Prioritising transport infrastructure projects: towards a multi-criterion analysis

I.C. Schutte & A. Brits

ABSTRACT

This paper explores a number of aspects relevant to developing a systematic framework for the appraisal of transport infrastructure projects of the type 'budget cycle projects with local economic impacts', and applying it to the City of Tshwane. Such a framework is needed as, by implication, the budgeting process for any transport agency requires projects to be ranked in terms of their relative value. Cost/benefit analysis, when applied in a classic sense, is not suitable for this purpose, given its exclusive focus on economic efficiency, whilst attempts to broaden it to include other impacts (or objectives) are not generally accepted. Multi-criterion analysis, however, is capable of facilitating project ranking in a multi-objective decision-making environment, but needs to be customised first to accurately reflect local conditions. The paper concludes that an appraisal framework should combine these two types of analysis by adopting an overall multi-criterion approach with economic efficiency (optimal allocation of resources), equity (impact distribution aspects), sustainability (environmental considerations) and compatibility (alignment with community goals and objectives, and other strategic initiatives) as decision criteria. This will ensure a usable protocol for the appraisal of this type of transport infrastructure project in an essentially multi-criterion decision-making environment.

Key words: cost–benefit analysis (CBA), decision criteria, general equilibrium analysis, multi-criterion analysis (MCA), partial equilibrium analysis, project appraisal, project feasibility, project impacts, economic efficiency, project prioritisation (ranking), project selection, transport infrastructure (projects)

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Introduction

Transport agencies are often confronted by a large number of feasible projects but have insufficient funds to implement them all. The budgeting process by implication therefore requires projects to be ranked in terms of their relative value, so as to enable project selection starting from the top of the list (the best project) and proceeding down the list, until funds are depleted. This highlights the need for some kind of prioritisation protocol. In the case of transport infrastructure projects, though, this is no mean task, given the diverse nature of impacts and the consequent shortcomings of traditional tools, in particular classic cost/benefit analysis (CBA) with its focus on economic efficiency. At the same time, problems with project ranking and selection are also experienced at a practical level. These aspects are discussed in the following section under three headings.

Research need

Diverse nature of project impacts

Impacts from investing in transport infrastructure are wide and varied; this is evident from the fact that impacts can be grouped under a wide range of headings, pointing to the need for different types of appraisal. Impacts may, for example, relate to the following: (1) costs; (2) convenience; (3) environmental aspects; (4) strategic factors; (5) political factors and national prestige; (6) alignment with policy goals and objectives; and (7) income distribution considerations (Schutte 1983: 7–8). In the case of public enterprises, the following types of appraisal may therefore be applicable (Adler 1987: 3–4): (1) economic appraisal; (2) technical appraisal; (3) institutional appraisal; (4) financial appraisal; (5) commercial appraisal; and (6) social appraisal.

Impacts may also differ between urban and rural projects. Litman (2001: 9) lists likely impacts of urban projects involving different modes of transport and travel demand management (TDM) projects: *downstream congestion* (the provision of a new link or the upgrading of an existing link may have negative impacts on other links of the network, or on other modes, by increasing traffic levels on such links or modes); *parking costs* (upgraded road infrastructure may increase the demand for parking space, whereas transit projects or TDM initiatives may lower it); *roadway impacts* (heavy vehicles may impose traffic congestion and road wear costs, requiring special facilities that may lead to additional cost); *traffic impacts on non-motorised modes* (delays, discomfort and the increased risk of collisions to cyclists and pedestrians); *vehicle ownership and mileage-based depreciation* (an improved road network and/ or increased travel options could reduce the number of vehicles per household);

transportation choice (the choices of non-drivers may be increased and their access may be improved); *land use objectives* (the community's strategic land use objectives, for example to minimise urban sprawl).

In the context of economic development considerations, Weisbrod (2011: 3) lists five categories of transport project impact, noting that, although they overlap, they constitute different perspectives for measuring project impacts: (1) travel benefits; (2) environmental and community impacts; (3) transport factors driving non-travel productivity gain; (4) other factors that affect economic growth; and (5) economic growth outcomes.

Focus and scope of classic CBA

The limitations of classic CBA as a decision-making tool, resulting from its exclusive focus on economic efficiency, are evident from the attempted broadening of its focus to include other objectives as well. It has therefore become necessary to draw a distinction between an *economic* CBA and a *social* CBA: the former addresses only the objective of efficiency (the optimal allocation of resources), whereas the latter, in addition to economic efficiency, also considers aspects such as equity effects and externalities (Brent 1996: 5). Dockel, Mirrilees and Curtayne (1991: 3), in their turn, distinguish between *narrow* CBA and *broad* CBA, and between the conventional school of thought favouring narrow CBA and the decision-making school of thought that supports broad CBA. These distinctions (between an economic and a social CBA, and between narrow and broad CBA), are taken to refer to two dimensions of CBA – *scope* (referring to the cost types included) and *focus* (referring to the objectives addressed) – as depicted in Figure 1 with reference to transport infrastructure projects. From Figure 1 it is also clear that *classic CBA*, for the purposes of this paper, refers to an economic CBA undertaken in a narrow manner.

The idea of broad, social CBA, though, has not been generally accepted (as explained in a later section of this paper). Decision-makers were therefore left with a dilemma, as CBA, when applied in a classic sense, would only render a partial answer to the decision-making problem.

Problems at a practical level

The Local Government Municipal Systems Act (No. 32 of 2000) requires local governments to prepare Integrated Development Plans (IDPs) in an attempt to ensure a holistic approach to development. The Act therefore requires that various functional plans (of which the Integrated Transport Plan [ITP] is but one) be con-

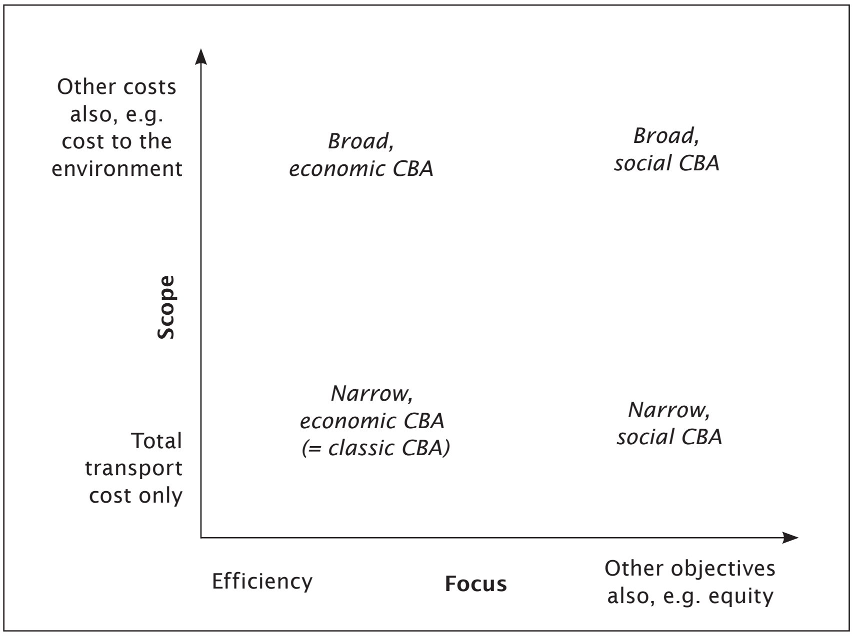


Figure 1: Dimensions of CBA

solidated in each local government's IDP – in this case, that of the City of Tshwane. The Local Government: Municipal Finance Management Act (No. 56 of 2003) further requires the municipal budget to be based on the relevant IDP; this means that the IDP process has major implications for the implementation of the ITP (CTMM 2007: 1–4). From the relevant City of Tshwane (CoT) planning documents, however, it is clear that problems are being experienced at a practical level. According to the ITP document (CTMM 2007: 20), the prioritisation of multi-modal transport proposals is done in two organisational units: the Division of Transport Development (in the Department of Economic Development), mainly for public transport projects; and the Roads and Stormwater Division (in the Department of Service Delivery) for all other transport projects. In addition, there are two prioritisation processes, namely the ITP (functional or departmental) and IDP (process-related) prioritisation processes (CTMM 2007: 12-1), resulting in two sets of priorities. The ITP set of priorities, essentially based on functional/technical considerations, may include return on investment as well as political influence from within the transport sector, whereas the IDP set of priorities reflects 'municipal priority areas'. The fact that the IDP process carries more weight than the ITP process, as budget allocations are based on IDP priorities (CTMM 2007: 12–1), presents a problem, in particular as IDP priorities are described as "not mathematically defensible". "This clearly plays havoc with the logical sequencing of projects" (CTMM 2007: 12–1). All this amounts to the fact that, although several criteria are considered in ranking and selecting projects, this is not done in a structured scientific manner.

Study objective

The diverse nature of project impacts arguably calls for a multi-criterion analysis (MCA)-type approach. According to Belton and Stewart (2002: 3), MCA should be seen as a process aimed at integrating objective measurement and value judgement, and of making explicit and managing subjectivity. MCA, therefore, is aimed at aiding decision-making (Belton & Stewart 2002: 4–5). However, an MCA-type approach needs to be customised to reflect local conditions and contexts before it can be applied. The objective of this paper, therefore, is to explore aspects relevant to developing a systematic MCA-type framework for the appraisal of transport infrastructure projects of the type 'budget cycle projects with local economic impacts', and applying it to the City of Tshwane. The terms 'MCA' and 'multi-criteria decision-making' (MCDM) are regarded as synonyms and are used interchangeably.

Structure of paper

Different contexts for project appraisal are explored first as they directly impact on the suitability of tools for project appraisal. Key features of existing tools for project appraisal are considered in order to establish their potential role, if any, in an appraisal framework for budget cycle type projects. The functional requirements for an appraisal framework for budget cycle-type projects are established. Given these requirements, the suitability of existing tools is investigated. The basic approach is developed and customised to the CoT context by identifying decision criteria relevant to the CoT and addressing the measurement of intra-criterion performance. Opportunities for improving decision-making and ensuring better outcomes, afforded by recent developments in the IT (information technology) sector, are investigated. Finally, the responsibilities of key stakeholders in applying the approach are identified.

Investment in transport infrastructure is traditionally seen as involving both the provision of new infrastructure and the improvement (upgrading) of existing infrastructure. Eberts (1999: 1–2, in Joynt 2004: 1–7) presents a different view, identifying two basic forms where the distinguishing factor is the type of technology, namely *capital expansion (*using traditional technology for the construction of additional highway segments, railway lines, runways, or additional air, sea, rail or terminal capacity) and *capital enhancement* (using new technologies for enhancing the efficiency of the existing system, such as intelligent highway systems, congestion pricing, intermodal freight facilities, geographic positioning systems and instrument landing systems). In this paper, the focus is on the former.

Contexts for project appraisal

For the reasons given below, a distinction is made between once-off projects and budget cycle-type projects, and also between projects with local impacts and projects with external impacts. Once-off projects include "overtly developmental or sustainability-enhancing interventions", as well as major policy intervention initiatives (Naude & Naude 2005: 1), such as: (1) development corridors and other integrated urban, rural or regional development initiatives – they typically include one or more transport anchor projects such as a new or upgraded port, a new road connection or a multi-modal transport interchange; (2) specifically targeted interventions aimed at poverty alleviation, such as the promotion of non-motorised transport and other affordable means of transport and travel; (3) transport demand management (TDM) strategies aimed at promoting more sustainable travel and land use patterns; and (4) interventions such as the phasing out of long-distance transport subsidies aimed at combating urban sprawl and encouraging more compact and sustainable urban settlement patterns. Once-off projects are also described as: "(1) very large projects with complex impacts; and (2) public-private partnerships type projects that require a kind of accounting-based analysis known as financial analysis" (Austroads 2005a: 8), whereas budget cycle-type projects are 'non-unique' (run-of-the-mill) projects, typically of a smaller scale and occurring on an ongoing basis, and thus subject to the annual budget cycle process of the transport authorities – hence termed 'budget-cycle projects'. Whereas once-off projects will normally require unique funding arrangements on a 'single-project basis', budget cycle-type projects imply a 'ranking problematique', requiring a relatively large number of investment options to be placed in some form of preference order (Roy 1996, in Belton & Stewart (2002: 15), to enable the composition of an optimum investment portfolio of projects under conditions of budget constraints.

Impacts can further be either local (i.e. limited to the area of jurisdiction of the relevant authority) or regional/national (i.e. extending beyond the boundaries of the relevant authority). The latter would apply in the case of 'traded' industries, defined as industries that sell their products and services to national or international markets, as opposed to 'local-serving' industries that essentially serve the needs of local residents. Local industries are merely instrumental in circulating and distributing wealth within a region, whereas traded industries serve as 'economic pumps', adding wealth within a region (EDRG 2008: 2). Traded industries can be identified by using measures such as: (1) a location quotient that compares a region's share of employment in a particular sector with the national share – a value greater than one indicates relative concentrations for that industry; and (2) the ratio of regional demand over regional supply, where a ratio of greater than one would also point to a traded industry. Regarding the latter, this is not always the case, though, as "the difference between local supply and demand (gross exports) does not necessarily equal total (net) exports. Even products in heavily exported industries may also be imported into a region, reflecting product variation within the industry sector" (EDRG 2008: 4).

These distinctions allow for the classification system in Table 1, resulting in different categories of projects, each with a unique set of implications for selecting appropriate tools for project appraisal, as argued in subsequent sections of this paper. This paper focuses on projects in Category AB.

Table 1: Contexts for project appraisal

Scope of impacts	Project type	
	Once-off	Budget cycle
Local	Category AA: Not applicable, as once-off projects by definition will have wide (regional and national) impacts.	Category AB: Budget cycle-type projects with local economic impacts only (the 'typical' case).
External	Category BA: Once-off projects which, by definition, have wide economic impacts, extending beyond the study area and across regional borders.	Category BB: Budget cycle-type projects with external economic impacts (not the typical case).

Tools for project appraisal

Key features of existing tools for appraisal are highlighted here in order to indicate their role, if any, in an MCA-type approach. Regarding classic CBA, multi-criterion ('scorecard') analysis and composite rating schemes, Weisbrod (2011: 3) notes that they all stem from the same theoretical basis, namely the existence of a social utility function representing the relative value to society of each project, and that all three approaches attempt to derive that relative value "by compiling positive and negative impact elements into a common set of metrics, and then applying factor weights to calculate aggregate ratings that enable comparison among competing projects". In practice, though, each approach uses a different set of impact factors and applies a different form of weights.

Cost/benefit analysis

Cost/benefit analysis (CBA) constitutes a specific application of welfare economics techniques, but excludes income distribution aspects (www.wikipedia.org). It originated when economists started to link the theory of consumers' surplus with the net gain to communities resulting from government spending projects (Mullins, Mosaka, Green, Downing & Mapekula 2007: 1). In its classic form, CBA considers a range of benefits and costs, and translates them into monetary terms by using appropriate unit valuation factors derived from actual cost or willingness-to-pay estimates (where the latter is derived from stated preference surveys or statistical studies of observed behaviour); impacts at different points in time are taken care of through discounting. By using common monetary valuation, the anticipated benefits and costs of a project can be compared (FHWA 2003, in Weisbrod 2011: 3).

There are a number of limitations of traditional CBA; they include its coverage (or not) of social considerations, such as a lack of sensitivity to wealth differentials, distributional impacts on vulnerable groups, and inter-generational impacts (Ackerman & Heinzerling 2004, Zerbe 2007, in Weisbrod 2011: 3). CBA, when used for transport decision-making, is also criticised when used in a narrow sense, considering only user benefits and, in so doing, missing non-user impacts on business productivity and competitiveness (Eddington 2006, Weisbrod 2008, in Weisbrod 2011: 3). Focusing solely on traveller benefits, for example, can undervalue freight-related projects. Moreover, CBA based on traveller benefit measures only can be biased to urban projects, ignoring market access and connectivity benefits to rural areas (Weisbrod 2011: 4).

Weisbrod (2011: 4) lists two approaches to addressing this line of criticism (Weisbrod 2011: 4). One approach involves a CBA of traditional user impacts (such as travel time, cost and safety), complemented by a qualitative consideration of other impacts (such as economic development, environment and community impacts). Another approach involves broadening the CBA process to include a wide range of non-user impacts, for example economic competitiveness (through measures of productivity associated with travel efficiency, reliability and access changes), liveability (through measures of the availability of multi-modal options, and health improvement), and environmental sustainability (through measures of energy efficiency and the reduction of air pollution and carbon emissions) (US DOT 2010, in Weisbrod 2011: 4).

Multi-criterion analysis

A key feature of MCDM is the existence of conflicting goals and criteria (Stewart, Joubert, Scott & Low 1997: 5). Multi-criterion analysis (MCA) is a decision-making tool for multi-criterion type problems; it can also accommodate quantitative as well as qualitative aspects (Mendoza & Macoun, with Prabhu, Sukadri, Purnomo & Hartanto 1999: 15). Several models have been developed to model preferences in the context of multi-criterion problems, all containing two primary elements: (1) preferences in terms of each criterion (i.e. intra-criterion comparisons); and (2) an aggregation model (i.e. inter-criteria comparisons, combining preferences across criteria) (Belton & Stewart 2002: 79). According to Diakoulaki and Grafakos (2004: 8), preference models fall into two groups: (1) multi-attribute value theory methods, namely, value measurement methods, which include AHP (Analytic Hierarchy Process) and SMART (Simple Multi-Attribute Rating Technique), and (2) outranking (partial aggregation) methods. Belton and Stewart (2002: 9, 84) add a third group: satisficing models (or goal programming). The value measurement method addresses the ranking problematique (placing options in some form of preference order), which is a primary challenge in the CoT case.

Composite factors for ranking and selecting

This approach involves the development of a composite score for each project using a set of alternative measurement perspectives, with public input being an important feature of the approach. The Kansas DOT (Department of Transport) scoring system for selecting projects for the state-wide long-term plan (Kansas DOT 2010, as described by Weisbrod 2011: 6–8), is an example of this approach. The numeric score for each project is based on the sum of three radically different scoring systems: the engineering score (worth up to 50 points); the local consult score (up to 25 points) and the economic impact score (also up to 25 points). The *engineering score* is based on project impact on traffic flow, considering six factors: current congestion in terms of the volume/capacity ratio; predicted congestion in 20 years; current truck volume per lane; the expected five-year accident rate; the expected five-year fatality rate; and level of traffic. The *local consult score* relies on ratings calculated by Kansas DOT staff on the basis of feedback at local consultation meetings. The *economic impact score* is based on the anticipated change in state-wide job generation over a twenty-year period, and the change in the present value of economic benefits. The latter is measured as the impact on state-wide gross regional product (GRP) plus the value of personal time and safety benefits that do not drive GRP changes. The TREDIS

(Transportation Economic Development Impact System) model (which is discussed further in a subsequent section) is used for calculating the economic score.

General equilibrium analysis

Whilst a partial equilibrium analysis (i.e. CBA) focuses on 'local' (direct, initial or first round) impacts, a general equilibrium analysis focuses on economy-wide impacts. Economy-wide models can be divided into two groups. *Econometric models* comprise sets of mathematical/statistical relationships to obtain key summary parameters (such as elasticities) that describe the underlying structure of the economy. These parameters and forecasts generated by the econometric models constitute important inputs to input/output (I/O) type models. *I/O-based models* are 'simulate-type' models, involving a disaggregation of the national accounts of a country. They model the impacts of projects and policies on the flow of inputs and outputs in the economy, given the inter-sector nature of transport interactions within the economy. The I/O model has led to the development of a number of other economy-wide models, such as the Computable General Equilibrium (CGE) model (Austroads 2005c: 8). They range from static models to dynamic models – the latter modelling how a project will impact on the economy over time – but, in both cases, modelling the impacts of a project on the economy on a 'with and without' basis (Austroads 2005c: 11).

Spatial models

In addition to the extent and nature of project impacts, their spatial distribution is also important. A number of spatial models have been developed to address this. They can be classified into three groups according to the dominant discipline involved (although a clear-cut distinction is not always possible): (1) CGEurope (Computable General Equilibrium Model for Europe), REMI (derived from Regional Economic Models, Inc) and TREDIS can be termed economic models; (2) SASI (Socio-economic and Spatial Impacts), IASON (which builds on SASI and involves the integrated appraisal of spatial economic and network effects) and MEPLAN (derived from Marcial Echenique and Partners) can be termed spatial planning models; and (3) DELTA (derived from Development, Transition, Location, Employment and Area quality) can be described as eclectic, building on, amongst others, urban and regional economics, geography and sociology. A common feature of economic models is the distinction between 'transportation drivers' and 'economic outcomes'. Whilst the emphasis in the 'traditional' form of regional economic models (such as REMI) is on cost competitiveness, 'economic development models' such as TREDIS recognise a broader set of market access and system connectivity factors impacting on freight movement as well as business attraction and retention (EDRG 2008: 22).

Functional requirements for an appraisal framework

An appraisal framework for Category AB projects – which are the focus of this paper (i.e. budget cycle-type projects with local economic impacts only; see Table 1) – should be capable of ranking projects in terms of their relative value (worth). It should also be capable of separating feasible projects from unfeasible ones. Stated differently, and more in line with the framework developed for the City of Tshwane, it should enable *feasible* projects to be *ranked* in terms of their relative value. This means that appraisal involves both project evaluation and ranking. The 'relative value' of a project depends on its score on each identified objective and the relative importance of each.

Suitability of existing tools

The tools for project appraisal discussed previously are judged here in terms of the functional requirements outlined above. *CBA* allows both the evaluation of projects (i.e. for feasible projects to be separated from unfeasible ones) and the ranking of feasible independent projects. With CBA, there are two conditions for a project to be feasible: benefits must exceed costs (or be at least equal to cost), given a minimum acceptable (official) discount rate, or the calculated internal rate of return (IRR) of a project must exceed the official discount rate. Feasible independent projects can be ranked in terms of either their IRR or their benefit/cost (B/C) ratio relative to the null alternative. *MCA*, however, also allows the evaluation of projects; this can happen by specifying a minimum cut-off value for each applicable criterion. MCA further allows feasible projects to be ranked in terms of their aggregate score. The *composite factors approach* does not allow evaluation, as it does not allow for specifying minimum acceptable values. It does, however, allow projects to be ranked in terms of their total scores (meaning that the list of prioritised projects can contain both feasible and unfeasible projects). *General equilibrium* (GE) and *spatial models* do not allow for projects to be evaluated as no minimum value is specified; they also do not allow ranking as no single value for project value is calculated.

The suitability of tools in terms of an appraisal framework is summarised in Table 2, from which it is clear that only CBA and MCA are suitable for the purposes of this paper, as they allow both the evaluation and ranking of projects.

Table 2: Suitability of tools for an appraisal framework

Aspect	CBA	MCA	Composite factors approach	General equilibrium models	Spatial models
Does it allow evaluation?	Yes	Yes	No	No	No
Does it allow ranking?	Yes	Yes	Yes	No	No

Although GE models and spatial models do not qualify for the purposes of an appraisal framework, they are nevertheless appropriate in the case of once-off projects with external (regional) impacts (i.e. Category BA projects in Table 1). Austroads (2005c: 3) concurs with this, noting that economy-wide modelling should be limited to cases of projects with major regional impact on land use or transport distribution patterns; projects likely to yield special benefits to traded goods sectors; projects facilitating regional and national development; and projects providing benefits that rely on geographic connections between regions. However, for the purposes of establishing the relative value of projects – a key aspect in the context of this paper – it can be argued that adding the benefits of the macro-economic analysis to those of the micro-economic analysis amounts to double counting (Austroads 2005c: 16).

Developing the basic approach

The likely impacts of projects in urban areas were examined (Schutte 2004: 54–60) in order to facilitate the development of a basic approach. Impacts are aggregated in the following boxes under headings deemed appropriate for the purposes of this paper.

Impacts relating to a better transport system

Manifesting in a reduction in total transport cost, consisting of:

Infrastructure cost, consisting of:

- Construction cost
- Maintenance cost

Road user cost, consisting of:

- Vehicle operating cost
- Collision cost
- Travel time cost

Macro-economic impacts resulting from a better transport system

Manifesting in economic growth, and evident from positive changes in aspects such as:

- Output (GDP)
- Employment
- Income
- Investment
- Fiscal environment
- Land and property values

Impacts relating to equity

Manifesting in economic development, and evident from changes in aspects such as:

- Mobility and accessibility
- Economic empowerment
- Skills transfer
- Income distribution
- Poverty alleviation
- Crime levels
- Health

Impacts relating to the physical environment

Manifesting in environmental impacts, and evident from changes in aspects such as:

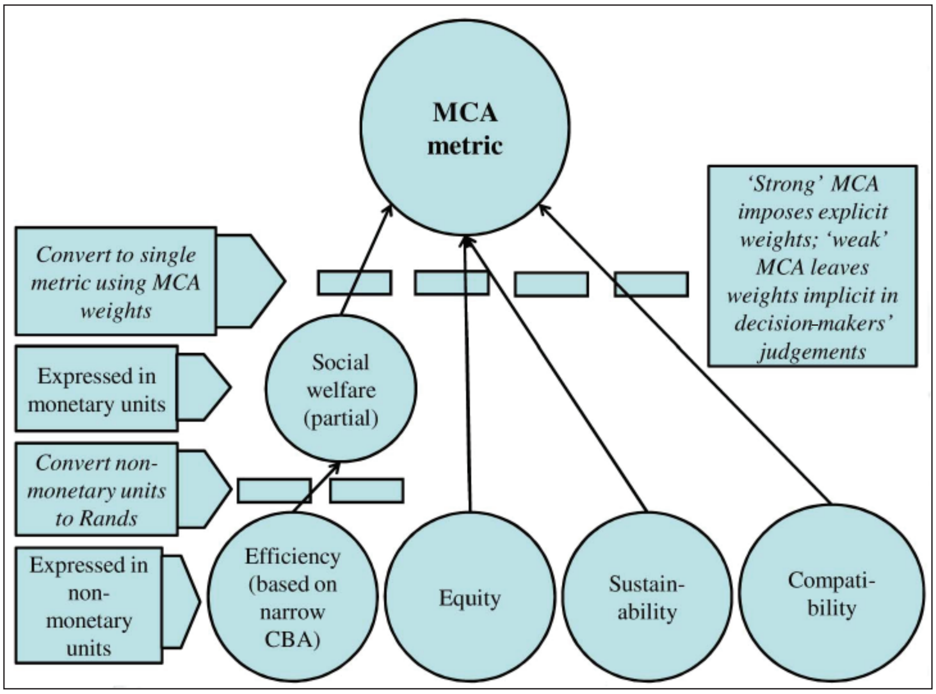
- Visual intrusion
- Air pollution
- Noise levels

Impacts relating to other impacts not included above
Evident from changes in aspects such as:
• Responsibilities of relevant authorities • TDM schemes • Patronage of public transport systems • Affordability of other 'necessary' projects • Policies, strategies and priorities • Other initiatives and projects • Land use and urban form • User-friendly transport environment • Protection of capital assets • Traffic levels and composition

These project categories underline the fact that a classic CBA would fail to identify a number of impacts. This brings to the fore the issue of broadening CBA in terms of focus and scope, and the choice between an economic and a social CBA, as well as between a narrow and broad CBA. However, the idea of 'broadening' CBA and using it in the manner suggested by the decision-making school of thought (Dockel et al. 1991: 3) is not generally accepted. Dockel et al. (1991: 8–9), for example, indicate their preference for narrow CBA, arguing that CBA at best is a 'soft' technique, and that it will become even softer – and, by implication, less reliable – if it were extended to include soft issues such as equity, strategic goals and objectives, and other social considerations. (A 'soft' technique, as used here, is defined as a subjective technique requiring human judgement, as opposed to a 'hard', objective technique based on hard facts.) This reasoning is also in line with the view expressed by Mishan (1988: 209–212). If this reasoning is accepted, it points to a preference for classic CBA. However, the analysis of impacts does underline the existence of conflicting decision criteria (both quantitative and qualitative), which points to the need for an MCA-type approach. Nevertheless, the importance of efficiency as a decision criterion should be borne in mind. The objective of classic CBA is just this and, as a result, CBA remains relevant as an appraisal tool. This means that an MCA-type approach should be the basic one – with efficiency as one of the decision criteria – and that classic CBA should be conducted to address the requirement of efficiency.

Identifying decision criteria

The MCA value measurement model, indicated earlier as the most appropriate model for the purposes of this paper, requires the following steps: (1) identify and structure the problem; (2) identify alternatives; (3) identify decision criteria; (4) determine the relative importance of criteria; (5) measure intra-criterion performance; (6) aggregate scores across criteria; and (7) perform a sensitivity analysis (adapted from Goodwin & Wright 2004: 30–48, in Engelbrecht 2007: 116; Diakoulaki & Grafakos 2004: 6–8). The identification of an appropriate set of decision criteria (the third of these criteria) is a critical aspect in customising the basic approach. As it may be argued that decision criteria should be derived from identified community goals and objectives, the CoT decision-making environment was scrutinised for this purpose, focusing on the following: statutory environment and spatial development framework; policy imperatives; and CoT vision, mission, goals and objectives for transport. This search did not prove fruitful: in general, the relevant CoT planning documents, in particular the ITP and the IDP documents, were not helpful for the purposes of identifying a list of decision criteria; and those objectives that do qualify as decision criteria were found not to be operational (in that they were not measurable). Decision criteria from other sources were also explored; to this end, the following were considered: (1) views of a selected number of independent researchers; (2) criteria suggested by, or for, a selected number of road/transport authorities abroad such as the UK Department for Transport with NATA (New Approach to Transport Appraisal) and Austroads (Guide to Project Evaluation), and also by the HDM-4 (Highway Development and Management) model (originally developed by the World Bank); (3) criteria used by selected state road/transport authorities in the USA; (4) criteria suggested by the South African Department of Transport; and (5) criteria suggested for a number of South African urban municipalities. This proved worthwhile, although the criteria in some cases related to projects with regional impacts. A third avenue involved unpacking likely impacts of municipal projects and aggregating them into logical groups, as was done above. This resulted in the following decision criteria being considered relevant in the case of budget cycle type projects: (1) *efficiency*, which deals with the requirement of the optimal allocation of scarce resources; (2) *equity*, which involves the objective of a fairer distribution of income between persons benefiting from the project; (3) *sustainability*, which focuses on minimising negative impacts on the environment; and (4) *compatibility*, which addresses the requirement that a project must be aligned to stated goals and objectives. The suggested basic approach, customised to CoT, is summarised in Figure 2.



Source: Adapted from Austroads (2005b: 23)

Figure 2: Suggested CoT appraisal strategy

Measuring intra-criterion performance

In order to ensure value for money, *all* options for meeting a given objective (solving a particular problem) must be identified and considered. This means that there will be a set of mutually exclusive alternatives (defined as different options for meeting a given objective) for each independent project (i.e. projects relating to different or unrelated objectives to be accomplished). Each set of mutually exclusive alternatives will, by definition, consist of the null alternative (the existing situation or do-nothing option) and one or more further alternatives aimed at improving the existing situation.

Logic requires that project appraisal involves two processes, executed in the following order: (1) the comparison of mutually exclusive alternatives in order to select the 'best' alternative from each set of mutually exclusive alternatives; and (2) the ranking of independent projects (i.e. the 'winners' from each set of mutually exclusive alternatives). For a mutually exclusive alternative to be indicated as the best from a given set of alternatives, it has to comply with two criteria: it must be feasible, and it must be better than all other options. The comparison of mutually exclusive alternatives therefore facilitates two objectives: (1) to evaluate options (in order to determine whether they are feasible), and (2) to rank options. In the context of this paper, this means that the mutually exclusive alternatives in each set of mutually exclusive alternatives must be compared in terms of all four decision criteria listed above. Likewise, independent projects must be ranked in terms of the same set of decision criteria. This means that a measurement scale and a measurement unit are required for each decision criterion. Possible measurement units for the purposes of an appraisal framework are listed in Table 3.

Table 3: Suggested measurement units

Criterion	Comparison of mutually exclusive alternatives	Ranking of independent projects
Efficiency	Efficiency EUAC	Efficiency IRR
Equity	Equity NPV	Equity B/C
Sustainability	Index	Index
Compatibility	Index	Index

EUAC (Equivalent Uniform Annual Cost), IRR (Internal Rate of Return), NPV (Net Present Value) and B/C (benefit/cost) ratio are all discounted cash-flow techniques which, by definition, consider the time value of money. When applied in a consistent manner, they will all lead to the same answer in the case of mutually exclusive alternatives. However, with independent projects, only IRR and B/C can be used, as EUAC and NPV cannot accommodate differences in project scale (size). The choice of these techniques can be motivated as follows:

- The EUAC technique selects the best alternative from a set of mutually exclusive alternatives on the basis of lowest cost. It is therefore suitable for comparing mutually exclusive alternatives in the case of efficiency, as it addresses the intuitive requirement of minimising cost when choosing between different options for reaching a given objective.
- The IRR technique ranks independent projects in terms of their IRR relative to the null alternative. It is therefore suitable for ranking independent projects in the case of efficiency, where the objective is to maximise benefits to the community when selecting a portfolio of independent projects.
- The NPV technique selects the best alternative from a set of mutually exclusive alternatives on the basis of highest net present value. It best portrays the ideal of maximising the positive difference between equity benefits and equity costs when comparing mutually exclusive alternatives in the case of equity.

- The B/C technique ranks independent projects on the basis of the B/C ratio relative to the null alternative. It is suitable for ranking independent projects in the case of equity, as it is based on the ideal of maximising equity benefits relative to equity costs.

Given the focus of the criterion of 'efficiency' on the optimal allocation of scarce resources, both cost and benefits have to be valued in terms of their economic (or resource) cost. The criterion of 'equity', however, involves the use of market prices, as the utility of income (or expenditure) to those who benefit and those who pay is based on market prices. For the criteria of 'sustainability' and 'compatibility', rating on a five-point performance scale is considered suitable.

Opportunities afforded by the IT sector

Developments in the IT sector afford the opportunity for improving decision-making and ensuring better governance outcomes in the public sector. As noted by Snellen and Van de Donk (1998: 16, in Cloete 2003: iii), 'informatisation' has radically changed the business processes in public administration, and has transformed the bureaucratic structures and processes that dominated it for ages. In the context of this paper, a number of electronic tools are available that are indispensable for implementing the framework. One example of such a tool is DEFINITE (derived from 'Decisions on a finite set of alternatives'), developed by the Vrije Universiteit Amsterdam in the Netherlands. "DEFINITE supports the whole decision process, from problem definition to report generation. The structured approach ensures that the decision arrived at is systematic and consistent" (Janssen, Van Herwijnen & Beinat 2001: 9).

Responsibilities of stakeholders

Stakeholders involved in the approach suggested in this paper fall into three groups. *Technocrats* are responsible for identifying needs (in the form of projects). They identify mutually exclusive alternatives for each project, scoring projects in terms of the criteria of efficiency, equity and sustainability, and consequently evaluating alternatives and removing unfeasible projects from the process. In addition to agreeing on the problem structure and overall objective, the responsibilities of *politicians* include agreeing on the decision criteria; determining the relative importance of decision criteria; and scoring projects in terms of the criterion of 'compatibility'. For the purposes of this paper, these are regarded as critical responsibilities of politicians as the selected representatives of the community; this is also a key point of difference with other systems where weights are pre-selected, such as the TRAC (Transportation Review and Advisory Council) Program of the Ohio Department of Transport (EDRG 2008: 18), the scoring system of the Wisconsin Department of Transport (EDRG 2008: 19), the Missouri Department of Transport roadway system scoring weights (EDRG 2008: 20) and the scoring weights for project prioritisation of the Virginia Department of Transport (EDRG 2008: 21). Finally, the *facilitator* is responsible for standardising scores for mutually exclusive alternatives; aggregating scores for mutually exclusive alternatives (including the identification of 'winners' among each set); standardising scores for independent projects and ranking them; and conducting a sensitivity analysis to determine the robustness of results.

Conclusion

Transport infrastructure enhances accessibility and facilitates mobility. It is thus a critical sub-component of transport which, in its turn, creates time and place utility. In order to ensure that transport infrastructure is provided in an optimal manner, this paper explores aspects to be considered in developing a systematic framework for the appraisal of transport infrastructure projects of the type 'budget cycle projects with local economic impacts' and applying it to the City of Tshwane. It is argued that such a framework should combine CBA and MCA by adopting an overall MCA approach with economic efficiency – focusing on the optimal allocation of scarce resources and thus requiring a classic CBA – as one of the decision criteria. For the sake of completeness, three additional decision criteria are deemed necessary: equity (focusing on income distribution impacts); sustainability (focusing on environmental impacts); and compatibility (focusing on the alignment of projects with stated goals and objectives). Such a framework may well apply to road authorities in other spheres of government – the optimum application in each case will depend on the composition of the relevant decision-making team. The inherent nature of project appraisal requires a two-phased approach in all cases: the evaluation of mutually exclusive alternatives, followed by the ranking of independent projects. State-of-the-art decision support software is indispensable for implementing this framework. The contribution of this paper is a protocol for the appraisal of transport infrastructure in an essentially multi-criterion decision-making environment.

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