Appraisal of integrated transport policies

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1 Need for Assessment of Integrated Transport

Only in recent years social science oriented views have begun to enter the discussion of transport behaviour and infrastructure, as transport policy nowadays is increasingly facing important tensions between economic-technological potential and environmental-social constraints. Efficiency-equity dilemmas and efficiency-ecology dilemmas call for integrated policy perspectives (see Nijkamp and Blaas, 1994). A further network expansion of traditional infrastructure is generally incompatible with the need for a high quality of life. Environmental and safety considerations have become major factors in the social acceptance of our mobile society. Thus new transport solutions and technologies will have to be implemented within increasingly narrower limits imposed by our society. The range of such solutions is even further limited by the simultaneous behaviour of all actors in our modern transport systems generating congestion effects (including high accident rates).

Appraisal is an important component of decision making. While recognizing that decision making is not necessarily a rational process, appraisal information is still a prominent key factor. One might regard decision making as a complex interplay of information, interests and opinions of groups in society on the one hand, and democratic action and political skill on the other. Transport policies typically have a host of very different impacts (DfT, 2009). Examples are travel times, emissions to the environment, road accidents, wider economic effects, investment costs and income distribution. In appraisal, it is important to find ways to make the impacts comparable, computing *total impact* indicators for society as a whole. Often-used methods are cost-benefit analysis, multi-criteria analysis and cost-effectiveness analysis (Nijkamp et al., 2003).

Appraisal of integrated transport policies is not straightforward, as these policies take different shapes. For instance, policies aimed at integration between transport modes (e.g. rail/bus or rail/bike) differ strongly from policies which integrate land use and transport. Another distinction among policies is the difference between specific projects and full policy plans. A general characteristic of integrated policies is that they affect more than one aspect or travel mode. This requires adequate assessment, not only of each of these aspects or travel modes, but also of the interaction between them. In this chapter, we focus on merits and limitations of evaluation methods, especially in their application to integrated transport.

Section 2 describes the current practice in the evaluation of integrated transport, looking first at estimating transport supply and demand, and then at impact evaluation, in particular cost-benefit analysis and multi-criteria analysis. In Section 3, we present a 'state-of-the-art' toolkit for research into integrated transport: methods for estimating the demand for integrated transport and joint cost-benefit analysis of land use and transport. Section 4 presents empirical applications, in particular in *park-and-ride* facilities. Finally, Section 5 concludes with a brief sketch of the achievements so far, and possibilities for further improvement in the future.

2 Current Practice in Evaluating Transport Plans

2.1 Demand vs. supply

This section considers the factors of demand and supply that determine passenger transport flows. Then we describe how these factors are incorporated in the mainstream demand forecasting process, an important input for transport policy appraisal studies. The last part of this section considers whether mainstream demand forecasting is sufficiently *integrated* and how it fits in CBA.

It is clear that an integrated transport plan does not differ from any other transport plan in its main goal: serving *demand* for transport. Consequently, analysis of demand is an essential part of the evaluation of transport plans. It is useful to give insight in the outlines of mainstream demand forecasting methods first, before starting the discussion how suitable these methods are for integrated transport policies.

The demand for transport is a result of individual travel behaviour, a process of individual choices. Dijst et al. (2002) present travel behaviour as the result of a confrontation of an individual's 'motivations to travel' against his 'feasibility to travel'. This process is essentially driven by three main factors: needs, opportunities and abilities (see Table 1).In this model an individual's decision to undertake a trip, or to choose a certain transport mode, is not only driven by rational considerations like travel time, price and comfort. Social and emotional factors play a role too. A bank director travelling by bike to a business appointment may fear to be seen as odd, even if in city centre traffic a bike is faster than a car or taxi. And driving a car will be more fun to some people than to others.

Table 1 Examples of needs, opportunities and abilities

Needs	*Opportunities*	*Abilities*
Social participation: personal activities impelling to reach locations (socio-economics)	Activities driving people to travel	Available time for transportation
Social acceptance, social status	Quality factors of car use, non-motorized transport and public transport	Exclusion factors: minimum age, need for driving license, physical impairments
Feeling safe, having fun etc.	Door to door speed, including availability, frequency, need for transfer, etc.	Entitlement to employer or state subsidy schemes
	Reliability	(Un)awareness of possibilities: information, marketing
	Comfort and attractiveness	
	Safety	
	Costs in relation to quality (efficiency)	

Mainstream travel demand forecasting methods are based on a simplified model. They base the analysis of travel demand on the theory of consumer behaviour. The model is simplified in the sense of neglecting that attitudes vary among people. Quinet and Vickerman (2004) for example, fit passenger traffic problems in the theory of consumer behaviour. Their main hypothesis assumes each consumer to have a utility function with a time and money constraint. They add a discrete choice process among transport modes. This type of model is the basis for mainstream passenger demand forecasting models.

In the United States, the standardized software package Urban Transportation Planning System (UTPS) is a tool for multi-modal transport planning, prepared for covering the road network as well as the public transport system. Other western countries have similar standardized models, for example the National Model System (LMS) in the Netherlands. These models predict what will happen under hypothetical conditions: for instance if a new motorway is built or a railway service is extended. At first the study area is divided into hundreds of traffic zones. These zones are filled with socio-economic data estimated for the forecast year: land use, population (including distribution over categories of age and social participation) and economic activity. Generally, these models contain four main modules:

- Trip generation (trips per zone)
- Trip distribution (pairing origins and destinations)
- Modal split
- Traffic assignment (to the network)

Most models either stress the choice between public transport and car use, without much attention to individual socio-economics (trip interchange models); or the trips themselves, not taking account of changes in level of transportation service (trip-end models; see Black, 1995). More complicated models may choose a two-way approach.

Modelling public transport *supply* is complicated. A first aspect is the involvement of the public transport operator. A premise in infrastructure appraisal studies, is that the opening of new infrastructure will be followed by new public transport services. In markets where infrastructure administration is separated from transport operations, this is not as obvious as one might think. Services sometimes are started later or less frequent as taken into account in the appraisal study, because of commercial or technical considerations of the operator.

Also, it is not sufficient to model supply with zones and links only. The length of the links only partially reflects travel friction. The supply of public transport is characterized by various quality aspects, like:

- density of bus stops and railway stations in the service area, determining the time needed for access and egress of the system;
- frequency of the services, determining waiting times;
- equal intervals between services (‘*Taktfahrplan*’);
- walking times during transfers;
- reliability, determining the need to incorporate time margins in trip planning;
- comfort in vehicles, stations and bus-stops;

- possibilities to park bikes and cars near stations and bus-stops.

An often-used approach is to dedicate each zone of the study area to one train station or bus stop. Sometimes artificial links are used, connecting zones without public transport to the transport system. Depending on the scale of the study, these artificial links may also be used for zones where in real life bus services are available, but not every single bus line is modelled in detail. Well elaborated models use penalties and weighting factors reflecting the traveller's aversion to transfers and his relative higher aversion to out-of-vehicle travel time.

Public transport only accounts for a limited part of all travel. For example in the Netherlands, public transport concerns 5% of all trips and 11% of all travelled kilometres (Bakker and Zwaneveld, 2009). From this point of view it is understandable that the public transport network is simplified. On the other hand the simplification of public transport supply ignores its 'true' nature: the fact that its attraction highly depends on the traveller's specific situation. Several studies show that the influence of public transport stops rapidly declines with increasing distances to the stop, especially on the 'not home-bound' side of trips. For instance De Graaff et al. (2007) show that the attraction of public transport is very site-specific: real estate property values prove to be substantially influenced in a circle of 500 metres around a railway station. But in the next 500 metres this impact is reduced by two-thirds. The exact locations of bus stops and railway stations in relation to traveller's trip origin and destination address do matter. It is clear that if the traffic zones in a model are larger, relevant public transport quality details are lost.

In mainstream travel forecasting models various other quality aspects are 'dissolved' in an average travel friction between zones. Improvements in public transport supply that are substantial from operator's and traveller's point of view, often can be modelled only by means of small changes in the general level-of-service. The traditional four-step travel-demand estimation process *"is cumbersome, expensive and requires a large amount of data. … The generation of trips is independent of the transportation supply characteristics and possible technical improvements, and the models are generally site-specific – that is they are not transferrable from one area to another"* (Dickey et al., 1983). Despite all those criticisms, this type of model is still the most used, primarily because it has been well tested and is completely operational.

In view of the high costs and long turnaround times of (integrated) travel demand forecasting studies, this process can be rather disappointing for policymakers. In some cases, a quick scan might be better: assess the impact of a single improvement on perceived travel times of travellers and clarify the relative importance of the service in total public transport and other traffic volumes.

The question can be raised whether mainstream travel demand forecasting is a suitable method for *integrated* transport planning. The process is referred to as the four step Land Use Transport Study (LUTS) (Lay, 2005), since land use is involved in transport by using zonal socioeconomics as input for trip generation. Various transport modes are involved in the demand forecasting process. The process is capable of estimating the effects of coherent transport policy packages. From various points of view it is indeed an integral planning method. But of course, the degree of integration can be improved. In the long run the transport system will have a feedback influence on land use. Various transport modes are concerned, but is the option of *multimodal* travelling considered sufficiently, too? And is the process capable of estimating the effects of policy packages including marketing instruments, seeking to affect the attitudes of people?

The mainstream four-step model is refined and extended in many ways. The TIGRIS XL model, for instance, was developed in the Netherlands and the UK as an extension of regular models in order to assess the long-term impacts of transport policies on the spatial distribution of residents and jobs as well as the assessment of the effect of alternative land-use policies on the transport system (Zondag and De Jong, 2005). Various models have been developed in order to better assess the effects of multimodal policies (particularly Park and Ride) (see, for instance, Cohn et al., 1996; Fox, 2005; Li et al., 2007; and Molin and Van Gelder, 2008). But is it worthwhile to use these new or extended models in regular transport planning and project assessment? Extended models ask for additional data collection and computing time. New modules have to be calibrated with empirical data and it may be doubted if these calibrations are valid for application in other regions. The contradiction is: the more completeness in combining the different aspects of integration, the less attention is feasible for the separate aspects. The desire to forecast various transport modes in one model is at the expense of a tailor-made approach for public transport.

2.2 Economic vs. societal impact evaluation

This section presents and compares different methods which can be used to evaluate integrated transport policies. First, the advantages and disadvantages of these methods are described. Then, the applicability of these methods to integrated transport policies is examined. Also, various methods used for policy appraisal in different countries are compared. Finally, we present – as an example – research into the impact of cost-benefit analysis on decision making in the Netherlands.

Rational evaluation of the total impact of a policy requires a set of possible choices, relationships that determine the 'pay-off' (satisfaction, goal attainment) of each choice, and a preference ordering among pay-offs (Simon, 1955). Assuming that the set of possible choices is given, we will look into the differences between methods in terms of the 'pay-off' criteria. Table 2 lists these characteristics for some popular appraisal methods.

Table 2 Decision criteria used in popular appraisal methods

Method	Type	Citerion	Measurement through
Cost-benefit analysis (CBA)	Economic	Welfare	Willingness-to-pay (WTP) for effects
Cost-effectiveness analysis (CEA)	Economic	Ratio of main effect to costs	Simple division
Multi-criteria analysis (MCA)	Social	Weighted sum of effects	Political weights for effects
Balance sheet	Social	No integral criterion	No measurement; decision makers look at separate effects

Given the nature of each method, we may compare them in terms of advantages and disadvantages. Table 3 shows that CBA is firmly rooted in economic science and yields clear policy conclusions. On the other hand, CBA is often incomplete and does not connect well to the political process of decision making. MCA is a complement to – but in many respects also the opposite of – CBA: it is complete in terms of effects and combines research results with political input. However, this also opens the door for ambiguous weights or methods or even manipulation. Usually, MCA only ranks policies and does not show whether a specific policy is attractive or not. Cost-effectiveness does not suffer from questionable weights, but it is often rather incomplete, as one only compares one (main) effect to the costs, while other benefits are ignored. The balance sheet method, finally, leaves the weighing of effects to decision makers, which is on the one hand very flexible, but on the other hand does not give much guidance from research.

Integrated transport policies have no single, central goal. Therefore, cost-effectiveness is less appropriate. Balance sheets are possible, but do not yield as much decision support as CBA and MCA. Therefore, CBA and MCA in most cases regarded the preferred methods. If (almost) all impacts can be monetised, CBA becomes more attractive. If, on the other hand, important impacts cannot be monetised, MCA or a mix of MCA and CBA might be preferable.

Table 3 Advantages (+) and disadvantages (-) of appraisal methods

	Method			
Aspect	Cost-benefit analysis	Multi-criteria analysis	Cost-effectiveness analysis	Balance sheet
Decision support	+ Discerns attractive policies from unattractive policies	+/- Usually ranks policies in terms of attractiveness	+/- Ranks policies in terms of attractiveness	- No attractiveness conclusion from the appraisal
General quality of weights	+ Based in economic science; analogy to utility theory	- Subjective weights or methods; risk of manipulation	+ Main effect and costs are weighted adequately	+/- No weights used
Completeness	- Some effects are hard to monetise (e.g. irreplaceable nature	+ Can be applied to all effects	- Only the main effect and the costs are counted; other effects are ignored	+ All effects can be included
Connection with political process	- High-income people (and business interests) have high WTP; count for more	+ Decision makers can apply their own weights (interests)	- No flexibility	+ Every decision maker can draw her own conclusions

2.3 Cost-benefit analysis: practice and extension

In this section, we 'zoom in' on the possibilities and limitations of CBA, focusing on three issues: (1) effects that are difficult to monetise in CBA's; (2) distributional effects; and (3) the transparency of CBA's for decision-makers..

The main advantage of CBA is that it captures, in principle, all impacts on society with objective, market-based weights. This yields important policy information which is largely independent of the process of decision-making. As such, it is an important benchmark for the quality of decisions, which may prevent that the interaction among policy makers results in

‘negotiated nonsense’ (Van de Riet, 2003). However, some impacts are notoriously hard to monetise, and concerns exist on some of the methods employed (Pearce et al., 2006). Examples are effects of transport projects on passenger comfort, on nature areas, and on ‘beauty’ aspects (e.g. architecture in bridges). Lacking direct information from market prices, a ‘good’ CBA should use special techniques to estimate the *willingness-to-pay* of households and firms for such effects. However, such research is often difficult and expensive. Therefore, these quality aspects are often not monetised. For example in the Netherlands, Annema et al. (2007) conclude that most transport CBAs do not monetise impacts of the project on landscape, nature and spatial quality. They do however, give qualitative information on these impacts. This qualitative approach may result in a presentation bias in the final conclusions. Especially in the final cost–benefit table and conclusions, there is a risk of overlooking the negative impacts of infrastructure on landscapes and/or nature, despite the fact that these negative impacts are mentioned qualitatively somewhere in the CBA.
Also, market-based weights, based on willingness-to-pay, are higher for business travelers and high-income groups than for low-income travelers. Public transport is often seen as a providing a minimum of accessibility to low-income groups, ageing people, handicapped users etc. Using relatively low weights for the effects which accrue to these groups is considered to be awkward and unjust from a political point of view. This problem may be reduced by not only presenting total costs and benefits, but also a Benefits Incidence Table, as practiced in Japan (Hayashi and Morisugi, 2000). Table 4 contains an example of such an incidence table, not only for benefits but also for costs. The benefits and costs pertain to the introduction of electronic ticketing (‘chipcards’) and access gates in public transport in the Netherlands.

An important problem in the interaction between appraisal and policy-making is the lack of transparency of CBA’s, at least from the point of view of policy-makers and the public. According to Pearce et al. (2006), CBA may be too complex for the busy civil servant. Annema et al. (2007) perform a benchmark study of transport CBA’s in the Netherlands, and conclude that poor transparency is one of three main points for improvement. The CBA’s are not written to make the main results of the CBA clear to non-welfare economists. Economic jargon is used abundantly. Categories of costs and benefits of the project are often not explained, such as ‘transport advantages’, ‘industrial site benefits’, and ‘exploitation surplus’. Pearce et al. (2006) note that *“…Theoretical economists need a far better understanding of the pressures that affect actual decisions”*, but they do not add specific recommendations to this observation. In the Netherlands, the transparency issue was the reason to add a ‘clear presentation of CBA results’ guide (Koopmans, 2004) to the existing guidelines for CBA. The ‘clear presentation’ guide recommends:

- Present not only monetised values, but also the comcomitant physical effects (e.g. time savings in hours, CO2 emissions in tonnes, number of road fatalities)
- If some effects are not monetised, present them as +?, -? or ?; and always include the non-monetised effects in the net benefits (the guide acknowledges that a net benefit of

‘340 to 460 mln +?’ is awkward, but considers this better policy information than the incomplete ’340 to 460 mln’)

- Avoid jargon and technicalities in the summary
- Link the CBA to policy objectives in the summary of the CBA

Table 4 Incidence table for electronic ticketing and access gates in public transport in the Netherlands

	Total	Travelers	Employers	Operators	Government	Wider economic effects	External effects (non-pecuniary)
	Net present value (mln. Euros)						
Costs of chipcard system, gates etc.	-440 to -1000			-500 to -1060	60		
Time savings in buying tickets	500 to 620	490 to 610	10				
Reduction of violence	100 to 120	60 to 70	30 to 40				10
Reduction of non-paying travel	380 to 480			380 to 480			
Differentiated rates	240 to 480	20	-20	240 to 480			
Sales of chipcards	0	-310		+310			
Additional trips	50 to 80			50 to 80			
Efficiency in transport	130 to 160			70 to 80	-20	80 to 100	
Environmental effects	20						20
Subsidies	0			50	-50		
More efficient procurement	0			-70 to -320	70 to 320		
Total	420 to 1520	260 to 390	20 to 30	-30 to +660	60 to 310	80 to 100	30

Source: Koopmans (2006)

Summing up, we may conclude that CBA has a great potential to be a factual counterweight in decision making. However, improvements are needed to fulfill this potential. The main improvements are more research into difficult-to-monetise effects, including incidence tables in CBA’s; and presenting CBA results in a clear and unbiased way.

2.4 Multi-criteria analysis: practice and extension

Transportation has a great variety of both intended and unintended, desirable and undesirable, and local and supra-local effects. The ‘undesirable’ outcome of a highly mobile society (in terms of pollution, lack of safety and congestion) is – almost paradoxically – the result of rational and plausible actions of a great many individuals. Social science research has convincingly demonstrated that the neglect of social costs in individual decision-making must by necessity lead to a macro outcome that is far from optimal. This explains, for example, worsening quality of life conditions in major cities all over the world. Transport has become both a friend and an enemy and has caused paradoxical feelings and views on its future. Such drastic changes are likely to exert a profound influence on the future spatial interaction pattern of our societies and will make it necessary for transportation planning to respond as efficiently as possible to new tendencies and new challenges. However, transportation planning is often marked by lack of resilience, so that flexible adjustments to new structural changes (e.g., deregulation, road pricing) often take place insufficiently (see also Nijkamp et al., 1992; Deakin et al., 2008).

Policy has not addressed itself so far to such fundamental questions as the legitimation of minimal levels of accessibility, the effect of the geographical concentration of public facilities and the districting of their service area on the supply of public transport, and the most important question of all, what the role of planning should be in society. One way out of this dilemma would be to increase the information-processing capacity of the planning system by installing computerized transport planning and management information systems. This would call for the need to design tailor-made *decision-support systems* in transportation planning. Complementary to this 'high-tech' approach, there is – as mentioned above – a 'low-tech' alternative of making the methods used more transparent and comprehensible to planners, politicians and the public at large. This may also require the design of user-friendly decision support systems and evaluation methods.

Planning concerns the integrated analysis of conflicting choice options. In general the relative social ('public') value of effects of planning projects (e.g. a highway project) is codetermined by political priorities at different institutional levels. Sometimes these values are – directly or indirectly – a result of prices resulting from a market mechanism, but very often such values are more subjectively determined and, for example, based on desiderata of individuals and groups in society (for instance, the value of a natural park or the visual beauty of an old theatre). Consequently, many conflicting views may emerge in evaluating alternative plans (e.g. different highway investment projects). Especially modern approaches like multicriteria analysis (MCAs) may serve as a meaningful evaluation vehicle for taking explicitly account of such conflicts regarding the foreseeable impacts of a plan. For example, everybody may agree on the fact that the implementation of a road project will destroy x hectares of a forest, but not everybody will attach the same value to these x hectares of the forest. Multicriteria analysis may then be helpful in taking into account such conflicting issues by considering priority schemes or weights as an ingredient in an evaluation analysis for investment projects. Of course, this will not always lead to a unique final solution, but the structure and consequences of conflicts among decision-makers can be made more explicit, so that also the range of politically feasible alternatives can be analyzed in greater detail (see also Figure 1).

Any evaluation technique for judging the desirability of public plans or projects should be logically and consistently connected with the nature of the decision problem concerned. Given the unique nature of many decision problems, there is no unambiguous method with a universal validity, and hence each type of decision problem may require its own specific evaluation method.

Depending on the problems at hand and on the precision of the data used, several subdivisions of evaluation methods can be made:

- *discrete* versus *continuous* evaluation problems;
- *soft* versus *hard* evaluation problems; soft problems include qualitative or ordinal information on impacts of alternatives or on priorities / weights, whereas hard problems are based on quantitative (i.e., mainly cardinal) information;
- *static* versus *dynamic* evaluation problems;

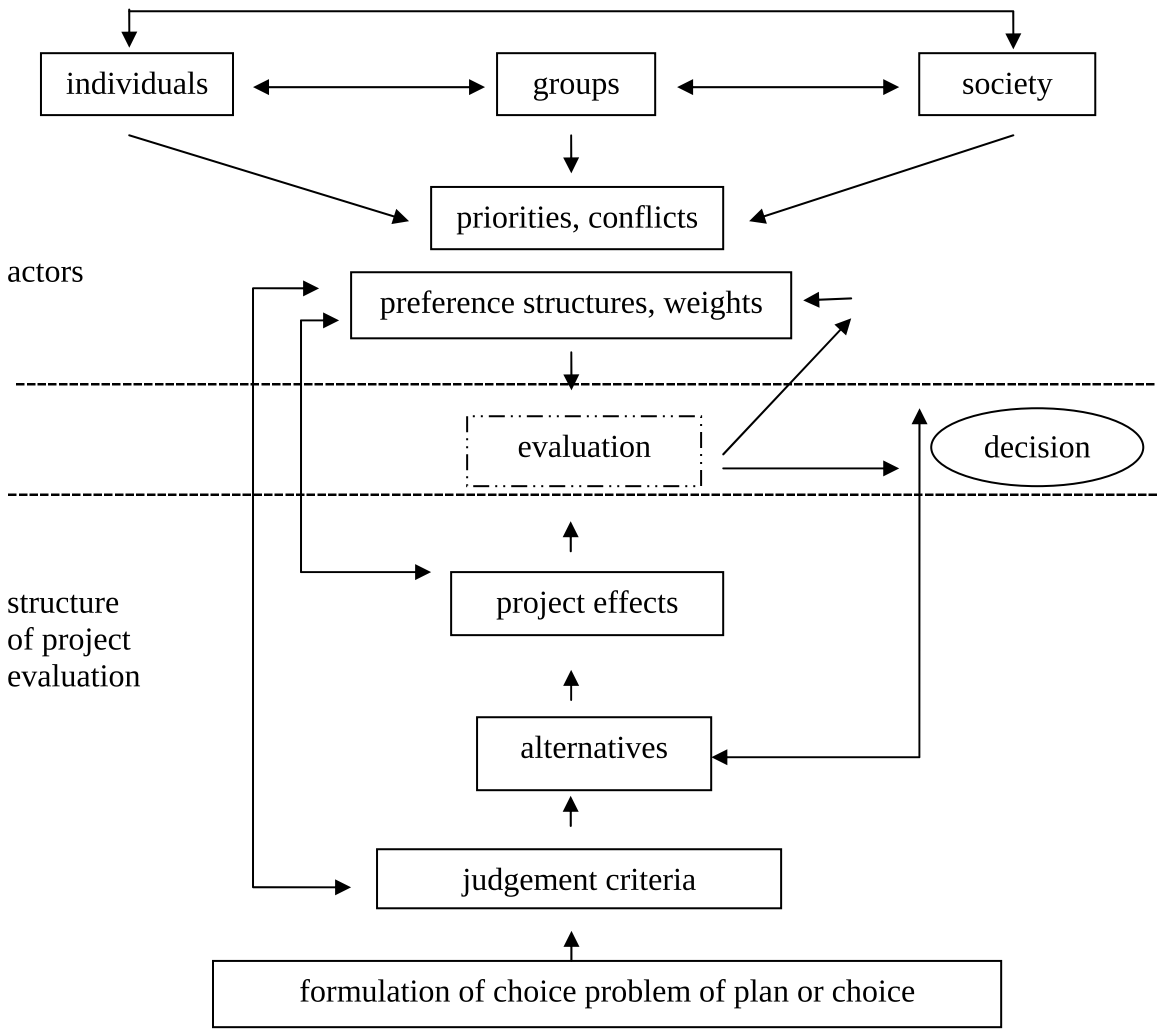

Figure 1 General structure of an evaluation problem.

- *multi-person* (or *multi-committee*) versus *single-person* (or *single-committee*) evaluation problems; in the case of multi-person or multi-committee problems one has to take into account the variation in preferences, while one may also consider the possibility of a multi-level decision structure;
- evaluation problems based on the *generation of preferred alternative solutions* versus those based on the *selection of one ultimate alternative*; in the first case the procedure aims at identifying only non-dominated solutions, i.e., solutions for which the value of one policy objective cannot be improved without reducing the value of a competing objective; in the second case the procedure aims at finding one alternative which is considered as satisfactory after the articulation of preferences. An intermediate approach may be based on the identification of a set of dominating alternatives;
- *single-step* versus *process* evaluation problems; the first category aims at finding the most satisfactory solution as an unambiguous result at a certain point in time; the second category considers policy making as a process during which one may add successively more information, so that the ultimate solution is identified in a series of successive steps.

Multi-criteria methods are appropriate to find a (complete or partial) ranking of choice alternatives that have to be judged on the basis of a broad (i.e. not exclusively monetary) set of decision or choice criteria. In various cases weighting procedures are used to arrive at an unambiguous solution, although the use of weights is not strictly necessary.

Like in all evaluation methods the use of a plan effect (or impact score) matrix (or table) is a central step in multi-criteria evaluation. This matrix contains for all choice alternatives the numerical estimates of outcomes of all relevant criteria, measured in their own appropriate dimensions (e.g., financial costs, reduction in traffic accidents, levels of air pollution, etc.).

Next, by confronting the *a priori* specified weights set for the judgement criteria with the plan-effect matrix, a ranking of alternatives may be obtained. There are, however, various procedures for confronting these two sets (depending amongst others on the level of precision of measurement of effects) and hence a wide variety of multi-criteria evaluation methods has been designed in the recent past, ranging from extremely simple to fairly complicated ones.

Various classifications of multi-criteria choice models may be made. In the literature, the following typology for these models has inter alia been proposed: *discrete* multi-criteria models versus *continuous* multi objective models, *hard information* models versus *soft information* models.

Discrete choice models display only a finite number of distinct feasible choice possibilities (courses of action, strategies, solutions, alternative plans or projects, etc.), while *continuous* models may encompass an infinite number of choice possibilities (as is usually the case in programming models).

Hard information means information measured on a cardinal scale, while *soft* information means information based on a qualitative (ordinal or nominal) scale. Clearly, one may also distinguish mixed information, in which the information is partly cardinal, partly qualitative. Consequently, the following typology may be used (see Table 5):

Table 5 A typology of multi-criteria choice models

	Cardinal information	Qualititative information	Mixed information
Discrete multiple criteria evaluation models	I	III	V
Continuous multiple objective programming models	II	IV	VI

Multiple criteria analysis may be seen as an important decision support method for planning under uncertainty. Especially in case of goal conflicts it may serve to rationalize complex decision problems, by providing both a tool for communication between all actors involved and a rigorous analytical technique for examining (implicitly or explicitly) the implications of policy trade-offs. Flexibility in the design and use of such methods is necessary to ensure a tailor-made research tool. The enormous variety in applications of such methods illustrates its great potential.

Clearly, in all empirical applications difficult analytical problems will be faced, e.g., regarding the precision of measurement, the identification of priorities, the demarcation of the impacts etc. Communication with all actors is then a sine qua non for an acceptance of results of such techniques. Recursive or cyclical planning procedures are hence necessary for a structural and generally accepted evaluation method.

3 Evaluation Tools for Integrated Transport Plans

3.1 Multimodal transport

In recent years among transport policy makers a lot of interest has arisen in multimodal transport solutions. What is referred to as 'multimodality', in practice usually only concerns Park-and-Ride concepts: the combined use of car and public transport in one trip. Near rail stations, metro stations, or bus stops from shuttle buses, car parks are created or extended to facilitate the transfer from car travellers to public transport or vice versa. Other combinations, like cycling and public transport use, or cycling and car use, have received much less attention.

From a policy maker's point of view, Park-and-Ride might be the best of both worlds, avoiding the need to finance public transport in less densely populated areas, as well as relieving the pressure on congested roads in more urban environments. However, a policy concept like this can only be a success if enough consumers share the feeling of 'best of both worlds' from their individual perspectives. If in their perception Park-and-Ride combines the 'need to possess a car' with 'the discomfort and extra costs of public transport use' and moreover the 'inconvenience of a transfer', they will choose this option only if other options will bring them even more inconvenience. Methods are needed to assess the real opportunities of Park-and-Ride concepts. The question in this section is whether mainstream demand forecasting methods are sufficiently capable to handle this travel option.

The share of multimodal transport in mobility will vary from region to region and country to country. Rijkswaterstaat-AVV (2002) gives figures on a nationwide base for the Netherlands. 2.7% of all trips and 12.3% of all kilometres travelled is multimodal in the sense that two or more transport modes are used in one trip[1]. Only considering trips that combine car and train use, no more than 0.1% of all trips is multimodal: clearly a niche market. In the Netherlands walking, cycling and public transport (bus, tram and metro) are more important in access and egress of train trips than car use. No wonder Park-and-Ride is a bit overlooked in mainstream demand forecasting. For regular transport plans the extra efforts needed to incorporate Park-and-Ride in the process does not seem to be worthwhile. But that does not help the transport plans particularly concerning Park-and-Ride.

Actually multimodality is no news at all. No transport mode, except walking, takes you exactly from the door you leave to the door you want to enter. Even to your bike shed or

[1] This is a very wide definition. As regular train transport inherently demands access and egress trips with other modes, the majority of all multimodal trips concern train trips (67% of the multimodal trips, 81% of all travelled kilometres in multimodal trips). 12% of all train trips combine train with car use (as driver or passenger) at the home end of the trip, 10% at the activity end (nearly only car passengers) (Givoni and Rietveld, 2007).

your parking space, you need to walk some meters. From this point of view, simple bike or car trips are multimodal too. Normally the walking distances are short and walking time is negligible in relation to all perceived door-to-door travel time. But this depends on the context. For trips to (or from) a city (centre) where car parking is forbidden or very expensive the time needed for walking can easily become substantial, depending on total trip length. In these cases, mainstream demand forecasting ignoring out-of-vehicle-time will no longer do.

Until twenty years ago, in modelling passenger behaviour, it was quite common to just compute total travel time. Usually no quality factors such as comfort at stops and type of vehicles were incorporated in the modelling and no distinction was made between different categories of (potential) public transport users (Van der Waard, 1988). In order to be able to be more effective in improving public transport quality, Van der Waard researched the relative importance of public transport trip attributes. Based on empirical data the disutility of the various trip-time attributes were estimated. Where total in-vehicle time accounts for 55% of total trip time 'on the clock', it accounts for only 39% of the disutility (see Table 6). Out-of-vehicle time is perceived as longer. Access time and walking time have particularly high disutilities.

Table 6 Contribution of trip-time attributes to total disutility of public transport trips (Van der Waard, 1988)

Trip-time attribute	Time in minutes	Percentage of trip time	Disutility in minutes in-vehicle time	Percentage of disutility
Access time	3.9	10.8	8.6	16.8
Waiting time at first stop	4.1	11.4	6.2	12.1
Total in vehicle time	19.7	54.9	19.7	38.6
Walking time at interchange	1.0	2.8	2.3	4.5
Waiting time at interchange	3.8	10.6	4.9	9.6
Number of transfers			5.7	11.2
Egress times	3.4	9.5	3.7	7.2
Total	35.9	100.0	51.1	100.0

Nowadays most models are refining the friction of public transport trips by using weighing factors and transfer penalties for the various trip attributes. A lot of research has been conducted into the valuation of these time attributes. Recently Iseki et al. (2006) produced a broad overview (see Table 7). The research results show that travellers are very sensitive to out-of-vehicle time, especially waiting time. People appear to be averse to making transfers at interchanges. There is quite a lot of variance in values, and one may wonder to what extent values are site and situation specific. *"In practice the rule of thumb could be that walking and waiting time are valued twice as much as in-vehicle time for non-business trips"* (Iseki et al. 2006). Most values concern interchanges bus-to-train, bus-to-bus, bus-to-metro etc. Only two studies give values for car-to-rail (a transfer penalty equivalent to 15 minutes in-vehicle time) and car-to-bus (8.3 minutes). Looking at the general aversion to transfers and waiting times, it is clear that few travellers will consider the park-and-ride option as long as driving the whole distance does not involve similar troubles. The perceived penalty of the transfer must be worthwhile compared with gained generalised travel time (congestion, searching for parking space, walking to parking meter, parking fee).

Table 7 Overall time valuations (relative to in-vehicle time = 1.0) in different studies as collected by Iseki et al. (2006), completed with Van der Waard (1988)

Study	Location/ Type	Factor	Mean	Standard deviation	Number of observations
Parsons Brinckerhoff Quade and Douglas Inc.	Houston	Waiting time	2.58	-	-
Barton-Ashman Associates	Cleveland	Waiting time	2.13	-	-
Parsons Brinckerhoff Quade and Douglas Inc.	Minneapolis-St. Paul	Waiting time (first 7.5 minutes) Waiting time (over 7.5 minutes) Transfer waiting time Transfer penalty (extra)	4.00-4.36 0.88-10.78 1.58-4.36 17.27-121.05	- -	- -
Parsons Brinckerhoff Quade and Douglas Inc.	Chicago	Waiting time	3.41	-	-
Kim	Portland	Various out-of-vehicle time, work trips Out-of-vehicle time, non-work trips	1.25-2.46 2.67	- -	- -
US Environmental Protection Agency	Review of 50 US studies	Walking time	2.0-2.72	-	-
Van der Waard (1988)	Amsterdam, Rotterdam, The Hague, Utrecht	Access time Waiting time at first stop Egress times Walking time at interchange Waiting time at interchange Number of transfers	2.2 1.5 1.1 2.3 1.3 5.7	- - - - - -	1.095 1.095 1.095 1.095 1.095 1.095
Wardman	Review of British studies from 1980 to 1996	Walking time Wait time Walk and wait time Headway Interchange 1 Interchange II Interchange III	1.66 1.47 1.46 0.80 17.61 34.59 33.08	0.71 0.52 0.79 0.46 10.93 25.88 22.73	140 34 64 145 8 16 23

For many car travellers considering Park-and-Ride their losses are clear (less comfort, extra costs) while their gains are unclear (Maybe I will find a parking space in the city, too; when it takes long till the next train comes, it will be quicker to drive all the way; is my car more safe here than in the city centre?). In situations where Park-and-Ride offers more certainties than a unimodal car trip, travellers might accept a little more (average) travel time. We may also note that travellers coming to the train station by bike or walking and having a car available are likely to shift to Park-and-Ride as soon as parking opportunities are expanded.

There are several ways to give Park-and-Ride a better place in demand forecasting:

1. Deal with Park-and-Ride as regular public transport trips, but stop the automated assignment of one zone to one particular public transport loading node. In a few iterations it can become clear whether it is profitable or not (for travellers having a car available) to travel a bit further by car;
2. Deal with Park-and-Ride as regular car trips, but recognize that in some zones weighing factors or penalties must be introduced regarding parking problems. Introduce the possibility of an access/egress mode for car trips towards these zones in analogy to

nested access-egress modal split modules in public transport, like ProMiSe (Cohn et al. 1996).

3. Consider Park-and-Ride as a separate mode beside public transport and car with its own disutilities. Li et al. (2007) and Molin and Van Gelder (2008) took this route.

A major problem is that policymakers can consider Park-and-Ride parks as a suitable option, but travellers will not automatically do so, too. On the one hand there will be travellers not knowing of the existence or exact location of Park-and-Ride parks at all. On the other hand there will be travellers considering nearly any station (or bus stop) in between their home and destination address with official or unofficial street parking possibilities as a potential Park-and-ride site. Especially the latter case, is a difficult one to develop algorithms for.

Although the few model-studies dedicated to Park-and-Ride give interesting results, it may be doubted whether they are easily transferrable to other places.

3.2 Generalized cost – benefit analysis

Cost-benefit analysis (CBA) is a widely used tool to evaluate policies for transport and climate change. The advantages and disadvantages of CBA were treated in Section 2. In this section, we look at the possibilities to generalize CBA of transport policies in such a way that spatial policies and their effects are included.

Urban land use policies often include investments in roads and public transport. As space is scarce, the effects of the travel modes on the use of space is an important factor in land use planning. Car use is associated with urban sprawl, while public transport is assumed to lead to more concentrated development. For instance Litman (2009) shows that American cities with ‘big rail’ (subways etc.) use much less space per capita than cities without ‘big rail’. However, looking at this correlation from a CBA viewpoint, we may note that the spatial structure of a city changes very slowly over time. Therefore, the effect of any policy occurs in the very long run. In CBA’s, the standard use of discounting factors for future benefits will reduce these long-run spatial benefits to a very small size. Therefore, the often-heard critique of CBA that discounting does not take account of long-term environmental effects in a proper way, may also apply to spatial effects. The way future costs and benefits are discounted, affects the distribution of environmental value, spatial value and welfare in general among generations. If we would adopt sustainability as a fixed restriction, we should not use standard discounting.

Generalized CBA of land use and transport investment requires analysis of both transport markets and the land market. This is particularly difficult for the land market, which is affected strongly by government regulation. Zoning laws effectively split up the land market into different segments: agricultural segments with low prices; and areas for industry, offices and housing with higher land prices. In effect, land for industry, offices and housing is rationed by government regulation. As economic activities and housing needs grow, agricultural zones are shifted to the industry/offices/housing segments. This reduction of land rationing increases the price, creating a windfall profit which is divided in some way among the original owners (farmers), project developers, the new owners of the land and local government.

Apart from creating windfall profits, expansion of the built-up area reduces open space and often affects scenery, heritage etc. The welfare costs of these effects are very hard to quantify. Sometimes, researchers assume that the value of open space is equal to the difference in land prices between agricultural land and built-up land. However, this is begging the question, because this assumption implicitly assumes that existing land policies optimally reflect the value of open space to society. Given the fact that decision making is not only influenced by rational/scientific considerations, but by many other factors as well (as described at the beginning of this chapter), this assumption is hardly sustainable. A better way to value open space is to measure the value for people (willingness-to-pay), comparing prices of housing and offices which are located near open space, to similar houses and offices which are not.

The forces which induce dispersion (population growth, economic growth) are partly countered by the benefits of agglomeration. Economic activities benefit from nearness to other economic activities. Also, high population densities support high-quality amenities, such as universities and opera houses (or specialized restaurants). Better transport allows us to reap the benefits of agglomeration without living and working very close to each other. Better public transport may increase agglomeration benefits without creating (much) urban sprawl. Integrated transport plans often aim at increasing spatial density, especially near train and subway stations. Therefore, agglomeration benefits are an important topic for transport CBA's, and especially for integrated transport plans. Unfortunately, the research into agglomeration benefits (which appear to be substantial) and the CBA literature have not really 'met' each other yet. An exception is Graham (2006). He computes an elasticity of productivity with respect to 'effective density' (defined as the employment that can be reached from locations) of 0.20 for the UK. That is, if an (integrated) transport policy makes it possible in an area to reach 10% more people (at the same costs), this leads to a 1.25% increase in the average productivity of the firms in that area. We may note that standard transport appraisals already evaluate travel time savings. Therefore, it is important to avoid double-counting.

In joint analysis of spatial and transport options, it is important not to assume ex ante that housing (or offices) requires new infrastructure, or vice versa. In the developed world, a lot of infrastructure is already present. New spatial developments are often served by existing infrastructure. Whether this infrastructure is adequate in the new situation, should be a research result, not an unproven assumption. Sometimes policy makers plan spatial developments 'to support public transport'. Here, means (public transport) turn into goals, on the implicit assumption that public transport is – without further research - a good thing. However, this approach mixes up political choices (to support public transport) with research (which should be neutral). Therefore, it is important to perform CBA's of all options, looking at the real benefits without prior restrictions.

As an example, we present an urbanization CBA from the Netherlands. Until 2005, the Netherlands had a goal of realizing at least 40% of new housing within city limits. The objectives of this policy were to preserve open space and to support public transport use. Also, a large part of housing outside of the large cities was built in commuter towns at distances of 15-20 kilometers, to preserve green areas near the cities. 'High quality public transport' was built to transport commuters. In practice, however, most commuters use private cars, causing serious congestion and heated debate on road expansion and road pricing. In 2005, the government commissioned a study of alternative policies (Ecorys, 2005), concentrating on the five largest urban areas (Amsterdam, Rotterdam, The Hague, Utrecht, Arnhem/Nijmegen). Three spatial alternatives were compared:

- Base case: the existing policy: 40% of new housing within city limits
- Higher density: 55% of new housing within city limits
- Controlled sprawl: 25% of new housing within city limits

Within these alternatives, public transport options were discerned.

Table 8 presents the main results. The value of open space was estimated in two ways: a (lower) estimate based on costs of compensation, and a (higher) estimate based on the assumption that government policies correctly reflect the benefits of open space. A higher density appears to have more costs than benefits, although a few intangible effects were not monetised. Allowing more sprawl shows more benefits than costs. The revenues of selling agricultural land for housing are reflected in negative investment costs (net benefits) in the controlled sprawl alternative. These benefits appear to be larger than the value of open space, especially if open space is valued using compensation costs. Also, the costs of building within city limits go up over time, as cheap locations are already filled up and expensive redevelopment areas are the next option. An additional result is that 'high quality public transport' (free bus lanes) is not viable, even to spatially concentrated commuter towns. Normal buses appear to be a better alternative in terms of costs and benefits.

From this example, we may conclude that strict zoning laws in densely populated areas may incur considerable costs, which are reduced by urban sprawl. However, as urbanization progresses, open space may become more scarce and more valuable. Also, we see that assumptions about an automatic need for expensive public transport may be refuted by a CBA which looks at a full set of alternatives.

Table 8 CBA of urbanisation in the Netherlands, net present values in 2004 (mln. Euros)

	Higher density	Controlled sprawl
Investment and running costs	-264	489
Land revenues	32	59
Benefits for housing consumers	3	8
Windfall profits to land owners	-106	97
User benefits of 'high-quality public transport'	7	-13
Quality&profitability existing public transport	+PM	-PM
Congestion (travel times)	11	-120
Open space (incl. 'green spots' in cities)	58 to 211	-45 to -194
Support for and variety of amenities	PM (+/-)	PM (-/+)
Quality of existing housing	20	-25
Synergy with urban improvement policies	PM (+)	PM (-)
Safety	PM	PM
Environmental effects of traffic	-3	-25
Net benefits	-88 to -242 +/-PM	275 to 424 +/-PM

4 Empirical Applications of Intermodal Transport Plan Evaluation

This section presents some brief results of empirical applications of intermodal transport plan evaluation. The empirical focus in *park and ride* ex-post policy evaluation is often restricted to the parking space occupation level and consumer satisfaction. These two aspects are most easily to monitor. A premature conclusion based on these indicators could be that policy goals are achieved, because the Park-and-Ride park is full and the users are satisfied. But most policy makers have other goals in mind. Park-and-Ride parks should lead to a reduction of car use, creating environmental benefits. Or Park-and-Ride parks should relieve congested roads in urban areas, and relieve the pressure on city centre parking space. Parkhurst (2000) and Mingardo (2008) show that Park-and-Ride facilities do not automatically serve these goals, and describe several side effects:

- Park-and-Ride parks attract other parkers from nearby locations. Not every occupied place is a new Park-and-ride traveller;
- Park-and-Ride parks attract additional visitors to nearby destinations. This problem can be of importance in city centre areas with scarce parking space and high parking fees;
- Park-and-Ride parks cause a switch from public transport and non-motorized trips to car trips in transport to and from the station;
- Park-and-Ride parks cause extra trip-generation;
- Inner-city road capacity or parking space is refilled by latent demand, coming from travellers who previously used public-transport or non-motorized transport.

In general *park and ride* generates more car kilometres than it saves. It can attribute to a redistribution of environmental pressure on the city centre area towards the outskirts of the city, as far as the latent demand from city centre inhabitants is suppressed. Li et al. (2007) show that the parking charging level and the number of parking spaces supplied at the Park-and-Ride site and in the city centre area, as well as the dispatching frequency and fare of metro line, significantly influence the commuters' choice behaviour and the network performance in terms of total realised travel demand and social welfare gain.

Not serving the goals set by policy makers, or generating side effects, does not automatically mean that Park-and-Ride is not desirable from a welfare economic point of view. Margail and Auzannet (1996) conducted a Cost Benefit Analysis on underground or covered Park-and-Ride facilities in the Paris region. They found that time savings were insignificant. The economic and social profitability of Park-and-Ride projects lies essentially in savings in parking provision in the centre, followed by the issue of the consumption of road space in heavily populated areas. It depends on the parking tariffs how societal profits are redistributed (see Table 9).

Table 9 Breakdown of costs and benefits for different scenarios of underground or covered Park-and-Ride in the Paris Region (Margail and Auzannet, 1996)

Assumption about number and origin of park and ride user	60 "ex-all car" 100 "ex-bus+RER" 100 "ex-car+RER	100 "ex-all car" 140 "ex-bus+RER" 100 "ex-car+RER"	100 "ex-all car" 100 "ex-bus+RER" 80 "ex-car+RER"	100 "ex-all car" 100 "ex-bus+RER" 100 "ex-car+RER"
COSTS				
- investments	15.05	19.67	16.17	17.36
- operations	0.65	0.84	0.69	0.74
BENEFITS				
- Time savings	0.01 (0.6%)	0.02 (0.7%)	0.01 (0.3%)	0.01 (0.3%)
- Reduction in car use	1.35	2.46	2.79	2.79
• consumption of highway space	0.66 (39.5%)	1.16 (41.6%)	1.25 (40.2%)	1.25 (40.2%)
• externalities	0.12 (7.2%)	0.21 (7.5%)	0.24 (7.7%)	0.24 (7.7%)
• direct costs of car use	0.39 (23.3%)	0.79 (28.3%)	1.00 (32.2%)	1.00 (32.2%)
• parking savings	0.18 (10.8%)	0.30 (10.8%)	0.30 (9.6%)	0.30 (9.6%)
- Variation in public transport use	0.31 (18.6%)	0.31 (11.1%)	0.31 (10%)	0.31 (10%)
Total yearly benefits	1.67 (100%)	2.79 (100%)	3.11 (100%)	3.11 (100%)
Parking costs avoided	5.85	9.35	9.23	9.35
- in the city centre	5.25	8.75	8.75	8.75
- on the outskirts	0.60	0.60	0.48	0.60
Net present value	3.34	13.50	22.64	20.95
Internal rate of return	11.08%	18.86%	34.85%	29.56%

5 Epilogue

In a modern society, spatial movements (mobility of people, transport of goods) are a basic feature. Intense spatial interaction and large volumes of transport flows put a heavy stress on the accommodation possibilities of regions and cities. We witness increasingly a 'struggle for space', where in a given area a multiplicity of spatial actors competes for a 'place under the sun'. This territorial competition – with many interactions between actors with different trip motives and spatial behaviours – is accompanied by various positive and negative externalities, impacting inter alia on throughflows in transport (e.g. congestion), safety, ecological quality, land use, access to transport systems etc. Transportation planning is thus not in the first place an engineering activity, by a multi-faceted rational investigation and organization of scarce space. This calls for a more integrated perspective on transportation planning. As a consequence, there is a need – and scope – for new, broader-based approaches that are able to include a wide variety of different types of impacts, as was illustrated in this paper. Of course, extensions of the currently available methodological state of the art would be desirable. Interactive decision-aid methods would be one direction, while GIS-based assessment might provide new departures for operational research in the transport field.

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