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6 Economics of everyday cycling and cycling facilities

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Introduction

Economics is the study of choice. In narrow terms, economics is concerned with choices in the production or consumption of goods and services traded in the market. In broader terms, economics matters whenever people need to make a choice amongst various options.

People make a choice in travelling amongst various transport modes. The use of bikes as a transport mode varies greatly depending on regional economic and social factors. For example, fossil-fuel-burning transport modes inclusive of motorised bikes and tricycles (also known as rickshaws or tuktuks) are widely used for relatively long-distance travelling in developing countries. Riding pushbikes may not be a desirable option for long-distance travelling in developing countries where the cycling infrastructure is not well established. In contrast, in some developed countries, cycling can be a transport mode even for long-distance travelling for recreation and physical fitness (Börjesson & Eliasson, 2012a; Pattinson & Thomson, 2014).

This chapter discusses the economics of cycling as a choice of transport, based on the neoclassical approach to the economic way of thinking. In the neoclassical economics paradigm, it is assumed that human beings are economic beings (*Homo economicus*) and are responsive to economic (dis)incentives. When some activity is found to become more costly and less beneficial to undertake, a 'rational' economic being is expected to do it less. Conversely, when doing something becomes less costly and more beneficial, the 'rational' person tends to do it more. When decisions are made with respect to transportation, the benefits and costs of each of the available transportation options are weighed up. In doing so, non-market benefits and costs are also taken into account.

The economics of cycling is not just about cycling as a choice of transport mode, but also about cycling facilities as a public choice of road use. In fact, no clear dividing line can be drawn between the benefits of cycling and the benefits of cycling facilities because the two are inextricably linked.

This chapter first develops a taxonomy of the various direct and indirect benefits associated with cycling and cycling facilities. Most of these benefits are not traded in the market and have no market values. The chapter thus introduces a range of non-market valuation methods, which can be employed to estimate the non-market benefits of cycling facilities. The section following this discussion provides a review of existing case studies, although there is very little peer-reviewed research that attempts to estimate the economic benefits of cycling facilities. Finally, the chapter outlines a few conventional techniques of integrating non-market values in the evaluation of cycling infrastructure projects.

The economic benefits of cycling and cycling facilities

Krizek (2007) has classified the benefits of cycling and cycling facilities into *direct benefits* and *indirect benefits*. Direct benefits refer to the benefits to cyclists, whereas indirect benefits refer to the benefits generated to society as itemised in Table 6.1. According to this classification, *direct benefits* include health benefits, recreational benefits and the value of time saved. *Indirect benefits* can be broken down into environmental externalities and industrial benefits. It is notable that there is no concrete boundary between direct and indirect benefits because cyclists are a part of society and can be directly motivated to choose cycling as a mode of transport to reduce traffic congestion and air pollution (see Kingham & Tranter for a discussion of environmental impacts and benefits, Chapter Seven, this volume). Any classificatory system would not be able to account for the multiplicity and interconnectedness of benefits of everyday cycling.

Table 6.1: Classification of the economic benefits of cycling and cycling facilities.

Type		Example
Direct benefits	Health benefits	Physical fitness
	Time saved	Transport cycling
	Recreational benefits	Leisure, tourism
Indirect benefits	Environmental externalities	Reduction in traffic congestion and air pollution
	Industrial benefits	Upstream flow-on benefits (e.g. employment in the bike-manufacturing industries)
		Downstream flow-on benefits (e.g. repair and rental services, eco-tourism industry)

(Source: Adapted from Krizek, 2007)

Let us turn first to the health benefits of cycling as a form of direct benefit to cyclists. A number of studies (for example, Börjesson & Eliasson, 2012b; Deenihan & Caulfield, 2014; Oja, Vuori, & Paronen, 1998; Oja et al., 2011; Sahlqvist, Song, & Ogilvie, 2012) have documented a myriad of health benefits generated by cycling in terms of reduced risk for cardiovascular diseases, stroke, cancer, and type 2 diabetes, and therefore mortality. Oja et al. (2011) and the World Health Organization [WHO] (2014) meta-analysed the existing literature on the health benefits of cycling and found it evident that there was a strong inverse relationship between all-cause mortality and cycling as a form of physical exercise. This means that more cycling leads to lower all-cause mortality when other variables remain the same. The Department of Infrastructure and Transport (2012) reported that the health cost of inactivity in Australia had been estimated at $13.8 billion per year. Börjesson and Eliasson (2012b) pointed out that an increase in the number of cyclists may not lead to an increase in health benefits because cycling is a substitute for other forms of exercise. However, their point is debatable because active travel is widely promoted as a way for people who do not currently get exercise to incorporate exercise into their daily life (White, Greenland, Hodge, & Bourke, 2014).

Cycling as an active transport mode in lieu of walking gives rise to time saving (Ellison & Greaves, 2011; Heesch, Giles-Cori, & Turrell, 2014). Cycling is time-efficient, particularly in areas of high traffic congestion, and is competitive compared with some forms of public transport such as buses and trams, which frequently stop to pick up and set down passengers. Ellison and Greaves (2011) found that cycling is the most competitive mode of journey for distances of up to 5 kilometres in terms of time spent in travelling. However, short distances are irrelevant if there are barriers to conducting a journey by cycling — for example, traffic, weather and road conditions, or obstacles such as highways, rivers or railways with no safe and convenient crossing. Further, Clement (2008) conducted a pilot study on travel time differences in Adelaide, Australia, and reported that cycling was competitive at distances longer than 5 kilometres during rush hours.

Time has an opportunity cost or scarcity value for each individual, since time is a limited resource. Thus individual time can have a commodity value if the use of time is enjoyable. Traditionally, the monetary value of travel time is thought to depend on the wage rates of individuals. Even though it is doubtful that each and every hour of a day can be counted as available for working, a number of empirical studies have assumed a relationship between time value and income levels (Freeman III, Herriges, & Kling, 2014). However, the traditional theory of the income-influenced time value has been controversial because the value of travel time is influenced by a complex array of cultural and social backgrounds (Boter, Rouwendal, & Wedel, 2005; Freeman III et al., 2014; Garrod & Wills, 1999).

The recreational benefits of cycling capture not only the monetary value of cycling activity as a recreational sport but also any cultural experience occurring during the cycling journey. 'Recreation' is a general word for what people do in their spare time for enjoyment. Interestingly and importantly, Jain and Lyons (2008) pointed out that travel time is wrongly interpreted as a disutility or a burden, which leads transport policy to be driven by the goal of time saving. These authors argued that travel time can generate enjoyable experiences and therefore should be interpreted as a gift rather than a burden.

The indirect benefits of cycling are generally measured in positive environmental externalities and increased economic activities through industrial linkages. Let us first discuss the positive environmental externalities of cycling, which refer to the environmental and ecological benefits generated by cycling —

such as reduction in traffic congestion or air pollution. In other words, the positive environmental externalities of cycling take place by reducing negative environmental externalities including traffic congestion and air pollution generated by fossil-fuel-burning cars (Pattinson & Thompson, 2014).

For example, the Department of Infrastructure and Transport (2013) reported that traffic congestion was a growing issue in Australia's largest cities and was predicted to cost Australians AU$20.4 billion per year by 2020, which does not take into account the cost of cleaning up the emissions. The external benefits of cycling in this example can occur in two different ways. First, existing cyclists implicitly generate external benefits by not shifting to motorised vehicles, given that external costs might accrue if cyclists were to transfer to motor vehicles (Hathway, 1996; Massink, Zuidgeest, Rijnsburger, Sarmiento, & van Maarseveen, 2011; Wang, Fang, & Shi, 2011). Massink et al. (2011) pointed out that one can estimate avoided CO_2 emissions by substituting bicycle trips with their most likely alternative transport modes and by calculating the additional CO_2 emissions resulting from the alternative transport modes. The Department of Infrastructure and Transport (2012) reported that motor vehicles were a major source of air pollution in Australian cities by emitting 302 grams of CO_2 equivalent per passenger per kilometre during peak travel times. This indicates that 1.5 kilograms of CO_2 equivalent emissions are avoided by an Australian urban dweller who travels 5 kilometres by cycling rather than driving a car during rush hours. Second, as Sælensminde (2004) argued, an increase in the number of commuters shifted from motorised cars to bicycles could generate additional external benefits or reduce external costs — for example, air pollution and noise (see Kingham & Tranter, Chapter Seven in this volume, for further discussion of this).

An increase in cycling in any economy can contribute to economic growth as well as pollution reduction (Irish Bicycle Business Association [IBBA], 2011). Upstream industrial benefits include business and employment opportunities in the bicycle production industries. Likewise, an increase in bicycle journeys can generate business and employment opportunities in downstream industries, including retail shops, repair shops and the cycling-related tourism sector (Buis & Wittink, 2000; Flusche, 2012; Litman, 2014). Infrastructure Australia (2009) reported that 10-20% of journeys are made by bicycles in some Western European countries compared to Australia, where less than 2% of journeys are made by bicycle. Blondiau and van Zeebroeck (2014) compiled data on employment in the cycling industries in the European Union countries, reporting that there were about 650 000 full-time-equivalent jobs across upstream and downstream cycling industries in these countries. They predicted that this figure could grow to more than 1 million if the cycling population was doubled. This indicates that there is a high potential for cycling-related industries to grow and contribute to the Australian economy.

Börjesson and Eliasson (2012b) pointed out that cycling promoters and traffic planners tend to place emphasis on indirect benefits, as if the magnitude of direct cycling benefits was not convincingly large enough to support investments in cycling facilities. These authors argued that the misplacement of emphasis results in discriminating against cyclists as if they were not travellers and the direct benefits to them were negligible. Thus it is important for transport planners to be informed of the direct economic benefits of cycling.

Very few studies have been undertaken to comprehend the total benefits of cycling (Cavoli, Christie, Mindell, & Titheridge, in press; Krizek, 2007). This dearth of literature is partly attributed to the fact that the individual benefit components of cycling are not mutually exclusive and therefore not additive to the total benefits of cycling (Wang et al., 2011). For instance, alleviated traffic congestion leads to a reduction in air pollution, which in turn leads to health benefits.

Except for industrial benefits, most types of benefits generated from cycling and cycling infrastructure are not traded in the market. These types of benefits are called non-market benefits. Although it is difficult to estimate the total non-market benefits, various non-market valuation techniques have been developed to measure the individual non-market benefits. The following section gives an overview of the most widely used non-market valuation techniques, and introduces some empirical applications to cycling and cycling facilities.

Valuation of the non-market benefits of cycling and cycling facilities

The direct and indirect benefits that are generated from cycling are not traded in the market and are difficult to estimate due to the lack of market transaction data. This section draws on the broader economic literature to examine how such a valuation might be conducted. The section gives an overview of major non-market valuation techniques and then goes on to review some applications in cycling.

Smith and Krutilla (1982) divided the estimation techniques of non-market benefits into the *physical linkage approach* and the *behavioural linkage approach*. Under the category of physical linkage approach, for example, a researcher can specify a model of the relationship between levels of an air pollutant and some type of observed damage, such as reduced agricultural crop yields or impaired human health. Linked with physical data, the benefit of the reduction in the pollutant can be estimated in dollar terms.

When there is no such physical link to be observed, an alternative is the behavioural linkage approach. The behavioural linkage approach relies on the proposition that non-market benefits can be measured in terms of how much consumers are willing to pay for the benefits. Benefits and *willingness-to-pay* [WTP] are related because, according to Smith and Krutilla (1982), people are willing to pay for something when, and only when, they believe it benefits them. Alternatively, consumers can be asked how much they are willing to accept in compensation for sacrificing the same benefits. In connection with cycling quality, WTP measures benefit estimates for quality-improving changes, whereas *willingness-to-accept* [WTA] compensation measures provide information about welfare decreases resulting from quality-decreasing moves. It is recommended to use WTP in preference to WTA, one of the reasons being that people tend to overstate WTA (Arrow et al., 1993). Table 6.2 presents the types of non-market valuation methods that can be employed for estimating the benefits of cycling or cycling facilities in monetary terms.

Table 6.2: Behavioural linkage approaches to non-market valuation.

Type of valuation approach	**Valuation method**
Revealed (observed) market behaviour	Travel cost method Hedonic price method
Stated (hypothetical) markets	Contingent valuation method Choice modelling

(Source: Adapted from de Dios Ortúzar and Rizzi, 2007; Krizek, 2007; and Mitchell & Carson, 1989, p. 75.)

Revealed preference techniques rely on actual consumer choices observed in the real market. With these techniques, the price of a product or service is used as a proxy to infer the WTP for something unpriced but closely related to the product or service (Boyle, 2003). The chief virtue of the revealed preference approach is that it measures the use value of a resource based on actual consumer expenditures. The basic idea of the *travel cost method* [TCM] is to measure the recreational use value of a resource (for example, a national park, a botanical garden or a bike trail) by examining the costs incurred by the visitor to travel to the resource (Clawson & Knetsch, 1966). A demand curve that relates visitation rate to costs per visit indicates demand for the 'whole recreation experience', which includes travel to, and experience, on the site; travel back; and recollection. In practice, there are a number of complexities arising in the application of the TCM:

- The valuation technique cannot be applied to some recreational sites that people do not visit for recreation purposes.
- When people visit multiple sites during a single recreation trip, it is hard to allocate a proportion of their travel cost to a specific site.
- Because recreation demand typically is highly seasonal, and has peak visitation during school and public holidays, it is normally necessary to carry out surveys for peak and off-peak demand periods.
- Where there is a group visit, with members of varying ages, issues arise such as which members to include as recreationists and how to allocate costs between party members.

Another example of a revealed preference technique is the *hedonic price method* [HPM], which utilises variations in property prices so as to estimate the value of the non-market characteristics of property vicinity that may influence the property prices. The data required for HTM applications is collected from the area where specific characteristics are believed to influence property prices. A best-fit multiple regression model is then estimated, property prices being the dependent variable. The independent variables of the model might contain the characteristics of the properties themselves (for example, building type, building space, plot size and number of rooms), neighbourhood characteristics (for example, bike paths, crime rates and proximity to schools or shopping malls), and environmental characteristics of interest (for example, air pollution). In hedonic regression models, bike paths may be controlled as a dummy variable. A differential in property prices is then derived to measure the marginal value of an independent variable of interest when all other variables remained unchanged (Garrod & Wills, 1999). One of the practical problems associated with this valuation technique is that it may not be possible to obtain an adequate sample of property transaction records.

When revealed market data is unavailable or incomplete, economists have used the *stated preference* approach, which relies on hypothetical market situations. One of the main advantages of stated preference techniques is that they can capture values that are not expressed through use or experience and are therefore not revealed in actual markets. The *contingent valuation method* [CVM] has been used to estimate the incremental economic value with respect to a change in the level of environmental service flows of an unpriced natural resource by directly asking people how much they would be willing to pay for a hypothetical change. Mitchell and Carson (1989) provided the full history of the early development of the CVM, which came into use in the early 1960s for the first time. There are two types of methods to elicit WTP amounts from CVM respondents: *continuous* (open-ended) and *discrete* (closed-ended). With the open-ended elicitation method, respondents are asked to state their maximum WTP for the good being valued. The discrete bidding method refers to dichotomous choice questions, where respondents determine whether their WTP is larger or smaller than a set dollar amount.

Choice modelling estimates the amount that people are willing to pay to achieve a greater amount of one or more environmental attribute, given that the dollar cost is treated as one of the characteristics for non-market goods. In fact, the price factor does not represent an inherent attribute of a commodity under consideration. Rather, the price presents dollar costs that are traded off for proposed changes in attribute levels.

The TCM, the HPM and the CVM have been employed to measure the non-market benefits of bicycle facilities (Krizek, 2007; van Leeuwen, Nijkamp, & de Noronha Vaz, 2010). Fix and Loomis (1997) used the TCM to estimate the economic benefits to users of mountain bike trails near Moab, a small town located in south-eastern Utah in the United States. Moab mountain biking trails, including the Slickrock trail, are visited by more than 100 000 mountain bikers per year. According to Fix and Loomis (1997), the estimated consumer surplus per trip per person to Moab biking trails was US$205. This means that the Moab biking trails generate a recreational benefit of US$205 for an individual mountain biker after cancelling out the actual travel costs (transport costs plus on-site costs) per trip to the mountain biking site. Fix and Loomis (1998) then employed the CVM to estimate how much more mountain bikers would be willing to pay for a trip to the Moab biking trails. The mountain bikers were asked whether they would still have come to the Moab area if the travel costs were *x* dollars higher to visit the area. The hypothetical extra travel cost ranged from $5 to $500, of which one was randomly given to a CVM respondent. The study estimated that the mean WTP per trip per person was $235.

There have been several empirical studies (Jim & Chen, 2010; Krizek, 2006; Lindsey, Man, Payton, & Dickson, 2004; Parent & vom Hofe, 2013; Racca & Dhanju, 2006) which employed the HPM to measure the benefits of cycling trails reflected in the housing markets, and these studies have arrived at conflicting findings. Racca and Dhanju (2006) used the HPM with Geographical Information Systems [GIS] techniques to estimate the impact of proximity to a bike path on the property prices in Delaware, United States. Their study found that the existence of a bike path within the proximity of 50 metres has a significant impact on property prices, other variables (inclusive of the number of bedrooms, and the area size, type and age of buildings) being controlled. Krizek (2006), meanwhile, collected home sales and GIS data for St Paul, Minnesota, in the United States, and measured the effect of bicycle trail proximity on sale prices. The study arrived at a finding that proximity to roadside bike trails actually significantly reduced home value in suburban locations. Krizek (2006) reasoned that bicycle facilities are not always considered an amenity, possibly because suburban residents dislike greater access to their property and neighbourhood by other cyclists. Finally, Parent and vom Hofe (2013) examined the impacts of the Little Miami Scenic Trail on residential property values, using a large sample of housing data in combination with a data set of street network distances. The Little Miami Scenic Trail is located in Hamilton County, the core county of the City of Cincinnati, in the United States. The trail is a public multipurpose trail shared by hikers, runners, skaters, bikers and equestrians. The study found that proximity to trail entrances had a positive effect on property values.

The revealed preference methods (that is, the TCM and the HPM) and the CVM have been employed mostly to estimate the recreational benefits of cycling facilities. There does not appear to be any peer-reviewed research that focuses on the benefits of cycling activity using these non-market valuation techniques. Instead, choice modelling has been widely employed in transport economics in situations where people make a choice in travelling amongst various transport modes (van Dyck, Deforche, Cardon, & de Bourdeaudhuij, 2009; Rabl & Nazelle, 2011). In choice modelling, it is assumed that travellers choose the best option by weighing up the benefits and costs of each and every transportation option available to them.

Choice modelling is grounded on rational choice theory. Like the contingent valuation method [CVM], choice modelling is a stated preference method. Choice modelling begins with establishing a hypothetical market situation in which respondents are expected to state their preferences. Respondents are faced with several choices at a time. It is assumed that rational respondents will weigh up those choices. When the choices are weighed up, it is assumed that rational respondents are aware of their budget constraints as well as the costs and benefits they will experience from each of the choices. Choice modelling relies on the indirect random utility model and on multi-attribute utility theory. Limited dependent variable econometric techniques are preferred to estimate the determinants of the systematic component of the indirect utility function. A regressor's influence on a limited dependent variable can be evaluated using multinomial logit models.

Two types of multinomial logit models are often employed in transportation studies. These models are *conditional logit* models and *polytomous logit* models. Conditional logit models can be employed to forecast the change in transport share as a result of changes in utility caused by alterations in a set of travel attributes such as travel time, transport cost and carbon emissions.[1] Some useful case studies include de Dios Ortúzar and Rizzi (2007), Massink et al. (2011), and Yi, Feeney, Adams, Garcia, and Chandra (2011). A key advantage of using conditional logit models is that one can predict a change in transport mode shares in correspondence to a hypothetical change in any travel attributes. Yi et al. (2011) conducted a choice experiment in Sydney and found that the choice of cycling as a transport mode can be increased three times with dedicated off-road bike paths, and two times with on-road bike lanes.

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1 For a more detailed explanation and exploration of conditional logit models, see Adamowicz, Louviere, and Williams (1994), and Zhang and Hoffman (1993).

Using polytomous models, one can treat the choices of transport modes as the dependent variable, and the socio-economic and attitudinal characteristics of the respondents as the independent variables, which may include age, income, gender, and environmental attitudes and behavior. Massink et al. (2011) estimated a polytomous logit model for transport mode choices and found that travellers from the lowest socio-economic stratum are most likely to walk to their school or university, whereas travellers from the highest socio-economic stratum are likely to drive their car for shopping. Massink et al. (2011) also found that cars would be the most likely transport mode alternative to cycling in developed cities, whereas walking or public transport would be the most likely alternative mode in developing cities. This finding indicates that the potential ecological value of cycling will be higher in developed cities than in developing cities. To the knowledge of the author of this chapter, no choice modelling study has been published to date that looks into how the choice of a transport mode is related to its environmental attributes or the environmental attitudes of travellers.

As briefly overviewed, several techniques have been developed to estimate non-market values. Although choice of valuation technique becomes complex in reality, simple statements can be made as a rough guide. When the task is to value the recreation benefits of cycling trails, the TCM is likely to be appropriate. Nevertheless, it is doubtful whether the TCM is appropriate for capturing the value of a specific characteristic of the cycling trails. The CVM can be considered when social welfare changes in relation to a hypothetical change in cycling facilities need to be estimated.

While the importance of non-market values is increasingly being recognised, the accuracy of valuation methods reviewed in this chapter remains a lingering problem. Reliability of value estimates might be the top criterion, from the viewpoint of policy makers, to judge whether to include them in project appraisal. Thus valuation researchers must continue to strive to refine existing valuation methods, or to develop new ones, as a way of enhancing the reliability. However, the ability to estimate non-market values precisely should be treated as a separate issue to the importance of integrating them in project appraisal (Harrison, 1999).

Decision-support systems for transport planning

If there is an increased demand for cycling facilities, policy makers need to evaluate a new investment into cycle facilities. Cycling projects tend to involve various evaluation criteria. Further, decision makers often face the situation where making trade-offs between the multiple decision criteria is unavoidable and a choice needs to be made between competing policy options. Social benefit-cost analysis and multicriteria analysis are widely used tools to aid decision making under these circumstances.

Social benefit-cost analysis

Benefit-cost analysis [BCA] is a discounted cash flow analysis for evaluating the desirability to the community of public sector investments (Callan & Thomas, 2010; Hüging, Glensor, & Lah, 2014). The basic idea of BCA is to determine whether investment projects are worthwhile from a social or taxpayer viewpoint, taking into account all the financial costs and revenues, and positive and negative externalities resulting from the project. Because environmental and social externalities are translated into monetary terms and incorporated into the analysis, BCA is sometimes referred to as *social* or *extended* BCA. BCA is different from 'financial analysis' in that the latter deals with only costs and revenues for the purpose of private investment project appraisal.

The BCA approach is to calculate the difference between project benefits and project costs. To give a green light to a public project, the present value of the project benefits minus the project costs must be positive. The underlying philosophy of BCA is the Kaldor-Hicks compensation principle. According to the Pareto optimum principle, a change in resource allocation in an economy is acceptable only if the change makes at least one person better off without making anyone worse off. In practice, it would be difficult to imagine any change in resource allocation that does not harm anyone. Relaxing the Pareto optimum principle, the Kaldor-Hicks compensation principle states that a 'potential Pareto improvement' can be said to have occurred if the gainers could compensate the losers and still gain a net benefit from a change (Hanley & Spash, 1993). This principle relies on the ethical ground of no interpersonal comparison, and justifies the welfare position that the gains outweigh the losses, even when the compensation is only hypothetical (Campbell & Brown, 2003).

Suppose there is a development project of a new section of bicycle path and a BCA needs to be untertaken. For the project benefits, the BCA of the cycling project can take into account the benefit identified in Table 6.1. The items of the project costs may include land acquisition costs as well as demolition and construction costs and maintenance costs (de Hartog, Boogaard, Nijland, & Hoek, 2010; Hathway, 1996; Sælensminde, 2004). These costs are itemised with the assumption that an off-road cycling path is built especially for cyclists. In the case of conducting a BCA of on-road cycling infrastructure, additional items of costs such as traffic accidents may need to be considered. Table 6.3 attempts to classify the potential project costs of developing cycling facilities. As a side note, the underlying assumption in this case is that roads do not have to be built for all road users. If a road must be built to safely accommodate all road users, one can argue that it would be unthinkable to do a BCA for the cycling component of the road. Thus a BCA of on-road cycling infrastructure is inherently biased, as it regards cycling as an 'option' rather than an integral part of the transport system (Mullen, Tight, Whiteing, & Jopson, 2014).

A major problem in undertaking benefit-cost analyses of developing cycling facilities lies in estimating the non-market benefits and costs of the development project (Wang et al., 2011). Although non-market valuation techniques can be employed to estimate these non-market values, it is not always possible to produce reliable estimates as discussed in the previous section. Multicriteria analysis [MCA] is an alternative to overcome this fundamental problem associated with BCA.

Multicriteria analysis

MCA is a structured framework for the evaluation of several distinct policy options across multiple objectives. In this technique, performance scores are assigned to

Table 6.3: Economic costs of cycling and cycling facilities.

Type		**Example**
Direct costs	Financial costs to cyclists	Purchase and maintenance of bikes Traffic accidents
Indirect costs	Requirement of human-made capital	Acquisition costs Demolition costs Construction costs including parking facilities
	Industrial costs	Negative impacts on businesses

(Source: Authors' own work.)

each of the policy options on each of various criteria that reflect the multiple objectives (for example, financial, environmental and social objectives) under consideration (Hüging et al., 2014). The performance matrix is called an *effects table* (Janssen, van Herwijnen, & Beinat, 2003; Janssen & van Herwijnen, 2006). The best-performed option is determined by computing the sum of the scores for each of the policy options.

In comparison to BCA, MCA does not have to involve the conversion of all costs and benefits associated with a policy option into monetary terms (Hüging et al., 2014). MCA thus has the advantage of avoiding the risk of spurious quantification of non-market values — that is, the difficulties of converting to dollar value can be avoided by leaving the results of qualitative assessments of environmental values in a qualitative form (Gurocak & Whittlesey, 1998; Hajkowicz, McDonald, & Smith, 2000). Another important aspect of MCA is that this decision-support technique enables diverse groups of stakeholders to play a key role (Hüging et al., 2014). They articulate their views of policy options and participate in identifying evaluation criteria and assigning performance scores to the options being evaluated (Bennett, 2000).

MCA is an integrated computing framework. *DEFINITE* — which stands for *De*cisions on a *finite* set of alternatives (Janssen et al., 2003; Janssen & van Herwijnen, 2006) — is a widely used MCA software package, the user interface of which is relatively complicated to use. One of the strengths of *DEFINITE* is that it has been designed to run on the Microsoft Windows operating system and allow Microsoft Office programs to be used for exporting *DEFINITE* analysis reports. The software is commercially licensed and therefore must be purchased from the developer.

MCA is applicable to assessing urban mobility projects (Hüging et al., 2014). There are several steps to be followed in the MCA process. The steps described below are adapted from the MCA procedures established in *DEFINITE* (Janssen et al., 2003; Janssen and van Herwijnen, 2006) as well as numerous other similar guidelines (for example, see Department for Communities and Local Government [DCLG], 2009; Hajkowicz et al., 2000; Keeney & Raifa, 1993; Munda, Nijkamp, & Rietvelt, 1994). It should be noted that the order of these steps is not written in stone. Each of the steps can be further divided. The actual working procedure may become more complex, involving interaction between analysts, decision makers and stakeholders.

1. *Identification of alternatives*. Stakeholders, whom MCA modellers need to identify beforehand, define the alternatives to be considered. The MCA modellers should give careful thought to finalising the set of alternatives. The alternatives should represent the current and hypothetical situations of the given issue and should be clearly defined and differentiated. Suppose a local government is considering multiple road-use scenarios in urban areas and needs to choose the best option by evaluating the multiple road-use options. In this scenario, we might suppose there are three alternatives identified — namely, roads without bike lanes, roads with bike lanes, and off-road bike paths.
2. *Identification of objectives and criteria for evaluation*. The stakeholders next identify decision-making criteria. These include the items of benefits and costs listed in Tables 6.1 and Table 6.3, respectively.
3. *Assignment of scores to the identified alternatives on each of the criteria*. The basis of the effects table has been constructed using the identification of policy alternatives and decision criteria. Scores are now assigned to each of the alternatives in relation to each criterion. At this stage, the analysts should consider the relevance of the criteria and the ability of the criteria to help decision makers discern differences in the alternatives. If a criterion gives the same score for each alternative and thus provides no additional information to the analysis, the analysts should consider removing the criterion. Table 6.4 illustrates what an effects table looks like. In this example, the three alternatives are evaluated against eight criteria.
4. *Standardisation of measurement scales into units that are commensurable*. In the effects table, some criteria are expressed in a ratio, whereas others are expressed in an interval scale. For instance, the criterion 'traffic accidents' is measured in a – – –/+ + + scale, while the criterion 'time saving' is measured in hours. In MCA, the problem of inconsistent measurement scales is handled through the standardisation of each of the criterion scales. After scoring, criterion scales need to be converted into commensurable units.
5. *Assignment of weights to the criteria to reflect their relative importance*. The next step in the MCA process is to allocate relative weights to

Table 6.4: An effects table for demonstration with three road-use options.

Criteria	Unit	Without bike lanes	With bike lanes	Off-road bike paths
Health	−−−/+++	−−	+	+++
Time saving	hour	0	1	2
Recreational benefits	$/person	0	3	4
Reduction in traffic congestion	hour	1	3	9
Reduction in air pollution	$ ('000)	5	25	40
Traffic accidents	−−−/+++	−−−	++	+++
Construction costs	$ (M)	1	2	5
Employment	person	100	150	250

(Source: Authors' own work.)

the decision criteria. The process of assigning different weights to the criteria is required in order to make it clear that some of the criteria are more important than others, and therefore should receive greater weights in the analysis. Thus, the weights of the criteria in MCA are usually derived from the stakeholders. Along with scoring the alternatives, giving relative importance to the criteria is one of the major judgmental components in the MCA process. Several methods have been devised for deriving weights information. They include rating and pairwise comparison, fixed point scoring and ordinal ranking.

6. *Aggregating and ranking the alternatives*. Once the effects table has been developed, the phase of ranking alternatives commences. The scores are combined to create an overall score for each option. The aggregated scores are generated by various mathematical methods described below. The type of method that is selected for ranking will depend on whether quantitative data is available in the effects table and which method of weighting was used.

One of the advantages of taking the MCA approach in project appraisal is that the modellers are able to incorporate a relatively large number of criteria from diverse disciplines in order to evaluate various choice possibilities, and are not restricted to using only numerical values. This does not mean, however, that estimates of non-market values are not useful.

The common disadvantage of MCA is that this assessment method relies on inputs from the subjectivity of stakeholders because it requires the stakeholders to identify preference weights for the decision criteria. Subjectivity itself is not necessarily undesirable but may cause an inconsistent framework in making the unavoidable hard choices, diminishing the effectiveness of MCA. In this context, Robinson (2000) emphasised that MCA is a decision-aid process suitable in limited circumstances, and should be used to complement rather than substitute other multi-objective decision-support methods such as BCA, especially to estimate the economic efficiency of a project. The use of qualitative measures in MCA could introduce a high degree of subjectivity and reduce the reliability of the outcomes. Therefore, estimating a monetary value for environmental impacts could remove some degree of the subjectivity surrounding the evaluation and improve the validity of the findings (Robinson, 2001).

Concluding comments

Both cycling and cycling facilities provide a range of socio-economic and environmental benefits beyond cycling activity, including recreation opportunities, reduction in traffic congestion and air pollution. These greatly add to the value of cycling as a time-saving transport mode. When attempting to maximise the sum of the direct and indirect benefits of cycling, one of the key questions is how the benefits can be quantified given there is no common measuring unit. Health benefits, recreational benefits, time saving, reduction in traffic congestion and reduction in air pollution are all measured in different measurement scales.

Most people travel on a daily basis. It is inevitable that they will face a situation where they have to choose a mode of transport for travelling. To make a decision, they take into account not only the financial benefits and costs of each of the modes, but also a range of non-market benefits and costs such as time saving and pollution reduction. Various non-market economic valuation techniques have been devised to translate non-market services into dollar values. While it is debatable whether these values could or should be estimated, such estimates are highly useful, particularly for decision making at a social level.

Transport planners can incorporate the estimates of the non-market values of cycling and cycling facilities into cycling-related project appraisals. Cycling facilities generate multiple classes of benefits and any investment decisions tend to affect a wide range of stakeholder groups. The BCA approach is based on the Kaldor-Hicks compensation principle, in which it does not matter which parties are made better off, or worse off, by a decision. In contrast, MCA takes a participatory decision-support approach, where stakeholders participate in the analysis process and strive to reach a consensus on decision criteria and the prioritisation of the criteria.

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