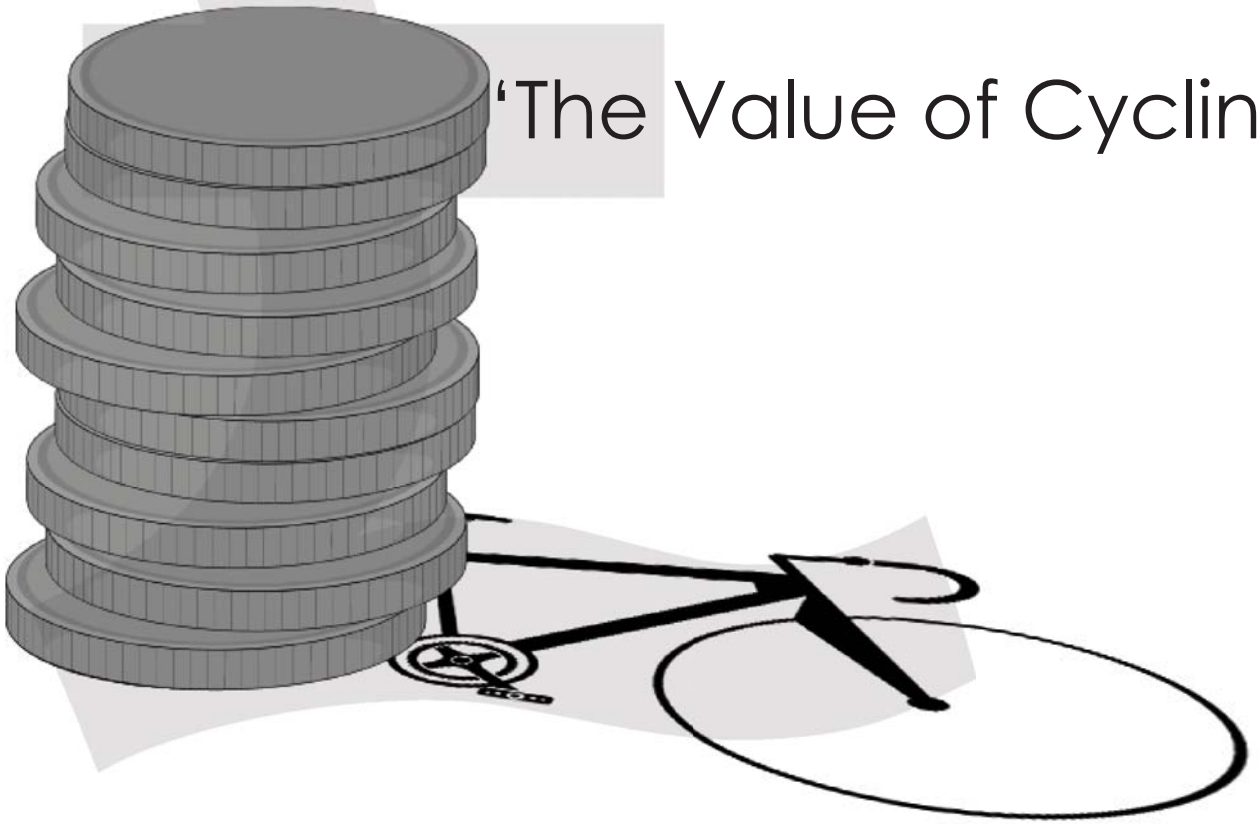
Fiona Rajé and Andrew Saffrey

'The Value of Cycling'



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Contents

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	Headline Findings
Strategic economic benef ts	• High-density, cycle-friendly urban form is conducive to achieve agglomeration benef ts • Annualised infrastructure costs in compact, less car-dependent metropolises are 33% less than in low-density, car-oriented 'sprawl' • Catering for cycling is steadily rising on the agenda of business leaders and city mayors
Local economic benef ts	• Cyclists visit local shops more regularly, spending more than users of most other modes of transport • Per square metre, cycle parking delivers 5 times higher retail spend than the same area of car parking • A compact town optimised for walking and cycling can have a "retail density" (spend per square metre) 2.5 times higher than a typical urban centre. • Public realm improvements, including those that cater for cycling, have been shown to result in increased trade at local businesses; up to 49% in New York City
Personal benef ts	• Neighbourhoods with cycle-friendly characteristics – low traff c volumes, walkable, close to off-road cycle paths – are more desirable or have higher property values • Residential property values rise 1% if motor vehicle traff c is reduced by 50% • Children who walk or cycle to school tend to be more attentive and achieve better results • Cycle friendly environments promote more physical activity in later years
Employment benef ts	• Facilitation of cycling to work leads to lower staff turnover • Cycling facilities can overcome diff culties in accessing employment opportunities • Cycling reduces absenteeism, boosting productivity: regular cyclists take one less sick day per year
Public expenditure benef ts	• Cycling schemes can achieve more for less, with benef t-to-cost ratios in the in the range of 5:1 to 19:1 – some as high as 35.5:1 • A typical "cycling city" could be worth £377 million to the NHS in healthcare cost savings, in 2011 prices • Facilities allowing children to cycle to school save on the public cost of school travel: amounting £390 million per annum in the Netherlands in 1987 prices. • Investment is effective in increasing usage
Tourism benef ts	• Cycle tourists on average spend more: around 9% per head per trip, or around £81 per head per trip. • Cycle tourism is inf uenced by utility mode share: i.e. where cycling is attractive and thus more people cycle, there is a greater propensity for cycle-tourism
Transport and logistics benef ts	• Cycle freight offers a competitive advantage in city locations and is cheaper than motorised freight for small payloads over short distances. Cost savings range between 39% and 64% compared to a van-based service. • Cycle freight is not affected by shortages of qualif ed drivers • An absence of dedicated cycling infrastructure will slow down buses and HGVs as mode share increases • Cycling has a lower capital cost than other forms of infrastructure • Cycling can increase the reach of public transport
Cycle industry benef ts	• Per capita spending on cycling equipment and maintenance is higher as mode share increases • Domestic production of bicycles, parts and accessories has doubled from 2007 to 2013.

Executive Summary 

This report was commissioned to provide a review of the literature on the value of cycling. It focuses on evidence of the wider economic benefits of cycling as a mode of transport, such as retail revenue, employment effects, and public spending efficiencies.

The aim of the research is to collate the evidence base which outlines the benefits and disbenefits of investment in cycling as a mode of transport. Existing appraisal methods already take into account health benefits (reduced mortality), decongestion benefits (including generalized reduction in traffic collisions), and personal journey amenity benefits.

Searches of the academic and grey literature were undertaken. These searches centred on the impacts of cycling at the individual, neighbourhood, town/city, regional and national levels, with a view to developing an understanding of the benefits of cycling and the value associated with the mode.

The findings of the review suggest that there is evidence of the value of cycling as a mode of transport. However, it is less clear what the exact nature of that value would look like: the valuation and monetization of the complete range of potential benefits of cycling do not appear to have been widely considered. This is not unexpected. It is relatively easy to assign financial and economic values to investment in infrastructure but the monetization of social and individual impacts is much more challenging.

The findings show that cycling has largely positive impacts for people and the places where they live. It can improve their well-being, lessen their spend on travel, and enhance the liveability of their environment.

In terms of public spending, cycling and related infrastructure have been found to be substantially lower cost than other transport modes. At the same time, there are benefits to businesses of cycling, both as a utility and leisure mode, as well as the benefit of running a business in an area which is conducive to cycling. These effects appear to have received more detailed economic valuation than individual impacts.

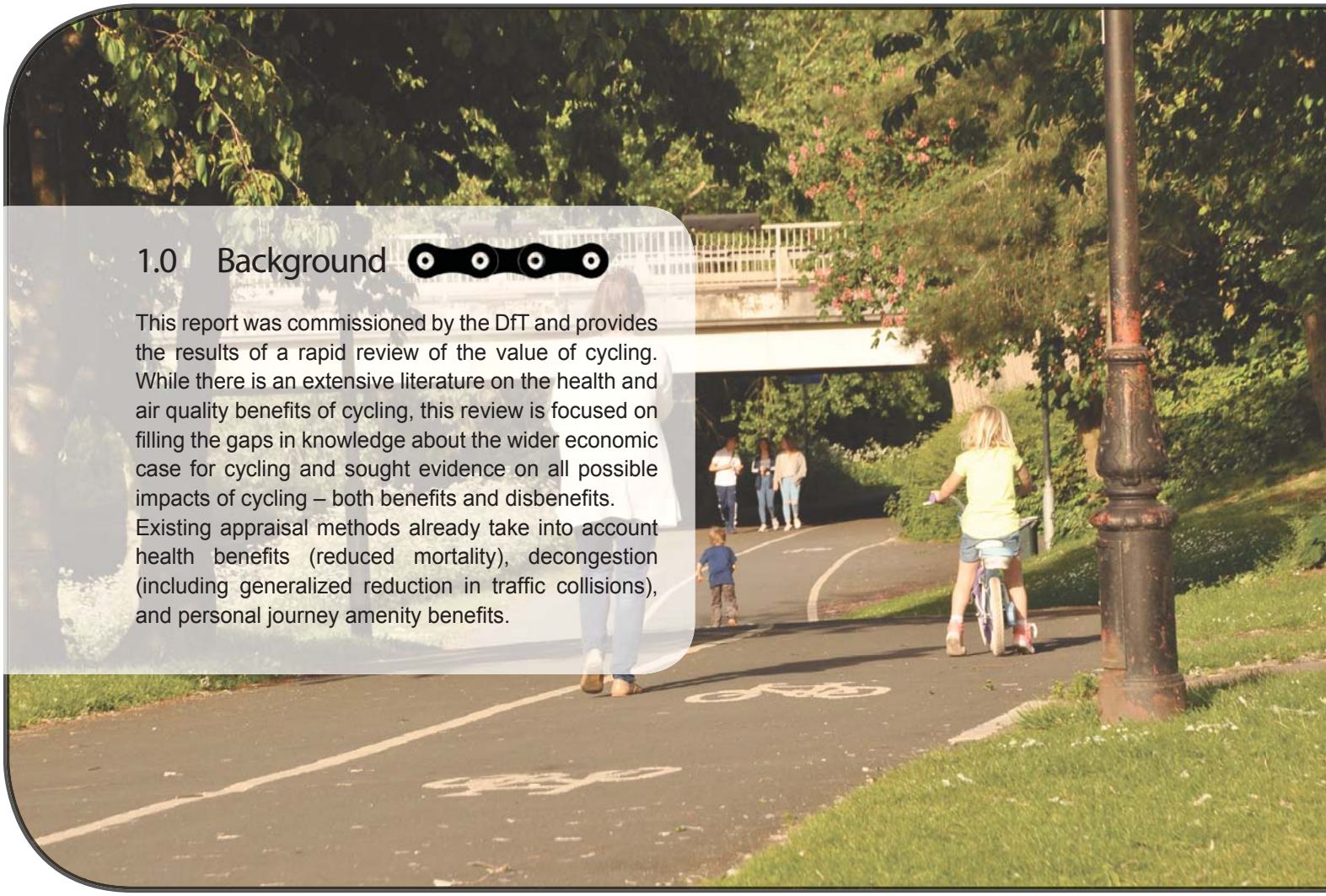
Cycling has been shown to benefit both the employer and the employee. While it would appear that the benefits in terms of sick leave are relatively low, the role of cycling facilities for attracting staff seems to hold great potential. Moreover, for the prospective employee, ease of physical access to work opportunities is central to the ability to gain employment and cycling provides a tool by which joblessness due to transport exclusion may be overcome for some social groups.

The literature suggests that cycling can assist in meeting strategic goals in diverse areas such as helping to introduce parity of access to employment opportunities, contribute to retail and other business vitality, and create vibrant spaces.

There is a concern in the literature that the currently widely-used appraisal methods do not incorporate the full extent of benefits associated with cycling and this means that, as the mode competes for funding, it may always be seen as less viable than other options. Furthermore, there is little recognition of the disbenefits of non-cycling modes of transport in current appraisal methods.

In conclusion, there is substantial discourse about the benefits of cycling. These benefits are found across a range of thematic spheres (e.g. improving accessibility, increasing employment access, contributing to vibrant communities and individual well-being) and geographic scales (neighbourhood, local, regional, national). However, despite assertions of various positive impacts, the literature is less forth-coming about the ways in which these may be realistically captured. The nuanced impacts that go beyond mainstream economic measures are difficult to harness into substantiated and replicable metrics.

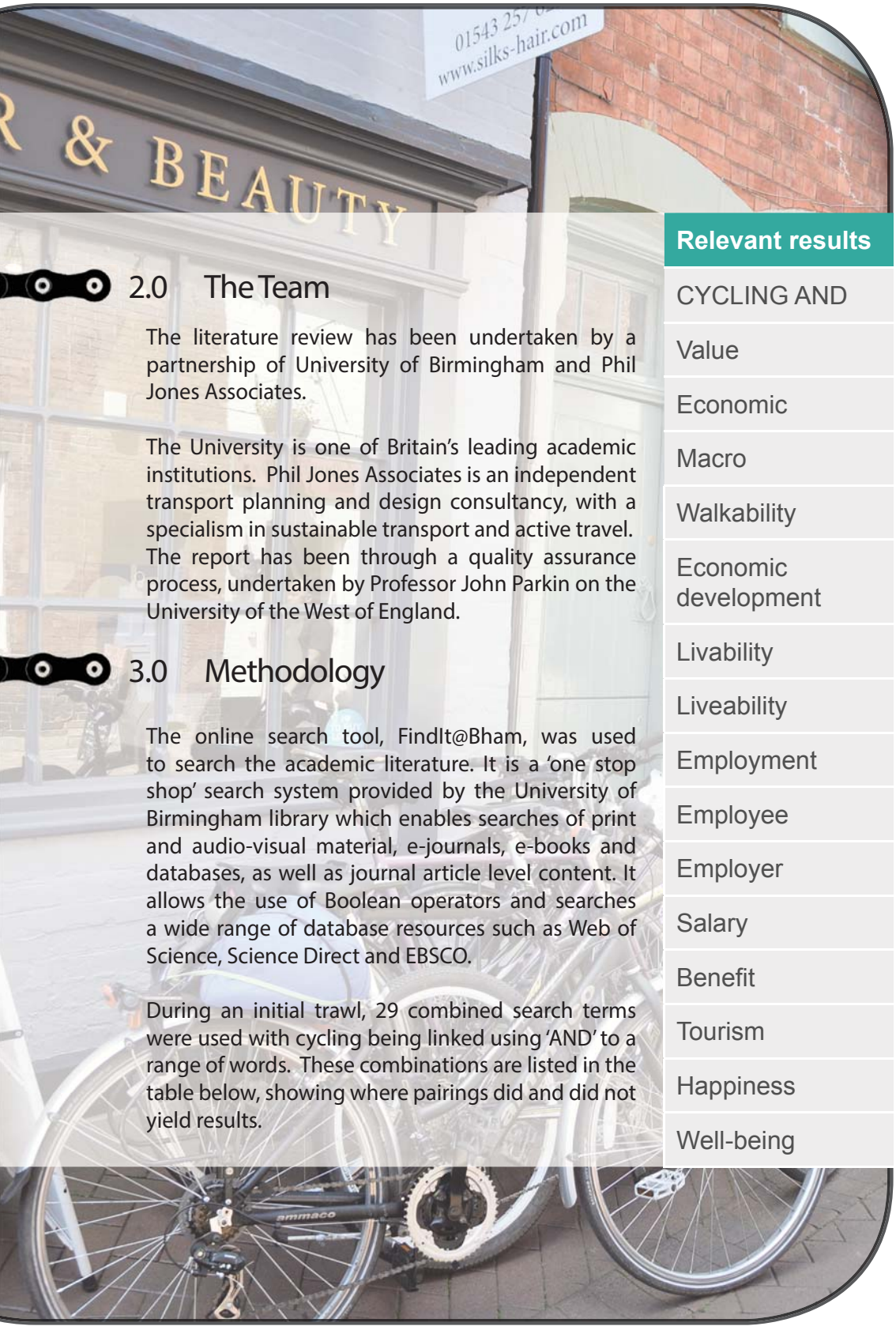
For cycling's potential to be realised and infrastructure schemes to be financed, there is a need to give priority to developing appraisal methods that incorporate the full range of relevant cost and benefits that relate to cycling, and indeed consistently across all modes of transport. Social accounting and audit may be one approach that offers a framework for exploring the broader scope of assessment as it concerns itself with more than economic impacts and is not solely expressed in financial terms. It accepts the use of qualitative input, incorporates multiple perspectives, and includes social, economic and environmental impacts.



1.0 Background

This report was commissioned by the DfT and provides the results of a rapid review of the value of cycling. While there is an extensive literature on the health and air quality benefits of cycling, this review is focused on filling the gaps in knowledge about the wider economic case for cycling and sought evidence on all possible impacts of cycling – both benefits and disbenefits.

Existing appraisal methods already take into account health benefits (reduced mortality), decongestion (including generalized reduction in traffic collisions), and personal journey amenity benefits.



2.0 The Team

The literature review has been undertaken by a partnership of University of Birmingham and Phil Jones Associates.

The University is one of Britain's leading academic institutions. Phil Jones Associates is an independent transport planning and design consultancy, with a specialism in sustainable transport and active travel. The report has been through a quality assurance process, undertaken by Professor John Parkin on the University of the West of England.

3.0 Methodology

The online search tool, FindIt@Bham, was used to search the academic literature. It is a 'one stop shop' search system provided by the University of Birmingham library which enables searches of print and audio-visual material, e-journals, e-books and databases, as well as journal article level content. It allows the use of Boolean operators and searches a wide range of database resources such as Web of Science, Science Direct and EBSCO.

During an initial trawl, 29 combined search terms were used with cycling being linked using 'AND' to a range of words. These combinations are listed in the table below, showing where pairings did and did not yield results.

Relevant results	No relevant results
CYCLING AND	CYCLING AND
Value	Micro
Economic	Business location
Macro	Commerce
Walkability	Land use
Economic development	Efficiency
Livability	Cost of living
Liveability	Staff
Employment	Property
Employee	Productivity
Employer	Absenteeism
Salary	Access
Benefit	Industr*
Tourism	Production
Happiness	Assessment
Well-being	

When no relevant references were obtained for a search, walking was substituted for the word cycling and the combined search re-run. This resulted in boosting the number of documents found to be of relevance to the review. Searches were also conducted using French, Spanish, Italian, German, Dutch and Danish terms for cycling and bicycle (and variations thereof). During reviewing, any references within documents to additional resources which appeared relevant to the focus were followed up. In total, 88 papers, webpages, blog entries and other sources were reviewed. While the main objective of this component of the review was to include material from academic sources (i.e. peer reviewed content) to ensure quality, there are cases where other sources have been included, if they were considered to clarify or add to the literature already found.

No specific search was undertaken to examine the disbenefit of cycling investment; however the search process outlined above looked at the links between cycling and various economic themes. Such a search would have found any sources discussing disbenefit, but none was found. Where papers were equivocal or presented mixed findings, this is reflected in our discussion of the evidence.

In addition, a search of the grey literature was conducted to capture additional insights to expand understanding of the benefits and value of cycling. The grey literature search was undertaken by examining existing policy documents from organisations and bodies with an interest in transport cycling or who have invested in cycling infrastructure. The grey literature search was also supplemented by a 'call for information' issued to the Cycling and Society academic discussion group. The call was also issued directly to a number of organisations drawn up by the study team in consultation with the client. Furthermore, throughout the course of the evidence review the study team monitored news sources likely to carry articles about sustainable transport interventions. Finally, Google and EBSCO were used to obtain any research material referred to in secondary or tertiary sources found through the grey literature search. A total of 83 sources were found in the grey literature review.

The results of the combined review process have been categorized by theme in the following sections where further discussion of the findings also takes place.

Where sources report financial costs and benefits, these are converted into sterling at the exchange rate on 1st April of that year as an arbitrary barometer. The exceptions to this are undated reports, where 1st April 2015 is used; or where the date of the paper predates the earliest exchange rate available on the OANDA.com website, where 1st January 1990 is used.

4.0 Findings

4.1 Introduction

The impacts of active travel have been studied for a number of years, resulting in an extensive literature on health and environmental benefits of walking and cycling. However, the wider economic impacts of these two modes have received less academic attention. This review set out to scope the coverage of the economic value and benefits of cycling available in the literature.

In general, it would appear that evidence on valuation and monetization of economic benefit has not been considered in great depth. At the same time, there is a strong narrative about the value of cycling, largely based upon statements that the mode is beneficial in economic terms (see, for example, Rahul and Verma, 2013; Weston and Mota, 2012; Lumsdon et al, 2009) but figures to substantiate such assertions are less readily accessible. Similarly, academic literature relating to evaluation and benchmarking investments in sustainable modes is also sparse (Henao et al, 2015).

To demonstrate the difficulties inherent within the literature, recent research[i] (Rajé, 2014:3 4) found that SQW (2007:4) highlighted that cycling has a beneficial impact that 'cuts across policy areas'. Some of the wider benefits suggested were related to health, such as protection from obesity and quality of life (e.g. mental health improvements). SQW's report also pointed to social gains and tourism opportunities associated with cycling – both of which could, arguably, be rendered in monetized values. Meanwhile, connectivity has also been highlighted as important to positive cycling experiences, as is the 'unique sensory experience' of being on a bike (Clayton and Musselwhite, 2013) – these are, perhaps, not so easily translated into economic benefits although WebTag does monetise the 'journey ambiance' benefit of cycling.

i Conducted by Tight and Rajé on the value of provision of walking and cycling infrastructure in UK urban areas as part of the EPSRC and ESRC funded iBUILD programme (https://research.ncl.ac.uk/ibuild/)

However, SQW (2007:6) cautioned that:

[not] all investment in cycling will produce huge returns. Each case needs to be assessed on its own merits, but relatively high values where projects are able to generate new cyclists, suggests (sic) that there is a major opportunity to make investments that will, over time, more than repay their costs.

While SQW's research indicates that there may be some unpredictability about the net benefits of some cycling schemes, Powell et al's (2010) reminder of Saelensminde's (2004) finding that walking and cycling investments are more beneficial for society than other transport investments seems less tentative. Nevertheless, SQW (2007:82) go on to conclude that

…cycling investment that targets new cyclists in particular would generate substantial economic benef t. Where this can be shown to reduce car travel, the combination of health benef ts and reduced congestion and pollution would in most cases justify investment. There are likely to be considerable economies of scale in investing to release the potential of existing infrastructure through training, promotion and travel planning, but there is also a great deal of scope for new and improved cycling infrastructure.

Given the apparent tenuous link between the prevalent qualitative descriptions of cycling's benefits and the less forthcoming quantification of such value, there appears to be a need to back up intuition with hard data.

The following four sections give an overview of the landscape of evidence available across the academic and grey literatures. The findings are divided into individual, fiscal, employment and strategic governance effects. At times, there is overlap between the categories. However, the overall findings weave together the tapestry of current understanding of the value of cycling.

4.2 Individual effects

There is a general recognition across the literature of the personal benefits of cycling. People on bikes (as well as pedestrians) are reported to be amongst the most satisfied consumers of transport (St-Louis et al, 2014) and active commuters have been found to be physically and mentally better off regardless of whether or not active commuting is their only form of exercise (Humphreys, 2013). Rauner et al (2013) indicate that physical activity leads students to achieve higher grades and Living Streets (2008) report that children who walk to school are more alert and ready to learn than children who are driven by car. As a corollary, given walking and cycling are similar activities, it is likely similar findings would also apply to cycling.

Some authors link cycling and well-being benefits to institutional interventions, for example, Baden-Württemburg (2012) report that employees of Miele who participated in a cycle-to-work scheme were found to demonstrate positive effects on stress levels and mood as a result of cycling. Others suggest that it is the provision of good quality cycling environments that provide the impetus for accruing individual benefits of the mode. For example, Aldred (2015) suggests that such environments result in more physical activity in later years. At this end of the age spectrum, in a qualitative survey, Zander et al (2013) found an overwhelming response that taking up cycling in older age was a liberating and fun experience with spin-off social benefits. This was linked to cycling providing a sense of pride and empowerment. Respondents felt that fear of cars was the main reason they did not cycle.

Examining the psychosocial and environmental predictors of cycling for transportation in Flanders, De Geus et al (2008:706) found a 'scarcity of research examining possible correlates of cycling for transportation'. Although the authors stated that 'individual factors (psychosocial, self-efficacy, perceived benefits and barriers) outperformed the environmental determinates in this sample of adults' where basic cycling infrastructure is available, there is no information about the value associated with these factors affecting propensity to cycle. De Geus et al recognize that ecological models that combine psychosocial and environmental variables are likely to best explain physical activity but it is a subjective statement rather than objective practice that is being reported. The authors' results suggest that:

…promotion campaigns aimed at increasing cycling for transportation should focus on creating social support by encouraging cycling with cycling partners, increasing self-eff cacy, raising ecological and economic awareness, decreasing lack of time and interest barriers and providing facilities for cyclists at the workplace.

However, there is no attempt at quantification of the costs and benefits of such promotional activity. It should be noted that the De Geus's focus on 'soft' measures has to be understood in the context of the study having taken place in Flanders, where cycling infrastructure conditions are different from those that can be found in the United Kingdom.

Martin et al (2014) looked at data for almost 18000 people in 18 waves of the longitudinal British Household Panel Survey (BHPS) to explore the links between well-being and active commuting. Their main findings were a negative relationship between travel time and well-being, avoiding car driving was positive to well-being and that there was a positive association between active commuting and well-being. The authors conclude that positive psychological well-being effects should be considered in cost–benefit assessments of interventions seeking to promote active travel. The way to incorporate such benefits into these assessments is not explored.

Nevertheless, building on the idea of well-being to include healthy lifestyles, cycling to work has been found to be associated with less sickness absence (Hendriksen et al, 2010), which is already acknowledged in the WebTag procedure for Active Mode Appraisal (Department for Transport, 2014:1)

Staying with ideas around infrastructure impacts, in a study of value of travel time savings in Sweden for cyclists and pedestrians, Bj□rklund (2014:7) states that

…the valuation of travel time savings are lower when cycling on a bicycle path than when cycling on a road way in either mixed traff c or in a bicycle lane in the roadway. Cycling on a path next to the road was not considering (sic) worse than cycling on a path not in connection to the road, indicating that the respondents did not take traff c noise and air pollution into account in their decision to cycle. Respondents who included health aspects in their choice to cycle had lower value of travel time savings for cycling than respondents that stated that health aspects were of less importance, at least when cycling on a bicycle path. Valuations of travel time savings regarding cycling differed markedly depending on the respondents' alternative travel mode, where persons with car as alternative travel mode had much higher values than those with public transport as alternative travel mode.

The author adds that

The mean values of travel time savings were 241 SEK/h for cycling in mixed traff c, 249 SEK/h for cycling on a bicycle lane in the road way, 178 SEK/h for cycling on a bicycle path next to the road, and 167 SEK/h for cycling on a bicycle path far from the road[i].

Whilst the monetization of time saving is rather abstract from an end-user's perspective, transportation costs are much more readily understood at the individual level. A study in Greater Manchester reveals the impact of household spend on transport as it reports that 16% of households are unable to afford essential items because of spending on transport (PTEG, 2010). Moreover, IPPR (2012) report that average household spend on transport costs in 2010 was £77 per week, of which fuel was only 34% (see Fig. 1). The figures shown in Fig. 1 would seem to indicate that the largest proportion of savings on household transport costs may be achieved if uptake of cycling leads to households decreasing the number of cars they own. However, it is likely there would still be a significant proportion of residual transport activity that may require ownership. Car clubs and other resources may lead to some of that residual activity being catered for by other means.

i 241 SEK = £22.29; 249 SEK = £23.03; 178 SEK = £16.47; 167 SEK = £15.45 (at 1st April 2014 exchange rate)

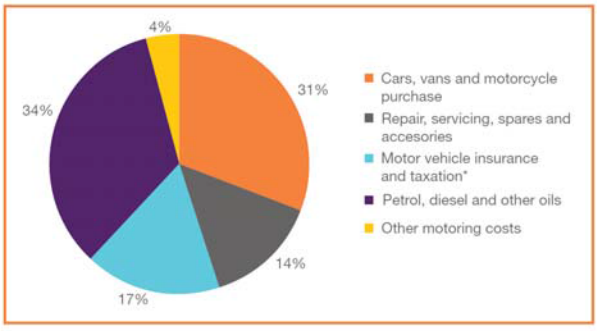


Fig. 1 Components of household expenditure on motoring (Source: IPPR, 2012)

Nevertheless, the discourse on the impacts of less dependence on cars is not all positive. For example, 23% of car-free households encounter difficulty accessing shopping facilities (PTEG, 2010). However, that in itself could be interpreted as a prompt for improvements to the walkability and cyclability of localities, and the broadening of transport options more generally.

Given the commonalities associated with walking and cycling, the apparent preference for walkable neighbourhoods points to a likelihood that cycle-friendly spaces will also be desirable places. Discussing the U.S. residential market and liveability, Litman (2010) suggests that

…there appears to be signif cant latent demand for housing in more walkable communities. A survey sponsored by the National Association of Realtors found that consumers value a shorter commute time and having sidewalks and places to walk in their neighborhood (Belden, Russonello & Stewart, 2004). Asked to choose between two communities, six in ten prospective homebuyers chose a neighborhood that offered a shorter commute, sidewalks and amenities like shops, restaurants, libraries, schools and public transportation within walking distance over a sprawling community with larger lots, limited walking opportunities, and longer commutes. Minorities are even more likely than other Americans to choose a walkable neighborhood that has a shorter commute, with 59% of women, 57% of Hispanics and 78% of African-Americans selecting more walkable communities.

Further, there is a suggestion that increased liveability comes with public space that enables cycling. Cycle-priority measures can help re-populate urban centres by attracting younger residents (Pharoah & Apel, 1995). As this group is less likely to drive, they benefit from being closer to employment and education opportunities. Their presence can lead to increased city centre vitality and allied accrued benefits for individual members of the wider local community. For example, investment in cycling infrastructure in Groningen led to an urban renewal of inner-city areas, increasing young population in central districts (Pharoah & Apel, 1995).

ODPM (2003) reports that children from the lowest social class are five times more likely to be involved in a fatal road traffic collision than those from the highest social class: therefore investment in schemes that reduce the volume or speed of motor traffic can have a benefit in terms of narrowing this gap. Such schemes could take the form of investment in cycle-friendly road layouts, e.g. 'filtered permeability[i] in residential areas, or reallocation of roadspace which results in calmer main road traffic or reduced severance. Casualty reduction is already recognised in the WebTag appraisal of the 'decongestion' benefits of cycling (Department for Transport, 2014:1).

Looking forward, recent research (Philips, 2014) explored whether places which have more walking and cycling, or more potential for these modes, are more resilient to environmental and other changes which might occur at some point in the future. The work seemed to show this is the case and, hence, it could be argued that this greater resilience to external shocks is an additional economic benefit of cycling.

Overall, the findings show that cycling has positive impacts for people and the places where they live. It can improve their well-being, lessen their spending on travel and enhance the liveability of their environment. To make the personal economic case for cycling, methods of capturing the value of such impacts could reveal the strength of their effects. This element would need to be built into traditional models of transport project assessment.

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i "Filtered permeability" is the practice of configuring streets in residential areas such that they do not provide a convenient route for through traffic, while access is maintained for residential traffic albeit limited in terms of the actual point of entry or exit, and throughput for pedestrians and cycles is unrestricted. Filtered permeability can be retro-fitted to existing neighbourhoods, for example De Beauvoir Town in London, or implemented in new-build residential estates. The principle of permeability is already recognised as good practice by the Manual for Streets as it reduces walking distances; the "filtering" out of motor traffic from the permeable network therefore retains the benefits of a walkable and cycleable neighbourhoods, but diminishes the negative effects of non-local motor traffic. (Melia, 2012)

4.3 Fiscal effects

There is a widely held view by economists (e.g. Glaeser, 2009) that agglomeration[i] is beneficial and this is borne out in greater per capita GDP with a denser urban form.

Density-dependent agglomeration appears to be one of many factors that are favourable to sustainable transport (Litman, 2010; Sherlock, 1991). Importantly, the relationship between non-motorized modes and agglomeration economies appears to be two-way: while density is conducive to these modes, urban public space for walking and cycling can also contribute to productivity associated with density. Glaeser (2009) states that

Agglomeration economies are, at their root, advantages that come from reducing transportation costs. After all, urban density is just the absence of physical space between people and f rms. Agglomeration economies can exist because of reduced transportation costs for goods: input suppliers and customers save on those costs if they locate near one another. Agglomeration economies can exist because of reduced transportation costs for people: labor markets may be more eff cient in urban areas and service providers may f nd it easier to cater to their customers. Finally, agglomeration economies can exist because of easier transmission of ideas: cities may thrive because they facilitate the f ow of knowledge across people and enterprises.

Experience in urban Japan helps elucidate the benefits of density. Intensive land use means 50% less resource is spent on transport costs (VNG, 2000):

...the intensive use of space in the population centres has stimulated use of the bicycle and public transport. Thanks to the relatively low costs of the transport system, the country has long been able to manufacture goods at lower costs and invest more in its production systems. For example, Japan spends almost 50% less … on transport than the United States. This has enabled Japanese industry to compete very effectively on international markets.

It has also been reported that annualised infrastructure costs in areas of urban sprawl are nearly 50% higher than in the most compact cities ($750 pcpa vs $502 pcpa)[ii](Litman, 2015). In addition, dense, cycling-friendly urban forms result in lower fuel consumption per capita (Newman and Kenworthy, 1989).

Blue (2013:90) points to the opportunity cost of car parking being potentially economically significant:

… parking lots represent a massive amount of taxable property that could yield thousands of dollars per lot, per year—representing millions of dollars of lost revenue for cities. Instead, the constant need for maintenance drains public and private coffers—and this cost is overshadowed by the opportunity cost of what could be built in our cities instead.

She then states that such parking capacity being given away free of charge amounts to a subsidy – public or private – citing a calculation by Donald Shoup that estimated this to cost $127 billion per year in 2002[iii].

i "Agglomeration refers to the idea that larger and/or denser places are more productive. In other words, businesses operating in large cities tend to produce more output per worker than similar businesses operating in small towns." http://transportblog.co.nz/2014/07/30/guide-to-economic-evaluation-part-3-what-is-agglomeration/

ii $US 750 = £505.88; $US 502 = £338.60 (at 1st April 2015 exchange rate)

iii $US 127 billion = £89.1 billion (at 1st April 2002 exchange rate)

Blue (89) also cites research by Akbari and Rose (2001) that revealed 25% of the land in central Houston was dedicated to parking. She also highlighted (ibid.) the Embarcadero freeway in San Francisco, which when demolished opened up a waterfront development which attracted millions of dollars of investment.

As part of a wider sustainable transport strategy, cycling has a role to play by facilitating density – 'cities of short distances' – in the country's economic powerhouses. Looking at Australian cities, Newman (1992) reports that there is a 'sharp increase at high densities' in walking and biking, perhaps as these two options become more viable than transit.

Retail density is high in Houten, a Dutch new town specifically built around walking and cycling: it enjoys two and a half times the turnover per square metre as other cities (VNG, 2000). This could influence the design of new garden cities, reducing their land take – i.e. less cost and greater stakeholder acceptance (reduced loss of green belt or open land).

Given the apparent cost and fuel savings associated with dense, liveable spaces that are conducive to non-motorized modes, the OECD suggested that cycling has a key role to play in 21st century urban development (OECD, 2015). For example, Buis (2000) suggests that

The bicycle can help to reduce the negative impact of motorised traff c on the urban quality of life. Which, especially in city centers, can lead to a more attractive climate for retailers, cafes and even companies to locate a new business.

Furthermore, it has been found that cycle infrastructure provision is cost effective (VNG, 2000):

Even in the German city of Freiburg, which has a strict cycling policy and where the bicycle's share of the total number of journeys is 19%, the costs of bicycle facilities amount to just 1% of all the costs of traff c and transport amenities. 57% of investments are for the car, which has a 42% share of all transport. In addition, 42% is spent on public transport, which has an 18% share.

However, there may be elements of the above splits in investments that have impacts across numerous modes.

Nevertheless, infrastructure cost savings accrued by developing cycle facilities instead of construction and maintenance costs associated with infrastructure for motorized transport can yield substantial economic benefits (Buis, 2000; Transport for London, 2014). This finding is extended by the suggestion by VNG (2000) that cheaper cycling infrastructure can substitute for expensive road schemes and for public transport investment and subsidy. There is also recognition that cycling infrastructure can bestow cost savings to government and other authorities by the lower maintenance impact of cycling (relative to cars), the ability to defer investment in more costly modes of transport and right-of-way preservation for future transport schemes. PWC (2009, citing Krizek, 2007) state that:

Depending on the extent of any substitution between car and cycle trips, increases in bicycle trips has the potential to reduce road maintenance costs, as bicycles produce only insignif cant wear and tear on roads. A potentially more signif cant source of road cost savings is derived from using cycle ways for preserving land for right-of-way passage which may be required for future infrastructure expansion. Placing a bicycle track along a right-of-way corridor is a relatively inexpensive way of ensuring a transportation use for the corridor, which provides user benef ts rather than allowing the land to lie fallow.

There appears to be a widely held view that cycle facilities are cost effective relative to other types of transport investment (BVDI, 2015; VNG, 2000, Litman 2010; PWC, 2009). Dordrecht decided to invest in cycling facilities rather than road widening when the two proposals were jointly considered. The cycling scheme was sufficient to reduce car trips to make the road widening unnecessary. The cycle infrastructure

cost 75% of the predicted cost of the road widening (VNG, 2000). In relation to cycling, it is reported that Transport for London's (TfL) position is that "do nothing is not an option" (TfL, 2014) because of the current trend of rising use of cycles.

Without providing dedicated space for cycling, (i.e. mixing cycling with other vehicles) modelling shows that as cycle rates increase (as they are in London and other metropolitan areas), this can lead to a delay to other vehicles (Gosse & Clarens, 2013). The 'Influencing Travel Behaviour' programme in Cambridge 'created' the equivalent of 5-6% increase in road capacity by facilitating the use of non-car alternatives (Department for Transport 2011). Seville's €32M[i] investment in its cycle network benefitted 70,000 users per day, compared to its €600M[ii] metro extension which is used by 30,000 daily (2010 ridership) (Sillero, 2011). To give this context, Seville's population is 700,000, equivalent to that of Leeds. In addition, cycling can be viewed as a means of extending the range of public transport through schemes such as OV-Fiets in the Netherlands, ATOC's Bike-n-Rail programme, and the recently-launched PlusBike initiative. Given these benefits, it is not unexpected that Transport for London is actively seeking to encourage "Dutch-style" cycling (TfL 2014).

Transport for London (2014) indicate that low-cost investment in cycle superhighways will help defer or reduce investment requirements for other infrastructure, especially where it is at capacity and expansion is likely to be problematic. Dedicated cycling infrastructure is seen as a way of mitigating existing and modelled delays to transport as a result of mixed traffic, where cyclists are sharing the road with other vehicles, yielding benefits for bus operators in reduced traffic delay costs.However, Buis (2000) cautions that investing in bicycle infrastructure will not automatically produce savings in the traffic budget. The author suggests that this will only be the case when bicycle use increases considerably. However, with substantial increases in personal and business travel by bicycle being complemented by a rise in cycle freight movement which may all come from greater investment in cycling infrastructure, changes in the nature of traffic and the budgets needed to sustain the current mix of vehicles may be achieved.

Rissel et al (2013), in a publication written in the format of a proposal, on evaluating the transport, health and economic impacts of new urban cycling infrastructure in Sydney, suggest a number of components of such a study. These attributes are: before/after assessment of local communities in relation to new cycle infrastructure, using intervention and comparison areas, online questionnaire and travel diary and supportive use of GPS devices. They considered a number of economic benefits – reduced environmental impacts (e.g. noise), congestion, car parking costs and changes to local economy - to be important. In addition, they highlighted the importance of qualitative impacts such as amenity value, improved access, community engagement and increased liveability. Given the nature of the paper, it does not supply any outcomes, but rather suggests what an investigation into these issues might comprise.

In a publication for US planners, researchers, engineers and the general public, Bushell et al (2013:6) summarize the findings of other studies of the economic benefits of walking and cycling infrastructure:

Developing pedestrian and bicycle infrastructure has economic benef ts also. Studies have found that bicycle infrastructure improvements can have a positive overall impact on business, and that people who walk or bike to a commercial area spend more money per month than those who accessed the area by automobile. The removal of on-street parking is often thought to negatively impact business, but reports show adding facilities such as bicycle racks and bicycle lanes can actually increase economic activity, and also help create a buffer from moving traff c that aids both pedestrian and bicyclist activity. Finally, improving bicycle and pedestrian infrastructure can lead to positively impacting real estate values. Homes near bicycle paths have been found to support higher sales prices, and areas that facilitate walkability and attract pedestrians sustain higher rents, revenues and resale values.

i EUR 32M = £28.24M (at 1st April 2011 exchange rate)

ii EUR 32M = £28.24M (at 1st April 2011 exchange rate)

While they do not report on their own empirical findings, Rissel et al (2013:963) do provide some commentary based on their assessment of other studies. This helps deepen understanding of the nuanced relationship between cycling infrastructure and business:

Traditional cost-benef t analyses of cycling infrastructure do not generally consider the wider/indirect economic impacts, including impacts on local business and retail establishments. The very limited evidence that does exist is generally favourable for cycling infrastructure. For instance, an inner city Melbourne study found that while car users averaged more overall spending per hour than bike riders, the small area of public space required for bike parking means that each square metre allocated to bike parking generated $31 per hour, compared to $6 generated for each square metre used for a car parking space (Lee and Marsh, 2010). Anecdotal reports from the City of Sydney [i]suggest that new businesses have started along new separated bike paths, adding to the local economy and reducing VKT to other retail centres.

The story from the non-academic US-based National Complete Streets Coalition (no date:2) is less equivocal. It reports that

When a bike lane was added along Valencia Street in San Francisco's Mission district, nearby businesses saw sales increase by 60 percent, which merchants attributed to increased pedestrian and bicycle activity. Similarly, a study in Toronto showed that nearly three-quarters of merchants along Bloor Street expected that better bicycle and pedestrian facilities would improve business.

i $AU 31 = £21.22, $AU 6 = £4.11 (at 1st April 2013 exchange rate)

Similar outcomes were found in a comprehensive study of public realm and "sustainable street" interventions in New York City (NYCDOT nd): most notably the 49% increase in sales on 9th Avenue after the implementation of protected bike lanes. The methodology compares each location to a similar 'control' where no intervention took place. While this increase was not universally found across all interventions, the report acknowledges that if even using a closely similar control site it is not possible to completely isolate all other factors. For example, in one scenario a massive change in turnover was largely down to a single shop changing from one business type to another.

The views of the business operators above represents a step change in the way that people perceive the benefits of walking/cycling infrastructure. These are generally at odds with recommendations of the Portas (2011) review, which placed much emphasis on the role of cheap or free parking, with less focus on pedestrians and public transport, and no consideration at all of cycle facilities. However, the comfort of pedestrians was at least acknowledged in terms of the attractiveness of a shopping environment.

Although not universal, cycling schemes (and wider public realm and sustainable transport schemes) have been shown to result in increased trade in local businesses (e.g. McCormick, nd; NYCDOT, nd; van Goedveren & Godefrooij, 2011) Cycle parking outside shops gives the impression of popularity or acts as a buffer between traffic and customers (Flusche 2012; UCD, 2015). Numerous studies have shown that while cyclists spend less per visit, they tend to visit shops more regularly resulting in higher weekly spends (e.g. Clifton, 2012; TfL, 2011; O'Connor et al, 2011). Cyclists have a similar shopping profile to car drivers (i.e. they are able to travel to different areas to complete a shopping trip) whereas pedestrians and bus users are usually more limited in their potential destinations (Sustrans, 2006). TfL (2011) report that 40% of town centre customers are making an "unencumbered" trip (i.e. not carrying or purchasing a bulky item), suggesting cycle use would be practical. Based on the experience of Groningen, despite initial negative impacts, further cycle infrastructure provision and improvement in the

UK could be expected to be positively viewed in the long run (Pharoah & Apel, 1995).
In terms of the cycle retail sector, there is reportedly a strong correlation between mode share and per capita spend on cycle equipment and maintenance (ECF, 2014). Individual spend is also relevant. Colibi (2012) indicates that the Dutch spend around €750[i] on a new bike and the market is dominated by sturdy "city bikes" (55%) which tend to be European-made, as opposed to Asian-made, suggesting British manufacturers could gain economically from a move to more utility cycling.

Looking at cycle freight, it is seen to offer a much cheaper and more flexible product than traditional vans for urban delivery of small parcels (in fact, payloads if up to 250kg) (King, 2013; Cycle Logistics, 2014). Cycle Logistics (2014) found cost savings of 39% and 64% for two example shipments taken by cargo bike compared to using a van-based service. While there is a shortage of qualified 7.5t drivers, cycle freight does not require specific qualifications other than being in reasonable physical condition (King, 2013). In wider terms, implications for freight that on the surface may seem like a disbenefit can in fact produce beneficial outcomes. Shifting deliveries to overnight in NYC has shown considerable time saving as a result, which suggests that even if road-space is lost to accommodate cycling, a consequential benefit may be that complementary freight management measures would have a positive impact overall despite the initial disadvantage of having to implement revised strategies (USDOT, 2010).

In a study in Bangalore, India, Rahul and Verma (2013:27) suggest a methodology for estimating the economic impact of non-motorized modes. While the study proposes an analysis that looks at qualitative and quantitative economic impacts, monetary benefits have been mainly associated with the customary areas of air pollution and accident reductions, congestion costs and mode shift to non-motorized transport and associated cost savings. The paper's main focus is on walking and pedestrianisation which are seen to lead to increase in retail income and price. There is also a limited discussion of user enjoyment and health benefits. However, the study tends to list possible benefits and does not provide values of what they are other than to indicate that application of the assessment framework suggested an estimated economic savings of Rs. 0.25[ii] million per day, and this is due to a 1% mode shift from motorized to non-motorized transport for trips below the length of 5 km. The authors suggest that this points to 'the immense potential of non-motorized traffic in achieving the goals of sustainability and such considerable savings for a small shift underlines the necessity of including it in the development agenda for Bangalore' (Rahul and Verma, 2013:33).

Borjesson and Eliasson (2012) examined the value of time and external benefits in cycle scheme appraisal for Sweden. They found that cycling on a separated bicycle path instead of on street with mixed traffic is valued at 5.4 EUR/h[iii] . Relating this to investment costs for bicycle paths, at a value of 0.6 MEUR[iv] per km (based on City of Stockholm, 2002, Hopkinson and Wardman, 1996), they suggest (678) that:

'bicycle paths are socially prof table already at yearly average cycling volumes of a little less than 300 cyclists per day, which in urban contexts is very low. Major bicycle paths can easily have 3000 cyclists per day, which would give a benef t/cost ratio of around 13. Note, however, that this is excluding the opportunity cost value of land, which in urban contexts can be a considerable cost'

Deenihan and Caulfield (2014:148) studied the health and economic benefits from construction of a new cycle route in Ireland using the HEAT tool. Amongst other estimates, they looked at potential changes, in terms of health, associated with an increase of cycling modal share from 1.72% to 2.5%, 5% and 10% and found that the increases in cycling rates would reduce the number of deaths per year by between 3.39 and 17.93, depending on the modal switch. Using the European Union's statistical value of life at €1,574,000[v] , they indicate that, over a 10 year period with a two year

i EUR 750 = £624.25 at 1st April 2012 exchange rate

ii INR 0.25M = £3025 at 1st April 2013 exchange rate

iii EUR 5.4 = £4.49 at 1st April 2012 exchange rate

iv EUR 0.6m = £0.5m at 1st April 2012 exchange rate

v EUR 1.57M = £1.3m at 1st April 2014 exchange rate

uptake of cycling and five years for the build-up of the health benefits, the benefits accumulated over 10 years would be between €26,695,000 and €141,222,000[i] , dependent on the modal switch. Ultimately, they suggest that this would lead to benefit–cost ratios of between 2.22:1 and 11.77:1, dependent on the mode switch which they state are 'very favourable' for a transport facility. Other non-health related economic benefits such as well-being effects were not explored.

Turning to leisure and tourism, a propensity for cycle tourism has been found to correlate with utility mode share (EuroParl, 2012). It is likely that this relates to the 'normalizing' of cycling, making it a more natural choice. For example, in the Netherlands, Colibi (2012) reports that 30% of domestic vacations were cycle holidays.

In addition, cycling trips for leisure purposes have been described as being important to both environmental and economic sustainability (Weston and Mota, 2012; Lumsdon et al, 2009). Runyan (2013) states that cycle tourists spend more than average, and tourist cycle facilities are said to have a very strong payback in terms of local economic spend (Flushe, 2012).
However, Weston and Mota (2009:1) caution that:

For example, poor integration with public transport and the lack of consistent infrastructure deter the development of the market. Demand tends to occur where good networks of cycle routes exist…

Downward et al (2009:39), through a case study of a cycle network in North East England, collected expenditure information from cyclists on a number of long distance cycling tourist routes using diaries and intercept surveys. The authors found that the amount spent was linked to group size and duration of trip.

Heldt and Liss (2013:7) investigated the extent of benefits from bicycle tourism and who stands to gain from a developed bicycle trail network in Sweden. They report that

(o)ne f nding from the study is that inbound bicycle tourism gives rise to mostly regional effects. A bicycle tourism effect on national level only occurs in cases where a tourist chooses a destination within Sweden instead of going abroad thanks to a new or developed bicycle trail. New incoming bicycle tourism is always a net contribution to the national bicycle tourism effect. The f ndings from the study of bicycle tourism in Varberg and Gotland are that there is a vast difference in the economic contribution of bicycle tourists. The range for the guest night spending is 466 SEK – 1,233 SEK depending on region and type of visitor[ii].

Ritchie and Hall (1999) report that cycle tourists in the south island of New Zealand were found to spend considerably higher amounts during their visits than other international tourists ($3021 versus the average of $2776 for international visitors within New Zealand in 1995/96)[iii] . This was attributed to their propensity to stay longer than other tourists. In addition, Ritchie and Hall suggest that the travel patterns of cycle tourists illustrate that these travellers disperse into smaller more peripheral and rural areas, bringing much needed economic development for local economies. Similar findings have been reported for European locations which are currently not part of mainstream tourism development (Lumsdon et al, 2009). There is also evidence that it may not only be the less tourism focused areas that may benefit from cycle tourism. Palau et al (2012:15-16) report on the concept of greenways being associated with major Spanish tourism brands:

"Greater development of greenways in mature tourist destinations through the creation of networks of pathways providing more peaceful routes for travel across the region by bicycle or on foot, helping tourists better understand the heritage, landscape and culture, will serve to increase the economic development of the region as a whole…"

i £22.1m to £116.92m at 1st April 2014 exchange rate

ii SEK 466 = £46.93; SEK 1233 = £124.16 (at 1st April 2013 exchange rate)

iii $NZ 3021 = £1,004.78; $NZ 2776 = £923.30 (at 1st April 1999 exchange rate)

Their research compared the cost per use of organised sports facilities in the boroughs through which the greenways run to the cost per use of the greenways themselves. The greenways offered a better cost per use than the sports facilities for all indicators analyzed. In overall terms, while the ratio for the greenways is Euro1.12[i] per use, the figure for sports facilities is Euro2.67[ii] per use. Amongst other results, the authors highlight that in the mountain section studied, the greenways had a ratio of E0.69[iii] per use, while for sports facilities there the figure was E3.18[iv] per use. This suggests that greenways may offer a higher level of return on investment compared to other investments in facilities for active pursuits. Palau et al (2012:22) suggest that "the superior cost/use ratio of the greenways should encourage governments to extend the network for the use of local residents and tourists, and prompt tourism promotion bodies to encourage their use by tourists, cyclists and walkers, both actual and potential, not only as travel routes but as a sustainable tourism resource serving as a showcase for the surrounding natural, social, cultural and economic attractions of the region".

Looking at the Danube Cycle Route, Meschik (2012) also discusses the regional economic benefits of cycle tourism:

With the average amount spent per day by cycle tourists estimated to be E65.70[v] , the total benef t to the area around Krems during July and August alone sums up to around E1 million[vi] . Importantly, the average distance covered per day is about 50 km, which means the spending is evenly distributed along the route, encouraging the development of good tourist infrastructure' (Meschik, 2012:53).

The author concludes that development of cycle routes can bring economic gains along the route from tourists, while also reducing their environmental impact.

A recent paper by Deenihan and Caulfield (2015) focuses on an Irish government objective to "provide designated rural signed cycle networks providing especially for visitors and recreational cycling". The case study is of a 42km off-road route, the longest in Ireland. The estimated payback for this new infrastructure is 6 years. The authors' study was based on a Stated Preference intercept survey which looked specifically at whether tourists would be willing to spend time, comfort and energy in order to travel on perceived safer cycling infrastructure. The respondents appeared to like such facilities as they expressed willingness to increase travel time by up to 100% to use such facilities (note this is in a leisure context). They were also willing to pay 48% more for a road with cycle lanes than one without.

There appears to be a correlation between mode share for utility cycling and tendency to cycle for holiday (European Parliament, 2012), perhaps because cycling is "normalised" and thus a more realistic option for a holiday or day trip. In the country in Europe with the biggest cycle-tourism market, Germany, 95% of cycle-tourists are domestic. This suggests an increase in UK utility cycling rates would help develop the UK cycle-tourism industry further, and the likelihood increased interest in cycle-tourism would largely translate into domestic activity.

Cycling and related infrastructure have been found to be substantially lower cost than other transport modes. At the same time, there are business benefits of cycling both as a utility and leisure mode, as well as the derived benefits of running a business in an area which is conducive to cycling. These and other fiscal effects of cycling appear to have received more detailed economic valuation than individual impacts. This is unsurprising as financial valuation is quantitatively based. Nevertheless, the more readily measurable impacts may end up stifling the importance of the less easily captured, yet important, individual and social effects which do not convert readily to monetized value.

i EUR 1.12 = £0.93 at 1st April 2012 exchange rate
ii EUR 2.67 = £2.22 at 1st April 2012 exchange rate
iii EUR 0.69 = £0.57 at 1st April 2012 exchange rate
iv EUR 3.18 = £2.65 at 1st April 2012 exchange rate
v EUR 65.70 = £54.68 at 1st April 2012 exchange rate
vi EUR 1 million = £832,200 at 1st April 2012 exchange rate

4.4 Employment effects

Cycling is now on the political agenda of major businesses (Cycling Weekly, 2014; British Cycling, 2015) and, within this context, the reported links between employment and infrastructure for non-motorized transport appear important. Garrett-Peltier (2011:2) reports on an evaluation of 58 studies of the employment impacts of pedestrian and cycling infrastructure in the US. Her research found that cycling infrastructure can be very effective – each $1 million[i] spent on cycling projects creates 11.4 jobs. Pedestrian infrastructure reportedly creates slightly fewer and roads projects are weakest of all.

The US National Complete Streets Coalition (no date:2) also highlights the link between cycling infrastructure and jobs:

Better bicycle infrastructure can create jobs directly, too. Cycling adds over $556 million and 3,400 jobs to Wisconsin's economy through increased tourism, bicycle manufacturing, sales and repair, bike tours, and other activities. Similarly, there's a $90 million benef t to the city's economy from Portland, Oregon's bicycling industry, and the state of Colorado reaps a benef t of over $1 billion each year from bicycle manufacturing, retail, and tourism[ii].

There are other reported relationships between cycling and employment. Hendriksen et al (2010), reporting on a Dutch study, state that cycling to work results in reduced absenteeism, with regular cycle commuters having on average one day less sickness absence per annum than other people.

The Estates Gazette (2012) reports that cycle facilities are now a factor in the career choice of over half the respondents to a British Council for Offices survey (n=149). Meanwhile, companies' promotion of cycling to work has led to lower job turnover (Sustrans 2011). There is also some suggestion that cycling facilities may be important to attracting particular types of employees: Walljasper (2013) reports that the mayor of Milwaukee reportedly views cycling as being critical in attracting creative talent.

Lack of transport options is recognized as a factor in joblessness (ODPM, 2003) and insufficient transport provision is a reason for declining employment (CfIT, 2002).The lowest economic quintile of society has a typical commute of 3 miles, whereas the national average is 8 miles (ODPM, 2003). This bears out the "Marchetti wall" principle (Marchetti, 1994) that people have a 'transport budget' of approximately 1 hour's maximum commute (3 miles = 1 hour's walk), while an hour's cycle commute corresponds to about 8 miles. This suggests that wider availability of cycling for transport has the potential to reduce transport inequality and promote access to jobs and education.

Referring to transportation costs in Bogotá, Columbia, Muñoz-Raskin (2010) highlights that for the least economically well off, the marginal utility of saving the monetary cost of a transportation ticket can be significant. This implies that low cost solutions may be key to lessening the travel burden in economically excluded communities, pointing to the potential within cycling to act as a tool for enabling accessibility. This prospect is heightened by the author's advice that in order

to save on the costs of transportation services, the poorest communities may end up landlocked in marginal peripheral areas, without adequate access to the areas where the job pools exist in the city.

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i $US 1 million = £622,800 at 1st April 2011 exchange rate

ii $US 556 million = £375.02 million; $US 90 million = £60.71 million; $US 1 billion = £670 million (at 1st April 2015 exchange rate; report is undated so this year's exchange rate is applied)

This finding would appear to be as relevant in the UK as it is elsewhere and cycling provides a simple solution to access difficulties across income levels.

Cycling has been shown to benefit both the employer and the employee. Aside from its benefits in terms of reducing sickness absences, the role of cycling facilities for attracting staff seems to hold great potential. For the prospective employee, ease of physical access to work opportunities is central to the ability to gain employment and cycling provides a tool by which joblessness due to transport exclusion may be overcome for some social groups. Transferring these impacts into benefits that can be included in transport project assessment would seem to be central to reflecting the true nature of cycling's potential in improving employment prospects and, thereby, helping to lower rates of unemployment.

4.5 Strategic governance effects

Cycling policy is relevant to the achievement of strategic governance objectives. For example, examining cycle to school impacts briefly, Dutch evaluation of children's cycling to school activity estimated the equivalent cost of providing school buses at NLG1.2 bn[i] (Boot & Ploeger, 1987). Children using active travel to get to school tend to be more attentive and achieve better results (Living Streets, 2008; Rauner et al, 2013). In addition, as the economic and social burden of school travel is reported to fall predominantly on women, restricting employment opportunities (Nottinghamshire County Council, 1995), cycling to school in groups may provide economic benefits in the form of increased employment options for those who once served as escorts to school. These benefits ultimately accrue across the population and economy, but are also experienced by individuals and employers. Thus this particular benefit, whilst minor, is felt across all interest areas of this review.

Another potential strategic economic effect of cycling is its role in business. Improved accessibility has been linked to increased economic activity. Cycling and related infrastructure have been seen earlier to play a role in retail and business activity. But Mejia-Dorantes and Lucas (2014:241) caution that the relationship 'is far from conclusive or consistent'. With respect to regeneration, they suggest that the nature and extent of the relationship and related economic impacts depends on the

type and scale of the infrastructure provided, its location and specif c operating characteristics, as well as on other factors outside the transport system, such as the pre-existing property market, land uses and local land policies.

Thus, pin-pointing the economic value of cycling infrastructure can be seen to be made difficult by the other attributes which may confound assignment of benefits to specific causation.

Evidence in relation to property effects is mixed. It appears to vary according to type of cycle infrastructure but stated preference analysis in the U.S. showed there is a greater willingness to pay for residential properties that are close to some types of cycle infrastructure (generally off-road routes), although on-road routes are regarded as a disbenefit (Krizek, 2007). In addition, traffic reduction schemes complementary to cycling, or cycling schemes that result in a reduction of through traffic, can be regarded as having positive local benefit economically. A Dutch study modelled traffic volume and residential property values and found that a 50% drop in traffic volume corresponds to an uplift in value by 1% (Ossokina and Verweij, 2014). This means that 'filtered permeability' schemes (removing all through traffic except cycles) from residential areas can be viewed and promoted as resulting in wider improvement to the area. It is also reported that revealed preference analysis shows strong favour among potential buyers for "walkable" neighbourhoods, particularly amongst women (Litman, 2010).

Looking now at the potential within investment in cycling infrastructure for influencing travel behavior, there is consistent evidence of new infrastructure helping to increase the volume of cycling significantly. For example, in increasing order of impact, refer to Sloman et al, 2011; MVA, 2011; and Sillero, 2011. Revealed preference analysis indicates a preference for protected, off-road and quiet-street cycling infrastructure, particular for trips involving vulnerable users (Aldred, 2015). However, Reid (2013) cautions that comprehensive cycling infrastructure is not likely to attract high usage where motoring is easy and uncongested, citing the example of the Stevenage cycle network which was copied by the Dutch in the 1970s. This does suggest investment is likely to be more worthwhile where cycling can offer competitive journey times. With a tendency for cycling in London

i NLG 1.2bn = £390 million at 1st January 1990 exchange rate (earliest date available for exchange rate calculation on OANDA.com)

to compete for physical space with other modes, the high cycling rates in the capital are against a backdrop of high 'churn' (i.e. a large proportion of new cyclists are replacing people who have stopped cycling) (TfL, 2010). This typifies a 'distressed' transport choice in response to a specific need (e.g. commuting or lack of tube access) and that behaviour changes when circumstances do. Conversely, in locations where cycling infrastructure is good (Munich) or universal (Utrecht), "practical travelling" by bicycle is much more widespread: that is, people use a cycle purely because it is convenient and not through any sense of environmental obligation or dissenting self-identification (Anable, 2013).

Aldred (2015, 1-2) argues that although it is possible to monetize and model many benefits associated with cycling, these values are rarely included within conventional transport models. She suggests that they are usually marginalized when data are collected and when conducting transport assessments, where travel time savings continue to dominate. While such savings may have dominated assessment traditionally, it is anticipated that this review may help reveal the gap in available data which could then be built on to better capture the values that may thus far have been less likely to have been considered. For example, Krizek et al (2007:211) provide an overview of an online tool developed to capture the value of investing in cycling in the US. They indicate that

A central problem troubling planning efforts is that cycling currently lacks the tools and methodologies that are available for automobiles and transit related to forecasting and benef t/cost calculations.

They go on to provide guidelines for an online tool to assess bicycle facilities. It looks at costs and benefits and effects on demand. They report that the recreational benefits of cycling typically in the US are around $40[i] per day (2004 values). The paper also discusses more obvious benefits (e.g. mobility, health, safety) and less obvious ones (e.g. automobile decline, and liveability). The paper also presents a positive correlation between house prices and off-road bicycle facilities, and on the other hand a negative correlation between house prices and on-road bike lanes. This is consistent with numerous studies (e.g. Aldred, 2015) that reveal acceptability of cycling as a mode of transport is strongest where dedicated infrastructure is provided or in environments where traffic volumes are low. Further investigation of the specification and detail of how the software works may help elucidate the process and outputs further.

Another paper contributes to the narrative of cycling's benefits and the impacts that need to be assessed when considering cycling. Handy and Xing (2011) describe the following:

▪Environmental (evidence not clear about car trip reduction)
▪Health – clearer cut, but causality direction an issue (do fitter people typically choose to cycle?)
▪Well-being
▪Economic – reduced health care costs, fewer sick days, transport cost savings, improved access to business, cycling based tourism, workplace productivity.

As with many other sources, the quantification of these benefits is absent from the discussion. However, one of the papers that does give quantitative evidence looks at cost benefit analysis for walking and cycling. Davis (2010:2) indicates that several studies have identified economic benefits of walking and cycling interventions which are highly significant. He indicates that the 'median result for all data identified is 13:1 and for UK data alone the median figure is higher, at 19:1'. Based on Cavill et al's economic analyses (2008),

i $US 40 = £21.56 at 1st April 2004 exchange rate

Connor (2014) suggests further that '(b)uilding a city for walkers or cyclists makes for a good investment all round: 'One review set the cost benefit ratio of the economic benefits of cycling interventions, including health impacts from more physical activity, at 5:1'. This is comparable to DfT's own estimates of the value for money of cycling investments (2014:2), which average at 5.5:1. One investment package assessed by DfT produced a BCR of 35.5:1. Note these assessments are conservative since they do not all capture all potential wider economic benefits as identified in this study.

Connor (2014) also states that:

Studies across the world report a positive economic multiplier effect when cities invest in and embrace cycling. One study focused on Portland, Oregon, where businesses have a culture that accepts the bicycle mode, sometimes offering specials for those who arrive by bike, plus amenities such as lockers, showers, and other services that are less obvious from the street. Portland is actively pursuing this development concept, but the individual elements of bike-supported development are catching on nationwide, even when support from the business community is mixed (Clifton et al, 2012).

Another source of monetized values is Henao et al's (2015) report on a review of transportation investments, in terms of economic spend, made between 1990 and 2009 in Boulder, Colorado. This data is presented along with mode share in order to highlight correlations between investments in sustainable transportation infrastructure and increased use of these modes. The city has invested heavily in sustainable transportation infrastructure over recent decades and simultaneously experienced increased share of these modes with the city being recognized by the League of American Bicyclists as a Platinum bicycle-friendly community.

The authors state that

The city is now well known for its grade-separated bicycle and pedestrian paths, which are integrated into a network of bicycle lanes, cycle-tracks, and on-street bicycle routes. (Henao et al, 2015:65)

The paper goes on to report that during the period studied (1990-2009)

…bicycling infrastructure investments varied from $2.4 to $5.7 million (in 2009 dollars) per year between 2000 and 2009, with a total of $84.7 million from 1990 to 2009. The percentage of the total budget allocated to bicycling infrastructure ranged from 10 to 20 percent, with a 17 percent average, for the study period. (B)etween 1990 and 2009, the city had approved over $45.5 million of bicycling infrastructure enhancements. Examples of bicycle infrastructure added during this time include the installation of bicycle lanes, multi-use path underpasses, and the addition of new multi-use paths. (Henao et al, 2015:67) [i]

The cycling mode share increase over the same period is equivalent to a 0.11 per cent increase per year or approximately 2 per cent between 1990 and 2009. However, the authors conclude that it is very difficult to quantify the benefits of active travel and therefore the results should be treated cautiously.

In the UK, Grous (2011) at the LSE prepared a report on the cycling economy in which a number of sources were reviewed. He suggests that the cycling sector generates £2.9 billion for the British economy or a value of £230 for every biking Briton in the country, which takes into account purchase and maintenance of bicycles.

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i $US 2.4 million = £1.67 million; $US 5.7 million = £3.97 million; $US 84.7 million = £58.99 million; $US 45.5 million = £31.69 million (at 1st April 2009 exchange rate)

Data from Colibi (2014) allows us to look deeper at the bicycle industry in the UK, Bicycle production is 20% higher in 2013 than at the time of the Grous report (50,000 units per year in 2013), although this is some way short of the era when bicycles were mass produced domestically (1 million units per year in 2001, after which point domestic production collapsed). Nevertheless, this is a steady improvement from the low point of 20,000 units produced per year in 2009.

Parts and accessories production is very strong: the output of €31 million[i] per year in 2013 is double the figure in 2001 (Colibi, 2014).

While Colibi (2014) figures report a dip in employment and retail sales since the Grous report, Halfords' UK annual sales broke the £1bn mark in 2014 with 1.3 million bicycles sold (Rankin, 2015) and the bicycle sector is now the strongest part of the retailer's business.

The Grous (2011) report contains a number of other figures which help develop an understanding of the UK cycling economy. Some of these are that almost a quarter of the UK population are now cyclists. Regular cyclists take one sick-day less per year, saving the economy £128 million per year in absenteeism. A 20% rise in cyclists by 2015 could save the NHS £52 million in costs.

While Grous's estimation of NHS budget savings may appear small, it is based on growthing up the already low volume of cycling in the UK. A more helpful way of considering the cost savings is to value it against the cost of the infrastructure provided, and taking into account actual demand for travel and thus reasonable prediction of potential usership. This approach by Gotschi (2011) found healthcare savings from cycling investment to be worth between $388 million and $594 million against capital costs in the range of $138 million to $605 million.

However, although figures such as those supplied by Grous and Gotschi are relatively rare, for Handy et al (2014:13), it is essential that all important benefits and costs are included in CBA for cycling:

…both those that impact gross domestic product (GDP) (such as reduced travel times for trucks or business travel) as well as those that have no impact on GDP (such as reduced travel times for social trips, or lower noise levels). Note that while all reductions in travel time should be included, even those that do not impact GDP (at least not directly), the analysis should account for the fact that the marginal value of time differs by the trip purpose as well as mode (Borjesson & Eliasson, 2012).

For investments in cycling infrastructure, Handy et al suggest that benefits such as environmental, health, economic, and well-being benefits, should all be included in CBAs. This is true at the national, strategic level and, equally so, at the regional and local scale. With Lee and March (2010) providing a reminder that cyclists are more likely to be from a smaller local catchment than car drivers who can travel from further afield, the role of local cyclists in their own community is central to the neighbourhood's businesses thriving, its vitality and general amenity – its liveability. The role of these individuals in their communities needs to be monetized if realistic decisions about infrastructure for cycling are to be made.

i EUR 31 million = £26 million, at 1st April 2013 exchange rate

The literature suggests that cycling can assist in meeting strategic goals in diverse areas such as helping to introduce parity of access to employment opportunities, contribute to retail and other business vitality and create vibrant spaces. However, there is a concern in the literature that appraisal methods do not incorporate the extent of benefits associated with cycling and this means that, as the mode competes for funding, it may unduly be seen as less viable than other options.

Borjesson and Eliasson (2012:682) offer the strongest case for considering the benefits of cycling in their own right:

The bicycle is in many contexts and circumstances an extremely eff cient mode of transport – cheap, fast, reliable and requires little space or physical investments. As we have seen, the value of cycling time savings is potentially very high. In our opinion, the bicycle deserves to be viewed as an important and eff cient mode of transport – rather than simply a means to obtain other effects'

In the United Kingdom context, the benefits of cycling are only measured where a "mode switch" occurs: i.e. health and other benefits begin to accrue if users switch from other forms of transport, but the absence of those benefits is not evaluated in the appraisal of non-cycling transport decisions. Nor is the disbenefit of mode switch in the other direction accounted for in the assessment of non-cycling transport schemes.

Social accounting and audit may be another approach that offers a framework for exploring the broader scope of assessment as it concerns itself with more than economic impacts and is not only expressed in financial terms. It accepts the use of qualitative input, incorporates multiple perspectives, and includes the social, economic and environmental.

6.0 Conclusion

The findings reveal a substantial discourse about the benefits of cycling. These are found across a range of thematic spheres (e.g. improving accessibility, increasing employment access, contributing to vibrant communities and individual well-being) and geographic scales (neighbourhood, local, regional, national). However, despite assertions of various positive impacts, the literature is less forth-coming about the ways in which these may be realistically captured. The nuanced impacts that go beyond mainstream economic measures are difficult to harness into substantiated and replicable metrics.

Yet, for the mode's potential to be revealed and infrastructure schemes to be financed, there is a need to give priority to developing holistic models that move beyond easily monetized factors to incorporate the softer factors that show the interaction between cycling and society.

There is also a need to appraise transport decisions on a consistent basis across different type of modes so that all benefits and disbenefits are captured in the business case.

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