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Measure No.21: Bike sharing



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Schemes that provide access to cycles in and across a city for short hire periods.

Cities can encourage greater use of cycling to facilitate short journeys by making numbers of cycles readily available on their streets. Schemes may vary in size, and in area covered, and may also extend to electric as well as pedal powered bikes to promote use to non-cyclists.

21.1 Context and background

Bike sharing schemes (BSSs) have existed for almost 50 years but only in the last decade have they significantly grown in prevalence and popularity to include over 800 cities across the world and a global fleet exceeding 900,000 bicycles¹.

Bike sharing is often named in different ways according to the geographical area of application, e.g. 'cycle hire' in the UK, 'public bicycle' in China and 'bicycle sharing' in North America. In some instances they are known locally by the name of a scheme commercial sponsor (i.e. 'Barclays Cycle Hire' for the original deployment in London) or even political proponent of the scheme (forgoing the sponsor in London, and renaming them as 'Boris bikes' after the then incumbent Mayor).

BSSs share a few key features²⁻⁵, which are listed in Box 1 below.

According to the evidence presented in this review but also to the wider body of knowledge about this measure, BSSs are typically introduced as part of sustainable mobility agendas and sometimes within more formalised SUMP. As such, they are expected to contribute to a number of different objectives, for example²⁻⁵:

Key messages:

- The limited evidence available suggests that bike sharing can increase cycling levels when combined with appropriate supporting measures.
- While predominantly enabling a commuting function, bike sharing also allows users to undertake key economic, social and leisure activities.
- Bike sharing can enhance local economies, by connecting people to employment, retail and other places where economic activity takes place. US evidence also suggests additional retail activity near cycle docking stations.
- Bike share users benefit from reduced, and more reliable journey times.
- Bike sharing can connect to, and substitute for public transport for some types of trips and some users, helping to manage public transport demand (benefitting users and transport operators).
- Successful schemes generate revenue that can reduce public funding and subsidy. However the readily available evidence on the financial viability of existing bike sharing systems is limited and predominantly qualitative in nature, partly due perhaps to commercial sensitivities

Potential interventions

- Provision of a pool of bicycles at strategically positioned and fully automated 'bike sharing stations', typically distributed in a dense network across an urban area,
- These to be accessible by different types of users (e.g. registered members or occasional/casual users) for short-term rentals allowing point-to-point journeys.

- a. The bicycles can be checked-in and out through the use of a personal 'smart card' using radio-frequency identification (RFI) technology, or a 'key';
- b. Each bike sharing station, i.e. the station where bikes can be checked in and out of their docking points, can be equipped with terminals, also termed 'kiosks', where users can get information on the scheme, view the local and overall station network map, communicate with customer service, and in some cases make the payment for use;
- c. Wireless communication technology, e.g. general packet radio service (GPRS), allows real-time monitoring of occupancy rates at each station. If the bicycles are equipped with global positioning system (GPS), their movement through the network can be monitored.
- d. BSSs incentivise short-term rental, hence maximise the number of times each bicycle is used, by allowing users to have the first 30 minutes free of charge (within their specific subscription for which they are charged upfront) and then increasing the charges rather substantially after that period. In this sense bike sharing is very different from a bike rental service: the former is about using the shared bikes to make short-term point-to-point journeys, the latter involves the renting, and private use, of a bicycle for a given amount of time. Users are generally required to provide credit card details, which serve both as a deposit, as well as payment for registration and usage fees.

Box 1: Key features of bike share schemes

- To reduce single occupancy car journeys and ease traffic congestion;
- To reduce CO2 emissions and to improve air quality by reducing other pollutant emissions from motorized traffic;
- To improve public health and increase levels of physical activity;
- To increase cycling levels, and help promote and normalise cycling;
- To improve accessibility and support flexible mobility and inter-modality by acting as a 'first' or 'last mile' solution, in particular in connection with public transport;
- To improve road safety, in particular for cyclists;
- To enhance the image and liveability of cities and to support local economies and tourism.

Box 2: Wider objectives for BSS

21.2 Extent and Sources of Evidence

Reflecting the rapid growth of BS in the past 10 years, a number of very different sources of information about bike sharing, across different media, have recently been made available. These include:

- a. *Guidelines and manuals for bike sharing operation*, such the handbook developed by the EU-funded Obis project²; the overview of Spanish BSSs³ (in Spanish but with a short summary of recommendations in English); and two planning guides to bike share implementation, the first focused on the U.S. experience and context, published by the Federal Highway Administration, U.S. Department of Transportation⁴; the second drawing on the global experience to date, published in 2013

by the Institute for Transportation & Development Policy⁵.

- b. *Websites*, comprising both those offering general information on bike sharing and those set up by BSS operators and/or projects, which sometimes include information on this measure as well as scheme-specific data on operational/financial performance and customers' profile and satisfaction. A well-known example among the former category is The Bike-sharing Blog⁶, which keeps track of all the BSSs across the globe and acts as a point of contact and reference for stakeholders involved in BSSs and, more broadly, anyone interested in this measure. Among the BSS operators that make performance data and/or reports available are: Capital Bikeshare⁷, Washington DC; Nice Ride Minnesota⁸; Barclays Cycle Hire⁹, London.

c. Reports and academic papers, including peer-reviewed, exploring one or more aspects and effects of bike sharing and focusing on one specific scheme or a range of schemes where usage data are available. Most of these reports and papers have appeared in the past 5 years, suggesting that this is still an emerging but potentially prolific area of research. It is among this category of resources that the present review of evidence has been conducted, as the most high-quality studies on the impacts of bike sharing have been published as outputs of academic research investigations.

This review focuses in particular on ten high quality studies selected from over fifty items of evidence considered for this task. Several considerations can be made in relation to the availability, scope, significance and quality of the range of existing evidence on this measure.

First, it must be noted that although bike sharing has recently started to attract attention from commentators around the globe, including academic researchers, independent and peer-reviewed in-depth evaluations of existing schemes are not readily available. No single BSS (of a sufficient scale^A) appears to have been fully and independently evaluated along an extensive range of impact and process dimensions. More frequently, the existing studies look at one particular aspect or a set of characteristics of one or more schemes, with different methodological approaches. As a result, the available evidence is somehow patchy and does not easily lend itself to comparative analysis.

Secondly, the evidence available on bike sharing does not generally offer a clear understanding of the specific objectives that a particular scheme had sought to achieve. This makes it difficult to assess whether, and to what extent, a scheme has been 'successful'. This is particularly relevant when interpreting the results of academic studies of specific BSSs, which often reflect the authors' own research objectives and line of academic inquiry, rather than provide an evaluation of the scheme's success against its original objectives.

The available evidence is relatively recent and generally refers to established schemes that have been operational for a while. A handful of major schemes in North America (US and Canada) and Europe (UK, Ireland, Spain and France) appear to have attracted the most interest and scrutiny, followed by schemes in China (currently the largest in the world) and Australia.

21.3 What the Evidence Claims

21.3.1 Introduction

The selected ten high quality studies include a variety of methodological approaches and objectives. Two are recent reviews of the available evidence to date^{10, 11}. Most involve the collection and analysis of operator data on users and usage characteristics; or the generation of quantitative and qualitative data, through surveys conducted with users, non-users and businesses, via on-street, online or telephone questionnaires. Two are before-after studies^{12,13}. Models have been used in two studies to determine demand for BSS use¹⁴ and health impacts¹⁵. The evidence presented in these studies concerns three main aspects of BSSs, described in more detail in Box 3 below.

21.3.2 Users' socio-economic profile

In terms of users' socio-economic and demographic characteristics, there is now an established and broadly consistent body of evidence. Overall BSSs seem to attract a particular profile of user: male, white, employed and, compared to the average population in which BSSs are implemented, younger, more affluent, more educated and more likely to be already engaged in cycling independently of bike sharing^{11, 15-18}.

^A The author contributed to an in-depth impact and process evaluation of a small-scale bike sharing pilot scheme in Bath, U.K., co-funded by the CIVITAS Plus Renaissance project, 2009-2012. The evaluation report is to be published by the European Commission

1. The first aspect is reviewing by whom, why and how BSSs are used, as this provides an understanding of how successful the schemes are in attracting customers, and thus generating cycling journeys and revenue. This is also connected to issues around equity of access.
2. The second broad aspect is about the direct and indirect impacts associated with BSS implementation and use. These include change in travel attitudes and behaviours, impacts on inter-modality, and environmental, health and economic impacts. The evidence on the first two aspects of BSSs is thematically examined in the following subsections.
3. Finally, the third aspect concerns issues around implementation and operation of BSSs, which however have attracted academic research scrutiny to a relatively lesser degree. This is discussed in the next section.

Box 3: Aspects of BSS presented in source material

21.3.3 Equity of access

Only two of the available studies specifically focus on equity of access, in particular using Barclays Cycle Hire (BCH) in London, U.K., as a case study. Overall, this evidence¹⁸⁻¹⁹ indicates that residents in less affluent areas can and do use bike sharing systems if these are made available in their local areas, but price increases may have contributed to reducing casual use in poorer areas. Trip rates among registered users were higher among residents in poorer areas after adjusting for the fact that these poorer areas were less likely to be near a BCH docking station¹⁹.

Lack of a debit/credit card has been highlighted as a barrier to a more equitable use of BSSs^{18, 20}.

21.3.4 Determinants of and barriers to bike sharing use

Evidence on the barriers and determinants of bike sharing use appears to be growing but there are limitations in the range of case studies examined and methodologies used.

According to user surveys conducted in different cities and countries, bike sharing can improve the experience, accessibility and affordability of personal travel, through greater transport choice, reduced journey times and reduced mobility costs. In short, the evidence suggests that “convenience” in its broadest meaning consistently emerges as the key motivating factor for bike sharing use. This has been found by a number of studies looking at BSSs in

Europe^{13, 21}, North America^{11, 22}, China¹⁰ and Australia¹⁰.

Barriers to joining and using bike sharing systems have been explored to a lesser extent and predominantly in an Australian context¹⁰. These are: mandatory helmet legislation, overnight closure, barriers to instant access, lack of cycle infrastructure and road safety concerns, which are also a major barrier to cycling in general.

In terms of factors that increase the likelihood of bike sharing use, proximity of residence to docking stations appears to be strongly correlated with use, as well as certain socio-economic characteristics and active travel behaviours^{12, 13}.

21.3.5 Usage characteristics

In terms of usage rates, reported usage rates vary from 3-8 trips per day per bike, and these have been found to increase significantly in conjunction with disruptions to the public transport systems. Some schemes, such as BCH in London and Capital Bikeshare (CaBi) in the Washington DC area, reported high usage levels, with each bike producing on average 3 trips per day¹⁷. Other schemes are comparably less used thus less successful in attracting customers, e.g. in Australia with 0.3 - 0.4 trips per day per bike¹⁰.

Concerning the factors influencing usage patterns, a study using real bicycle flow data from BIXI, Montreal, identified the following key variables¹⁴: weather conditions, with users more likely to bike-share under good weather conditions; time of

day/week: during the weekends the bicycle usage reduced, however Friday and Saturday nights were positively correlated to arrival and departure rates; the provision of cycle infrastructure, with bicycle flows and usage of the BSS increasing with cycle lanes/paths nearby a BIXI station; and the characteristics of the built environment around the stations, with bicycle flows decreasing further away from the core business district. Accessibility indicators appeared to be correlated to bicycle usage for every BIXI station. Restaurants, other commercial enterprises and universities in the vicinity of a station significantly influenced the arrival and departure rates of the BIXI station. Population density and job density around bike sharing stations appeared to influence demand and usage rates at different times of the day/week.

Reallocating capacity by adding a further BIXI station had a stronger impact on bicycle flows compared to increasing one station's capacity. This means that dense bike sharing station networks may have a beneficial effect on usage levels.

In a study¹⁹ that combined usage data with members' residence data, proximity of residence to bike sharing stations significantly increased frequency of use of the London BCH scheme.

Work-related purposes dominate bike sharing use, as the available evidence on journey purpose suggests^{16, 23}. However, the prevalence of different purposes may be influenced by temporal variables, such as time of the day and day of the week²⁰.

21.3.6 Change in travel attitudes and behaviours

This area of impacts has received comparably more attention and there are now several studies looking at this issue across different BSSs. The ability of bike sharing to attract trips previously made by private vehicles remains a key challenge, with the available evidence exposing relatively low mode substitution rates and suggesting that bike sharing is predominantly used instead of walking and public transport¹⁰. Findings from user surveys suggest that only a minority of journeys transfer from the private car. Among European exam-

ples are London BCH (2% of car trips substituted for)¹⁷, Velo'V, Lyon (7%)¹⁰, Dublin (19.8%)²⁰ and Bicing, Barcelona (9.6%)²⁴. Examples outside Europe include BIXI Montreal (2%)²⁵, CaBi in Washington DC (7%), Nice Ride Minnesota in the twin cities of Minneapolis-Saint Paul (19.3%), and Melbourne (19%) and Brisbane (21%) in Australia^{10, 17}.

In terms of broader travel behaviour change, bike sharing has been found to influence and change the travel behaviour of users, but with differing results in different contexts and in respect of different transport modes.

With respect to cycling, bike sharing appears to increase the frequency in which a bicycle (personal or shared) is used, thus contributing to promote cycling behaviour and increase overall cycling levels^{11-13, 16, 20-21}. As BSS users don't generally use helmets or other dedicated cycling clothing, bike sharing can potentially normalise the image of cycling¹⁸.

Considering changes in car driving, the available evidence suggests that bike sharing can reduce car use¹¹.

Evidence on behaviour change in walking and use of public transport modes as a result of bike sharing is more mixed and appears to depend upon the particular scheme attributes, transport infrastructure and population characteristic/travel patterns/preferences in the cities implementing the schemes. This is linked to how far bike sharing can support inter-modality, which is discussed the next sub-section.

The reviewed studies offer a number of possible explanations for the different patterns of behaviour change across different BSSs. For example, Fishman et al. (2013)¹⁰ suggested that BSS users in cities with relatively high car modal share exhibited a higher car mode substitution rate than BSS users in cities with an already low car modal share. However, robust statistical analysis of data from existing schemes is needed to check whether this observation can be supported. Other contextual factors identified as possible reasons for differential patterns of change in relation to public transport use include

the quality, level of service and patronage of the available public transport options^{11, 26}.

The main weakness of this body of evidence on travel behaviour change is the lack of reliable quantitative data on the extent, in terms of frequency and magnitude, of the change in overall motorised travel on one hand and active travel on the other. As a result, the available evidence on travel behaviour outcomes cannot currently be used to robustly determine direct and indirect impacts, for example on public health and the environment.

The impact of BSSs on attitudes to cyclists has received very little attention to date thus evidence is limited. The study of Dublinbikes²⁰ found that bike sharing can contribute towards raising awareness and acceptance of cyclists, thus contributing to increasing road safety for cyclists. BSS users in Brisbane perceived better behaviour from motorists when riding the shared bikes than when cycling with their own bikes²⁷.

21.3.7 Effects on inter-modality

Bike sharing can, at the same time, connect to and substitute for public transport. The exact outcome of this combination is the result of a complex interrelationship among various factors, such as the characteristics of the scheme and the location where it is implemented, including public transport infrastructure attributes and population travel behaviours and preferences.

An analysis of bike sharing usage in Melbourne, for example, revealed that the number of trips was significantly higher for docking stations located in areas with relatively less accessible public transit opportunities, suggesting that the BSS was potentially substituting for public transport rather than connecting to it²⁸. This contrasts with evidence from other cities such as London¹⁸, Washington DC and Paris¹¹, where bike sharing usage was significantly higher in correspondence to rail stations (London and Washington DC) and Metro stations (Paris).

In London in particular, Goodman & Cheshire (2014)¹⁸ found the BCH to be relatively popular with non-Londoners from commuter towns with a cycling culture such as Oxford and Cambridge, so strategic marketing of a BSS in rail-connected commuter towns with an existing cycling culture could potentially increase participation and support bike-rail integration.

21.3.8 Environmental impacts

Many commentators and publications supportive of bike sharing provide estimates of the CO₂ emission savings resulting from bike share use to assess potential environmental impacts. However the significance of these results is questionable because such estimates are not normally substantiated with robust evidence from usage data and/or user surveys, but rest on the invalid assumption that all bike sharing journeys substitute for car journeys.

One study¹⁷, among the ones reviewed, attempted to conduct a more realistic, indirect, assessment of the environmental impacts of bike sharing. Using data from BSSs in London (UK), Melbourne and Brisbane (Australia), Washington DC and Minnesota in the U.S., it found that bike sharing can increase rather than reduce overall motor vehicle usage, when the effect of bike maintenance and re-distribution is accounted for. Re-distribution of bicycles is necessary to correct any imbalance in the number of available bikes and free docking points across the network.

A key limitation of this study relates to the inability to include the contribution of casual users, who might have a different pattern of use and mode substitution rate than those of members.

21.3.9 Health impacts

Health impacts from bike sharing have recently started to attract attention and a few studies are now available, which collectively suggest that bike sharing can have health benefits. However the different methodological approaches used do not allow for reliable comparative assessments.

Commuting by Valenbisi was found to provide about half the recommended weekly physical activity (150 min) and a small reduction in the students' Body Mass Index (BMI) was reported. These results suggest that BSSs can have a positive role in the promotion of healthy weight, potentially preventing 2 kg/academic year of weight gain¹³. Similarly, a survey of CaBi found that of over 3,100 responses, 31.5% reported reduced stress, and about 30% indicated they lost weight due to using Capital Bikeshare¹¹.

Positive health benefits from bike sharing were reported by two health impact studies using different modelling techniques, data and assumptions.

The most recent¹⁵, based on actual data from the London BCH, found positive health impacts, but not currently accruing equally to the different social groups using the scheme. The benefits were clearer for men than for women and for older users than for younger users. A limitation of this study is that it only modelled health benefits from short-medium term behaviour change, without accounting for the possibility that cycling at a particular age increases cycling across the life course, or otherwise affects disease incidence at older ages. According to the authors, reliable data on such long term effects are limited and their omission in the model may have underestimated the lifetime health benefits to those who start cycling at young ages.

The other health impact study, using Bicing in Barcelona as a case study²⁴, estimated 69.2 deaths averted per million users per year, significantly higher than the results obtained by the London study, which generated estimates of 3.3 to 10.9. This is due to the different schemes and cities under consideration, models used and assumptions made.

21.3.10 Economic impacts

Only two studies seeking to quantify the local economic impacts of bike sharing have been identified, thus the evidence on this issue is limited. These examined the economic benefits accruing to both users and businesses and suggested that bike

sharing can generate economic benefits and contribute to enhancing local economies. The magnitude of such benefits, and associated level of confidence, is however limited.

Buehler & Hamre (2014)²² investigated potential economic benefits of CaBi, Washington DC, at the neighbourhood level through a survey of users and businesses proximate to bike sharing stations. Only a minority of surveyed users (23%) reported spending more money because they used CaBi. The business survey showed that while 70% identified a positive impact of BSS on the neighbourhood, only 20% reported a positive direct impact of bike sharing on sales. In addition, 61% would have either a positive or neutral reaction to replacing car parking in front of their business with a bike sharing station but were less favourable towards converting the sidewalk.

The other study²⁹, looking at Nice Ride Minnesota, also found positive economic impacts and estimated that BSSs can generate additional economic activity in the proximity of bike stations. An average of US\$1.29 per week was reported, which would equate to US\$29,000 over the season April to November.

Limitations of both studies include the timing of the surveys in a particular time of the year, which affects the results obtained, and the fact that both the user and business surveys collected estimated spending information based on subjective assessments and perceptions, rather than actual monetary transactions.

As discussed earlier, bike sharing can further benefit users by reducing their travel time and associated costs, which has relevant economic implications. Using actual usage data on bike sharing journeys, including duration and distance, Jensen et al. (2010)³⁰ found that most journeys on the Lyon scheme were shorter than a trip by car and calculated a 13% reduction in travel time compared to using a car for the same journey. In their study of the health impacts of the London BCH, Woodcock et al. (2014)¹⁵ estimated a 20% average time saving for trips made using the shared bikes as opposed to the alternative

modes used previously. Although these estimates for time saving have not been translated into monetary benefits by the respective studies, a report by Transport for London (2014)²³ provides a calculation of such benefits as part of a broader economic appraisal of the London BCH. This is discussed in the following section.

21.3.11 Evidence gaps

This review has found that the overall evidence on the impacts, and especially on the benefits, of bike sharing is growing but is still limited in terms of the range of case studies available, the methods used, the data collected and/or generated, and the range of characteristics and impacts that have been examined. Further research is needed to allow for systematic comparative analysis of schemes and to increase the level of confidence associated with the results. In addition to the evidence gaps and areas of weakness highlighted earlier, there are further issues that need to be addressed in depth:

1. The perceptions, attitudes and preferences of the social groups that least join and use these schemes, such as those who are able to ride a bicycle but do not cycle, ethnic minorities, disadvantaged social groups, women and older people;
2. The wider impacts of bike sharing on BSS users, in terms of overall mental and physical well-being;
3. The effects of bike sharing on the wider population, in terms of perceptions of the schemes and attitudes to cycling and cyclists, which would improve understanding of whether and to what extent BSSs can act as catalysts for private bike riding and help 'normalise' cycling;
4. The links between bike sharing and travel plans, and the extent to which BSSs systems can support them through strategic location at major workplaces, hospitals and other key destinations.
5. Finally, the impacts of BSSs on urban liveability, city image and tourism.

This review also found a very limited range of robust evidence on the process of setting up and operating BSSs,

in particular generated by in-depth process evaluations of the drivers and barriers to implementation, and of the characteristics that support or hinder the continuing 'success' of a scheme. Crucially, evidence on whether schemes are successful according to their original objectives is also lacking. These are all areas that merit further attention and investigation.

21.4 Lessons for Successful Deployment of this measure

21.4.1 Issues around Complementarity and Transferability

Despite the limitations identified by this review, some of the available evidence does contribute to shed light on what factors are at play and in which context in producing specific outcomes from bike sharing. This can be helpful in understanding how particular beneficial impacts, or positive implementation and operation processes, could be replicated in other locations wishing to introduce bike sharing.

The most significant consideration to be drawn from the reviewed evidence is that bike sharing benefits from, and is dependent upon, clear political, policy and public support to sustainable travel and cycling in particular. The development of a positive cycling culture, growing cycling levels and supportive policy measures, such as the provision of quality cycling infrastructure, have all been identified as important complementary factors that can sustain bike sharing during and after implementation. Bike sharing, in turn, has the potential to reinforce a positive image of cycling, as some of the evidence shows.

The London scheme, for example, was conceived and implemented in the broader context of the Mayor's Transport Strategy, the Mayor's 'Cycling Revolution' and effectively contributes to deliver the Mayor's Vision for Cycling in London²³.

Moreover, this and other successful schemes, such as Dublinbikes in Ireland and Bixi in Montreal, were implemented alongside improvements in the cycling infrastructure and in the context of sustained growing cycling trends.

However, achieving success in terms of usage rates does not guarantee that BSSs are also socially inclusive. Bike sharing tends to attract a particular profile of user: male, white, employed and, compared to the average population in which BSSs are implemented, younger, more affluent, more educated and more likely to be already engaged in cycling independently of bike sharing.

If promoters and operators of BSSs wish to achieve equity of access, then schemes need to be made available, attractive, accessible and affordable to a variety of social groups and types of users (registered members and casual users). Furthermore, the evidence on enabling factors to bike sharing operation suggests that effective and ongoing public engagement, including challenging negative perceptions of cycling, may help attract and maintain a diverse range of users.

Making bike sharing more inclusive could also contribute to a more equitable distribution of its positive outcomes, in particular in relation to health benefits and improved experience, accessibility and affordability of personal travel, through greater transport choice, reduced journey times and mobility costs.

Shared bicycles flows have been shown to be dependent on BSS attributes, such as station location and capacity, and positively correlated with a number of variables specific to the area in which a BSS is introduced. These include the availability of cycle infrastructure, mixed land use, spatial accessibility, population and job density. Therefore these factors need to be considered when planning BSSs.

Moreover, whilst commuting appears to be a key purpose for using bike sharing, temporal variables have been shown to affect patterns and purpose of use, so bike sharing can provide access to a variety of activities, including but not limited to employment. This is relevant to understand how bike sharing can contribute to enhancing users' social inclusion and well-being.

Rather than substituting for car journeys, bike sharing is predominantly used instead of walking and public transport. Overall, cycling behaviour is shown to increase while driving to decrease, albeit for a smaller proportion of users. However, while cycling levels may increase as a result of bike sharing, the potential displacement of physical activity through walking should be borne in mind when supporting the introduction of bike sharing on public health grounds.

Bike sharing can, at the same time, connect to and substitute for public transport for different types of trips and users. The exact outcome of this combination is the result of a complex interrelationship among various factors, such as scheme attributes and the characteristics of the area of implementation, including travel patterns and public transport infrastructure. Therefore it is important to understand how these factors play out in different contexts, in particular by taking into account the specific regulatory framework underpinning bike sharing and public transport ownership/operation. This in turn may have a significant impact on how bike sharing can be used to help manage public transport demand, and how the outcomes of this interaction benefit users and transport operators.

When the effect of using motorised fleets for bike maintenance and re-distribution is accounted for, bike sharing can increase rather than reduce overall motor vehicle usage and emissions, with associated negative environmental and air quality impacts. Re-balancing the bike network has also been identified as a key operational challenge. Deploying low or zero emission vehicles for this task may help increase the environmental credentials of BSSs. Additionally, by using a system of financial incentives and/or dynamic pricing to users based on real-time assessment of the re-balancing needs of the network, BSSs might become more self-rebalancing and need less external intervention.

Bike sharing can generate economic benefits and contribute to enhancing local economies, by connecting people to employment, retail and other places where economic activity takes place. It is impor-

tant to develop innovative evaluation tools that are specific to bike sharing and capture their full range of impacts, not just those which are easily quantifiable.

21.4.2 Issues around barriers and drivers to implementation / operation and resilience / durability

An important area of 'success' emerging from various guides to bike sharing implementation is the ability of BSSs to generate revenue, hence reducing the amount of public funding or other subsidies necessary to run these schemes. Local governments can support bike sharing directly with a subsidy or indirectly by allowing operators to advertise on the bicycles, stations or other public spaces. Overall, the readily available evidence on the financial viability of existing bike sharing systems is limited and predominantly qualitative in nature. This may be due to the commercial sensitivity of such information. Only one quantitative economic appraisal has been identified, which however acknowledges limitations in the assumptions and values used to monetise the costs and benefits of bike sharing²³.

Interviews with North American scheme operators^{11, 16} found that membership fees, usage fees, and sponsorships account for the vast majority of operating income. Additionally, four key factors impacting profitability were identified: the location of bike sharing stations, in particular near tourist attractions and public transport, and in mixed-use areas; the ability to retain registered members, e.g. annual members; providing a range of discounts; and, finally, the ability to find new revenue sources. The interviewed operators also stressed that whilst securing a strong core of annual members was important to success, tailoring the system to encourage occasional/casual use was imperative for a system's long-term economic viability, especially in lieu of public subsidy.

A recent economic appraisal of the Barclays Cycle Hire by Transport for London (2014)²³ found a Benefit-To-Cost Ratio (BCR) of 0.7:1 based on outturn costs, revenues and benefits realised to date plus forecasts up to 2017/18. The mon-

etised benefits realised to 2013/14 accounted for £55.3m of the expected total of £129.4m to 2017/18 and included: journey time savings of £26m (£61.2m expected overall to 2017/18); health benefits of £22.5m (£70m overall); ambience benefits of £7.4m (£20.6m overall). Ambience benefits include the provision of way-finding at stations, the value of a new bicycle and maintained bicycle, improvements in bicycle and docking point availability and the value of CCTV and lighting at docking stations. The total cost of the scheme to date is £133m, including both capital and operating costs from scheme inception to 2013/14.

In terms of drivers and barriers, only two studies^{11, 16} appear to have systematically collected and analysed the views of BSS operators and stakeholders to understand the challenges and facilitating factors experienced in the implementation and operation of BSSs. However, these reflect only the North American context. Process evaluations of existing schemes are therefore needed to improve knowledge of what works and where in delivering and operating BSSs.

Challenges include bicycle re-distribution, which can be a complex and costly task to organise; addressing negative perceptions of cycling as unsafe and, in certain cultures (e.g. Mexico City), associated with being poor; mandatory helmet legislation; insurance and other legal issues.

Vandalism and theft are both reported to negligible, as are bike sharing accident rates (4.3 accidents per year for schemes with over 1,000 bikes are reported).

Facilitating factors include: establishing partnerships within local government and with community stakeholders; marketing and public outreach prior to and after launch, e.g. by engaging the public through public fora and online-based "suggest-a-station" platforms; locating bike sharing stations through appropriate spatial analysis to support system use; employing mobile station technology that can be easily relocated according to usage patterns; the use of advanced technologies to track bicycles, understand user behaviour, deter bike theft and support system manage-

ment, for example through pay-as-you-go services; and facilitating membership portability and interoperability.

Similar recommendations are provided by Transport for London (2014)²³, in particular around the value of enhanced partnership working with London Boroughs; the adoption of appropriate project management tools to control costs and improve scheme delivery; detailed launch management; accounting for customer feedback; adopting a system software with enhanced asset management, automated job scheduling capabilities and improved billing and customer self-service processes.

Among the challenges experienced in the delivery and evaluation of the Barclays Cycle Hire, Transport for London (2014)²³ highlights the lack of performance benchmarks specifically for bike sharing at the time of scheme implementation, and the need for improved bike sharing modelling/appraisal techniques and tools.

21.5 Additional benefits

As well as the evidence of economic and financial benefits of interventions discussed above, there are a number of additional benefits that are claimed for these policies:

- **Health benefits:** Users can benefit through improved personal health, as well as potentially contributing to air quality improvements if changing from motorized transport.
- **Access to mobility:** BSS offer increased transport choice and convenience, reduced travel times, increased affordability of personal travel and potentially an improved travel experience for users.
- **Mode choice:** Bike sharing can influence and change the travel behaviour of users, but with differing results in different contexts. The ability of bike sharing to attract trips previously made by private vehicles remains a key challenge, with bike sharing predominantly replacing walking and public transport.
- **Cycling culture / road safety:** Bike sharing can contribute towards raising awareness and acceptance of cyclists, contributing to increasing road safety for cyclists.

21.6 Summary

The most significant consideration to be drawn from the all reviewed evidence is that bike sharing benefits from, and is dependent upon, clear and consistent political, policy and public support to sustainable mobility and cycling in particular. The development of a positive cycling culture, growing cycling levels and pro-cycling policy measures, such as the provision of high quality and safe cycle infrastructure, have all been identified as important complementary, and in some cases determining, factors that can sustain bike sharing during and after implementation. In other words, bike sharing needs to be implemented as part of a comprehensive and consistent package of measures making active travel safe, attractive and inclusive. Process evidence also identified partnership working and continuing involvement of stakeholders and local communities as facilitators to bike sharing implementation. Bike sharing, in turn, has the potential to reinforce a positive image of cycling. Achieving success in terms of usage rates does not guarantee that BSSs are also socially inclusive. An established and broadly consistent body of evidence suggests that bike sharing tends to attract a particular profile of user: male, white, employed and, compared to the average population in which BSSs are implemented, younger, more affluent, more educated and more likely to be already engaged in cycling independently of bike sharing.

Making bike sharing more inclusive could also contribute to a more equitable distribution of its positive outcomes, in particular in relation to health benefits and improved experience, accessibility and affordability of personal travel, through greater transport choice, reduced journey times and mobility costs.

Shared bicycles flows have been shown to be dependent on BSS attributes, such as station location and capacity, and positively correlated with a number of variables specific to the area in which a BSS is introduced. These include the availability of cycle infrastructure, mixed land use, spatial accessibility, population and job density.

Rather than substituting for car journeys, bike sharing is predominantly used instead of walking and public transport. Evidence on broader travel behaviour change as a result of bike sharing is more mixed and varies according to the specific context of implementation and in respect of different transport modes. Overall, cycling behaviour is shown to increase while driving to decrease, albeit for a smaller proportion of users. Bike sharing can, at the same time, connect to and substitute for public transport for different types of trips and users. The evidence on environmental impacts is very limited. When the effect of using motorised fleets for bike maintenance and re-distribution is accounted for, bike sharing can increase rather than reduce overall motor vehicle usage and emissions, with associated negative environmental and air quality impacts.

Bike sharing can generate economic benefits and contribute to enhancing local economies, by connecting people to employment, retail and other places where economic activity takes place. However the evidence is very limited and the magnitude of benefits appears to be modest. Rather than being an isolated cycling measure, bike sharing shows the ability to be an effective part of sustainable mobility packages, especially when schemes are designed with a set of measurable objectives in mind, are implemented in partnership with local governments and other local stakeholders, are inclusive in the range of communities involved, employ effective delivery, management, monitoring and evaluation processes, and are continuously improved by taking into account monitoring data, users' feedback and changes in the overall transport network characteristics.

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