflected a mix of cartoon strategies 5 and 6 That was a strong public transport emphasis augmented by some selective road improvements and some decentralisation

The shadow prices for the various objectives were:

- public sector transport investment \$5.67/\$
- year 15 daily car vehicle kilometres was not a binding constraint
- year 15 daily CO₂ emissions was not a binding constraint
- year 15 regional economic output -\$0.104/\$
- year 15 social impact ranking was not a binding constraint

The sensitivity analysis showed that the strategy mix was influenced by the tightening or relaxing of the objective's goals The nature of the influence is illustrated in Figure 6

- decreasing CO₂ emissions
- decreasing car vehicle km
- increasing transport benefits
- increasing regional economic output
- increasing social impact ranking



Figure 6 The impact of objectives on strategy mix per dollar of public sector investment in transport, no tolls

Project appraisal

The appraisal of projects that makes up the desired strategy followed directly from the above analysis The shadow prices indicate what value in economic terms we are placing on achieving the objectives that make up the strategy. If these values are acceptable then they can be used directly to value the performance of individual projects.

If these shadow prices were not acceptable then the strategy and its objectives should be reviewed and new shadow prices obtained.

Conclusions

The techniques described in this paper provides a means of evaluating strategic transport packages in a manner that is consistent with the objectives that the strategy seeks to achieve. This technique has several implications.

Firstly, it provides a means of valuing attributes of an intangible nature that would otherwise be difficult to quantify. This valuation is independent of transport mode and is able to use a mix of the full range of measures available.

Secondly, the valuation process is consistent with the vision and objectives of the community which the transport system is designed to serve. In this way valuations are consistent with explicit performances required of the transport system.

Finally this process adds significantly to the robustness of transport strategies by providing fundamental insights into the performance of these strategies and their inter-dependencies. The implications for strategies are as follows:

- they are objectives led
- strategy objectives are tested for feasibility
- the transport benefits foregone to achieve wider community objectives is made explicit
- the trade off of transport benefits to achieve a specific objective is made explicit enabling the community an opportunity to reassess its willingness to achieve the particular objective
- insights are provided on how particular objectives influence the ultimate make-up of transport strategies and therefore the trade offs between objectives is made explicit.

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