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Transport in Human Scale Cities

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Transport in Human Scale Cities
Edited by Miloš N. Mladenović, Tuuli Toivonen, Elias Willberg and Karst T. Geurs

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This book is dedicated to the memory of Moshe Givoni. Moshe has been an active and much appreciated member of NECTAR since 2003. He joined the cluster leadership of the Networks Cluster (Cluster 1) in 2005 and has been active in organizing several NECTAR events. Moshe was an inspiration for many of us by pushing high-quality research and promoting better transport policies. At the same time Moshe was a kind, generous, humble and an incredibly positive person, always interested in other peoples' research and lives, encouraging publications and meetings. We hope this book will help to continue Moshe's ambition to promote research and better policy making to transform our urban mobility systems.

The book is also dedicated to all those practitioners who urgently feel the need to act on transforming our mobility systems but have not always historically been trained to do so from the perspective of human beings. Thus, we hope this book will be of help to them in making one step closer to human scale cities, for all our sakes.

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PART I

Introduction

1. Setting the stage for transport in human scale cities

Miloš N. Mladenović, Karst T. Geurs, Elias Willberg and Tuuli Toivonen

By far the greatest and most admirable form of wisdom is that needed to plan and beautify cities and human communities. (Attributed to Socrates)

THE NEED FOR MOBILITY SYSTEM TRANSFORMATION TOWARDS A HUMAN SCALE

Millennia have passed since the above statement attributed to Socrates of Athens. One can only imagine that Socrates had something in mind for posterity with that statement. Nonetheless, one could wonder what can Socrates teach us in the 21st century. After all, are not the problems of Athens rather minute to us, as we now collectively as humanity face a range of wicked challenges? Was not Athens rather an exception of its time, since the majority of the population did not live in cities, as opposed to our rapidly urbanizing planet at the moment? Nowadays, we recognize our existence in a state of deep uncertainty, for all our cities. Such a deep uncertainty became widely apparent with the worldwide COVID-19 pandemic. During this time, it has become even more obvious how crucial a role transport systems have for the functioning of our urban communities.

Besides the important role for functioning of 21st century cities, the transport sector is still one of our greatest sustainability challenges (Geurs and Macharis, 2019). The 21st century is the century when we need to radically reduce our dependence on fossil fuels and thus reduce the amount of greenhouse gas emissions. This includes a significant reduction in carbon emissions from urban transport, which are not declining at an acceptable rate (IPCC, 2019). Of course, transport is contributing not only to greenhouse gas emissions, but also to a range of other environmental pollutants, affecting a range of aspects, from our bodies to cultural soundscapes. At the same time, energy and other resources are limited, just as is our planet (Raworth, 2012), and we have to adapt to the ongoing changes of our planet (Koetse and Rietveld,

2012). In addition, transport is the eighth-leading cause of death globally, with 1.35 million deaths and 50 million injuries each year (WHO, 2018). Hand in hand with direct safety and security issues, our urban mobility systems have contributed to further deterioration of our physical and mental health, locking us further into inactive lifestyles and depleting our social capital (Lucas et al., 2016).

All in all, we have a long list of challenges ahead for our automobility regime (Urry, 2004). However, the challenge is not solely that we experience these and many other undesired consequences. In addition, the challenge is not only that aggregate negative effects are significant, but also that mobility is so intertwined with the functioning of our society that any initiative aimed at either increasing or reducing it inevitably leads to both positive and negative effects – making it a true moral dilemma (Bertolini, 2017). Thus, our challenge is one of not only utilitarian but also distributive justice. Observed through this perspective of distributive justice (Rawls, 1971), we now know that many of these harmful consequences are not equally distributed across diverse humans in our cities. We all too often find that certain groups of people bear the greatest burden, including for example children, the elderly, poor, LGBTQ (lesbian, gay, bisexual, transgender, queer or questioning), or persons of colour.

In general, we know what should be done to transform our currently unsustainable urban mobility systems. First and foremost, we need to reduce the total amount of travelling and make a rapid modal shift away from car-dependent lifestyles supported by systemic efficiency increases (Banister, 2008). However, the devil in the details still lurks, if we are to change our future lifestyles. We have to face the fact that our urban mobility systems are irreducibly complex, with non-linear and rapidly changing dynamics due to a large number of interdependent natural and infrastructural relations (de Roo and Silva, 2010). Thus, systemic transformation requires a necessary trade-off by ensuring fairness during and from this transition, and delivering well-being and quality of life for all; making this transition essentially an intra- and intergenerational social justice question (Sheller, 2018). Such transitions out of our unsustainable lifestyles require changes not only in the built environment, technological systems or even policies but also, most importantly, in our behaviours and societal values (Geels et al., 2017).

A HUMAN BEING ON THE MOVE IN THE HUMAN SCALE CITY

If we are to talk about changes in human behaviour, values and ultimately lifestyles, we ought to ask ourselves: what is it to be a human on the move in the city? The human in the city imagined after World War Two (WW2), during the foundational stage of transport engineering as a discipline, is *Homo*

economicus. Travelling for that human is a burden and derived demand, as demand for a factor of production or intermediate good that occurs as a result of the demand for another intermediate or final good. Such a human is able to calculate the generalized cost of each journey as the risk- and comfort-adjusted weighted sum of time spent on travel or activity, the associated expenditure and the social content of the movements and activities. Such a human is essentially a utility maximizer, capable of perfectly understanding and ranking all alternatives, with stable preferences over time, and living in a world with little to no externalities. The rational decision made by such a human is to minimize transport costs, often expressed as quantity of travel time.

This simplified image of a human being has combined well with civil engineering and operations research disciplines gaining importance after experiences during WW2, and the strengthening of research-based universities. At the core of their epistemology, these disciplines, in line with neoclassical economics, focus on an aggregated, and some would say narrow utilitarian, perspective on mobility systems. Thus, understanding complex mobility systems needs primarily aggregated spatio-temporal representations, such as average annual daily traffic or origin–destination desire lines. Moreover, understanding mobility system dynamics requires only understanding relations between quantifiable parameters of traffic volume, density, speed and travel time. Conveniently, such aggregations fit well with the supply and demand curves used to represent system equilibrium in neoclassical economics. As a result, taking actions in regard to mobility systems is seemingly impossible to not be formulated as a straightforward objective function, such as minimizing total travel time of all the users on a given network.

Contrary to the *Homo economicus* model, there is a large body of evidence developed after WW2 that everyday travel decisions are not exclusively governed by perfectly evaluating, cost-minimizing and utility-maximizing human beings. Our rationality is not as comprehensive as the *Homo economicus* model would suggest, but it is ultimately bounded (Simon, 1990), as we rely on mental shortcuts and heuristics, with plenty of decision biases. We are at the same time driven by risk aversion, seeking stability and routine on the one hand; while often seeking variety, as desire for the unfamiliar or even alteration between familiar alternatives, on the other hand. We often simplify everyday decisions to a manageable level using these heuristics, as long as they keep on working without a critical failure of the decision-making process. These rules of thumb about everyday mobility decisions, such as choices of modes or routes, are coloured with different affective and cognitive experiences (De Vos, 2019), whose effect over time helps them to be formed and reformed. These individual experiential considerations are vital for the overall happiness and wellbeing, and can in turn have far-reaching implications on social and environmental issues (Nasar, 1988). In addition, urban mobility systems are

determined by our collective customs and assigned meanings of normality, and in relation to these have an important role to play in creating stability and reliability needed for everyday mobility practices (Cairns et al., 2014). Finally, such norm-based underpinnings of our mobility behaviour might be framed by both positive freedom, as opportunity to act, and negative freedom, as permission to act without constraints (Berlin, 1969 [2000]).

In addition to the above examples, at the centre of much-needed reinterpretation of the human being on the move in the city is that human ends are multidimensional, but are also not static and fully defined, with changes within a single individual and over various groups, all over time. In addition, one of the key knowledge turns is that humans are in their everyday essence moving beings: *Homo mobilis* (Mladenović et al., 2019; Van Geenhuizen and Nijkamp, 2003). To get a glimpse at further layers in our understanding beyond *Homo economicus*, one only needs to think about the greatest punishment we impose in the modern legal systems, which is significant restriction of movement in prisons; or the difficulty of citizens across the globe to comply with travel restrictions imposed by governments to cope with COVID-19 pandemic. Thus, *Homo mobilis* often has an intrinsic desire to move in the everyday environment, with travelling being an endemic fact of daily flow that can be a purposive activity in itself (Jensen, 2009). With these examples, our intention is certainly not to end the story of *Homo mobilis*, or to pretend to have a unified grand theory of human beings. Nonetheless, we would underline the need to move away from the imagined *Homo economicus*, no matter whether on the surface such a model presents us with an apparent unity in understanding the human being.

TOWARDS TRANSFORMING OUR UNDERSTANDING OF FUTURE-MAKING ORGANIZATIONS

The 20th century paradigm of *Homo economicus*, aggregation as the way to understand system dynamics, and straightforward objective functions focused all too often on minimizing, is now in turmoil. Perhaps it is not only inevitable that the paradigm will gradually decline and fade away. Perhaps it is bound to disappear into history by rapid and sudden collapse. Perhaps this disadvantageous paradigm just needs the final nudge to collapse. With the above-mentioned fundamental gap in our understanding about mobile humans in the city, was there after all some wisdom in Socrates mentioning the greatest and most admirable form of ‘wisdom’ needed for shaping these living environments? It seems that we need to continue our reflection further. What deeper challenges for the paradigm shift and adaptation of the institutional capacity can we identify beyond the usually mentioned resource constraints, or often-lacking political will for a necessary change?

Finding further challenges for the paradigm shift requires us to unpack assumptions about actants and processes in diverse organizational networks responsible for future-making. Here, we cannot limit ourselves only to the usual focus on transport planners as civil servants. We need to expand our focus to include other actants in the wider planning and innovation realm, especially since in this historical moment we have an unfolding of a significant amount of a diverse set of technologies and services in urban transport worldwide. Having in mind these people, the 20th century paradigm assumes that their role in future-making is one of experts and analysts, who should be objective and value free. Furthermore, the purpose of future-making is problem-solving and optimization, often framed as finding the best solution for a fixed and known set of ends, while also knowing beforehand all constraints. Hand in hand with this assumption, any future-making process should be a sequence of linear and logical steps, with some feedback loops, where facts and values can be addressed separately. Thus, in these processes, analysis and decision-making are separate, and problems can be defined in the absence of solutions. Ultimately, our organizational processes are mainly about predicting all the future problems, finding all the relevant alternatives, predicting the future status of the world, estimating outcomes, defining preferences for all outcomes, and effectively communicating with – or, some would say, educating – the decision-makers in our modern democracies.

An essential challenge to how we understand these human organizations and processes behind the much-needed transformation of our cities stems from the deep uncertainty of our lifeworld. The state of irreducibly high uncertainty creates huge difficulties for any attempts to define and predict the consequences of our actions in the present. Thus, we are facing self-reinforcing uncertainty, where we cannot know the future states of the world, and thus cannot predict and provide (Lyons and Davidson, 2016). This uncertainty should not be confused with our lack of data or of more advanced models. So, we are not just talking about content uncertainty, such as availability of information on time or contested knowledge in modern pluralistic societies with diverse social relations (Mouffe, 2000). Quite the contrary, this is an irreducible uncertainty of human existence, and is in fact plural: uncertainties. We can identify at least two more types, one being strategic uncertainty, such as challenges in articulating problems, anticipating actor responses, interactions and interests; and the other being institutional uncertainty, as we have processes with many actants with different institutional backgrounds stemming from often divergent institutional regimes and informalities (Koppenjan and Klijn, 2004).

Given the contested, complex and ambiguous nature of our lifeworld, how are we supposed to ‘muddle through’ (Lindblom, 1959) when making decisions about the future? Here, it is certainly obvious that future-making, especially underlined by diversity of values, requires advanced democratic

institutions and processes. Future-making – and city-making – is thus not a technocratic but rather a political process, and a practice of knowing and acting. Given the above-mentioned uncertainties, future-making as the process of context-specific knowing thus includes several knowledge dimensions, as knowing what (cognitive/theoretical knowledge), knowing how (skills/technical knowledge), knowing to what end (moral choices) and doing (action/practice) (Davoudi, 2015). This situated knowing is provisional in the sense that it is constructed and constantly changing in a context which itself is constantly developing, where diverse actants have a varying capacity for knowing. These different capacities for knowing ultimately lead to challenges at the level of a single individual learner and knowledge integration, exposing previously hidden interrelatedness of (un)known factors.

Taking the idea of situated knowledge integration further through a processual perspective, we can find many parallels between many different fields reflecting on future-making, from urban planning to responsible innovation (Stilgoe et al., 2013). A similar set of principles emerges across these disciplines, which do not agree with the aforementioned predict-and-provide paradigm from the 20th century. Moving beyond the simplistic top-down towards more open-system processes, we should: (1) anticipate; (2) reflect; (3) deliberate; and (4) organize. This process assumption involves a higher degree of collective imagination about futures beyond path dependence, unpacking our assumptions and dilemmas, recognizing unknown unknowns, co-constructing and deliberating about (un)desirable visions, and understanding missing actants or relations between them, with associated roles and responsibilities in dynamic future-making networks.

As already mentioned, all this knowing and acting does not only happen at the level of individual actants, from offices of public administration in Lapland to coders in Silicon Valley. All the knowing and acting is both distributed and collective, requiring individuals to learn, but also to share group understanding. In learning from others, new practices are transferred, recombined and learned as they are created, and often involve knowledge that cannot be transferred. In addition, knowing and acting is mediated and contested through various relations between humans and with technologies (Verbeek, 2011). Taking into account these strong and loose webs of diverse actants, transformation of our cities will have to go hand in hand with transformation of our multi-level networked institutions. This transformation of our networks will require an understanding of their multiple ways of (un)learning over time (Albrechts et al., 2019; Baum, 1999). Such intra- and interorganizational (un)learning over time will have to recognize and embrace the human scale of these institutions themselves, recognizing unavoidable socio-emotional aspects (Mladenović and Eräranta, 2020). Ultimately, just as in our cities, socio-cultural structures within organizations are all too often in non-integrated silos. Such structures

provide templates for the actant's experience, behaviour and identity, and are in turn shaped by the actant's activities over time.

PERVASIVENESS OF HUMAN SCALE IN OUR CITIES AND ORGANIZATIONS

Our reflection so far has taken us to recognize that we need to move away from the narrowly defined rationalist perspective on people on the move in the city, and people within organizations responsible for crafting futures of cities. Instead, we need to recognize the dynamically complex nature of people both in cities and in organizations. Anywhere we look into our modern systems, human scale seems inevitable. Perhaps embracing this pervasiveness of human scale seems inevitable. Perhaps the preservation of the status quo seems irresponsible. For example, we cannot pretend there are some 'average' humans in our cities, whose primarily commuting needs in the morning and return from work are all we need to care about. Similarly, we cannot pretend there are 'average' organizations and processes responsible for crafting urban futures. Either way, such assumptions will keep on locking us into the fundamentally unjust state that our systems recreate.

To unpack the multidimensional challenge for sustainability transformation, we need to further underline the potential in the concept of human scale cities. Similar terms such as 'liveable city', 'inclusive city', 'convivial city', and others have been emerging in recent years across policy and research documents. They are in themselves a proof of a need for paradigm change, as the 20th century paradigm is proving ineffective to deal with a multitude of present challenges. For this reason, the concept of human scale is an essential inspiration for a perspective shift in (un)learning in modern transport organizations. In addition, human scale is a foundation for a robust understanding of present problems and barriers to change. As such, human scale can be a guiding principle in context-dependent situations for nurturing the wide range of cities around the world, by opening the windows of opportunity for challenging the obsolete 20th century approach. With all this in mind, it seems that we still have something to learn from Socrates and his message from more than two millennia ago. Rescaling our focus towards human communities in cities can be a turning point for us collectively making cities and transport systems better for all life on this planet. How we integrate different kinds of knowledge–action aspects is something that is underpinning the 21st century endeavour, and an underlying motivation for any piece of writing.

THE SCOPE OF THIS BOOK AS A CONTRIBUTION TOWARDS HUMAN SCALE CITIES

This is the ninth book in the Network on European Communications and Transport Activities Research (NECTAR) Series on Transportation and Communications Networks Research, and stems from the contributions to the 2019 NECTAR conference organized in Helsinki, Finland. The theme of the conference, and thus the theme of this book, was ‘Towards Human Scale Cities – Open and Happy’. Despite the fact that the chapters were mostly written before the COVID-19 pandemic, lessons for this and future times when deep uncertainties surface can be found across the chapters.

The book itself is organized into five parts, and all contributed chapters have been peer reviewed. Part II of this book includes six chapters, and aims to further expand our understanding of the human scale in the urban transport systems. Chapter 2 presents a critical analysis of relationships between transport and wellbeing. Chapter 3 explores a relationship between the distribution of the walkable qualities across different socio-economic groups, considering the distance to the city centre where most of the facilities are concentrated, through a case of Lisbon, Portugal. Chapter 4 assesses the relationship between accessibility, mode choice and income in Recife, Brazil. Chapter 5 focuses analysis on the difference that public transport subsidies make to workers’ quality of life, using the case of Vancouver, Canada. Chapter 6 aims to understand challenges and motivators for walking and public transport use among the elderly, with insights from Porto and Lisbon, Portugal. Similarly, with a focus on mobility of elderly, Chapter 7 focuses on the needs and preferences related to car sharing in Oslo, Norway.

Part III of the book includes four chapters, further outlining the lessons for responsible innovation practices in mobility systems if we are to advance the human scale mobility technologies. Chapter 8 provides lessons for using stated adaptation experiments to understand the intended mode choice change in relation to the emerging Mobility-as-a-Service concept. Chapter 9 overviews the lessons from an automated bus deployment on a public road in Stockholm, Sweden. Next, Chapter 10 focuses on implications for behavioural change from monthly cycling challenges by using a smartphone application. The last chapter in Part III, Chapter 11, examines expert perspectives in Germany on neighbourhood-level integration of mobility measures and services.

Part IV includes seven chapters, elaborating on lessons for developing urban and transport planning processes, taking into account new data, methods and approaches. Chapter 12 provides a set of heuristics for repurposing street networks away from sole focus on private car use, using bicycles as proxies for human-scaled vehicles. Chapter 13 presents a case study of a planning

support system aimed at areas with potential for cycling investments in starter cycling cities, applied to Matosinhos, Portugal. Chapter 14 compares a range of common qualitative and quantitative data sources for conducting cycling studies worldwide. Next, Chapter 15 presents a performance analysis of factors associated with citizens' sensing from case studies in the Netherlands. Chapter 16 reviews experiences from transport planning projects in the United States, United Kingdom, Finland, the Netherlands, Australia and New Zealand which have implemented public participation geographic information system (GIS) methodology. Chapter 17 analyses the application of Multi-Actor Multi-Criteria Analysis for participatory evaluation of co-designed solutions to transport problems in Brussels, Belgium. The last chapter of Part IV, Chapter 18, is a case study analysis of metro planning and implementation in Lima, Peru. Finally, the book ends with Part V, which in Chapter 19 provides a summarized set of findings and selected points for action from the whole book, thus serving as its conclusion.

As any piece of literature, the book also had to leave certain aspects out of its scope. Overall, the book mostly focuses on lessons from medium- and high-income countries, showing that transformation even in these places is not as straightforward as one could assume, given the resources available. Nonetheless, some lessons could be drawn indirectly for low-income countries, if they are to avoid and leapfrog over the unsustainable path dependencies associated with the petroleum-fuelled car-dependent societies. Ultimately, we hope that this book will be another swing at the cracking 20th century paradigm, and a gust of wind in the sails of the emerging, and much needed, human scale one – the one suitable for the challenges of the 21st century.

The book is considered to be useful for a range of policy-makers, practitioners, as well as citizen advocates, as they would find a range of compelling arguments for broadening the discussion on understanding humans in the city, and necessary actions for the transition out of the current unsustainable regime. In addition, educators and graduate students could use parts of this book, especially from Parts I and III, as general reading material in (transport) planning and policy courses. Finally, researchers would find plenty of inspiration for exploring new research and action directions across specific chapters, and as summarized in the concluding Part V.

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PART II

Understanding human scale transport in cities

2. Urban transport and wellbeing: a critical analysis

Tim Schwanen

I just wanted to be recognized and remembered by my nephews, by my kids ... always be an example to someone, like many were for me, as a reference of good things for those growing up. At least that, do something nice for the people in the suburbs [peripheral, typically poor areas at considerable distance from São Paulo's city centre], show the people that there are good things around here as well, there are some guys doing nice things here, right ... [I want to] transform them [by] showing a way out, even if they are in some sort of financial challenge, which is quite common [with] social inequality, and [that] you don't have to remain caught in consumerism, capitalism, right. Sometimes the guy wants to have that car anyway, he wants to have that car and there's no way to have it. You can be there walking and doing good things, right, instead of doing the wrong thing to be able to have that car. And look out for the community as well, right. Because in a certain way to the same people [to whom] you said 'we bring people to the streets and the streets become more secure', you are like the agents of well-being for that community, you are looking after the community, you are taking care of the community, occupy the streets to make them more attractive to everyone.

2.1 INTRODUCTION

Pedro was running a scheme of group jogs between and across peripheral, lower-class neighbourhoods in São Paulo when he was interviewed for a research project about community initiatives to promote walking and cycling. Like many other leaders of initiatives in São Paulo and London that were studied, Pedro was driven by a vision of the good life, society, and city and (local) community (see Schwanen and Nixon, 2020 for details on the study and methodology). It is interviews with the likes of Pedro that have helped me to realize that most of the conceptualizations of wellbeing in transport research are not as attuned to complexity, nuance and context as they might and perhaps should be. This shortcoming is particularly salient if research is concerned with the relationship between transport and wellbeing in cities characterized by sharp social and spatial inequalities, when disadvantaged groups are considered, and/or outside the Global North. Understandings of what the good life is and how it might be achieved are central to transport in human scale cities, and

academic perspectives on wellbeing and its relationship with transport must be able to capture their full diversity and dynamism.

In this chapter, I will elaborate a critique of the conceptual underpinnings of research on transport and wellbeing, and point towards other ways of thinking about that relationship. I will selectively review existing transport literature, most of which works with hedonic conceptions of wellbeing that concentrate on satisfaction with life or travel, or positive and negative emotions during mobility. Research adopting eudaimonic conceptions developed in psychology and focused on flourishing and fulfilment is also considered. I then identify several risks associated with deployment of these hedonic and eudaimonic conceptions in transport research, and offer some suggestions for a context-sensitive and process-oriented approach to wellbeing in transport research.

2.2 DOMINANCE OF HEDONIC UNDERSTANDINGS

The field of transport studies has long had an interest in the relationships between mobility and wellbeing. At least since the 1970s researchers have analysed satisfaction with transport modes, often in the context of work on the links between travel behaviour and attitudes (Recker and Golob, 1976; Dobson et al., 1978), or used measures of observed travel behaviour and/or accessibility to understand inequalities in fulfilment of need and opportunities to lead a satisfying life (Cutler, 1975; Pas and Koppelman, 1986). In this century, there has been extensive interest in transport-related social exclusion (Lucas, 2012), and much of this work also touches on themes related to wellbeing.

It is only since the late 2000s that research has been explicitly framed in terms of the relationship between subjectively experienced wellbeing and travel behaviour. Reviews of this research are available in De Vos et al. (2013), Mokhtarian (2019) and Chatterjee et al. (2020). Suffice to say that research in this vein tends to focus on individual experience and to privilege hedonic over eudaimonic understandings of wellbeing.

The previously introduced hedonic/eudaimonic distinction is common in the interdisciplinary ‘science of happiness’ literature. Hedonic perspectives on wellbeing focus on the passions; they typically rely on the measurement of, firstly, satisfaction as a cognitive evaluation of an individual’s experience of life in general or in specific domains, such as work or indeed travel; and secondly, affective responses in terms of pleasure experienced and pain avoided (Diener, 2009). The Satisfaction with Travel Scale (STS), originally proposed by Ettema et al. (2011) and now widely used, exemplifies the hedonic perspective very well, as it merges the cognitive and affective dimensions in a nine-item construct. Also belonging to the hedonic category are travel behaviour studies that examine the interrelations between feelings during specific

trips and longer-term mood and satisfaction (Gärling, 2018; Le and Carrel, 2021), or that work with Kahneman et al.'s (1997) distinction between utility as anticipated outcomes of choice alternatives (decision utility), and utility as experiences of pleasure and pain (experienced utility) (Abou-Zeid and Ben-Akiva, 2012). Even studies using bio-markers, such as skin conductance, to measure stress while travelling in a pre-cognitive manner – that is, without recourse to asking people what they (thought they) felt, and instead placing sensors on people's bodies (Teixeira et al., 2020) – belong to the hedonic tradition. Whatever the method, wellbeing is taken to be a subjective state that individuals can move in and out of, depending on experienced action or choice.

The dominance of hedonic perspectives on wellbeing in the transport literature has multiple causes. One is their popularity in the science of happiness literature, another their proximity to the theoretical frameworks that prevail in transport research. The work of authors such as Abou-Zeid and Ben-Akiva builds on the venerable random utility theory tradition that has long been influential in transport engineering. The STS approach developed by Ettema and colleagues is also no radical departure from thinking and research praxis in transport research. Both lines of inquiry build on (tacit) understandings of travel behaviour in their respective research communities. Linked to theoretical proximity is methodological continuity; psychometric measurement scales of hedonic wellbeing can be integrated relatively easily in the data collection instruments and procedures and econometric techniques that are widely used in transport research. Some of the early studies into the links between travel behaviour and attitudes (Recker and Golob, 1976; Dobson et al., 1978) used ordinal scale satisfaction ratings of service attributes to evaluate different transport modes, while research on pedestrian facility level of service has complemented 'objective' measures with indicators of the level of satisfaction with a given facility that study participants experienced (Khisty, 1994). Meanwhile, public transport research has for decades drawn on measures of user satisfaction informed by measures from marketing studies (Morton et al., 2016).

There has, however, been some experimentation with eudaimonic conceptions of wellbeing in transport research (Vella-Brodrick and Stanley, 2013; Singleton, 2019; Cuiquet et al., 2020). Eudaimonic perspectives come in different shapes and sizes but concentrate on self-fulfilment and flourishing (Waterman, 1993). They often go back to Aristotle, for whom pleasure and enjoyment were vulgar pursuits. Happiness, for him, is the self-sufficient 'end of all actions' that 'makes life desirable and lacking in nothing' (Aristotle, 2009 [n.d.], p. 11). Realizing individuals' *daimon* (the best in them), happiness is a state of being that makes people capable of political life in the *polis*. Aristotle also argues that happiness does not befall people but is a disposition to be achieved through the work (*ergon*) of virtuous action driven by rational thought. Aristotle defines multiple virtues, including temperance, friendliness

and truthfulness, all of which hold the middle ground between excess and deficiency. Significantly, he limited the ability to achieve happiness through virtuous action to free men. While the resulting exclusion of women and slaves was normal in the Athens of his days, it also makes Aristotelian happiness a political state of being (Agamben, 2016).

Rather than engaging directly with Aristotle, transport researchers have relied more on the writings of contemporary psychologists (Ryan et al., 2008; Ryff and Singer, 2008) who offer a very partial reading of the original works and typically ignore the politics of wellbeing in Aristotle's texts. As a result, transport research follows eudaimonic psychology in concentrating on the presence and attainment of constructs such as autonomy, positive relations, security, purpose in life, environmental mastery and personal growth. These are either imagined to co-exist alongside hedonic wellbeing (Singleton, 2019; Cuiquet et al., 2020) or act as precedents of hedonic wellbeing (Vella-Brodrick and Stanley, 2013; Ingvardson et al., 2020). For instance, Singleton (2019) uses survey data from Portland, Oregon to identify health, confidence, autonomy and security as eudaimonic constructs alongside the hedonic ones of enjoyment, attentiveness, distress and fear, and then correlates all of these with a series of travel behaviour indicators in a structural equation model.

2.3 RISKS AND ASSUMPTIONS

Much can be said in favour of the above perspectives on wellbeing in relation to transport, both of which help us make sense of Pedro's narrative at the start of this chapter. Without over-generalizing from a single case in a particular context, we can see from his reflections how moving around on foot can contribute to positive relations, environmental mastery and security for both the participants in Pedro's scheme and the inhabitants of the traversed neighbourhoods. The jog group scheme also gives purpose in life and positive relations to Pedro himself. Hedonic conceptions of wellbeing are evident in his discussion of (male) youngsters chasing the satisfaction that car use/ownership can give (and the dubious pathways this may lead them on). The interview also suggests that, on the whole, Pedro was quite satisfied with what had been achieved.

At the same time, his words offer a more critically reflexive and socialized account of wellbeing than most transport research on wellbeing does. Not only does he discuss multiple social and socio-spatial relationships, but he also refers to concrete individuals (his nephews and children), categories ('people in the suburbs', 'the guy') and socialities ('the community') in specific places within São Paulo, and positions them within the broader political economy contexts of consumerism and capitalism, known for the deep socio-spatial inequalities they engender. A hierarchy of wellbeing forms is emerging here,

one that is not grounded in the writings of one of antiquity's most well-known philosophers, but in the effects on people's lives and urban communities generated by the pursuit of different forms of wellbeing (in a manner that goes beyond discussions in the eudaimonic psychology literature; for example, Kasser et al., 2007; Richins, 2017). Pedro was certainly not the only participant in our study of community initiatives supporting walking and cycling in London and São Paulo to differentiate between 'wellbeings' in terms of the effects that their pursuit generates.

Transport researchers can benefit from critical reflection on the effects that the pursuit of wellbeing generates. It can help them to come to grips with the challenging political dilemma which researchers empirically probing the transport link tend to shy away from (at least in their publications): is the pursuit by some of wellbeing in urban transport desirable if it marginalizes or disadvantages others? This question is particularly salient in respect of, but not limited to, the pursuit of hedonic wellbeing which can end up valorizing and triggering what are ultimately selfish forms of urban mobility. The use of sports utility vehicles (SUVs) and light utility vehicles (LUVs) in urban settings epitomizes the dilemma. Promoted and used because of the comfort, pleasure and security they provide to drivers and passengers, SUVs and LUVs make roads less safe for the pedestrians, cyclists, e-scooter users, and so forth, who encounter them. They also create more pollution and carbon dioxide (CO₂) emissions than most other passenger vehicle classes (unless they are completely electrified), and have potentially major adverse impacts on the health and lives of people near and far (cf. Horrocks and Wilson, 2019). Addressing the effects that the promotion and pursuit of particular forms of wellbeing generate can help transport researchers to mitigate the risk of generating depoliticized outcomes and policy recommendations that may – indirectly and inadvertently – reduce the environmental and social sustainability of urban mobility.

Addressing those effects head-on also offers transport researchers a way of connecting with critical social science scholarship on wellbeing. That scholarship is highly diversified in terms of theoretical basis and substantive themes (Burnett, 2012; Frawley, 2015; Smith, 2019), but some of its insights are directly pertinent to transport research. Drawing on such scholarship can reduce the risks that research on the transport–wellbeing connection remains wedded to limited perspectives on what drives human action, and narrow understandings of human beings. These claims may seem far-fetched, but reflect that '[t]heories of wellbeing or quality of life cannot be disengaged from theories of what it is to be human and what life is for' (Scott, 2012, p. 16). Examining the connections between transport and wellbeing means engaging in politics and practising philosophy.

Once we pause to reflect on the assumptions about human action that underpin the hedonic tradition of examining wellbeing, we can see that they

are surprisingly one-dimensional and deterministic: human beings are taken to act, all else equal, in ways that enhance – if not optimize or even maximize – their own pleasure or satisfaction. This teleological structure is made possible by two underlying assumptions, which also underpin the work of eudaimonic psychologists.

The first assumption relates to the purported existence of universal and stable affective and cognitive states that can objectively be classified as positive or negative. This belief has been criticized in multiple ways. Anthropologists, geographers, and others, have convincingly argued that emotions and cognitions are both neuro-chemical processes and linguistically and culturally constituted (Frawley, 2015). Some psychologists are making similar claims (Gendron et al., 2020, p. 13):

[I]nstances of emotion are emergent products of multiple biologically-evolved mechanisms that depend on cultural learning. We specifically propose that the developing brain bootstraps embodied concepts into its wiring, creating an internal model for how to best regulate the body across a range of situations within the constraints of a culturally-shaped world ... This embraining of culture may allow people to survive and thrive as a social species in a wide variety of contexts.

A related argument is that the identification of certain affective and cognitive states as positive is a normative process, with non-innocent consequences. For Burnett (2012), that identification needs to be seen as emerging from a series of changes in the nature and organization of capitalism in the Anglo-American world over the 20th and 21st centuries, which have embedded a neoliberal ‘tyranny of positivity’ (Frawley, 2015), first in countries such as the United States and United Kingdom, and increasingly across the planet. Thus, people are expected to feel good and be positive, and to work on themselves if they do not – for instance, by making better choices – if they wish to avoid being blamed for their own ‘ill-being’.

In the transport context the normative working of the classification of affects and cognitions as positive or negative is a decidedly mixed bag with unavoidably context-specific consequences: the association of, say, driving with security may make some people reluctant to shift to other modes of transport – often with adverse consequences for the environment and those without access to cars – whereas it may make others consider forms of transport that offer a more direct relation with the traversed urban environment (for example, walking, cycling or bus transport).

The implication is that both hedonic and eudaimonic scholarship on wellbeing is prescriptive rather than descriptive, making claims that – critics contend – are not universally true, but ethnocentric (Christopher and Hickinbottom, 2008). The teleological logics they assume and promote are ultimately contingent and are but one possibility among many, even if they may hold particular

attraction in situations of ‘high levels of instability, insecurity, uncertainty, or economic misfortune’ (Cabanas, 2018, p. 13).

The second assumption is the idea that human beings are individuals with innate needs that pre-exist their expression and are independent of place, time and culture. This idea underpins Ryan et al.’s (2008) self-determination theory and has informed multiple studies on the transport–wellbeing connection (Abou-Zeid and Ben-Akiva, 2012; Singleton and Clifton, 2019). Yet, once non-Western thinking on the nature of wellbeing and the individual is considered, the historical-geographical contingency of the belief in a priori needs becomes apparent. Thinking with its roots in Africa, Asia, Latin America and the Caribbean, or by indigenous peoples in countries such as New Zealand or Canada, is informative here. Consider Daoist and Buddhist thought, for instance. Daoism’s highly influential *Zhuangzi* text teaches that the self is not contained in the individual body and spirit, but is part of a much larger unified whole (Tiwald, 2015), while the South Asian Mahāyāna approach to Buddhism holds that ‘there is no self in the sense of being a distinct entity with identity through time (and related to this, the Mahāyāna teaching that all things are empty of an inherent nature)’ (Gowans, 2015, p. 71).

While non-Western thinking can open up exciting avenues for rethinking the relationships among wellbeing, needs and transport, strands of Euro-American thought have also challenged the assumptions of stable and objectively classifiable cognitive and affective status and universal, a priori needs. American pragmatism, feminist and queer theory, and Deleuzian thought (influenced by the writings of Gilles Deleuze and Félix Guattari), among others, can open up new ways of thinking about the transport–wellbeing connection, especially if combined with ideas from non-Western philosophies. Despite important differences, all these modes of thinking share a commitment to eschewing essentialism (the idea that there is an inherent nature to humans or any other object), and to foregrounding relationality and contextuality (meaning that understandings of wellbeing, needs and the nature of the human being are dependent on the time, place and situation in which they emerge).

2.4 SOME INITIAL PROPOSITIONS

There can be no ‘one-size-fits-all’ anti-essentialist and relational perspective on the relationships between wellbeing and transport. Particular approaches and ideas will work better in some circumstances and places than in others. Nevertheless, based on participation in various research projects, including the one for which Pedro was interviewed, I believe that a given perspective will generate more useful and interesting insights if it meets at least two criteria. First is the replacement of a static and decontextualized teleology (maximize pleasure, pursue wisdom, achieve environmental mastery, and so

on) with a focus on the processes through which desirable qualities and goals worth pursuing emerge out of – and co-evolve with – actions, experiences and (social) learning in particular social collectives, places and spaces. The nature of the good life and ways to achieve it are constantly becoming, worked out iteratively in doings and dialogues by and with social collectives in particular places, and conditioned by ideas and practices from elsewhere and the past. Secondly, if actions and the associated experiences and learning are key to both the conception or character of wellbeing and the relationship of wellbeing with transport, then it is important to give due consideration to the potential for action, or capabilities (Sen, 1993; see also Nussbaum, 2011). Such a focus can generate a great deal of insight into how the good life and its relationship with transport come to be understood in particular communities, times and places. Much more ought to be said about these criteria but there is only space for some illustrative remarks here.

Interest in the capabilities concept has increased markedly in transport research in the past decade (e.g., Beyazit, 2011; Hickman et al., 2017; Ryan et al., 2019; Schwanen and Nixon, 2020). These studies accept Sen's claim that wellbeing is about the positive freedom to achieve 'functionings', or activities and states of being, which individuals have reason to value, and focus on the conversion of capabilities, defined as real opportunities of potentials, into functionings. This conversion is mediated by all kinds of factors, from acquired skills and remembered experiences to policy outcomes, economic structures and discourses (Robeyns, 2017). This idea has significant implications for transport research because it means that simply providing resources or enhancing (person-based) accessibility – the ease of reaching destinations – is not enough to achieve functionings (see also Hickman et al., 2017). After all, what is the point of making bicycles available to individuals with a snazzy smartphone app or a Mobility-as-a-Service (MaaS) scheme if people have not learnt how to cycle, are discouraged by road designs that privilege vehicular transport, or cannot afford a digital payment system?

Nonetheless, there are multiple risks associated with the translation of the capability approach (CA) into transport research, due to both their original formulation within Amartya Sen's liberal-individualist framework and the habits of the research communities within which they are appropriated. Especially when adopted under a Euro-American eudaimonic psychology framing of human action and wellbeing in transport research, CA studies on transport can consolidate a narrow individualistic perspective on (and an a priori, externally determined conception of) wellbeing. This tendency is reinforced by the fact that much CA research ignores the interrelatedness and relational constitution of capabilities. One consequence of this is that enhancement of the capabilities of person *A* or group *X* to undertake certain travel may come at the expense of the capabilities of *B* or *Y*; a connection that undergirds many forms of (dis-

tributional) injustice in urban transport and one that transport research should help to diminish and avoid.

A dynamic, relational and anti-essentialist perspective on capabilities in relation to urban mobility is certainly possible (Schwanen and Nixon, 2020). Mapping Kaufmann's (2002) concept of motility and its constituent elements of access (the set of available mobilities), competencies (abilities that make particular mobilities possible) and appropriation (turning access and competencies into action) onto Sen's capabilities is useful in this context, but all the invoked terms need to be understood as precarious achievements, constituted relationally and through actions, and possibly diminished or annulled if circumstances change (Schwanen and Nixon, 2020).

This is where returning to Pedro is useful. His neighbourhood jogging scheme opened up opportunities to move and experience the 'suburbs' (access) and allowed novices to build up their fitness, skills and confidence (competencies) through its do-it-yourself/do-it-together approach. The appropriation of those capabilities and consequent turning them into functionings by participants generated capabilities for others – the communities whose neighbourhoods become more secure – as well as generating for Pedro the opportunity to make his nephews and children proud. The merit of his scheme, then, is to put in place a tapestry of capabilities for a wide array of people and to make conversion of those capabilities into functionings more likely. This merit derives from his scheme (and other cycling and walking groups, bike maintenance workshops, cycle lane improvement, and so on, initiatives that we studied) acting as a commons. Informed by critical geography scholarship (e.g., Chatterton, 2010), I use this term to denote a configuration of practices (functionings) that brings different people together in a cooperative spirit and turns an initially inhospitable urban environment – because it is unsafe for many, and strongly car-dependent – into a place where new capabilities and functionings are cultivated, also for more vulnerable residents of the 'suburbs'. The scale of the generated capabilities should not be exaggerated, and their creation is dependent on the scheme's continuation, which is never guaranteed; findings that held for most of the studied community initiatives to support walking and cycling. They nonetheless provide a pathway to a better life for at least some, through changes in how people move around the city.

It should be noticed that few assumptions are made in the above discussion about the nature of human actions or human beings. While Pedro's words at the start of this chapter may suggest that he acted on the basis of a predetermined plan or set of goals, this seems more an artefact of how interviews as research method often induce post-hoc rationalization than a reflection of how his scheme evolved. Other parts of the interview suggest that goals emerged from doings, and practical experimentation was worked out iteratively, dialogically and in an evolutionary manner. That manner is perhaps

best qualified as ‘agapistic’, after pragmatist philosopher Charles Peirce’s evolutionary understanding of *agape*. The notion of *agape* is understood in many different ways (Oord, 2005), but for Peirce (1893, p. 179) is summed up in the ‘golden rule’ of ‘[s]acrific[ing] your own perfection to the perfectionment of your neighbor’. For Peirce this was not a predetermined principle to be implemented by decontextualized individuals. It, rather, was a rule that could emerge in, and direct, evolutionary processes in the cosmos or the whole, of which (individual) human beings are only one part. He called the resulting form of evolution ‘agapasm’ and favoured it over others, including the Darwinian variety premised on chance and greed, because he considered it a creative love that enhanced value for the whole during its evolution. I do not wish to generalize from Pedro’s scheme, and the other community-led initiatives to support walking and cycling that were studied, to urban transport and cities in general. Nonetheless, the notion of agapasm aids our understanding of how commons-producing initiatives, over time, generate capabilities and functionings that open up a better life for the many in the places affected by the schemes.

2.5 CONCLUSIONS

If transport research is to contribute to the creation of sustainable, just and human scale cities for all, then it needs to allow for multiple imaginings of what wellbeing is and how it can be achieved. It also needs to critically reflect on the effects generated by the pursuit of particular versions of wellbeing through travel behaviour and policies. This does not mean that research should stop working with hedonic conceptions or ideas from eudaimonic psychology, for these can be useful and insightful. They are, however, only two possibilities that come with a complex back-story within and outside academia, are culturally specific, and have normative consequences when used in empirical studies and stakeholder engagement. They should not be assumed to be universally applicable across the planet, or to every social group in a particular place. Their applicability across space, time and culture needs to be ascertained, and effects of their use critically interrogated.

Transport research can benefit from experimenting with other, more context-sensitive and relational perspectives on wellbeing and human action. The ideas in the previous section begin to outline one option in this direction. Requiring further development, they build on earlier engagement with the capability approach in transport research, and recognize the unavoidably social and interrelated nature of emergent capabilities and the functionings they enable. The ideas are also avowedly normative in their grounding in the notion that the capabilities enjoyed by some should not diminish those available to others near and far, in space and time. Not only should transport

policy and urban planning promote walking and cycling as the default forms of transport, and plan cities accordingly, or discourage the selfish hedonism of SUVs. They should also avoid situations where (physical) interventions that help to normalize walking and cycling in particular sites raise land values and enhance gentrification dynamics that displace poor and otherwise vulnerable households from their residences, or assume all pedestrians to be able-bodied, and cyclists to be literate and have access to a smartphone or digital payment system. Truly sustainable transport in human scale cities requires recognition of the relationally constituted tapestry of movement capabilities in particular places and across space and time.

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3. The relationship between the population's socio-economic status and walkability measures: the context of the Lisbon metropolitan area

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3.1 INTRODUCTION

The socio-economic status (SES) of an individual is crucial to define the most significant aspects of individual life (Marmot et al., 2012). Aspects such as employment, education and income shape lifestyle and access to different opportunities (Marmot et al., 2012). Population distribution in the cities is made according to their SES, reflecting the wealth of these places. A walkable environment with better accessibility by different transport modes results in higher property values, which reduces the diverse population status with income capacity to access these places (Gilderbloom et al., 2015). Property value defines the ability of different socio-economic groups to acquire or rent houses (Drewnowski et al., 2014; Gilderbloom et al., 2015). Property value is influenced not only by the features of the property itself, but also by different built environment characteristics; namely, neighbourhood perception, the streetscape's qualities, and mostly by accessibility (Carr et al., 2010). Accessibility is crucial to individuals' daily activities, access to work, access to healthcare, and so on. Accessibility to places affects differently individuals of different socio-economic groups (Delbosc and Currie, 2011; Lucas, 2012). Low accessibility has a high impact in the most deprived groups because their reduced income decreases the options available to access different activities. For example, higher income socio-economic groups have the power to suppress the scarcity of walking infrastructures and public transport access by using several individual modes (Delbosc and Currie, 2011).

The Lisbon Metropolitan Area (LMA) is a particularly interesting context because it has very different urban and demographic contexts, a result of its

dimension and changes across time. However, there is little knowledge about the relationship between socio-economic groups' distribution and walkable characteristics. The goal of the chapter is to understand the distribution and relationship between walkable characteristics and socio-economic groups across the LMA, distinguishing areas according to their travel time to the city centre. To achieve this goal, different indicators used to measure walkability were tested and correlated with SES indicators.

3.2 BACKGROUND

Health and wellbeing determinants define an ecological model where individual characteristics are in the centre of this model, but context spheres also influence individual health and wellbeing (Barton and Grant, 2006). Individual socio-demographics play a crucial role in health and wellbeing. However, the sphere of closer context at the level of the bespoke neighbourhood had influences on these individual characteristics, allowing healthier lifestyles. The spatial built environment characteristics define the access level of different opportunities and where transport options are crucial to access these opportunities (Geurs and van Wee, 2004). Transport options have different costs, and different socio-economic groups have distinct resources to face these costs (Delbosc and Currie, 2011). A walkable environment with a walkable distance to the most important daily activities is the cheapest option and it reduces the need for longer distance trips. Moreover, it is well known that a walkable place has impact on other health determinants, such as physical activity and social interaction, that increase wellbeing (Loureiro et al., 2019).

Most previous studies about the relationship between walkable environment and socio-economic status were performed in the North American and Australian contexts, where the spatial distribution of socio-economic groups is stronger (Gullón et al., 2017). The European context has different development patterns with different spatial reasons to shape population distribution (Munoz, 2003). The Portuguese context, in this case, the LMA, shares these different developments where different socio-economic groups occupy different built environment characteristics across the city, with different levels of accessibility (Santana, 2007).

The design of a walkable environment that supports the use of active and public transport modes to the most important destinations allows the reduction of inequalities, promoting access by inexpensive modes of transportation (Badland et al., 2014; Giles-Corti et al., 2016). A built environment that promotes walking and cycling helps to reduce inequities and can benefit such aspects as health, traffic management, air quality and economy. Urban areas that reduce the need of mandatory transportation far from walkable distances can improve individual wellbeing and living conditions (Giles-Corti et al.,

2016). Unfortunately, disadvantaged populations face disparities on walkability, safety and health, and also inequities in facilities and built environment conditions. The benefits of walking are especially important for disadvantaged groups and they have a higher cost for disadvantaged and vulnerable populations (Adkins et al., 2017). The identification of less walkable areas can improve the design of policy and planning interventions (King and Clarke, 2015).

A walkable built environment refers to how favourable the built environment is for walking, and it can be used to improve physical activity and active travel. Walkability is commonly defined as a measure which defines whether the existing neighbourhood qualities encourage people to walk (Wang and Yang, 2019). The most used walkability indexes are composed of such built environment dimensions as residential density, intersection density, the retail floor area ratio and land use mix. The indicators follow three main categories ('three Ds'): density, diversity and design as determinants of walking. Later, these were expanded to 'five Ds' to include destination accessibility and distance to transit (Ewing and Cervero, 2010), which some authors claim can be conceived not as pure built environment but as (dependent) accessibility indicators, reframing the 'five Ds' as '3 Ds + A' (Vale and Pereira, 2016).

Pedestrian accessibility conditions of the residential neighbourhood define several aspects of daily life with impacts on wellbeing (Delbosch and Currie, 2011). One of these aspects is time spent on travelling, which reduces the free time available for other important activities, such as social interactions, family time and leisure (Lachapelle et al., 2016). In addition, the absence of free time is one of the major determinants of reduced social interaction. This shortage of free time is called 'time poverty', and can contribute to increase social exclusion and to reduce subjective wellbeing (Currie and Delbosch, 2010). Public transport accessibility is especially important for the disadvantaged population, more dependent on these mobility options (Lucas, 2012).

Urban green areas contribute to wellbeing by improving social interaction and integration (Picavet et al., 2016; Ward Thompson et al., 2016). Some interesting facts are the different effects on mental health and stress levels that urban green areas have in different socio-economic groups, and also the contribution of urban green areas to reducing economic health inequalities (Ward Thompson et al., 2016). A consensual result in the literature highlights the effects of urban green areas on health, not only in terms of physical activity but also in terms of mental health (Douglas et al., 2017; Loureiro et al., 2019; Picavet et al., 2016). Moreover, proximity to green areas is considered relevant for a walkable environment and contributes to better living conditions and healthy environments (Picavet et al., 2016). The contribution of green area accessibility to wellbeing is supported by literature which points to the influence on individual behaviours such as physical activity and social interaction.

A walkable environment has been shown to influence property value (Carr et al., 2010). One of the most used walkability indicators, the Walk Score®, has been used to evaluate house prices, reflecting the impact of walkability on increasing this price and, consequently, influencing the socio-economic groups' location (Carr et al., 2010; Vale et al., 2016).

Property value has been used as a measure of socio-economic characteristics (Drewnowski et al., 2014; Jiao et al., 2016), due to the role of property value to conditionate the type of SES present in a place. Property value emphasizes the perception of poverty or wealth of a place. The individuals' perception of the surrounding built environment has an impact in their own view of SES, but it also has an impact on property values (Drewnowski et al., 2014). These aspects reinforce the impact of the built environment to the spatial distribution of different socio-economic groups, with property value being a condition for housing access. Accessibility to the city centre shapes individuals' home location, which results from the competition between several activities. The higher property values in the city centre exclude the most deprived population, yet the sprawl effects in modern development create settlements of higher SES far from the city centre (Koschinsky and Talen, 2015). Nevertheless, the distribution of population differs from city to city, and the occupation of a particular place by different socio-economic groups can change through time (Gullón et al., 2017). Furthermore, the spatial distribution of these places across countries and cities is not equal, and it is not always representative of the population status present in these places.

3.3 METHODOLOGY

3.3.1 Study Area and Design

The LMA is a regional administrative division composed of 18 municipalities and 211 civil parishes (34 937 census blocks). The LMA represents 3.3 per cent of the total area of Portugal, with approximately 3 million inhabitants (25 per cent of the Portuguese population). In economic terms, it represents more than 36 per cent of the national gross domestic product. The built environment was measured considering the walkability concept, including accessibility measures and topography conditions. The SES evaluation uses indicators of population wealth.

The relationship between walkability and SES was evaluated by a Spearman correlation matrix. Due to different urban and demographic contexts existent in LMA, four groups of census tracts were created considering 15 minutes, 30 minutes, 45 minutes and more than 45 minutes morning peak travel times from city centre (see Figure 3.1c in the 'Results' section). Travel time was calculated for car mode considering traffic information. The selection of 15

minutes groups was supported by the impact of the commuting time for well-being, which is one of the major reasons for travel mode selection (Delbosc and Currie, 2011; Giles-Corti et al., 2016). Linear regression was performed for each group separately. We have analysed relationships between SES and walkability indicators and for the two indexes created.

3.3.2 SES Measures

The most common SES indexes use indicators such as income, education or occupation (Cebrecos et al., 2018; Santana et al., 2015). However, property value is important in shaping several aspects of health and wellbeing (Drewnowski et al., 2014; Jiao et al., 2016). In this chapter, we calculated an SES index that is composed of four indicators: (1) literacy rate; (2) employment rate; (3) percentage of households with a toilet; and (4) property value (€/m²). The indicators were standardized, and the z-scores were summed to form the composite SES index (Santana et al., 2015):

$$\text{SES Index} = \text{z-score LiteracyRate} + \text{z-score EmploymentRate} + \text{z-scoreHouse-} \\ \text{WithToilet} + \text{z-score PropertyValue} \quad (3.1)$$

Property value (euros/m²) was obtained from a retail housing website (www.imovirtual.com), collecting the coordinates of the real estate property for sale in November 2018. Based on the asking price and dimensions of the house, the price per square metre was calculated for each point. The points obtained were used to interpolate a surface using Empirical Bayesian Kriging available in ArcGIS 10.6 and predicting the property value to the census block centroids (euros/m²). The results for census block were then aggregated at census tract with an average value. The source of the remaining SES indicators is the 2011 census data aggregated at census tracts.

3.3.3 Walkability Measure

Walkability was measured for a 500 m buffer around each urban census block. The indicators were then aggregated at the census tract to better describe the bespoke neighbourhood and to control the modifiable area unit problem (Openshaw, 1983). We have calculated a walkability index in line with the most used walkability indexes (Wang and Yang, 2019), including density, diversity and design, but also comprising accessibility measures and topography conditions. Density was measured by household density based on the 2011 census data. Diversity was measured by the number of different types of activities obtained from points of interest information (POIs) from the Navteq¹ database. The design dimension was measured by density of road intersections

(nodes) with three or more links, also from the Navteq database. Topography was evaluated by the percentage of census block with a slope less than 8 per cent, calculated based on a digital terrain model raster with 30 metres resolution. Accessibility measures evaluate the accessibility to green areas and public transport accessibility. The green areas considered were ‘green urban areas’ and ‘forests’ classification in Urban Atlas (Kabisch and Haase, 2014). Two green areas indicators were created: the percentage of the buffer area occupied by green area and the total of green area in the census block.

Public transport accessibility was measured following Currie and Delbosc’s (2010) methodology, adapted to the LMA context by considering station buffers sizes of 400m to bus, 800m to train, 500m to tram and 800m to ferryboat. The public transport index consists of daily transport supply in each walking buffer, which is calculated by the proportion of overlapped buffers in the census tract. The calculation was performed with BetterBusBuffers, an ArcGIS tool based on a General Transit Feed Specification (GTFS) database available at the city’s open data portal.² The final walkability index is given by the formula:

$$\text{Walkability Index} = \text{z-score Density} + \text{z-score Diversity} + \text{z-score Design} + \text{z-score Green Area} + \text{z-score Slope} + \text{z-score PT Accessibility} \quad (3.2)$$

3.4 RESULTS

Figure 3.1 illustrates the spatial pattern of the SES and walkability index. The SES index does not reveal a clear pattern, having high and low values in the four census tract groups. The SES map highlights the spatial pattern of property values, particularly clear for Lisbon’s city centre and coastal line, which have higher property values. In the case of the walkability index, a clear distinction is visible between Lisbon’s city centre and the rest of the LMA. The 15 minutes census tract group and Lisbon municipality have the highest walkability index values. The walkability index emphasizes the city centre with the highest public transport offer, but also highlights the census tracts further from the city centre, which have lower accessibility but possess higher levels of green areas and higher percentages of low slope area.

The results of the Spearman correlation (Figure 3.2) show no association between socio-economic indicators and walkability indicators (grey box). Property value is the socio-economic indicator with the highest correlation values with walkability indicators. Particularly, accessibility to public transport shows a significant relation with property value, although the value is small (0.53). The variety dimension (0.48) and walkability index (0.46) are also significantly related to property values, but with lower coefficients. The

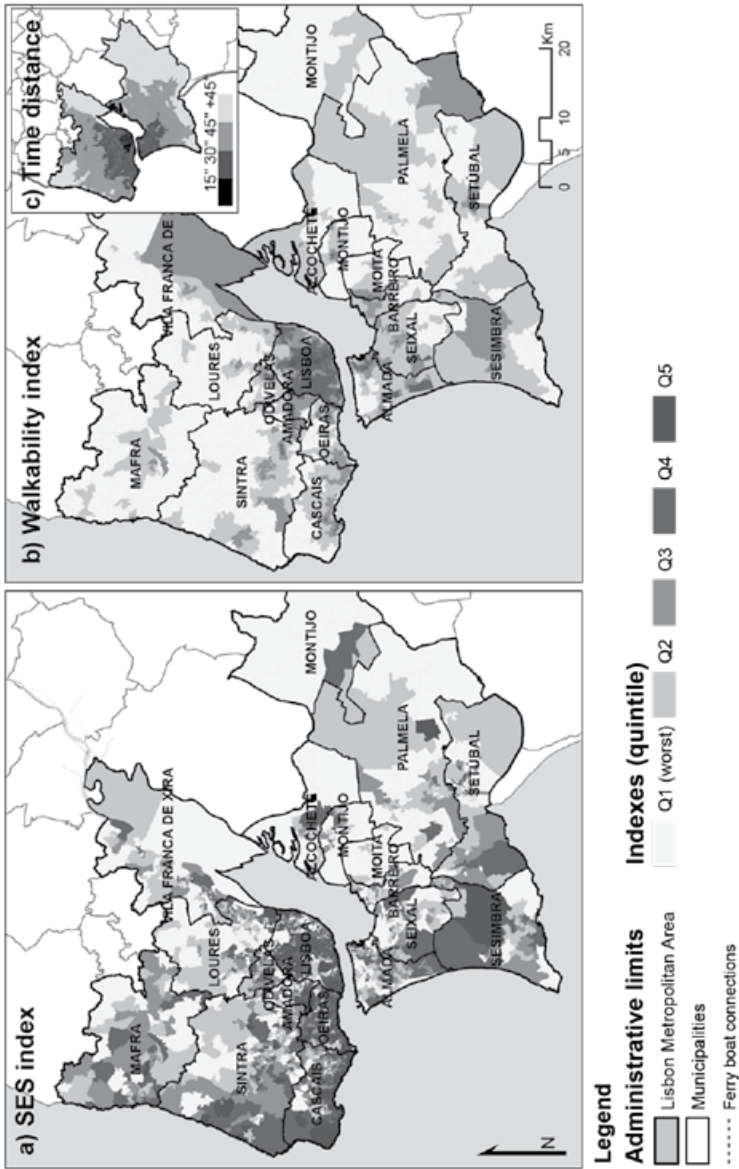


Figure 3.1 a) SES index map; b) Walkability index map; c) Time distance to city centre

Spearman's rho	Indicator	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	SES_LR	Literacy rate (%)	1.00													
	SES_ER	Employment rate (%)	<u>0.50</u>	1.00												
	SES_HWMT	Households with toilet (%)	0.36	0.19	1.00											
	SES_EuroSq2	Property value (€/m2)	0.23	0.27	0.15	1.00										
	SES_Index	Socio-economic status index	0.75	0.73	0.43	0.64	1.00									
	Den_Dwel	Residential density (ha)	0.18	0.14	0.25	0.23	0.19	1.00								
	Div_POIs	Number of activities	0.22	0.03	0.23	0.46	0.36	<u>0.72</u>	1.00							
	Div_Variety	Variety of activities (0 - 6)	0.21	0.05	0.22	0.48	0.37	<u>0.62</u>	0.86	1.00						
	Con_1	Density of nodes with three or more links (ha)	0.16	0.07	0.20	0.37	0.27	<u>0.69</u>	<u>0.74</u>	<u>0.63</u>	1.00					
	Per_Green_Area	Percentage of area occupied by urban green areas	0.05	0.07	0.03	0.12	0.11	0.08	0.02	0.06	0.06	1.00				
	Tot_Green_Area	Total of green area (ha)	0.04	0.09	0.01	0.11	0.10	0.12	0.01	0.02	0.11	0.99	1.00			
	Slope_8Perc	Percentage of area with a slope less than 8%	0.01	0.04	0.01	0.29	0.13	0.10	0.12	0.17	0.05	0.03	0.03	1.00		
	Acc_TPTrips	Public transport supply	0.15	0.04	0.21	0.53	0.36	<u>0.62</u>	0.81	<u>0.73</u>	<u>0.60</u>	0.02	0.01	0.27	1.00	
	Walkindex	Walkability index	0.20	0.02	0.25	0.46	0.35	<u>0.74</u>	0.83	0.78	0.77	0.27	0.23	0.10	0.74	1.00

All correlations are significant at 0.01 level (two-tailed), except the values in gray

Underlined - strong correlation values (0.50 < x < 0.75)

In bold - very strong correlation values (> 0.75)

Figure 3.2 Spearman correlation matrix

highest values are observed between the different built environment indicators and the walkability index; for example, walkability index and variety of activities (0.86), and the walkability index and public transport supply (0.74).

Figure 3.3 consists of scatter plots which show the relationship between walkability indicators and socio-economic indicators for the four groups of census tracts considered. Considering the entire LMA, the highest regression value is between the walkability index and property value ($r^2 = 0.32$). The highest walkability indicator value correlated with the SES index is public transport supply ($r^2 = 0.13$), followed by diversity ($r^2=0.12$) and the walkability index ($r^2 = 0.12$). The results stress the importance of these components for the indexes created. The remaining walkability indicators do not reveal a correlation with the SES index.

Regression values for the four groups are low. However, the difference between the closest group, at 15 minutes from the city centre, and the rest of the LMA are clear. The highest correlation value is diversity ($r^2 = 0.16$) for the 15 minutes group, and the following group has a much lower correlation value ($r^2 = 0.03$). The following highest correlation is between the walkability index and property value for the 15 minutes group ($r^2 = 0.13$). In this case, the difference for the next group is lower ($r^2 = 0.11$). The slope and SES index have a high value for the 15 minutes group ($r^2 = 0.12$), but a very low value for the rest of the groups. The walkability index and the SES index have the following highest value for the 15 minutes group ($r^2 = 0.09$). For the next group, the difference is not as high ($r^2 = 0.05$). Public transport supply, green area and design have a similar behaviour for correlation values, stressing the difference between the closest census tracts and the rest of the city. The density indicator reveals a lack of correlation with the SES index for all the four groups.

3.5 CONCLUSIONS

This chapter has explored the relationship between the distribution of the walkable qualities across different socio-economic groups, considering the distance to the city centre where most of the facilities are concentrated. The description of the built environment by walkability measures defines most of the qualities of a human scale city. The analysis of distribution of the human scale city qualities by the type of population served by these qualities can point towards policies and interventions to improve wellbeing by creating a walkable environment.

We have found a low correlation between socio-economic indicators and walkable indicators. The results reveal a relationship between property value and accessibility by walking and also by public transport, in line with other studies (Carr et al., 2010; Koster and Rouwendal, 2012). Correlation values are significantly different between the closer groups and the rest of the LMA,

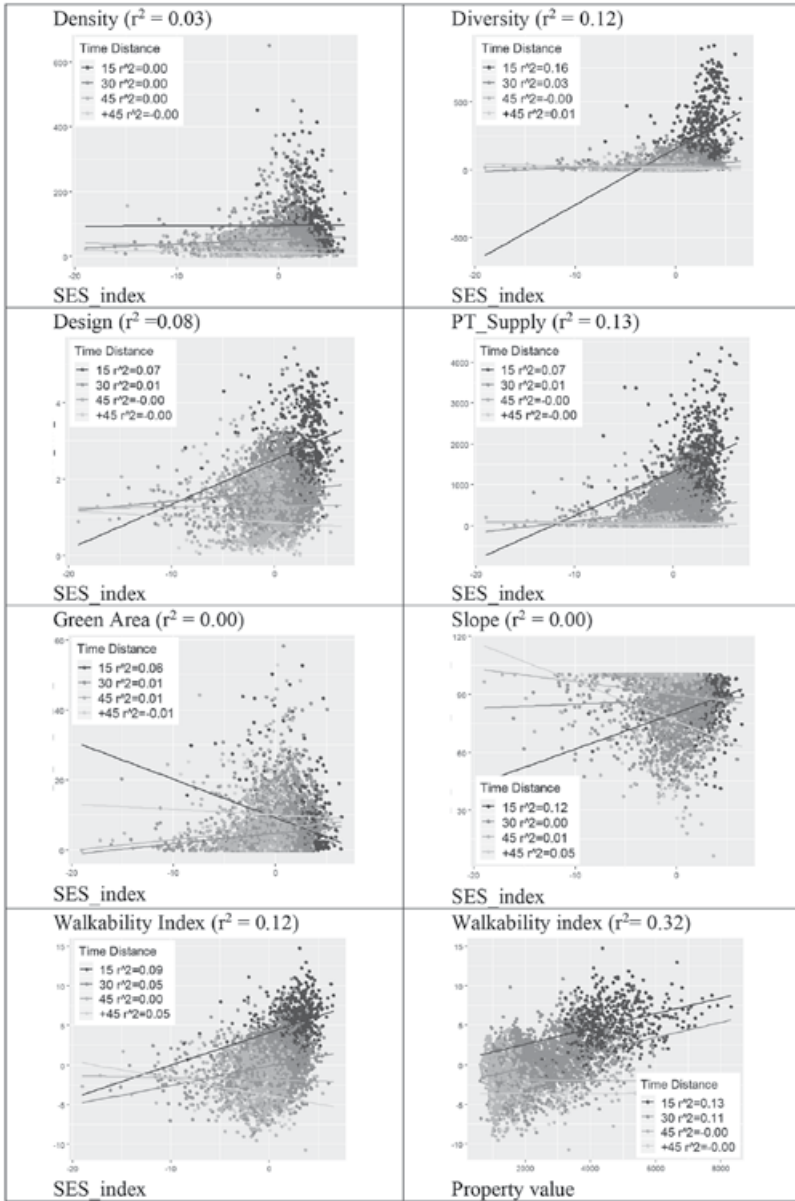


Figure 3.3 Scatter plots for each walkability measure and SES index, by time distance to city centre

especially for diversity of activities and public transport supply. The four groups remain with lower correlation values, but the closest group is significantly different. The highest correlation between the SES index and diversity identifies that the most central area is best served by public transport and activities. However, only 10 per cent of the LMA population lives within 15 minutes of the city centre. The major proportion of the population (63 per cent) lives in the second group (15 to 30 minutes) where a relatively good value of walkability was registered. The census tracts at more than 45 minutes from the city centre represent only 2 per cent of the LMA population, with the lowest walkability measures. The lower correlation and regression values between walkability and SES reveal that the most deprived people occupy places with different walkability qualities. Nonetheless, it seems that the city centre is mostly an exclusive area, occupied by the highest SES.

The results point to a relatively good distribution of the walkability qualities in the LMA, though an important distinction exists between the city centre and the rest of the LMA, especially in public transport supply and diversity of activities. Future studies should consider time distance to the centre in other modes, and different census tract groups should be tested. The chapter is a starting point to evaluate the distribution of walkability qualities in the LMA, pointing to the most human scale parts of the city that can contribute to better social inclusion.

NOTES

1. See <https://www.here.com/navteq>.
2. See <http://lisboaaberta.cm-lisboa.pt/index.php/pt>.

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4. Avoiding public transport? Assessing the relationship between accessibility, income and commuting mode in Recife, Brazil

Geneviève Boisjoly, Ahmed El-Geneidy and Bernardo Serra

4.1 INTRODUCTION

Accessibility, the ease of reaching destinations (Handy and Niemeier, 1997), plays a significant role in developing human scale cities. Planning for increased access to destinations, rather than higher travel speeds only, implies bringing origins and destinations closer to one another and supporting higher speeds and convenience for a variety of transport modes. In doing so, dense, mixed-use liveable neighbourhoods are prioritized, enabling all individuals to have access to a variety of destinations by active and public transport.

Accessibility is increasingly being used as a measure of land use and transport performance (Boisjoly and El-Geneidy, 2017; Handy, 2005; World Bank, 2016; van Wee and Geurs, 2016). From a travel behaviour perspective, previous research has shown a positive association between accessibility by public transport to jobs and commuting by public transport mode share in several cities in the Global North (Legrain et al., 2015; Moniruzzaman and Páez, 2012; Owen and Levinson, 2015), especially among low-income households who often rely on public transport (Lucas, 2012; Stanley and Lucas, 2008). In contrast, a low level of accessibility by public transport can result in forced car ownership, which is a major financial burden for low-income families (Curl et al., 2018; Mattioli, 2017).

While this reality is well documented in the Global North, cities in the Global South did not receive much attention with respect to the relationship between accessibility, travel behaviour and social equity. Looking specifically at Latin America, recent research has highlighted the socio-spatial segregation patterns that characterize many large metropolitan regions (Blanco et

al., 2018; Keeling, 2008). There exist significant mobility disparities across income groups, as low-income individuals often depend on public and active transport modes for their everyday mobility needs, although they are facing disadvantageous conditions in terms of access to destinations by public and active transport modes (Bocarejo and Oviedo, 2012; Delmelle and Casas, 2012; Hernandez, 2018; Hernandez and Rossel, 2015; Jaramillo et al., 2012). This can result in longer travel times, suppressed trips and/or limited access to opportunities (Falavigna and Hernandez, 2016; Martínez et al., 2018; Ureta, 2008; Vasconcellos, 2018).

Recent research has more specifically focused on accessibility and equity in Brazil. For example, using accessibility measures, researchers have demonstrated how various policies, namely school agglomeration policies in São Paulo and the development of transport infrastructure for mega-events in Rio de Janeiro, have contributed to exacerbating existing inequalities (Moreno-Monroy et al., 2018; Pereira, 2018). The relationship between accessibility to employment and informal employment in São Paulo has also been explored, demonstrating the importance of supporting accessibility by public transport for low-income individuals (Boisjoly et al., 2017). In a qualitative study in Recife, Maia et al. (2016) emphasized the importance of local land use mix and transport interventions for meeting the needs of low-income individuals.

The current chapter complements these studies by taking a travel behaviour perspective. Given the important social disparities and spatial segregation characterizing many of these cities, understanding this relationship across income groups is particularly important. The aim of this research, therefore, is to assess the relationship between accessibility by public transport, mode choice and income in Recife, Brazil. This study is amongst the first to combine accessibility data with individual-level origin–destination (OD) survey data to shed light on the relationship between income, accessibility and travel behaviour in the Global South. In doing so, the study provides quantitative evidence to support researchers, planners and policy-makers in developing equitable land use and transport systems, while highlighting the need for more context-specific research on accessibility and travel behaviour in the Global South.

4.2 METHODS

The Recife metropolitan region, in the Northeast Region of Brazil, comprises 14 municipalities, with a total population of around 3.7 million inhabitants in 2011 (Prefeitura da cidade do Recife, 2016). The public transport system consists of a metro and light rail system, complemented by a bus network.

The main data source used for this study is the Recife 2016 OD survey (Prefeitura da cidade do Recife, 2016). The survey contains 58 644 valid observations, at the individual level, and includes socio-demographic individual and household characteristics such as income, home and work location, and gender as well as questions related to work and study trips. Around 2.5 per cent of the population is surveyed through a sampling technique ensuring a representative spatial distribution of the sample. For the purpose of this study, only respondents that commuted to work, from home, were selected. For example, students, children and unemployed individuals were suppressed from the sample. After removing missing data, a total of 15 862 respondents were included in this study. Based on the home and work locations of the OD survey, two additional variables were calculated: distance from home to central business district (CBD) and commuting network distance. Note that commuting trips shorter than 100 m and longer than 50 km were excluded. The survey data was then combined with the 2010 census data and the neighbourhood average income was attributed based on the home location.

Three types of accessibility measures were included in this study: local accessibility to amenities (walking); accessibility to jobs, from home, by public transport; and accessibility to workers by public transport at place of work. The Walk Score measures, collected through the Walk Score application programming interface (API), were used to quantify local accessibility. Walk Score gives a score between 1 and 100 based on a variety of characteristics, namely street design and the number of amenities in the vicinity (Walk Score, 2016). Accessibility to jobs, by public transport, was calculated as the number of jobs or workers within a given travel time (that is, cumulative opportunities). Travel times were obtained from the Google Distance Matrix API for morning peak travel times (Google Maps, n.d.). Based on the OD survey, a travel time threshold of 45 minutes was selected, and departure time was set at 7 a.m.

Jobs and workers data were derived from the OD survey. To do so, we hypothesized that a respondent's commute trip destination corresponded to one job, while their home location represented one worker. Job locations were also obtained from the Ministry of Labour and gave consistent results in terms of accessibility to jobs. To be consistent with the measures of accessibility to workers, we decided to use the job locations from the OD in this study. The number of jobs and workers accessible were then divided by the total number of jobs and workers, respectively, to obtain a share of jobs and workers. The accessibility values thereby range from 0 to 1.

Since the aim of this study is to assess the determinants of mode choice across income groups, three multinomial logistic regressions were conducted, one for each income group specified in this study. The dependent variable was the mode used to commute to work. A series of independent variables were selected based on the literature and tested in a stepwise manner, including local

and regional accessibility variables, trip characteristics and socio-economic characteristics. The summary statistics of the variables included in the final model are presented in Table 4.1.

For ease of interpretation and presentation, all income groups above two times the minimum wage were grouped in the high-income group. Accessibility to workers, to jobs, Walk Score, distance from home to CBD and commute distance were integrated in the model in a stepwise manner. We decided not to include accessibility to jobs, by public transport, in the final model since it appeared to be positively and significantly associated with the likelihood of commuting by car in the medium-income model. This result is inconsistent with the literature and is probably due to the fact that the variable captures some socio-spatial patterns that are not controlled for in the model. It was accordingly removed from the model. It is important to mention that the three models remained stable when removing the variable. Given the large income variations within income groups, the neighbourhood average income was included in the models to further control for poverty levels. Number of children, having a mobile with Internet access, having a mobility impairment, gender and age group (as defined in the survey) were also included in the model. Finally, a variable indicating whether the individual commuted fewer than five days a week is included to capture part-time employment or requirement to go to the place of work. The correlation between the variables were tested and variation inflation factors below two were found in all three models.

4.3 RESULTS

4.3.1 Discrepancies in Mode Share and Accessibility Levels across Income Groups

The mode share across income groups is presented in Figure 4.1 (top). As expected, public transport use is generally higher across individuals from low- and medium-income households, while car use is predominant among high-income individuals. This is consistent with the literature that suggests the low-income individuals are more likely to rely on public transport for commuting. Walking and cycling mode share is relatively low in all three income groups, with the lowest proportion among high-income individuals.

Figure 4.1 (bottom) presents the level of accessibility, by public transport, to jobs (from home) and to workers (from place of work) for the three income groups. Accessibility to workers within each income group exhibits lower variations compared to accessibility to jobs. This is likely due to the dispersion of workers across the territory, whereas jobs are more concentrated spatially, namely in the central areas of the metropolitan region. Accordingly, workers

Table 4.1 Summary statistics of the variables included in the final model (15 862 observations)

	Mean	Standard deviation	Minimum	Maximum
Accessibility to workers at workplace	0.30	0.12	0	0.45
Accessibility to jobs ^b	0.34	0.24	0	0.75
Walk Score	82.36	16.16	1	100
Distance to CBD	7.84	4.18	0.59	34.39
Commute distance	6.62	4.89	0.10	50.00
Neighbourhood median income	1 228 122	1 171 066	640	6 612 581
Number of children	0.65	0.98	0	8
Proportion of users (categorical variables)				
Mobility impairment		0.01		
Access to Internet on cellphone		0.89		
Commuting fewer than 5 days		0.17		
Gender (woman = 1)		0.51		
<i>Age category</i>				
16 to 24 years		0.08		
25 to 39 years		0.47		
40 to 59 years		0.41		
60 + years		0.04		
<i>Income</i>				
Below 1 MW ^a (low)		0.12		
1 to 2 MW ^a (medium)		0.33		
2 to 3 MW ^a (high)		0.15		
3 to 5 MW ^a (high)		0.13		
5 to 10 MW ^a (high)		0.15		
More than 10 MW ^a (high)		0.13		
<i>Commuting mode</i>				
Motorized modes (car and motorcycle)		0.52		
Public transport		0.42		
Walking and cycling		0.06		

Notes: ^a MW: minimum wage; ^b As noted in the methodology, this variable is not included in the final model.

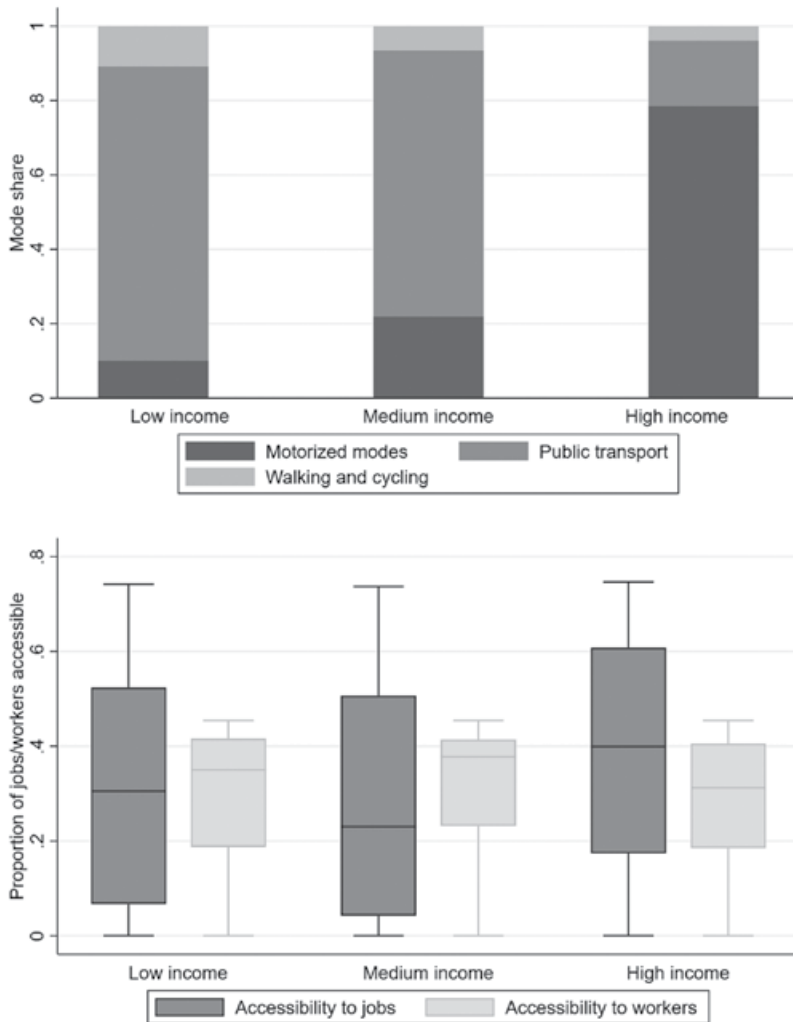


Figure 4.1 Mode share and accessibility to jobs (from home) and to workers (from place of work) by public transport in Recife, Brazil for low-, medium- and high-income individuals

residing in peripheral areas have very low accessibility to jobs, and those residing in central areas have a much higher accessibility to jobs.

Comparing the levels of accessibility to jobs, it is typically higher for high-income individuals. Furthermore, the 25th percentile, the median and the 75th percentile are higher than for the other income groups, suggesting that a lower proportion of high-income individuals experience very low levels of accessibility. In contrast, several low- and medium-income individuals experience relatively low levels of accessibility to jobs. Note that low-income individuals are characterized by a higher accessibility to jobs than medium-income individuals, which potentially results from land use policies that were implemented in the 1980s to allow low-income individuals to remain in central locations (Maia, 1995). In terms of accessibility to workers at the place of work, the differences are less pronounced. The level of accessibility is comparable across income groups, suggesting lower discrepancies in workplace locations of different income groups, whereas residential segregation appears to be more pronounced.

In a nutshell, it is difficult to conclude that the higher public transport usage among low- and medium-income individuals is associated with a greater accessibility to jobs and to workers. In fact, although close to 50 per cent (47 per cent for accessibility to jobs and 51 per cent for accessibility to workers) of the low-income workers have accessibility levels below the regional median (33 per cent and 32 per cent, respectively), 79 per cent commute to work by public transport. For medium-income households, this proportion is 71 per cent.

4.3.2 Determinants of Mode Choice across Income Groups

Three multinomial regressions were conducted, one for each of the income groups specified in this study. The results are presented in Table 4.2. The reference category is public transport. The top part of the table presents the odds ratio for driving while the bottom part presents the odds ratio for walking or cycling. In other words, the top part refers to the likelihood of commuting by car as compared to public transport, and the bottom part refers to the likelihood of commuting by walking or cycling as compared to public transport.

We now concentrate on the results associated with the likelihood of commuting by car. Looking first at the low-income workers, we observe that the variables related to the characteristics of the land use and transport systems (accessibility to workers, Walk Score and distance to the CBD) are not significant. In contrast, variables that can be related to socio-economic conditions appear to be strong determinants of mode choice: higher neighbourhood average income and having a mobile phone with Internet access are strongly associated with a higher likelihood of commuting by car. Furthermore, gender is statistically significant and consistent with the literature: being a woman is strongly associated with a lower likelihood of commuting by car. Overall, the

Table 4.2 *Multinomial regression results for the commuting mode choice (bold coefficients are significant at the 95 per cent confidence level)*

	Low income		Medium income		High income	
	OR	P>z	OR	P>z	OR	P>z
<u>Driving (ref: public transport)</u>						
Access. to workers at workplace	0.43	0.208	0.19	0.000	0.86	0.567
Walk Score	1.01	0.296	1.00	0.323	1.00	0.801
Distance to CBD	1.02	0.422	0.99	0.396	0.99	0.276
Commute distance	0.96	0.042	0.98	0.059	0.98	0.007
Neighbourhood median income	1.63	0.000	1.51	0.000	1.61	0.000
Mobility impairment	1.81	0.263	0.86	0.617	0.75	0.294
Access to Internet on cellphone	2.40	0.001	1.90	0.000	2.75	0.000
Number of children	0.94	0.524	1.14	0.000	1.26	0.000
Commuting fewer than 5 days	1.32	0.129	1.56	0.000	1.76	0.000
Gender	0.49	0.000	0.34	0.000	0.98	0.742
<i>Age (ref: 25 to 39 years)</i>						
16 to 24 years	0.75	0.154	0.79	0.058	0.46	0.000
40 to 59 years	0.90	0.597	0.64	0.000	0.75	0.000
60 + years	0.47	0.344	0.86	0.531	0.86	0.342
<i>Income (ref: 2 to 3 MW)</i>						
3 to 5 MW					3.23	0.000
5 to 10 MW					8.28	0.000
More than 10 MW					24.39	0.000
Constant	0.00	0.000	0.00	0.000	0.00	0.000
<u>Walking or cycling (ref: public transport)</u>						
Access to workers at workplace	0.00	0.000	0.01	0.000	0.09	0.004
Walk Score	1.00	0.804	1.02	0.000	1.01	0.093
Distance to CBD	0.84	0.000	1.01	0.681	0.92	0.030
Commute distance	0.70	0.000	0.57	0.000	0.40	0.000
Neighbourhood median income	1.04	0.638	1.06	0.497	1.39	0.001
Mobility impairment	1.05	0.935	0.44	0.279	0.33	0.158
Access to Internet on cellphone	0.74	0.143	1.02	0.898	0.89	0.646

	Low income		Medium income		High income	
	OR	P>z	OR	P>z	OR	P>z
Number of children	1.23	0.013	1.29	0.000	1.20	0.009
Commuting fewer than 5 days	0.39	0.001	0.75	0.167	1.15	0.537
Gender	0.76	0.112	0.33	0.000	0.49	0.000
<i>Age (ref: 25 to 39 years)</i>						
16 to 24 years	1.14	0.559	1.16	0.452	0.33	0.008
40 to 59 years	1.22	0.334	0.84	0.232	0.76	0.056
60 + years	1.13	0.920	0.94	0.875	0.44	0.019
<i>Income (ref: 2 to 3 MW)</i>						
3 to 5 MW					1.41	0.050
5 to 10 MW					2.33	0.000
More than 10 MW					4.09	0.000
Constant	9.02	0.109	0.53	0.575	0.05	0.022
Log-likelihood	-1043		-3319		-3973	
Number of observations	1875		5181		8806	

results demonstrate that for low-income individuals, characteristics associated with poverty and gender are the major determinants of mode choice.

In contrast, for the medium-income individuals, we find that higher accessibility by public transport at place of work is highly significant and associated with a lower likelihood of commuting by car compared to public transport. This suggests that having a workplace which is well connected by public transport potentially influences medium-income individuals' commute decisions. Poverty-related variables (neighbourhood average income and access to Internet on mobile) and gender are strongly significant, as is the case for the low-income individuals. In addition, the number of children is positively associated with the likelihood of commuting by car, which is consistent with the literature. Part-time commuting is also positive and significant. Note that these two variables were not significant in the low-income model.

Finally, the magnitude and significance of the variables in the high-income model are similar overall to the ones in the medium-income model. There are, however, two notable differences. First, accessibility to workers is not significant (this was also the case in the low-income model). Second, the gender variable is not significant. Finally, it is important to highlight that a higher income is strongly associated with a higher likelihood of commuting by car, confirming that the economic situation plays an important role in mode choice.

Other results are worth mentioning for the three models. The commuting distance is significant (although marginally in some models), with a higher distance reducing the likelihood of commuting by car. Since it is probable that this variable captures socio-spatial patterns, rather than an actual explanatory factor of decision-making, these results suggest that further data (namely, more detailed income and transport and land use data) should be collected to gain a better understanding of this relationship.

We now turn to the walking and cycling results of the three regression models. For low-income individuals, the likelihood of commuting by walking or cycling is largely explained by variables reflecting local commutes, namely lower commute distances and lower accessibility to workers at the place of work (which is likely to reflect a place of work that is not centrally located). The number of children is also associated with a higher likelihood of walking or cycling, which might be associated with additional constraints that refrain workers from commuting outside the neighbourhood. In contrast, Walk Score does not appear to be statistically significant, while a higher distance from CBD decreases the likelihood of cycling or walking. This is also the case in the high-income model. Again, it is unclear whether distance from CBD accounts for socio-spatial patterns that are not currently considered in the models.

With respect to the medium- and high-income individuals, the likelihood to walk or cycle is also explained by variables that can be associated with local commutes (accessibility to workers, commute distance and number of children). Gender is also a significant determinant: women are less likely to walk and cycle (as compared to using public transport) than men. The Walk Score is also a significant determinant of mode choice for the medium-income model, with a higher Walk Score being associated with a higher likelihood of walking or cycling. Interestingly, for high-income individuals, a higher household income is associated with a higher likelihood of walking or cycling, while a higher neighbourhood average income is associated with a decreased likelihood. It is important, however, to note the low number of walking and cycling trips among high-income individuals, which may affect the results obtained here.

4.4 CONCLUSION

Combining OD survey data with local and regional accessibility measures, this chapter has investigated the relationship between accessibility, mode choice and income in Recife, Brazil. The results highlight that commuting mode choice is not closely tied to accessibility, contrary to what is observed in several cities in the Global North. While high-income groups tend to have higher accessibility by public transport at their place of home, they largely commute by car. Conversely, low- and medium-income individuals mainly

commute by public transport, although their level of accessibility is not significantly higher.

The multinomial regression models demonstrate that income and poverty-related variables are amongst the main determinants of mode choice, as found in previous studies. Yet, contrary to the literature, land use and transport variables – namely accessibility to workers by public transport and Walk Score – are found to be non-significant for both the low-income and high-income individuals. On the one hand, the results suggest that low-income individuals depend on public transport, regardless of their accessibility conditions. On the other hand, it appears that high-income individuals decide not to use public transport, for reasons other than the lack of accessibility. A recent study conducted in Recife demonstrated that public safety is the main motivation behind car use (dos Santos, 2017). It is also important to mention that gender is an important predictor of mode choice, women being generally more likely to use public transport. This is an important equity concern that should be considered in future research.

These findings have several implications. From a modal shift perspective, providing higher accessibility at place of work for medium-income individuals has the potential to support higher public transport use. Conversely, providing higher accessibility to high-income individuals does not appear to be an effective approach to support higher public transport usage. Other factors, namely safety and comfort, should be explored, as pointed out in previous studies (dos Santos, 2017; Jaramillo et al., 2012). This is also true for other income groups. From an equity perspective, while improvements in accessibility are not likely to yield changes in travel behaviour for low-income individuals, improving accessibility by public transport is likely to improve the quality of the commute and offer new opportunities in terms of accessible jobs.

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5. The quality of life effects of enhancing public transport subsidies for hospitality workers in Vancouver, British Columbia

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5.1 INTRODUCTION

What difference do public transport (PT) subsidies make to the quality of life of workers? In a research partnership between Simon Fraser University, the City of Vancouver, TransLink (the regional PT authority), the hotel workers' union, UNITE HERE Local 40, and the management of seven hotels in the urban core, hotel workers in downtown Vancouver were offered experimental PT subsidies and were surveyed about their commuting patterns, work life and housing circumstances. The research, which was completed before the COVID-19 pandemic, was designed to identify the effects of PT subsidies. The study yielded the first data that we know of regarding the mobility influences and experiences of workers in downtown Vancouver's hospitality sector. In addition, it also identified important positive effects of reported quality of life by those who received the enhanced PT subsidies. We report on those findings here, showing the invaluable role that PT plays in supporting the quality of life of service workers in the post-industrial urban economy.

The psychological and social effects of the journey to and from work have been explored by researchers over multiple scales and mobility modes (Bergstad et al., 2011; Ettema et al., 2011; Páez and Whalen, 2010). Lorenz (2018) identified commuting as a significant influence on the traveller's cognitive wellbeing, while Lachapelle et al. (2011) confirmed a relationship between travel on PT and physical activity levels that promote public health. Our analysis seeks to contextualize these findings about the relationship between the mode of travel to work and social wellbeing, in an important sector of the urban economy.

Furthermore, while there is literature on the effects of PT subsidies on commute behaviour (see, e.g., TRB, 2005), there is relatively little written about the effects of such subsidies on specific industries and socio-demographic groups of workers. Hotel workers support tourism, business travel, conferences and conventions that connect Vancouver with the world, while also serving Vancouverites who patronize the city's hotels. Our research has revealed that the modes by which hospitality workers access their jobs in Vancouver's downtown core affects their quality of life in ways that are more nuanced than orthodox travel behaviour theory would suggest.

5.2 DATA AND METHODS

Practical considerations were foremost in our selection of the seven participating hotels where we would obtain data on workforce mobility. For comparison purposes, we restricted ourselves to hotels whose workers belonged to UNITE HERE Local 40. We also needed participating hotels to be willing to give us access to their premises. Finally, administering the experimental subsidy for PT commuting required that the hotels whose workforce we studied participate in TransLink's Compass for Organizations (CFO) payroll deduction programme.

Within these parameters, we sought hotels that could be assigned into pairs that had similar locations in relation to PT and pre-study availability of the PT subsidy, so that we could more easily isolate and observe the effects of the experimental subsidies. We selected two pairs that offered a monthly PT subsidy before the study: one pair located directly adjacent to a downtown SkyTrain station (Hotels A and B), and the other located a short walk from a downtown Skytrain station (Hotels C and D). We also selected a pair of hotels that did not offer a monthly PT subsidy. These two hotels were a short walk from a downtown SkyTrain station (Hotels F and G). The seventh participating hotel did not offer a monthly PT subsidy at the outset of the study (Hotel E). It was in a location that provided a good point of comparison with the second pair of hotels that offered a monthly PT subsidy prior to the start of the study.

The study was designed so that in each of the three hotel pairs, workers at one hotel would receive the new or enhanced experimental subsidies (Hotels A, D and F) while workers at the other would not (Hotels B, C and G). Workers at the final, non-paired hotel also received a new experimental subsidy (Hotel E). Pairing the hotels allowed us to compare workers' travel behaviour, including PT ridership levels and patterns, employee mode choice and commuting patterns, as well as quality of life.

Our primary data for this analysis was obtained through a survey of hotel workers, conducted in three waves over the course of a year, about their travel

behaviour, workplace and general life satisfaction, housing arrangements and income. This survey was conducted at six-month intervals (in March 2018, September 2018 and March 2019). Every employee at the seven hotels was eligible and encouraged to participate in the surveys, regardless of their commuting mode, subsidy uptake or enrolment in TransLink's programme for employer-sponsored PT discounts. Recruitment took place at the participating hotels, with explicit support of hotel management and the union. Recruitment followed standard consent and incentive procedures, and the response rates were over 40 per cent in all three waves. These survey data provided a solid foundation for our analysis.

Using name and contact information provided when respondents gave their informed consent, we have been able to match the survey responses across the survey waves. Most importantly, we have identified and matched a subset of 444 respondents who completed both wave 1 and wave 3 surveys, which corresponds to the month of March before the experimental subsidies began, and March one year later. This group of respondents provide the basis for a quasi-panel analysis of the relationship between subsidy offer and uptake, commute behaviour and perceived quality of life.

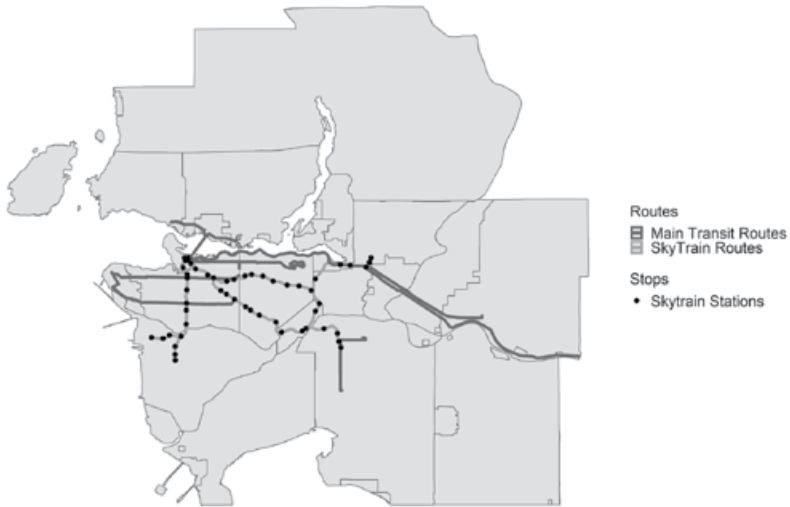
5.3 SOCIAL CHARACTERISTICS OF HOTEL WORKFORCE

Transport studies, and the mobility planning practices that they feed into, tend to focus on geographical zones and mode choices, paying limited attention to the social and occupational contexts of commuting needs and behaviours (Jones and Lucas, 2012). Here, we strive to untangle and identify, where possible, how responses to the experimental subsidies varied by subgroups of our study population. We thus seek to highlight some demographic attributes of our study population to illuminate how this group of downtown hospitality workers is similar to or different from the overall population of travellers and residents in the City of Vancouver and the Vancouver census metropolitan area (CMA) (see Figure 5.1), especially when it comes to factors that may affect their commuting needs and choices. We were particularly interested in examining the effects of an increased PT subsidy on hotel workers' sense of emotional wellbeing, which has been identified as a focus for needed research (Gärling et al., 2020), and where our analysis reveals new knowledge.

5.3.1 Age and Employment Demographics

Our study population is somewhat older than the city and region as a whole. The percentage of the working age (20–64 years) population that is between 55 and 64 years old in the City of Vancouver is 18 per cent, and 21 per cent in

Vancouver Metropolitan Area



Note: Specific locations of the hotels are not indicated for confidentiality reasons.

Source: Statistics Canada, 2016 Census; TransLink, General Transit Feed Specification (7 August 2020); Data collected with Cancensus, developed by Jens von Bergmann, Dmitry Shkolnik, Aaron Jacobs.

Figure 5.1 Vancouver census metropolitan area

the Vancouver CMA (Statistics Canada, 2016), while that age range made up 24–28 per cent of our study population. Those under 25 made up about 4 per cent of our study, whereas those in the 20–24 age group alone make up about 10 per cent of the City of Vancouver and Vancouver CMA working age populations. One implication for our study is that it may be harder to influence the commuting patterns and choices of older workers. In our study population, the average number of years a respondent had worked in their current job ranged from 11 to 13, depending on the wave of the survey.

Hotel occupations encompass a full range of post-industrial service sector work. Housekeepers made up the largest component of our study population, at 26–29 per cent over the three survey waves, followed by food and beverage service workers (22–25 per cent), back of house workers (a diverse group including dishwashers, cooks, janitors, security and maintenance workers; 18–20 per cent), management and administration (12–15 per cent) and front of house workers (including front desk, concierges, receptionists; 10–12 per cent).

5.3.2 Work Schedules, Responsibilities and Commuting

The work schedules of many hotel employees run counter to the standard daily commute patterns around which PT systems are typically organized. Across our three survey waves, 24–28 per cent of our study population reported that they did not have regular start and end times for their shifts. Workers in food and beverage service were the least likely to have regular start and end times: in the three survey waves, 37–48 per cent reported that their shift start and end times were not regular. While the majority of our study population leaves and returns home within the hours that frequent transit service (TransLink, n.d.) is available (6 a.m. to 9 p.m.), a substantial percentage – 36–44 per cent in each wave – did not.

Our study population faced longer commutes than city and regional residents overall. We calculated commute times based on survey responses to questions about leaving and arrival times on the reference day. Only about 4 per cent of our respondents had commutes of 15 minutes or less, whereas in the city and region, 17 per cent and 18 per cent did. On the longer end, between 43 and 51 per cent of our study population commuted over 45 minutes during the three waves, compared to only 6 per cent of the City of Vancouver and 11 per cent of regional residents in 2016 (Statistics Canada, 2016).

Differences in the length of commute by job class were noticeable. For instance, less than 1.5 per cent of housekeepers in any of the survey waves commutes to work for 15 minutes or less. By contrast about 10 per cent of those in the management and administration job class had commutes this short. About 18 per cent of food and beverage service staff across the three survey waves had commutes of 60 minutes or more. The latter is a group of workers that tends to have irregular and off-peak hours.

We found little difference in the average duration of women's commutes compared to men's, with the exception of commutes to home with stops. The gender gap in commutes home with stops was eight minutes, with women's commutes lasting 71 minutes and men's 63 minutes. Women's longer commutes home with stops may reflect women stopping to shop or perform other household maintenance tasks on the way home. Commuting is thus a non-trivial part of hotel workers' life experience, and the vast majority of respondents do not live near their workplace. The financial and experiential terms of that commute could thus make a material difference in quality of life.

5.3.3 Housing Characteristics

Respondents who rent households made up 45–46 per cent of our study population over waves 1, 2 and 3 of the survey. This is a considerably lower percentage of renters than in the City of Vancouver, where 53 per cent of

households rented, according to the 2016 Census. However, regionally, renters were much below our sample, at 36 per cent of households. This means that our study population is more likely to rent than residents of Metro Vancouver overall.

We used the definition of affordability from the Canada Mortgage and Housing Corporation, which says that when a household spends more than 30 per cent of its gross income on shelter costs, that housing is unaffordable for the household (CMHC, n.d.). In each of the three survey waves, more than 30 per cent of our study population reported living in unaffordable housing (31 per cent, 34 per cent and 31 per cent for waves 1, 2 and 3, respectively). Thus, more than one-third of the survey population is under housing stress, and it should be noted that the hotels in our sample are among the city's best in terms of earning and employment stability. Any financial resource that is made available to a population in need could be expected to influence the sense of wellbeing among individuals who feel such economic pressure.

5.4 TRAVEL CHARACTERISTICS

We knew at the outset of this study that Vancouver's hotel workers were frequent PT users on their commutes: UNITE HERE Local 40 and hotel management both reported this, based on their front-line experience with membership and employees, respectively. The data collected for this study has offered a more detailed and nuanced picture of how these workers commute and use PT. It has also enabled us to contextualize their PT and commute patterns within city and regional mobility patterns.

Engagement with PT can be measured in different ways, including whether it is used at all, used for commuting or for non-work purposes, and whether it is combined with other modes. We focus here on use of PT, commuting modes, use of Compass Cards and monthly Compass Card products (see below), and subsidy acceptance. Most studies that look at PT use or the effect of subsidies on PT use and commuting do not specify or differentiate impacts by occupational group. These studies also do not distinguish between the general economic effect and the specific experiences that arise from making use of alternatives to the automobile.

5.4.1 Prior Month's Public Transport Usage

In wave 1 of the survey, 89 per cent of respondents reported taking PT in Metro Vancouver in the past month. This is considerably higher than the 52 per cent of employed Metro Vancouverites who reported doing so in the 2018 Transit Incidence Survey (Mustel Group, 2018). In the same survey, 77 per cent of the total respondents residing in the City of Vancouver and 46 per cent of those

Table 5.1 Major commute modes and monthly pass product by hotel, wave 1

Hotel	PT subsidy % at baseline	Major commute mode				Has a monthly Compass Pass product (%)
		PT-only (%)	Walk-only (%)	Auto-only (%)	Auto and PT (%)	
A	15	59.8	12.3	8.7	16.1	60.1
B	15	59.7	7.4	14.8	15.7	64.3
C	15	66.0	6.1	12.3	9.4	72.1
D	15	34.3	3.8	48.1	11.4	52.0
E	None	63.3	7.8	21.1	7.8	66.7
F	None	47.8	9.8	29.3	6.5	60.5
G	None	50.6	10.1	30.4	6.3	56.7
All		54.0	7.7	22.5	12.5	61.6

Note: The three shaded row pairs highlight comparable hotel pairs.

residing in the rest of Metro Vancouver reported using PT in the last 30 days. We also looked at PT use by job class in our study population. In wave 1, 94 per cent of housekeepers reported using PT in the last month. This was the highest percentage of any of five broad job classes, with food and beverage service workers coming in the lowest, at 83 per cent.

5.4.2 Mode Choice

As we see in Table 5.1 (last row), overall, 54 per cent of our respondents were PT-only commuters on the days we first surveyed them in March 2018. The percentage of people using PT to get to and from work in our study population was also substantially higher than the share of trips to work by PT reported in trip diaries completed for TransLink's 2014 *Transportation Panel Survey*, which was based on a representative sample of 3,071 Vancouver residents at least 15 years old (TransLink, 2014). In that data, 27 per cent of trips to work were by PT, 41 per cent by auto, 9 per cent by bike and 23 per cent by walking. In our first survey, only 23 per cent had auto-only commutes on the days we surveyed them, though another 14 per cent combined auto with PT or some other mode. Our study population was also much less likely to commute by walking or cycling than city residents, though the rates were more similar to those for the region. Thus, the subset of our population who already commute by PT could be expected to have an immediate gain in satisfaction from a reduction in the price of their travel through the subsidy program.

The proportion of hotel employees with PT-only commutes in wave 1 varied considerably by job class. Housekeepers had the highest share of this mode

at 75 per cent, with only 38 per cent of managers and administrators making PT-only commutes. Managers and administrators had the highest percentage of auto-only commute mode, but also a high percentage of active commuters (16 per cent). Housekeepers and back of house employees had the lowest percentages of active commuters in wave 1, which makes sense given that only 3–4 per cent of housekeepers and 7–9 per cent of back of house workers lived in downtown Vancouver (across the three survey waves), compared to 18–24 per cent of those in management and administration jobs. This reflects relative housing prices.

Considerable differences in commute mode by hotel were also apparent (see Table 5.1). This is no surprise, given the locations of the pairs of hotels in relation to PT and parking. Hotel D is the least proximate to PT and has a correspondingly low PT-only commute percentage and the highest percentage of auto-only commuters, despite the availability of a 15 per cent PT subsidy. Hotel E is closer to PT than Hotel D and, despite the absence of a subsidy at the time of the wave 1 survey, had a much higher percentage of PT-only commuters.

5.4.3 Has a Compass Card and Monthly Pass Product

In wave 1 of the survey, 90 per cent of our total respondents had a Compass Card, which can be used to pay for single trips on an as-needed basis using ‘stored value’, or used as a monthly pass. Sixty-two per cent of our total respondents had some type of monthly pass product on their Compass Card at the time of the baseline survey. Although a strict comparison is not available, the rate at which these hotel workers held monthly pass products appears to be much higher than the rate among Compass Card holders in general. According to TransLink, in March 2019, 75 per cent of all Compass Cards, excluding specialty passes such as those available to university students, youth, seniors or those on income assistance, had only stored value.

Again, housekeepers held Compass Cards at the highest rate, 96 per cent. They were also the group that held monthly pass products (of some sort) at the highest rate, which was 77 per cent. The management and administration (47 per cent) and food and beverage job classes (49 per cent) had the lowest percentages of monthly pass product holders. As shown in Table 5.1, respondents at Hotel D, the least PT accessible location, held monthly pass products at the lowest rate (52 per cent), but the highest rates were not at those hotels adjacent to SkyTrain stations (hotels A and B), but instead were at hotels C and E, both of which are a short walk from a SkyTrain station.

5.4.4 Subsidy Acceptance

In wave 1, 28 per cent of respondents said that they had accepted a PT subsidy from their employer; with 43 per cent reporting that while their employer offers a PT subsidy, they had not accepted it. Among occupational groups, housekeepers were the job class with the highest percentage of subsidy accepters in wave 1, with 41 per cent of them doing so. Front of house staff were the second biggest group to accept the subsidy at 27 per cent, followed by food and beverage service workers (25 per cent), management and administration (20 per cent) and back of house workers (20 per cent).

Subsidy acceptance also varied among the four hotels (A, B, C and D) where the 15 per cent subsidy was available at the time of the first survey, and before the new and enhanced experimental subsidies became available. Hotel C had the highest rate of subsidy acceptance (48 per cent) and Hotel A the lowest (21 per cent), despite its PT-proximate location. Hotel D, which is the furthest from PT, had the second lowest subsidy acceptance rate (23 per cent) and a high percentage of respondents indicating that a subsidy was available but they had not accepted it.

The data we matched from waves 1 and 3 allow us to examine the characteristics of workers who were most likely to accept the subsidy or change commuting behaviours in response to the PT subsidies. One of the characteristics of subsidy accepters was a higher likelihood to work weekends. This may reflect the current pricing advantage of weekends, which is when SeaBus and SkyTrain trips across the entire Metro Vancouver region (three zones) are priced at the one-zone fare. It is possible that the weekend discount combined with the discount from the experimental subsidy were sufficient to trigger subsidy acceptance. This would echo a broader reality in transport pricing, whereby mobility that is perceived as a good bargain draws attention and can influence travel behaviour change. This is the principle on which airlines' 'seat sales' and auto dealers' 'employee pricing for all' is based.

5.5 QUALITY OF LIFE EFFECTS OF PUBLIC TRANSPORT

Using eight quality-of-life indicators with a five-point Likert-type scale in all three questionnaires, we found that overall, for our entire study population, respondents reported small declines in perceived quality of life in most categories from waves 1 to 3 of the surveys. This tells us that any subsidy- or PT-related improvements in how workers perceived their quality of life were not large enough to override the overall (small) declines in perceived quality of life. After all, a new PT subsidy, or an increase to an existing PT subsidy, is only one of many factors affecting workers' perceptions of their quality of life.

The facts that Vancouver was in the grip of a worsening housing affordability crisis, and that hotels and their employees were deadlocked in contract negotiations, may have contributed to this overall context that drove down quality of life perceptions during our survey period.

Table 5.2 shows perceived quality of life (QoL) for waves 1 and 3, with index of quality of life change in the last column. This index was calculated as wave 3 net change minus the wave 1 net change, where wave 3 net change is equal to twice 'very positive' plus 'positive' minus twice 'very negative' minus 'negative'. We do note in Table 5.2, however, that there were absolute improvements to indicators in two areas that may be closely related to commuting: stress level (+3.1 per cent) and predictability of commute to work and to home (+8.2 per cent and +3.5 per cent, respectively). One of the reasons why people find commuting unpleasant and stressful is the degree to which the length of time it will take and what will happen on the way is uncertain. For example, unpredictability is a challenge for auto-only commuters in areas with traffic congestion, just as it is for PT commuters in areas with unreliable service.

In contrast, respondents reported an overall absolute decline in all other dimensions of quality of life, including general happiness with life, time spent with family and friends, physical health, shift scheduling and general happiness with work. Our analysis shows that the relative decline in some of these was smaller for those who accepted the subsidy and/or used PT.

5.5.1 Quasi-Panel Analysis

Among the quasi-panel of respondents matched from waves 1 to 3, 25 per cent reported a decline in happiness at work, but among those who switched away from commutes that included PT, this rate was much higher: 50 per cent. Meanwhile, only 19 per cent of those who added PT to their commutes reported a decline in their happiness at work. These differential rates of decline in reported happiness at work indicate that those whose commutes included PT were more likely to have stable or improved feelings of happiness at work than those who commuted by other modes.

Everyone in the quasi-panel of matched respondents (waves 1 to 3) who added PT to their commutes reported either constant or improved stress levels. Meanwhile, only 69 per cent of those in the quasi-panel who shifted away from PT in their commutes reported improved (that is, reduced) stress levels. Almost one-third (31 per cent) of those who shifted away from PT in their commutes reported increased stress levels. Whether the increased stress came from the general economic effect of losing access to a resource (PT subsidy) and having to pay more for mobility, or whether it came from the physical and psycholog-

Table 5.2 Perceived quality of life, waves 1 and 3 and index of QoL

	Wave 1 (%)					Wave 3 (%)					Index of QoL change
	Very pos.	Pos.	Neut.	Neg.	Very neg.	Very pos.	Pos.	Neut.	Neg.	Very neg.	
General happiness – life	36.6	49.6	12.5	1.2	0.1	33.5	47.0	17.9	1.1	0.5	-9.5
Time spent with family/ friends	37.1	42.8	16.2	2.7	1.2	33.1	42.2	19.9	4.1	0.7	-9
Physical health	23.7	50.2	20.8	4.6	0.6	20.4	47.4	27.4	4.2	0.5	-8.8
Level of stress	8.3	26.8	48.4	14.5	1.9	9.4	28.8	44.6	15.0	2.2	3.1
Commute predictability – to work	17.8	45.3	28.6	6.3	2.1	20.2	44.5	30.1	4.1	1.1	8.2
Commute predictability – to home	16.8	46.9	27.4	6.7	2.1	18.7	43.7	30.6	5.8	1.1	3.5
Shift schedule(s)	21.4	42.8	29.1	5.6	1.0	18.6	44.0	28.4	7.2	1.7	-7.4
General happiness – work	19.5	51.9	25.0	3.1	0.5	19.2	43.8	30.2	5.8	1.1	-12.6

ical attributes associated with a less predictable and relaxing mode of travel, or whether both factors were operative, deserves further investigation.

Further supporting the association between reported level of stress and the use of PT in commuting, those who switched to PT-only commuting were more likely to express improved or constant stress levels: over 90 per cent, compared to only 68 per cent of those who stopped being PT-only commuters. When it comes to those who gave up auto-only commuting from waves 1 to 3, 54 per cent reported improved stress levels. This contrasts with the 100 per cent of those who switched to auto-only commuting who reported static or worsened stress levels. Note, however, that this apparently overwhelming finding may not be statistically significant due to low cell counts.

5.5.2 Multivariate Analysis

The positive relationship between some self-reported quality of life dimensions and PT usage, identified through bivariate analysis in the section above, was further confirmed through a series of binary logistic regressions. Here we model the likelihood of positive or very positive reports on each of the quality of life indicators, as a function of a series of independent variables including demographic characteristics, geographic (accessibility, sub region), work circumstances, and PT subsidy offer. We report on just some of the statistically significant relationships.

First, in a pooled cross-sectional sample of all respondents from all three waves, those who had accepted the subsidy were significantly more likely to report:

- Positive or very positive health ($p = 0.037$, $\text{Exp}(B) = 1.316$).
- Positive or very positive level of stress ($p = 0.011$, $\text{Exp}(B) = 1.366$).
- Positive or very positive predictability of commute back home from work ($p = 0.026$, $\text{Exp}(B) = 1.326$).

Subsidy acceptance was thus related to some positive quality of life outcomes, namely health, stress and commute predictability. In other words, subsidy acceptance appears to give workers a general sense of assuredness about their lives, including commute predictability, which may affect workplace outcomes. This effect appears to be an early impact of increasing available resources to a population who need all they can gather to make ends meet.

Second, among the quasi-panel of respondents matched from waves 1 to 3, a higher initial subsidy level is associated with a greater likelihood of an improved or unchanged general happiness with life ($p = 0.021$, $\text{Exp}(B) = 1.062$). Third, also among the quasi-panel respondents, a higher initial subsidy level is associated with a greater likelihood of improved or unchanged pre-

dictability of commute from home to work ($p = 0.004$; $\text{Exp}(B) = 1.078$), and of the commute back home from work ($p = 0.009$; $\text{Exp}(B) = 1.069$). Fourth, also among the quasi-panel respondents, those accepting a subsidy between waves 1 and 3 are much more likely to report a positive change in the level of stress ($p = 0.000$, $\text{Exp}(B) = 4.454$). This finding lends considerable support to the findings above about the positive relationship between self-reported stress level and PT engagement.

In summary, it is important to note that a higher subsidy level in the first survey was associated with improved or unchanged quality of life indicators between waves 1 and 3, including general happiness with life, level of stress, time with family and friends, and commute predictability. This supports other findings that it takes time for the implications of PT subsidies to become apparent to commuters, since commuting is a learned, routine-based behaviour. In other words, the value of shifting to a more predictable and less stressful mobility mode only becomes apparent to the users over time. Like increasing physical exercise, switching to PT may bring some initial pain and then a lag period before the benefits are felt. Subsidy acceptance was also associated with an improvement in the reported level of stress.

5.6 CONCLUSIONS

Our findings thus confirm that PT plays a necessary and important role in the lives of Vancouver's downtown hotel workers. Even though a substantial minority of workers commute at hours falling outside the period when PT services are planned and operated to support work trips, many hotel employees make use of PT and experience its effects on their quality of life. The unique dataset we have compiled provides a rich opportunity for analysis of the relationship between work and commuting among rarely recognized workers in post-industrial urban economies.

We have discovered from the application of an experimental PT subsidy, and occupationally and socially disaggregated survey data, that PT makes a positive contribution to the work and life satisfaction within the population that we studied. This occurred by reducing the cost of travel and improving travel reliability as compared to commuting by automobile. As a result, many hotel workers who contribute to making Vancouver a happier and more connected city can gain enhanced social wellbeing from programmes that encourage PT use. The leading and lagging components of this effect have begun to reveal themselves in our findings, but further investigation would be needed to validate these dynamics with greater confidence and precision.

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6. Analysing urban mobility in ageing populations: the case of two Portuguese historic centres

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6.1 INTRODUCTION

The promotion of sustainable cities is part of the global agenda, and care for social dimensions (including inclusion and equity) is fundamental to the wellbeing of their inhabitants. This chapter focuses on the trend of the ageing population in the most developed countries, and the needs and conditions of mobility of those who are older, considering that the urban environment and the transport system must be adapted to guarantee these conditions and meet those needs. Projections indicate that, between 2016 and 2060, the proportion of people over 65 will rise from 19.3 per cent to 29.0 per cent of the total population. In the same period, the active population (15–64 years of age) in the European Union is expected to decrease by 11.6 per cent (EC, 2009, 2012). Illustrating this, and according to the National Statistics Institute of Portugal (INE), a ratio of 317 elderly people per 100 young people is expected by 2080 (INE, 2017).

Although this circumstance is a triumph of medical, social and economic development (Ball and Lawler, 2014; Fernández-Ballesteros, 2011; Plouffe and Kalache, 2010) it is simultaneously one of the greatest challenges for public policies (Coughlin, 2017; WHO, 2019; UN, 2019; UNECE, 2019). Recognizing these demographic changes, policies, projects and various initiatives have aimed to adapt to these new circumstances. The role of the United Nations, World Health Organization and the European Commission has been relevant in encouraging the promotion of relevant policies. The increased attention devoted to this type of issue is expressed in some publications, such

as in Cheng et al. (2019) which analyses how the built environment affects the possibilities of active mobility for the older adults, or in Bergefurt et al. (2019) which highlights the influence of active mobility on their quality of life. Among other contributions, Guo et al. (2019) analyse accessibility to urban parks, one of the essential urban facilities for maintaining active mobility.

The mobility of older adults is particularly difficult in old European urban centres, where roads are often steep, narrow, and have uneven pavements, and where this age group tends to be concentrated, both residents and visitors. This situation is particularly relevant in Southern European cities less affected by the world wars, where various layers of urban structures remain. This happens in almost all the old centres of Portugal. Many of these urban centres have been classified as World Heritage Sites by the United Nations Educational, Scientific and Cultural Organization (UNESCO). This last circumstance often means the impossibility of altering several aspects of the urban space, creating difficulties for local accessibility to public transport and for walking. The elderly are particularly affected by these circumstances. In addition, much of the urban rehabilitation is dedicated to new tourist facilities and not to the urban public space.

The travelling population is also ageing, not only in Portugal, but throughout Europe. The tourist activity, natural in this type of areas, also creates some gentrification problems, and the changes allowed are not always adapted to the needs of visitors or residents. These aspects are presented in the work of Temelová and Dvoráková (2012) showing the consequences of the invasion of tourism in these areas, which affects the lives of the local population, especially the low-income older population with mobility restrictions. Similarly, gentrification also creates problems in Sarajevo, as specified in a work by Pobric and Robinson (2019).

Another characteristic of the mobility of older people, namely in Portugal, is the fact that they usually walk or use public transport, for different reasons, namely because in the past they did not take a driving licence or because they can no longer drive for health or retirement/income reasons. In general, in Portuguese historic urban centres, a large part of the older population has low income and is less likely to own or drive a car. Therefore, the present chapter focuses on the mobility of the elderly in public spaces, and the quality of access to services and transport systems, identifying barriers and motivators both on the side of urban design and on the side of the transport system.

This research focuses on identifying criteria for the establishment of future indexes able to manage and classify urban walking routes and transport systems in terms of quality of mobility and accessibility for all, active and sustainable, assuming that cities more adapted for the older are cities optimized for all citizens. The choice of the Coimbra and Porto case studies is also related to their difficult urban structures and higher ageing problems.

In terms of structure, this chapter begins with a literature review (section 6.2) on motivators and barriers in pedestrian movements and in the use of public transport by the elderly, dividing the relevant factors into categories of personal characteristics and urban environments (with subcategories). Then, it focuses on the case studies (the cities of Coimbra and Porto), presenting the locations and explaining the interview method and the analysis of the results (sections 6.3 and 6.4). Finally, it ends with some conclusions in view of the initial objectives (section 6.5).

6.2 LITERATURE REVIEW

A considerable amount of information already exists showing us that this topic has been growing in importance, mainly in the last decade, due to the growing need to adapt the urban public space to elderly adults' special needs. Urban public spaces must be adapted to the needs of the elderly (Cinderby et al., 2018) to improve the quality of life for this age group and the general population. The perspective of an age-friendly city is therefore influenced by awareness of the impact of an ageing population on urban planning and design (Buffel et al., 2012). Transport is indicated as a key element in this relationship.

Currently, older people tend to remain active. However, this population has specific travel needs, in terms of destinations, travel times and options for modes of transport. Thus, the urban planning of the public urban space and the public transport system that adequately accommodates these needs is fundamental, also contributing to the conditions of an active life, fundamental for all ages. Factors related to the physical environment can make the difference between an elderly person's autonomy and their dependence on others. Thus, it is essential to understand not only the characteristics of the elderly, but also the factors that influence their mobility.

Regarding the main characteristics of trips made by the elderly, we can say that they travel less frequently (Collia et al., 2003; Habib, 2014; Tacken, 1998; Wretstrand et al., 2019; Yang et al., 2018), walk more slowly (it is estimated that while adults aged 25 to 34 years walk at an average speed of around 1.25 m/s, adults over 64 years walk at 0.96 m/s, according to a study by de Silva et al. (2014) and travel for a shorter time and distance (Collia et al., 2003; Moniruzzaman et al., 2013; O'Hern and Oxley, 2015; Szeto et al., 2017; Yang et al., 2018). In addition, some factors can be impeding mobility such as living alone (Tacken, 1998), having health problems (Yang et al., 2018), having a low level of education (Tacken, 1998) and having a low income (Habib, 2014).

In addition to the specific characteristics of older adults and their trips – which act as factors for or against their mobility – it is important to consider the characteristics that make a city more inclusive, in terms of urban design and also in terms of the transport system. Table 6.1 shows the barriers and

motivators for pedestrian mobility of the elderly, identified through a systematic analysis of the literature.

Table 6.2 shows the barriers and motivators for mobility using public transport, also identified through the literature.

Previous literature identifies several main motivators and barriers for the mobility of the elderly as pedestrians and public transport users. It identifies common factors valid for all places with characteristics similar to those considered in these case studies of historical city centres. Therefore, the case studies were selected by also taking into account their representativeness, especially considering the similarities of many historic urban centres in Southern Europe.

6.3 INTERVIEW ANALYSIS

Portugal follows the ageing trend of the European population. Two case studies were considered, in Coimbra and in Porto, delimiting an area of analysis within their historic centres. These areas have a higher concentration of older residents and both represent critical areas in terms of mobility and accessibility, due to the old and irregular urban structure. In these areas, the car was gradually phased out (more in Porto than in Coimbra) due to some urban rehabilitation projects, and they are still inhabited by a local population mainly formed by older adults, despite the growth in tourism and in visiting population. The urban structure is made up of streets and small, rugged squares, narrow and maintained with old pavements. People travel the areas mainly on foot and using public transport lines, which in the case of Coimbra are mostly composed of small buses that cross its inner areas.

Residents and tourists were interviewed. Participants were chosen from a stratified sample. In the first phase, the city councils responsible for the historical centres (in Coimbra and Porto) were consulted for recommendations on how to interview the older adults who live in those areas. The recommendation was to contact the social institutions that daily support those elderly and where they stay during the day. In a second phase, in those institutions, the social assistants provided indications about the people to be interviewed, selecting those who were in good cognitive condition and/or who still had autonomy to walk and use public transport.

In the case of the residents interviewed, the interviews sought to identify their routines in terms of mobility, covering three main sets of aspects: personal characteristics; motivators and barriers in pedestrian movements; and motivators and barriers in the use of the public transport system. Tourists were interviewed on the street, with the same type of questions. Overall, the interviews in Coimbra and Porto corresponded to a total of 46 respondents, being 24 residents and 22 tourists, 28 women and 18 men, all in the 65 to 95 age group. Regardless of age or gender, or the condition of residents or tourists, the

Table 6.1 Motivators and barriers in older people's pedestrian movements

Factor types	Motivator/barrier	Sample of specific literature
Safety issues	Presence of pedestrian paths	Boarnet et al. (2005), Kerr et al. (2012), Powell et al. (2003), Southworth (2005)
	Signal-controlled pedestrian crossings	Boarnet et al. (2005), Powell et al. (2003), Southworth (2005)
	Buffering from road traffic	Powell et al. (2003), Southworth (2005)
	Sense of personal safety	Kerr et al. (2012), Southworth (2005), Gallagher et al. (2010), Moniruzzaman et al. (2013), Cinderby et al. (2018), Gómez et al. (2010), Plouffe and Kalache (2010), Sonmez Turel et al. (2007), Van Cauwenberg et al. (2012), Wang and Lee (2010)
	Enforcement of speeding and other traffic laws	Powell et al. (2003), Southworth (2005)
Interac.	Availability for shopping/eating/recreational activities	Cervero and Duncan (2003), Handy et al. (2002), Sugiyama et al. (2012)
	Opportunities to talk or meet with friends and neighbours	Carver et al. (2005), Krizek (2003)
Pleasant/visual qualities	Concern for the natural environment or 'being green'	Nilsson and Kuller (2000)
	Pleasant environment/cleanliness of neighbourhood and streets	Alfonzo et al. (2008), Handy et al. (2002), Gallagher et al. (2010), Yung et al. (2016), Feng (2017), Gómez et al. (2010), Borst et al. (2009), Wang and Lee (2010), Moniruzzaman et al. (2013), Cinderby et al. (2018)
	A visually appealing environment/attractive points	Alfonzo et al. (2008), Kerr et al. (2012), Sugiyama et al. (2012), Michael et al. (2006), Moniruzzaman et al. (2015), Van Cauwenberg et al. (2012), Wang and Lee (2010), Yoo and Kim (2017), Yung et al. (2016), Feng (2017), Cao et al. (2010), Musselwhite and Haddad (2010)
Activity	Opportunities for exercise	Owen et al. (2004), Suminski et al. (2005)
	Easy terrain	Cervero and Duncan (2003), Dill (2004), Humpel et al. (2004), Pucher and Buehler (2006)
	Weather on a given day	Cervero and Duncan (2003), Dill (2004), Humpel et al. (2004), Pucher and Buehler (2006)

Factor types	Motivator/barrier	Sample of specific literature
	Walking for pleasure	Cao et al. (2010), Gallagher et al. (2010), Plouffe and Kalache (2010), Wang and Lee (2010), Moniruzzaman et al. (2015), Borst et al. (2009), Sonmez Turel et al. (2007), Cinderby et al. (2018)
	Distance to destination	Cervero and Duncan (2003), Dill (2004)
	Saving money	Pucher and Buehler (2006)

Table 6.2 Motivators and barriers for older adults in transport system use

Factor types	Motivator/barrier	Sample of specific literature
Urban design/urban environment	Good pedestrian environment	Moniruzzaman et al. (2015), Cinderby et al. (2018)
Public transport services	Transport availability	Gilhooly et al. (2002), Burkhardt (2003), Banister and Bowling (2004), Su and Bell (2009), Ipingbemi (2010), Wong et al. (2018)
	Low travel costs	Burkhardt (2003), Su and Bell (2009), Olawole and Aloba (2014), Szeto et al. (2017)
	Clear information	Ipingbemi (2010), Wong et al. (2018)
	Proper vehicle design	Gilhooly et al. (2002), Burkhardt (2003), Ipingbemi (2010), Aceves-González et al. (2015), Wong et al. (2017)
Safety issues	Personal safety	Gilhooly et al. (2002), Gallagher et al. (2010), Olawole and Aloba (2014), Aceves-González et al. (2015)

results were aggregated considering motivators and barriers, both for walking and for using public transport.

6.4 INTERVIEW RESULTS

The common factors identified in the interviews of both residents and tourists are presented in Table 6.3. The reason for this aggregation has to do with the fact that there are no substantial differences between residents and tourists, except in the case of tourists who noticed, on the one hand, the feeling of good cleanliness and urban security (the residents have a different opinion since they live there permanently) and, on the other hand, the lack of urban signs (not important for residents). It was considered that these differences would not be enough to disaggregate the two groups and, consequently, it was considered that all the factors mentioned should be considered important for the mobility of the older population as a whole.

Table 6.3 *Motivators and barriers identified in the interviews*

Using public transport		
Walking		
Motivators	Barriers	Motivators
<ul style="list-style-type: none"> • Travel to the day centre, supermarket, pharmacy, hairdresser, church; • exercise, good for health; • greater flexibility; • enjoy the landscape; • simpler than using public transport; • preference for the flatter and safer path (floor, lighting, handrail); • density of points of interest; • cleanliness and safety 	<ul style="list-style-type: none"> • Inadequate pavement with slippery or uneven surface material; • lack of maintenance; • steep slopes; • moving traffic; • parked cars; • lack of public safety; • steps without handrails; • poor lighting; • dirty walls; • poor hygiene; • poor sign quality 	<ul style="list-style-type: none"> • Travel to the day centre, supermarket, hospital, physiotherapy; • prevent physical tiredness; • socialize with other passengers; • enjoy looking out of the window; • easier to carry weights (shopping); • being empty out of rush hours; • some minibuses tailored for historic centres that they can use
		Barriers
		<ul style="list-style-type: none"> • Long waiting time/poor availability; • not punctual; • difficulties getting on and off the bus; • behaviour of other passengers; • lack of seating; • driver antipathy; • driver does not always wait for older person to take a seat; • unsafe driver driving; • unstable vehicle;

Regarding age, the group interviewed showed good cognitive condition and autonomy to walk and use public transport, and no noticeable differences were found between them, regardless of being 65 or 95. Considering these results, and cross-checking them with the bibliographic review and with the characterization of the public urban space and the transport system in the two case studies, there is a generalized convergence of what can be the main factors to consider in promoting the mobility of the older population, both in terms of barriers and in terms of motivators.

With regard to pedestrian infrastructure, in particular, reference is made to the lack of some elements of the infrastructure, the inadequacy of physical characteristics and/or the lack of maintenance in relation to pavements with inadequate surfaces, lack of stairs, ramps and handrails (a slope that is too steep and without supports is a central aspect in this analysis). In terms of interaction with other modes of transport, namely with motor vehicles, reference is made to the lack of buffer zones and the prevalence of motor vehicles (moving and parked), increasing the sense of insecurity. Interestingly, the constraints related to intersections between cars and pedestrians are more pressing in the historic centre of Coimbra than in Porto, probably because there has been greater urban regeneration, with the creation of shared spaces in Porto.

In relation to public transport, the interviewees emphasized negative aspects related to human behaviour, such as the performance of public transport drivers and the behaviour of younger travellers, who do not give way to older people. This last aspect may not be specific to the Portuguese case, but it was not identified in previous studies, which is why its detection in this case study was considered interesting.

The interviewees also highlighted the feeling of insecurity caused by walls with offensive graffiti or the lack of public lighting. The feeling of urban insecurity, emphasized by local residents, is based on their contextualized local assessment. Most likely, this is due to age-related vulnerability and not to any real problem of local or regional insecurity. The opposing opinions of tourists give weight to this finding.

6.5 CONCLUSIONS

Through this analysis, the identification of common factors that influence the mobility of the older adults will allow the development of planning tools that can help to promote sustainable urban mobility (on foot and by public transport) for adults with increased physical difficulties, being beneficial for all. These instruments should advocate the adaptation of both the public urban space and its multiple infrastructures and the public transport system. The convergence between the factors identified in the literature and the results of the analysis of the case studies allows us to validate those factors to a large extent.

This analysis also identified other factors related to human behaviour that may be a consequence of the local urban mobility culture itself, which highlights the importance of analyses developed with social proximity, with the public participation of some of those most directly affected by motivators and barriers to mobility in historic urban centres: the still active older adults (much more active than the word ‘elderly’ makes us think), who are a growing population in the developed world.

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7. Car sharing for older adults in Oslo: practices, needs and preferences

Tanu Priya Uteng

7.1 INTRODUCTION

The re-densification project, popularly discussed under conceptual framing of transit-oriented development (Knowles, 2012; Pojani and Stead, 2014), has been adopted in Norway as a means to combat climate change. This strategy is coupled with a defined aim of reducing any increase in vehicle kilometres by private vehicles and shifting the entire bulk of future transport on sustainable modes such as walking, bicycling and public transport. One of the plug-in elements emerging in this narrative comprises the car sharing (CS) solution, which shifts the car-based private mobility from ownership to service use, and from regular to intermittent, needs-based use. A structured analysis of 137 papers on CS reveals that though CS has been analysed through different lenses – business models, customer validation, operational details, modelling, and so on – the topic of travel behaviour of older adults and CS remains unexplored (Ferrero et al., 2018).

This chapter focuses on the possibilities and problems related to CS in Oslo for the population segment of 65+, building on the conceptual framing of social practice theory. The idea is, firstly, to show that the persistent problem¹ of car driving is embedded in the practices of this demographic group; and secondly, to highlight how CS may be inserted in their travel behaviour. The chapter proceeds with a brief literature review and the theoretical framework, followed by an overview of the Norwegian active ageing agenda, population projection and spatial distribution of Oslo's 65+ population. Section 7.3 presents the background of this study, while the data and analyses are presented in sections 7.4 and 7.5. The chapter concludes with some thoughts on future policy interventions and research work in section 7.6.

7.2 LITERATURE REVIEW

7.2.1 Older Adults' Travel Behaviour

Studies, both in and outside Norway, confirm that age and travel behaviour exhibit strong correlations, and car usage has become a routinized practice for the 65+ age group (Hjorthol et al., 2010; Scheiner, 2006). Further, urban areas in Norway exhibit the following tendencies (Saeterøy, 2018; Priya Uteng, 2012; Hjorthol et al., 2011):

1. Men aged 35–45 are the most eager drivers, but the average number of daily car trips has been declining.
2. Simultaneously, for middle-aged men (45–65-year-olds), there has been an increase in average number of daily car trips.
3. This trend is even stronger for 65+ years where an accelerating increase in the number of daily car trips has been recorded.

Additionally, a recent study (Hjorteset and Böcker, 2020) exploring the intentions to participate in CS in the nine largest urban areas of Norway revealed that older adults were less likely to participate in car sharing in the near future. The lack of intention to participate in car sharing is explained by the fact that this group is less financially conscious compared to younger people. Analysing the patterns of current CS membership further revealed that older members more often owned a private car, thereby making them less likely to be members of car sharing platforms (*ibid.*). Previous literature does indicate that CS, so far, has the highest uptake among the younger generations (Prieto et al., 2017; Priya Uteng and Farstad, 2020).

It might be tempting to assume that the older adults are more reluctant to adopt new modes of transport, particularly modes embedded in technology such as CS. Such blanket statements have proven to be unhelpful and have largely been refuted (Olson et al., 2011). The complexity of the population's transport needs, along with its social systems, is important to keep in mind when analysing and discussing future pathways. In line with Kent and Dowling (2013), the guiding principle is understanding the routines, age-based necessities, circularity and preferences, which can be approached through employing the conceptual framing of social practice theory.

7.2.2 Social Practice Theory (SPT)

Social Practice Theory (SPT) states that a practice is a routinized behaviour consisting of a set of interconnected elements: materials, skills and meaning (Reckwitz, 2002; Pantzar and Shove, 2010). A central tenet is that a practice

can be understood both as a performance through the observable behaviour of individuals, and as an entity which emerges through socially shared ideas and meanings, knowledge, skills, materials and infrastructures (Wilson, 2015).

Pantzar and Shove (2010) argue that innovation is a continuous process that persists through the reproduction of practices, and this reproduction takes place through a collusion of managers, manufacturers and consumers who make and sustain connections between the defining elements of practices. They raise some pertinent questions for the case of CS: ‘how can managers and manufacturers institutionalise practices that require consumption of the things they make? Is there any fundamental difference in the role of “lead” and “ordinary” users in generating and sustaining innovations in practice?’ (ibid: 441).

Framing innovation in the lingo of SPT, Wilson (2015, p. 10) borrows Shove and Pantzar’s (2005) framing that ‘Innovations in practice are about making and breaking links between elements of material, image and skill. We suggest that such linkages are always local and that what looks like the “diffusion” of practice is better understood as its successive (re)invention’. These successive (re)inventions typically take place at the macro and micro levels, which Jensen (2014) frames as ‘staging mobilities’. For CS, the macro level or staging from above entails the actions of planners, engineers, politicians and information technology companies designing smart solutions; while staging from below consists of performing mobilities. The following questions can be further analysed to understand the meaning and embodied performances of CS by the older adults population:

- How is CS being staged from below?
- How can we promote CS in the 65+ age group?

7.3 BACKGROUND

7.3.1 Active Ageing Agenda of Norway

Norway’s development agendas are rooted in the welfare model. Consequently, ageing is also framed in the welfare format, and is rooted in the financial and social sector. The financial repercussions of an expanding older adult population are evident through increasing old-age dependency ratios, imbalances in net tax payments, downward trends in average pension age, and a particularly Norwegian indicator known as ‘shark jaw’, revealing the growing gap between increasing pension expenditure and decreasing oil revenues (Foss, 2003; Ervik and Helgøy, 2013). Given these framings, keeping the older adults in paid employment for an extended period of time has been emphasized.

As a primary response, the social framing of the ageing agenda was designed to support the economic underpinnings:

if people are kept in work, supported in developing their competences and provided with interesting work tasks, then they will develop, grow and remain in good health. Work gives the individual challenges and opportunities needed for learning. It provides a person with an opportunity for social contact and inclusion. The key problem at the individual level was social exclusion. (Ervik and Helgøy, 2013, p. 189)

A secondary response is evident in redesigning of the health and care services to enable older adults to stay as long as possible in their private residences. The public social services wing of the municipality provides personal care services to dependent, older people to support them live autonomously, when independent living becomes an issue.

Effectively, there are three dimensions on which the Norwegian ageing agenda is formulated: pension, extended employment and care services (Strand, 2018). Discussions related to long term solutions and supportive environments focus primarily on these three domains. This framing, however, fails to appreciate the broader conception of civic participation and its interlocking with spatiality – location, daily travel, activity participation, and so on – remains fuzzy. Additionally, the third pillar of sustainability, environment, is absent in discussions on active ageing. The two most prominent responses to the Norwegian social inclusion approach, bearing significant environmental consequences, are evident in the following trends (Priya Uteng, 2012; Saeterøy, 2018):

1. Relocation of the older adults to apartment blocks built near the transit nodes and central locations.
2. Though these relocated older adults have good public transport connectivity, their mobility remains car-based.

7.3.2 Population Projection for Oslo

According to Statistics Norway's projections, the share of Oslo's 65+ population will grow from 15 per cent in 2016 to 20 per cent by 2040. Another facet of Oslo's ageing population will be evident by 2028 when 'established workers' (40–64 age group) will overtake the 'young workers' (25–39 age group), and the young workers' growth trajectory is also projected to stagnate around the same year. Contrary to the current promoters and active users of CS, the elder age groups will constitute a larger share of Oslo's overall population by 2040, thereby exerting a higher influence on future mobility.

7.3.3 Ageing and Residential Pattern in Oslo

In order to map the relationship between residential location of older adults and distance to the nearest local centre (according to Statistics Norway's definition of local centres), we plotted the distance between the centre and residential location of the different age groups for 2014. Distance plotting highlighted that the average distance between a local centre and the residential location of the different age groups drops by approximately 3 metres with each successive year of ageing as we progress from the age of 50 to 90. This synchronizes with observations of several Norwegian researchers and planners pointing towards a general tendency of older adults to shift closer to the local centres in urban areas. A detailed analysis of this emerging pattern at the national level has not been undertaken in this research.

7.4 DATA

This chapter employs a mixed-methods approach, where the qualitative data constitutes of in-depth personal interviews of households conducted in Oslo between May 2017 and February 2018. These interviews were held at the households' residences, lasting about 60–90 minutes each, covering a number of aspects related to the households' daily mobility practices, with a particular focus on CS. The interviews were conducted with households subscribing to one or multiple CS platforms in Oslo. Of the 39 interviewed households, only the following three households qualified to represent the older adults. They were extracted to reflect the needs and preferences of the older adults in relation to CS's potential for addressing their daily mobility needs.

1. HH_A. 65-year-old single woman, living independently. CS membership: Hertz bilpool (business-to-consumer model, B2C).
2. HH_B. 60-year-old woman, living with partner. CS membership: Bilkollektivet (cooperative model).
3. HH_C. 50- and 52-year-old couple. CS membership: Bilkollektivet (cooperative model), Nabobil (peer-to-peer model, P2P), Hertz (business-to-consumer model, B2C), and others.

The household interviews were followed by an online questionnaire survey, distributed in November–December 2017, among members of different CS platforms. The total of number of respondents from Oslo was 2030, out of which 70 were in the age category of 65+.

7.4.1 Survey Format

Data collected from both surveys were framed in the narrative of SPT, taking materiality, skills and meanings associated with CS as departure points, and included the following three dimensions.

First, motives for CS. To capture the distinction between instrumental, normative, affective and symbolic dimensions (Jensen, 1999; Noppers et al., 2014; Steg, 2005) on both starting and continuing with CS, we applied a minimal set of questions, assessed on a Likert-scale of 1 to 7. For the instrumental dimension, we asked to respond on: 'I can save money with CS' and 'CS is more practical than owning a car'. For symbolic motives, we asked for responses to: 'CS fits with my identity' and 'I identify as a motorist'. To capture more normative types of motives, the following were posed: 'I wish to travel in environmentally friendly ways' and 'CS is more social and inclusive'. The same questions were framed as open-ended questions in the face-to-face interviews.

Second, car ownership and sharing history. Given that the daily mobility of the older adults is primarily car-based, and their history as car owners and usage of other modes of sharing may play an important role in influencing their choices in opting for CS, we asked the following two questions: whether they or someone in their household previously owned a private car and/or whether they had one in the household; and whether they had used CS or other sharing platforms such as Airbnb before and the extent of usage.

Third, material and social infrastructure. To capture the material dimension, we asked the following questions: 'How good is access to parking where you live?' and 'Approximately what is the distance to the closest public transport stop?'

7.5 ANALYSIS

7.5.1 Face-to-Face Interviews

Table 7.1 presents the most vital elements extracted from interviews with the three households shedding light on issues related to adoption and retention of CS for the older adults. All three households had previously been car owners, decided to give up car ownership and opted for CS instead.

The materiality of cars and CS

The interviews reveal that there exists a willingness to forgo car-based mobility, as owning and maintaining a car is considered to be a hassle. Apart from the set of activities involved in maintaining a car, another major hassle involved parking issues. The decision to forgo car ownership was simulta-

Table 7.1 Summary of the qualitative interviews

	HH_A	HH_B	HH_C
Most vital elements identified from the interviews	65-year-old single woman, living independently, Hertz bilpool (B2C)	60-year-old woman, living with partner, BK (co-op)	50- and 52-year-old couple, Bilkollektiv (co-op), Nabobil (P2P), Hertz (B2C), and others
<i>Materiality</i>			
Using CS helps to avoid ownership hassles	Avoid hassles of owning a car	Avoid hassles of owning a car	Finds CS practical
Primary use of CS	For emergency purposes	Two weekends per month for travelling to cabin/cottage (summer or winter cabins in the Norwegian context) Secondary purpose is heavy shopping	Primary use – driving to cottage Followed by heavy shopping
Parking	Suggestion – CS availability in shared garages to be prioritized	Bypasses the normal parking issues Suggestion – CS parking to be prioritized	Suggestion – CS parking to be prioritized
Sharing history	Negative experiences from sharing	Positive experiences from Airbnb	Positive experiences from Airbnb
Family obligations	Convenient with CS for visiting children Too many transfers involved with PT on long trips	Convenient if child seat was provided (cf. grandchildren)	–
Multiple CS options	–	–	Uses multiple CS platforms to pick the car best suited for the trip purpose: short trips – BK; long trips – Nabobil

	HH_A	HH_B	HH_C
<i>Meaning</i>			
Economics	Primary reason – saving money. Currently, no expenses on car and rents out the garage	Primary reason – saving money Tipping point – if CS becomes too expensive for cabin visits once they retire, might buy a car	Primary reason – saving money and a practical option
Identification as a motorist	Negative	Negative	Negative
Car as a status symbol	Negative	Negative	Negative
<i>Skills/habit formation</i>			
Habit formation	Not yet	Checks for damage, cleanliness	Established routines
Awareness of expenses involved	Positive	Detailed plotting of the expenses	Detailed plotting of the expenses on different platforms
Using the booking system	Tricky on the first trip	Advance booking; issues with secondary member delivering the car A habit has been eventually formed	New way of picking/delivery the car keys for Nabobil (P2P) – through the local kiosk

neously dependent on high accessibility levels to basic facilities afforded to the respondents by virtue of living in high-density neighbourhoods. All three respondents lived in areas well connected by public transport, bicycling and walking, and the residential location allowed for easy access to the CS pick-up points.

CS is used primarily for accessing cabins, often located in areas difficult to reach with conventional public transport. The frequency of visiting cabins seems to increase with age, which becomes almost a primary trip, with at least bi-monthly frequency, at the onset of retired life. Both economics of charges (per hour versus per day) and the type of available car play a vital role here. The seasoned car sharers have developed schematics to calculate the costs of cabin trips on different platforms and decide accordingly. The cooperative model of CS is typically preferred for short-distance, intra-city trips; while peer-to-peer (P2P) gets precedence for long-distance trips both due to pricing and the array of cars available on P2P.

Dedicated parking in the neighbourhood or an easy access to shared cars emerged as a single most vital element in need of immediate attention and correction, according to the respondents.

Meanings associated with cars and CS

The car itself seems to have lost its vantage standpoint as a status symbol or harbinger of happiness, and for the seasoned users, CS is fast replacing the traditional meanings of freedom associated with private ownership of cars. HH_B's partner responded as following:

I wonder if you actually need to turn the problem upside down and ask – why use a car? It is absurd that people continue to possess and use a car in their daily lives. Car has absolutely no meaning in this day and age as anything other than a means to an end. And for that, we don't need to possess it really!

Skills associated with cars and CS

The households which had lived abroad in countries where CS is a normalized routine were adept at using the system, underlining a most important element: routinized practices. HH_A, for example, had trouble in using the app-based lock system and opening the parking garage, which she categorized as being tricky and irritating. This ceased to bother her once she had figured out the mechanics of the app-based system. Similarly, HH_C has come to an original solution of picking up and dropping off car keys at the local kiosk, bypassing the need to fix meetings with the car owner for a regular P2P arrangement.

7.5.2 Quantitative Survey Analyses

As Figure 7.1 demonstrates, even for the older adults who are CS members, there is a dominance of private car usage for different trip purposes. This is surprising, since close to 80 per cent of the older respondents live near public transport (PT) stations connected to a high-frequency network. A comparison of these two facets – high car dependence (private car usage) and simultaneously having good access to PT – reveal the element of practice where private car usage has become a routinized practice for the 65+ population.

Figure 7.2 shows scores on a scale of 1 ‘to a low extent’, to 7 ‘to a great extent’. It is evident that the older adults have a constricted association with CS. They do not rank CS high on any of the elements, which could be an explanatory factor behind their high dependence on private cars and low uptake of CS. It seems that the older adults are passive members of CS schemes, or they participate in the peer-to-peer scheme to rent out their car instead of curtailing their car dependency. The sample size for the peer-to-peer members was too small to comment specifically on this issue, and can be explored in future studies.

From a practice perspective, the interviews revealed that ease of access to shared cars through fixed parking slots in the vicinity is an essential aspect to enhance the uptake of CS among older adults. A similar line of enquiry was pursued in the questionnaire survey. The results highlight that dedicated parking space received the highest scores. Further, though this group followed the same pattern as the other age groups in their ranking of the preferred changes to the CS system, their web of responses remained constricted.

We were curious to explore the positionality of the car per se in terms of both materiality and meanings attached to it. What emerges is a confusing picture. The older adults, who have so far displayed a strong propensity and preference for car usage, displayed a rather distanced position from the car. They gave high scores to the car being an uneconomical choice, and low on their own interest and identification with the car. Simultaneously, they are actively seeking to live in urban areas.

Considering these contradictory findings, one could assume that there are certain deficiencies in the system itself which have so far failed to capture the needs of the older adults. We therefore asked them to score the following elements regarding ease of using the organizational interfaces of CS (scored on a scale of 1 to 7, where 1 is ‘completely disagree’): ‘I feel confident and safe while using the booking-system for car sharing and I feel confident and safe in picking and delivering the car’. The differences in scores given by the different age groups (≤ 24 , 25–39, 40–64 and 65+) were statistically significant ($p < 0.001$ chi-sq), and mean score for feeling confident and safe in using the system was lowest for the 65+ population. It is evident that the older adults

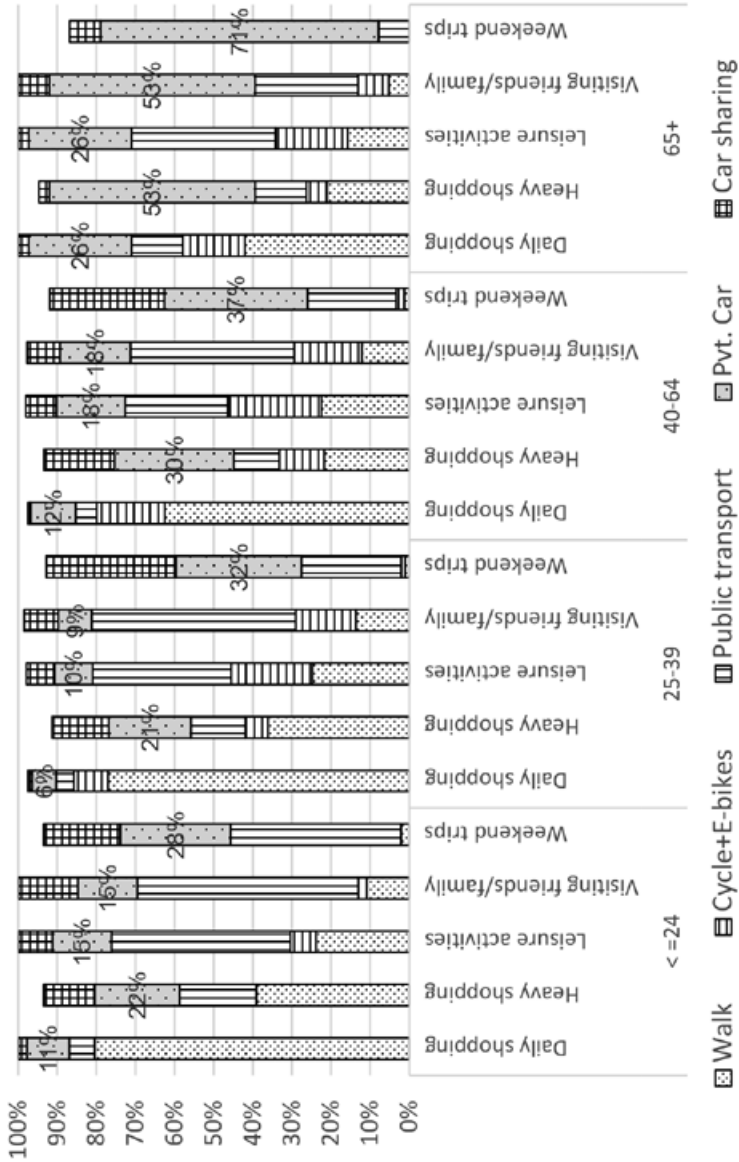


Figure 7.1 Mode share for members of car sharing organization, disaggregated by trip purposes and age groups

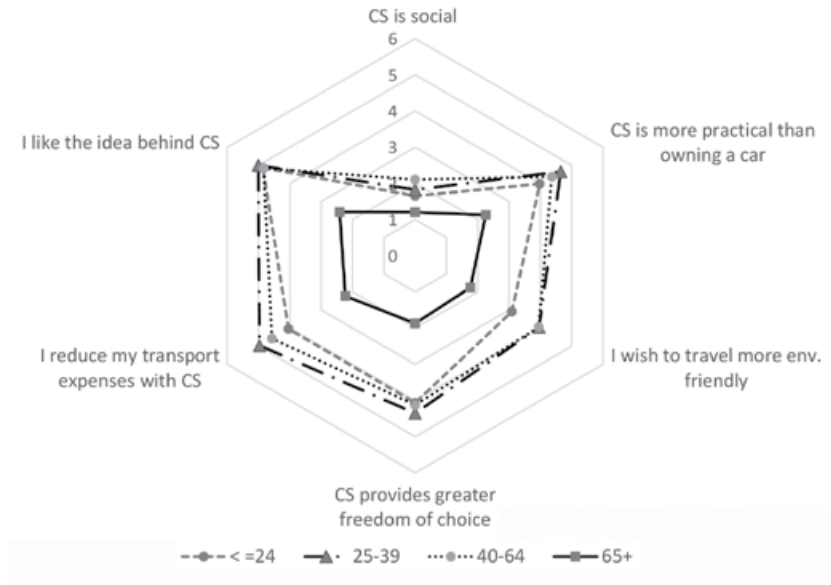


Figure 7.2 Meanings attached to CS by the members of CS organizations

need special assistance in using the CS booking, picking and delivering systems.

7.6 CONCLUSION AND RECOMMENDATIONS

The mutual overlaps and occasional interlocking of the topic of active ageing and CS has so far not been explored in research studies. The preliminary findings presented in this chapter highlight that it is a good idea to integrate CS to ageing strategies, as a replacement for private car ownership. This will not only ensure a more active lifestyle for the older adults despite less car use, but holds the potential to reduce the fleet of cars on the streets, and thus reduce requirements for facilitating car-based traffic. Given the population projections for the entire Western world, substantial gains can be harnessed from subsequent freed-up space for active modes and a renewed framing of the urban mobility and active ageing agenda.

Zooming in to the case at hand, the Norwegian active ageing agenda remains preoccupied with the economics of ageing, evident through focus on flexible pension and health reforms to keep older adults in working life for a longer stretch. Social inclusion is also being interpreted in terms of prolonged

working life. Ageing in their own residence with state-supported assistance as and when needed is the established rule, as a result of which a vast majority of the older adults are shifting to apartments near transit nodes and hubs with a dense concentration of easily accessible basic facilities. Simultaneously, daily mobility of the older adults is largely car-based. Given that the 65+ population is a fast-growing age group, and when these developments are seen in light of Norway's objective of focusing future traffic growth on sustainable modes, there exists a gap unaddressed by the active ageing agenda.

CS, a mode which is integrated and dependent on a high usage of walking, cycling and public transport in daily routines, provides a viable option to shift older adults from car-based mobility to more active forms. However, CS has not been discussed in mapping future mobility of older adults. The reduced effort costs of using PT in living close to transport hubs seems to be offset by this group's inability to shed their car-based mobility. This leads to a sub-optimum usage of the convenience and financial benefits that transport hubs offer. Alternatively, as a starting point, CS needs to target the older adults as an important and untapped consumer group, and make modifications to meet their needs and preferences.

The first step towards this end is to conduct focused surveys to understand their needs and preferences for an eventual shift to CS. A general questionnaire survey, such as that presented in this study, fails to elicit a satisfactory response rate from the older adults. Qualitative interviews revealed that CS was an attractive mode, since it facilitates independent and fast mobility whenever desired. The older adults recognize the benefits of CS, and frame it primarily in terms of convenience and economics, followed by the environmental concerns. Convenience of CS is directly dependent on provision of on-street parking for shared cars, easily accessible delivery points for station-based CS, and innovative solutions such as delivering the car keys to local kiosks for peer-to-peer services. The quantitative data analyses reveal that though the shape of preferences for the older adults and general population remain the same, the magnitude differs, implying that the current CS system is unable to cater to particular needs and preferences of this group. Future studies and CS projects could use the framing of experimentation and interventions to explore possibilities of increased CS for the older adults. These studies should further also adopt a combination of 'travel demand management' and 'lifestyle' approach to explore the openings in an everyday life centred around walking, cycling and PT, and then focus on whether and how CS can be adapted to daily routines to facilitate new mobility habits.

NOTE

1. See Schuitmaker-Warnaar (2012) for a discussion on persistent problems, formulations similar to the ‘wicked problem’ developed by Rittel and Webber (1973), and the ‘ill-structured problem’ discussed by Hisschemöller and Hoppe (1995).

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PART III

Responsible innovation practices for human scale cities

8. Issues in the design and application of stated adaptation surveys to examine behavioural change: the example of Mobility-as-a-Service

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8.1 INTRODUCTION

The extensive application of stated preference and choice (SP/C) experiments for eliciting human preferences and predicting choice behaviour, and their relevance for marketing, urban planning, economics, environmental sciences, recreation/leisure studies and transport, has been discussed at length (Green and Srinivasan, 1978; Louviere and Timmermans, 1990; Hensher and Battellino, 1997; Louviere et al., 2000). Several reasons have been mentioned to use SP/C rather than the more commonly used revealed preference (RP) surveys. Perhaps the most important is the study of behavioural change in response to new products or services in the marketplace, for which, by definition, no historical data exist. In the transport context, examples include the application of such surveys to measure users' intention to purchase new products such as non-conventional vehicles (for example, electric, automated) or the willingness to pay/subscribe to new mobility services, that is, vehicle-sharing and shared-mobility platforms (Kim et al., 2014; Krueger et al., 2016; Winter et al., 2017; Caiati et al., 2019).

In this chapter, we will discuss some issues that complicate the application to these problems, and suggest an integral approach to address them. Rather than using SP/C designs, less commonly used stated adaptation (SA) designs may be used to collect data on intended behavioural change. SA experiments differ by shifting the focus from preference elicitation towards behavioural change observation.

Drawing from the experience of SP/C surveys to predict consumer choices and preferences, we present in this chapter the design of an SA survey in order

to examine the propensity of behavioural change in light of upcoming mobility services such as Mobility as a Service (MaaS). The data collected through this experiment were then used to examine the impact of MaaS on travel behaviour (Feneri et al., 2020).

8.2 FROM STATED PREFERENCE TO STATED ADAPTATION EXPERIMENTS

8.2.1 Stated Preference Approach and Experimental Design Considerations

SP procedures have gained considerable attention in urban planning and transport since the 1980s (Louviere and Timmermans, 1990; Polak and Jones, 1993, 1997). SP methods that have been employed as data collection tools to examine market demand and user preferences can be distinguished on the basis of the respondents' task. These tasks include ranking the alternatives, rating the alternatives and choosing an alternative from a set of choice alternatives. The use of experiments is particularly appropriate when the existing market is constrained and observations are unlikely to reflect preferences only, when the distribution of data strongly violates assumptions underlying the applied methods, and when observational data do not exist or are extremely hard to obtain.

One of the clear advantages of SP methods is that they can capture information at the individual level for alternatives that the real market lacks (Hensher, 1994). Experimental design data can be used to model choices and predict future market shares for new alternatives before their actual entrance in the market, while the researcher has control over the survey design and can capture individual preferences with a more extended attribute range. Moreover, SP/C surveys may provide a better answer to a set of research questions, even when RP data do exist but show little or inadequate variation in the explanatory variables. Researchers have the flexibility to test specific scenarios or hypotheses, while controlling for market disequilibrium, or multicollinearity (Louviere et al., 2000; Wang et al., 2000), as common concerns of RP data.

There are a number of steps one should undertake to design a choice experiment. First is the selection of the number of alternatives and attribute levels, a challenging and time-consuming task, since it is largely affected by the decision context, the research topic and the depth that the analyst wants to dive into, in order to derive complex relationships between covariates and the dependent variable(s). The design of the experiment is based on an underlying design theory, which is the method that analysts use to distribute those predetermined attribute levels across the choice situations that will be posed to respondents. These levels relate not only to each alternative, but also to the

design itself, since many strategies exist to generate experimental designs, with discussion focused on efficiency versus orthogonality and the robustness of each design strategy to detect statistical relationships that may exist within the dataset (Rose and Bliemer, 2009; Hensher et al., 2015; Walker et al., 2018).

8.2.2 The Stated Adaptation Approach and Methodological Considerations

Despite the advantages of SC surveys to collect information at the disaggregated level to estimate discrete choice models (Louviere and Woodworth, 1983; Hensher, 1994; Louviere et al., 2000), limitations often arise. To start with, drawbacks of SP methods include the issue of realism (stated intentions versus actual choices) and relevance (too-hypothetical scenarios). Moreover, conventional SP methods do not directly collect data on intended change, so additional assumptions are required to convert cross-sectional choice data into predictions of change; therefore, less commonly used SA designs may be used to directly collect such data.

SA experiments differ from SP/C experiments in that subjects are asked to indicate changes, if any, in their current choices, and they have been applied to examine the behavioural response of a user when faced with new hypothetical scenarios (Lee-Gosselin, 1996; D’Arcier et al., 1998). In SA surveys, the experimental design is framed around an individual’s current experience, and they are asked to indicate their reaction due to some change in their individual decision context. This type of survey, designed to capture reactions based on situational changes, increases choice task realism, reduces bias and increases variation in explanatory variables, since the presented attribute levels are customized to each respondent. Hence, the collected responses across the sample have more variability and are more realistic. Earlier applications on adaptive behaviour can be traced back to the time when games were being applied to examine social susceptibility to new decision contexts and policies, but this approach was based on simplified assumptions rather than systematically designed experiments with a certain experimental design and statistical efficiency requirements (Bladel et al., 2008).

In the transport studies, literature on the use of SA experiments includes examination of behavioural change with respect to short-term (that is, mode/route choice) or long-term (that is, job/residence location) aspects of travel behaviour. La Paix and Geurs (2014) investigated mode choice selection in the access/egress stage prior to a public transport trip, and estimated a mixed logit model controlling for various attributes on modal choice. Bergantino and Bolis (2008) evaluated trade-offs for transport attributes for logistics operators. Tilahun et al. (2007) examined route choice and cyclists’ preferences for different cycling environments. Cools et al. (2010) investigated the effect

of various weather conditions on individuals' trip diaries, and respondents were asked to express the likelihood of a temporary change in their travel behaviour, such as a change in transport mode or trip planning/timing/location/route. Arentze and Timmermans (2007) examined short- and long-term travel adaptations, especially for residential or job location change, as a response to road pricing scenarios. Another web-based SA survey was administered in the Netherlands to examine the effects of a tradable driving credit scheme, estimating binary logit models for the likelihood to change car use or not (Dogterom et al., 2018).

8.3 CASE STUDY: MOBILITY-AS-A-SERVICE

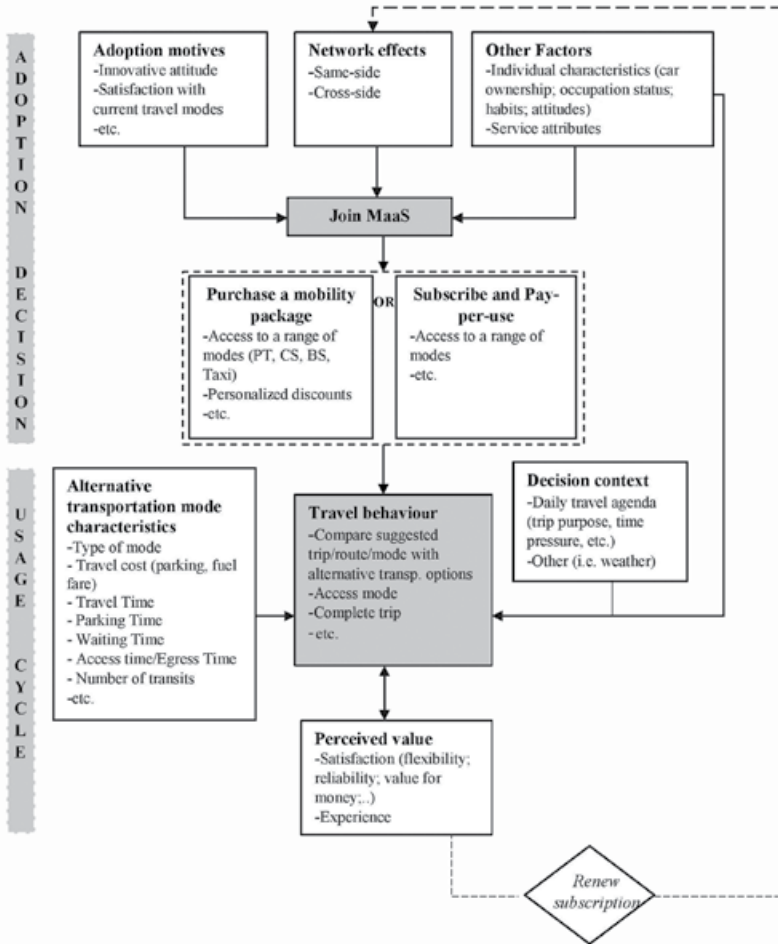
8.3.1 The MaaS Paradigm and the Usage Cycle

Mobility-as-a-Service (MaaS) as a concept has received a great deal of attention lately in the field of smart mobility, as an integrated mobility application that offers travellers, upon registration, access to a wide range of transport mode options. It symbolizes the convergence of services into a single platform that allows users to plan, book and pay for an entire journey in a hassle-free way (Hietanen, 2014; Finger et al., 2015; Kamargianni et al., 2016; Jittrapirom et al., 2017). Considering the complexity of implementing and introducing a MaaS service, there have been only a few advanced schemes around the globe, therefore little is known about the impact of MaaS on behavioural activity-travel patterns. Figure 8.1 visualizes the individual decision-making process for the decision to join MaaS as well as the usage cycle. To shed light on the impact of MaaS, we need to investigate how a potential user might use it for their daily mobility needs.

Our specific goal is to investigate the effect of MaaS on the choice of transport mode. Since MaaS provides travellers with a broader set of mobility options, mode selection (as well as travel distances, destination, route, departure time) will be influenced by the other offered transport solutions as part of MaaS and all mode-specific attributes (access/egress time, travel duration/distance/cost, and so on). All these factors, along with the perceived value as a function of satisfaction and experience, influence decisions with respect to the short-term (mode selection) and mid/long-term aspects (subscription/bundle discontinuance).

8.3.2 The Survey and Construction of the SA Design

Considering our focus on examining behavioural change in response to MaaS introduction, an SA experiment was designed as part of a larger questionnaire (Feneri et al., 2019). The first stage consists of a screening question that



Notes: PT – public transport; CS – car sharing; BS – bike sharing.

Source: Modified from Caiati et al. (2017).

Figure 8.1 Extended individual decision-making process

defined the eligibility of respondents to enter the survey, asking them to indicate how interested they are in this new mobility concept, which was briefly described to them via an introductory animated video. They could choose one of the following answers: (1) not interested; (2) interested/there is a good chance of subscribing to MaaS; or (3) very interested/there is a high chance

of subscribing to MaaS. Only those having indicated good or high chances of taking a subscription to MaaS were invited to proceed. In the second part of the survey, the respondents had to consider their typical weekly travel patterns and to document two trips per day for three weekdays and one non-weekday (a total of eight trips). The third part concerned the SA experiment, designed to collect data on mode choice adaptation of travellers in response to a hypothetical subscription to a preconfigured MaaS mobility bundle, indicating any travel mode alterations they would be willing to make on the basis of their revealed agenda.

An orthogonal fractional factorial design was made in Ngene. For each choice set, respondents were asked whether, and if so how, they would adapt their travel mode. That is, they could indicate not to change the transport mode for that trip and therefore not to use their MaaS bundle (remain with current mode), or choose one of the transport modes included in their MaaS bundle. Four MaaS bundles were configured for the survey; respondents were randomly assigned to one of these and shown eight choice situations.

To increase realism and collect validated responses, the experiment incorporated principles of pivoted designs and the presented attribute levels were customized based on respondents' current situation. For example, attribute levels of travel time were expressed as a relative difference to the reference, and travel cost was measured and varied based on the registered distance in kilometres based on the reference trips. The selection of attributes and attribute levels and the complexity of travel time transformation matrix are presented in Tables 8.1 and 8.2. This design strategy results in an orthogonal attribute difference design, with the same potential advantages as commonly used orthogonal designs including equidistant coverage of attribute space, attribute level balance and likely smaller error variance (Feneri et al., 2019).

For every mode and distance category, realistic proportional speed profiles were assumed, while these proportional factors were then used to pivot the design and customize it on respondents' reported attributes per registered trip, using an orthogonal fractional factorial design.

8.4 THE ADDED VALUE OF SA TO EXAMINE BEHAVIOURAL EFFECT OF MAAS

8.4.1 Mitigation of Hypothetical Bias

In this chapter we put forward the use of SA as an advantageous approach to examine intended behavioural change. Focusing on common issues found in SP studies, we will, therefore, address concerns related to validity, realism and relevance (Lee-Gosselin, 1996). All these terms are linked to hypothetical bias,

Table 8.1 Attributes and levels

Mode	Attribute	Levels
Current mode	Access time	0–3 min; 3–6 min; 6–9 min; 9–12 min
	Egress time	0–3 min; 3–6; 6–9 min; 9–12 min
	Parking search time	<5 min; <10 min; <15 min; >15 min
	Parking cost	Free; €1.10/hour; €2.20/hour; €3.30/hour
	Waiting time	0 min; 5 min; 10 min; >10 min
MaaS _{PT} ^a	Access time	0–3 min; 3–6; 6–9 min; 9–12 min
	Egress time	0–3 min; 3–6; 6–9 min; 9–12 min
	Waiting Time	0 min; 5 min; 10 min; >10 min
	Number of transfers	Zero; One or more
	Travel Cost _{-TRAIN}	Bundle A: €0.18/km; €0.24/km; €0.30/km; €0.36/km Bundle B: €0.12/km; €0.18/km; €0.24/km; €0.30/km Bundle C: €0.06/km; €0.12/km; €0.18/km; €0.24/km Bundle D: Free
MaaS _{CS} ^a	Travel Cost _{-BUS}	Bundle A: €0.30/km; €0.36/km; €0.42/km; €0.48/km Bundle B: €0.24/km; €0.30/km; €0.36/km; €0.42/km Bundle C: €0.18/km; €0.24/km; €0.30/km; €0.36/km Bundle D: Free
	Travel Time _{-PT}	(4 levels): PT_TT1; PT_TT2; PT_TT3; PT_TT4 ^b
	Access time	0–3 min; 3–6 min; 6–9 min; 9–12 min
	Egress time	0–3 min; 3–6 min; 6–9 min; 9–12 min
	Travel Time _{-CS}	(4 levels): CS_TT1; CS_TT2; CS_TT3; CS_TT4 ^b
MaaS _{BS} ^a	Waiting time	0 min; 5 min; 10 min; >10 min
	Parking search time	<5 min; 5–10 min; 10–15 min; >15 min
	Travel Cost _{-CS}	Bundle A: €0.40/km; €0.45/km; €0.50/km; €0.55/km Bundle B: €0.35/km; €0.40/km; €0.45/km; €0.50/km Bundle C: €0.30/km; €0.35/km; €0.40/km; €0.45/km Bundle D: €0.25/km; €0.30/km; €0.35/km; €0.40/km
	Access time	0–3 min; 3–6; 6–9 min; 9–12 min
	Travel Time _{-BS}	(4 levels): BS_TT1; BS_TT2; BS_TT3; BS_TT4 ^b
MaaS _{BS} ^a	Travel Cost _{-BS}	Bundle A: €0.75/hour; €1.50/hour; €2.25/hour; €3.00/hour Bundle B: Free Bundle C: Free Bundle D: Free

Mode	Attribute	Levels
MaaS _{TAXI} ^a	Travel Time _{TAXI}	(4 levels): Taxi_TT1; Taxi_TT2; Taxi_TT3; Taxi_TT4 ^b
	Travel Cost _{TAXI}	2,5€ start tarif plus Bundle A: €2.55/km; €2.65/km; €2.75/km; €2.85/km Bundle B: €2.25/km; €2.35/km; €2.45/km; €2.55/km Bundle C: €1.95/km; €2.05/km; €2.15/km; €2.25/km Bundle D: €1.65/km; €1.75/km; €1.85/km; €1.95/km

Notes:^a MaaS_{PT}, MaaS_{CS}, MaaS_{BS} and MaaS_{TAXI} are short for the four transport mode alternatives (public transport, car sharing, bike sharing and taxi, respectively), included in each MaaS bundle;
^b TT1, TT2, TT3, TT4 are short for the four attribute levels of travel time. The speed factors are shown in Table 8.2.

Table 8.2 Travel time attribute levels

	PT_TT	CS_TT	BS_TT	Taxi_TT
If Current Mode: Walk	0.5	0.2	0.3	0.2
	0.6	0.3	0.4	0.3
	0.7	0.4	0.5	0.4
	0.8	0.5	0.6	0.5
If Current Mode: Bike/BS	0.5	0.2	0.3	0.2
	0.6	0.3	0.4	0.3
	0.7	0.4	0.5	0.4
	0.8	0.5	0.6	0.5
If Current Mode: E-Bike	0.6	0.3	1	0.3
	0.7	0.4	1.1	0.4
	0.8	0.5	1.2	0.5
	0.9	0.6	1.3	0.6
If Current Mode: Drive Alone/ Passenger/ Motorbike/ CarShare/ RideShare/ Taxi	0.7	1	1.8	1
	0.8	1.1	1.9	1.1
	0.9	1.2	2	1.2
	1	1.3	2.1	1.3
If Current Mode: Train	1	0.7	1.9	0.7
	1.1	0.8	2	0.8
	1.2	0.9	2.1	0.9
	1.3	1	2.2	1
If Current Mode: Bus/ Tram	1	0.4	1.2	0.4
	1.1	0.5	1.3	0.5
	1.2	0.6	1.4	0.6
	1.3	0.7	1.5	0.7

Source: Feneri et al. (2019).

into which a great effort was put in order to tackle the fictitious nature of the survey by various means.

To start with, a screening question was included prior to the survey to define the eligibility of an individual to participate. More specifically, initially 2143 users were invited to participate in the survey and were first shown a short video about this new mobility concept. Of these, only those who seemed interested (53 per cent) or highly interested (10 per cent) in the service could proceed. In that way, the obtained data are more valid since they are provided by potential future users of MaaS and early adopters.

Moreover, we accounted for what is commonly referred to in the literature as ‘cheap talk’, since respondents are alerted upfront about possible bias while emphasizing their level of attention and the importance of their honest answers despite there being no real consequences for these choices (Fifer et al., 2014). Detailed information was provided to the respondents before entering the survey explaining the study’s purpose to examine the effect of a new mobility concept that is going to enter the Dutch market in the near future; therefore insights into to what extent this app can be used at an individual level has high scientific and societal value before implementing a real-life pilot. Secondly, despite the inexistence of this product, a video was made illustrating how this service will look like as a real application. Lastly, reminders were popping up during each choice task highlighting the importance of obtaining realistic answers from individuals, as if they were faced with this new decision context in real life.

Regarding internal and external validity, a high degree of customization has been involved in our survey, since the underlying statistical design is pivoted around the individual’s current behaviour, resulting in more realistic choice scenarios per respondent. In our case, the SA experiment collected data about the mode choice process adaptation of travellers, and the presented experimental design is framed around a reference trip, which in turn increases choice task realism. Lastly, we included the ‘no change’ option (status quo) as an alternative, when respondents had previously reported a trip made by private vehicle, or modes which were not part of their assigned MaaS bundle (that is, e-/bike, walk), which adds realism (Louviere et al., 2000).

8.4.2 Mitigation of Cognitive Bias

Concerning the issue of cognitive burden and maintaining the respondent’s level of attention, SA surveys can be demanding for users to mentally process all new information, understand the new decision context, and decide whether the new alternatives outperform the current alternative in order to make a new choice or keep the current one (Bladel et al., 2008). This cognitive burden can subsequently affect the complexity and reliability of responses (Swait and Adamowicz, 1996). The level of complexity can also affect individual choice

process throughout the survey, such as by triggering status quo selections and increasing omission bias (Boxall et al., 2009).

Bladel et al. (2008) highlight that the respondent's burden may increase in case choice situations differ from the subject's experiences, but in our case, each choice task is framed around the registered trip that was taken as reference. Much emphasis was also put into creating a user-friendly environment for respondents. We created and illustrated an animated video about MaaS in order to familiarize them with this mobility concept, and provided descriptive information along with an example before the choice experiment to further engage them and decrease the uncertainty associated with the choice tasks they were about to be confronted with. Lastly, to mitigate the slightest need for numerical calculation by the respondent, the web-based survey was designed using the software developed by our research group (Berg System¹), which enabled us to internally implement all necessary calculations.

8.5 CONCLUSION

The chapter discussed the relevance of SA techniques and their usefulness to estimate the propensity of behavioural change. Principles were illustrated using the design of a study on behavioural change as a consequence of subscription to MaaS, a concept that has gained a great deal of attention lately in the field of smart mobility.

The purpose of this work is mainly focused on addressing the commonly used stated preference and choice designs and their limitations to examine behavioural change in light of a new mobility concept. We provide useful insights and points for discussion about the possibility of such an approach to be used as a methodological tool following the lines of literature. We explained how SA approaches differ and pinpointed their added value for our specific context to examine the effects of MaaS on mode choice. Lastly, we discussed the potential of SA to reduce response bias, which is an artefact of most hypothetical studies.

This chapter discusses thoroughly the design of our survey that was used to examine the likely behavioural impacts of MaaS, with respect to the transport mode choice. Our proposed approach is aiming at providing evidence to transport planning and policy-making. Considering growing urbanization levels, it is necessary for planners and policy-makers to implement plans and steer innovations that maximize the spatial and temporal efficiency of transport modes and services for people. Particularly in the context of novel transport services, collecting realistic and valid user response and intention data is fundamental to analyse potential changes in people's travel behaviour as a result of emerging innovative transport solutions.

NOTE

1. Berg Enquete System: software developed by the Design and Decision Support Systems group, Faculty of the Built Environment, Eindhoven University of Technology (TU/e), the Netherlands.

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9. Lessons from the deployment of the world's first automated bus service on a mixed public road in Stockholm

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9.1 HUMAN, CITY, AND AUTOMATED FUTURE

To achieve a human scale city, in particular ‘safe, affordable, accessible and sustainable transport systems for all’ (UN, 2019), technology and innovation have been promoted by both authorities and industries to enable viable solutions. Automation and digitalization of transport and mobility systems are at the centre, and enabled several solutions that have been strongly echoed through urban and transport research communities. For example, Milakis et al. (2017) argue that automation will reduce the wasted value of travel time, and subsequently the total costs of travelling by private cars. As fully automated vehicles could perform some activities on their own – for example, picking up shopping, or dropping off children at school – there will be journeys which essentially overcome today’s individual time and space constraints (Bagloe et al., 2016; MANTRA, 2019). For further extensive reviews of the plausible impacts of automated vehicles, McGehee et al. (2016), Milakis et al. (2017), Innamaa et al. (2017) and the MANTRA (2019) project report provide a comprehensive description of the plausible societal impacts and policy implementation challenges. Hoogendoorn et al. (2014) discussed the roles of human factors and expected traffic impacts; Chee et al. (2020a) and Nordhoff et al. (2019) reported on automated vehicle (AV) technology acceptance for daily travel; and Do et al. (2019) reported on design and control of the automated vehicle system. More recently, Soteropoulos et al. (2019) provided a systematic overview of different modelling approaches that have been used to explain the impacts of automated vehicles on travel behaviour and land use characteristics.

Although state-of-the-art research studies are very compelling, in reality we hardly know what is really going to happen when self-driving vehicles

are deployed. Most of the literature on use cases for self-driving vehicles is heavily biased towards transportation systems based on (shared) autonomous taxis, and their performance as an alternative to private car usage (e.g., Chen and Kockelman, 2016; Meyer et al., 2017; OECD, 2015), or routing strategies for such systems (e.g., Han et al., 2016; Sukanuma and Yamamoto, 2016). Literature on self-driving vehicles in public transport is even more limited, and provides primarily two types of applications. These applications are: complete systems of smaller self-driving vehicles that replace existing public transportation; and first/last mile transportation services, for example, between a public transportation hub and the user's home/work location (Pernestål-Brenden and Kottenhoff, 2018). Many authors (e.g., Guo et al., 2020; Soteropoulos et al., 2019) question whether the assumptions and approaches of such studies are realistic. Several studies (e.g., Milakis et al., 2017; Hoogendoorn et al., 2014) highlighted the unpredictability of individual responses. Furthermore, some studies (e.g., Mladenović, 2019) highlighted plausible negative impacts of the use of active travel modes, and the inequality issue that comes with them. Based on the uncertainties mentioned above, it is extremely important to have a reflection process based on a revealed observation of a real deployment of the technology.

To address the above-mentioned research gap, this chapter provides readers with an overview of lessons learned from an automated bus deployment on a public road in Sweden, and the adoption behaviour surrounding the technology. Further detailed results of each analysis summarized in this chapter can be found in the relevant referenced publications.

9.2 A STEP INTO THE UNKNOWN: DEPLOYING AN AUTOMATED VEHICLE ON A PUBLIC ROAD

In 2018, the Autopiloten pilot project was launched in Sweden. This pilot was a step into the unknown of self-driving vehicles to explore the technology capability in real-life traffic conditions. Located in the north of Stockholm, the project aimed at testing the first self-driving bus as a regular service in Kista, Sweden's Silicon Valley. The project partners were Nobina AB, Ericsson, the city of Stockholm, KTH, Drive Sweden, Klöver and SJ (the Swedish rail company). Operationally speaking, two vehicles, small buses with seats for 12 passengers (six seating and six standing, including the steward) were in service on weekdays from 24 January 2018 to 22 June 2018. The operation was free of charge for the public.

The vehicles used in the test were of the brand EasyMile EZ10 generation 2. The speed during the first four months was a maximum 12 km/hour, and afterwards the speed was raised to a maximum of 15 km/hour. The number of travellers during the trial ended at 20 165 people, giving an average of 182

per day, which is higher than expected. The expectation was lower due to the limited mileage and lack of connection to other public transport services and main residential areas (as this was the first ever development of the technology on a public road, the permission given was rather limited). Electricity consumption for transporting 20 165 persons was 2948 kW/hour. With regard to the battery capacity, the buses could be in operation for about 6–7 hours in winter without charge, and during the summer worked for longer hours.

To evaluate users' responses and system-level impacts of this technology deployment, a three-wave survey of more than 500 respondents was administered within the six-month trial operating period, and a professional survey company was employed to conduct the survey. The respondents were recruited by the survey company to take part in all three rounds of online surveys throughout the period from February 2018 to June 2018. The participants who completed all three rounds of surveys were entitled to participate in the contest to win one of ten cash prizes worth 1500 SEK. The survey focused on potential users of the service: people who work, study or live near the trial operation area (the Helenelund commuter train station, and Kista Science City). This area is a science and technology park, hosting many prominent technology companies as well as a technical university. Further information about the project, and the summary of results of all its activities, can be found in Pernestål-Brenden et al. (2018).

9.3 USERS' INTENTIONS, EXPECTATIONS AND REACTIONS

In this section, we focus the discussion on a few basic issues on human adoption of the deployed technology, which are important for our operators and authorities to reflect on whether they will make further investment in this new transport technology. First, we briefly explore the factors that may encourage individuals to use the automated service. Then, given these factors, we discuss what would influence the users' willingness to pay, given different types of possible service deployments. This particular topic is important as no innovation will be adopted by industries without knowing that there is a solid business case and viable business models to be gained from such investment. Lastly, we explore how other road users reacted to this automated shuttle in real-life cases. As the basis of these analyses, a three-wave panel survey was conducted among 500 people who live and work along the serviced corridor. Light detection and ranging (LIDAR) data¹ for a limited time was collected in order to get a glimpse of the interaction between the automated bus and pedestrians, private cars and other road users, in the given road space. The complete analyses of each of these cases can be seen at Chee et al. (2020a, 2020b, 2021, forthcoming).

9.3.1 Factors that Influence Willingness-to-Use

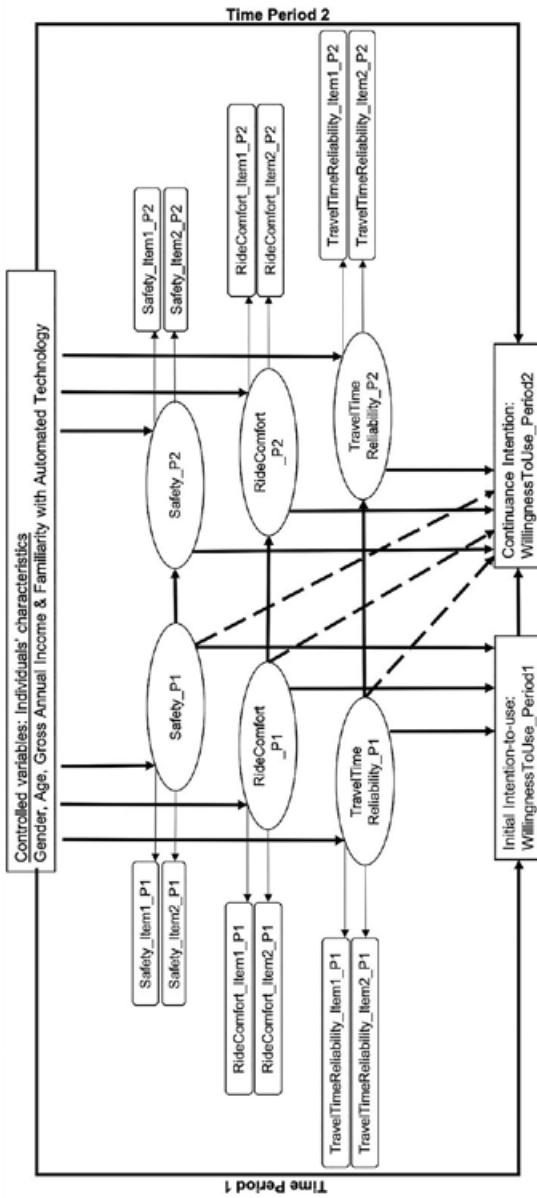
When it comes to socio-demographic characteristics which are found to be significant in affecting acceptance of automated buses, previous studies (e.g., Bansal et al., 2016; Meyer et al., 2017; Salonen, 2018) show that age, gender, income, technology awareness and using multimodal preference are consistently found significant. In terms of service quality attributes, on-board safety, existence of steward, comfort, travel time and travel fare matter. However, the appreciation of these variables is not constant over time, in line with the learning curve of the users (Guo et al., 2020). Thus, in investigating the factors that influence the willingness-to-use, we tested a conceptual model explaining the transition of pre-use value to post-use value, and their effects on willingness to use a shared automated bus before and after use of the service (as shown in Figure 9.1).

The detailed estimation results of the model shown in Figure 9.1 can be found in Chee et al. (2021). In a summary, we found that continuous adoption of first-/last-mile automated bus service does not depend solely on the users' pre-use perceptions (expectations of the service) but also on the post-use perceptions of the service (levels of satisfaction with the service). Results show that users' judging criteria of the service changed after using the service. The issues affecting the users' willingness to use the service before experiencing the service might become irrelevant after the use of the service. Therefore, modelling travel demand of such service only based on pre-use perceptions may result in fallacies of the prediction.

9.3.2 Factors that Influence Willingness-to-Pay

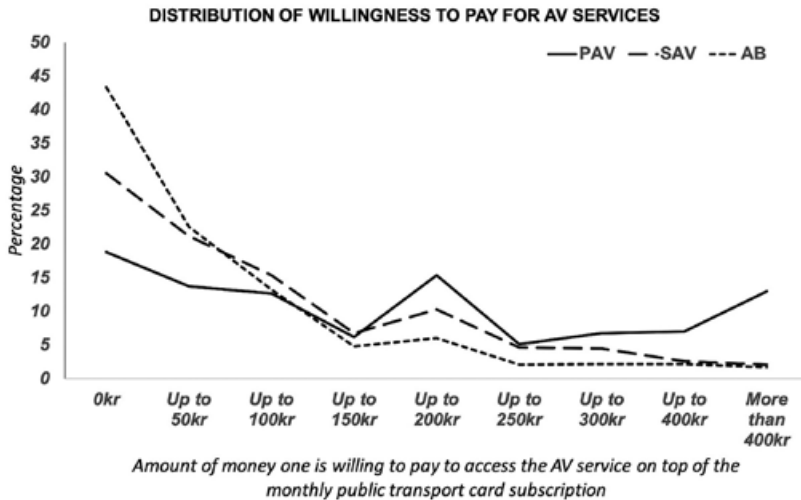
Figure 9.2 shows the distribution of the willingness to pay for: (1) on-demand personalized automated vehicle (PAV) service; (2) shared automated vehicle (SAV) service; and (3) first-/last-mile automated bus (AB) service. Almost half of the respondents (44 per cent) were not willing to pay an additional fee on top of their monthly travel pass for an AB service (which is currently (summer 2020) approximately €90/month for a working adult). The distribution of willingness to pay for a PAV service is more evenly distributed than others: 16 per cent of the respondents were willing to pay up to 200 SEK (about €19) to gain access to a PAV service given the same travel distance. Surprisingly, about 12 per cent of the respondents were willing to pay more than 400 SEK (about €38) on top of their monthly travel pass (Chee et al., 2020a).

Further exploration with structural equation modelling shows that cognitive responses such as service quality perceptions are significant to people's willingness to pay for automated vehicle services. Chee et al. (2020a) reported that people hold different expectations towards each type of AV service.



Source: Chee et al. (2021).

Figure 9.1 Framework to examine the changes of willingness-to-use before and after use of the service



Source: Chee et al. (2020a).

Figure 9.2 Distribution of willingness to pay for three different automated vehicle service types

These expectations act as the minimum requirements for people to pay for the AV services. In detail, the respondents are willing to pay more for a PAV service if the service is safe, provides good ride comfort, and they perceive that the service provides better value for money compared to the metro and train alternatives. Other than service quality attribute perceptions, income level, existing travel modes for daily trips, familiarity with automated driving technology and automated bus ride experience are important factors affecting the willingness to pay for the services. These align with the past findings by Bansal et al. (2016). Further detailed analysis on this issue can be seen at Chee et al. (2020a).

9.3.3 What Matters More in Delivering the Service?

To make the service attractive for the users, we need to improve the service quality attributes that matter for the service adopters. The majority of previous studies assumed that the relationship between attribute-level performance and overall satisfaction is linear and symmetric (e.g., Susilo and Cats, 2014). However, there is evidence (e.g., Kano et al., 1984; Matzler et al., 2003) to suggest that the service and product attributes have distinct relationship patterns between attribute-level performance and overall travel satisfaction. To

overcome these limitations, the three-factor theory is applied to capture the complexity underlying the relationships between the perceptions and the intention to use a first-/last-mile automated bus service by statistically separating the quality indicators into three categories:

1. Basic factor: when attributes belonging to this category are well delivered, they do not positively influence overall satisfaction, yet when delivered poorly they induce dissatisfaction.
2. Performance factor: this category of attributes can contribute to both satisfaction and dissatisfaction, depending on whether their performance is high or low, respectively.
3. Exciting factor: this category is the reverse of the basic factor. Attributes belonging to this category are unexpected attributes that can only bring joy and satisfaction with the service.

The theory is not widely used in transport, but a few examples of these can be seen in Abenoza et al. (2019), Wu et al. (2018) and Zhang et al. (2017). Detailed estimation of this can be seen at Chee et al. (2020b). The estimation result reveals different levels of essentiality of service quality attribute perceptions in affecting intention to use automated bus services among experienced users, inexperienced users, and all users. It was found that whilst for non-experienced users travel time and fare, compared to regular service, linearly associated with travellers' travel satisfaction, only frequency was found to have similar relationship for the experienced users. Affordable travel fare is a basic expectation for experienced users, whilst ride comfort is a bonus for both experienced and non-experienced users.

9.3.4 On-Road Interaction between Automated Buses and Other Road Users

Whilst it is widely assumed that automated vehicles would enable us to maximize the use of road space (e.g., OECD, 2015), it is not clear whether during the early-stage deployment of automated vehicles on the public road this would be the case. To anticipate different plausible road users' interactions with the automated vehicle, most previous studies used either lab experiments (for example, virtual reality simulation) or a controlled field experiment or a video analysis of comparable real-life road interaction cases. The last two approaches have challenges in dealing with privacy protection issues, in particular if we would like to have a longer observation in order to identify the variance of the interaction behaviour. Using the opportunity that we had through the automated bus deployment, we collected LIDAR footage of other road users' interactions with the operated automated bus. As we are not

allowed to access the data collected by the factory built-in sensors, additional LIDAR sensors were installed on the automated bus on operation.

During the observed route, the highest number of occurrences was pedestrians crossing the road without crossing facilities when encountering the vehicle. Out of the 55 observed encounters between pedestrians with the automated bus, there are 30 encounters where the pedestrian took a conscious deflection movement path. Detailed analyses of this dataset can be seen at Chee et al. (forthcoming). Results show that while different groups of road users react differently, the alert distance between an observer agent, for example, pedestrian to cross the road without using crossing facilities, when encountering an incoming automated bus is between 30 metres to 40 metres. Pedestrians accelerated when they crossed the road with distance less than the alert distance.

9.4 CONCLUDING REMARKS

9.4.1 Lessons from the Deployment: The Limitation of Technologies, Users' Unique Travel Needs, and Business Case Framework

There are high expectations for driverless vehicles: that they will provide on-demand mobility services door to door at a low cost. However, the Kista trial results so far (and also elsewhere) show that the technology is currently not able to deliver these services. Consequently, there is a gap between people's expectations of the driverless vehicles and the actual performance of the automated buses, among users, urban planners and mobility operators. Simulations in the research literature show that in ideal cases there is a large potential to replace private cars with shared mobility services (for overviews of simulation results see, e.g., Pernestål and Kristoffersson, 2019; Soteropoulos et al., 2019). In reality, there are still many challenges to overcome (the vehicles are slow, people feel unsafe, and so on). Thus, it is important to be cautious while developing and exploring the current state of technology from a holistic point of view. Simulations, with restrictions on the vehicle's performance (for example, limited speed), can show what parameters are important to develop in order to provide effective services.

It is also important to continue testing the automated vehicles and the services in real trials and deployments, to improve the technology and to let people learn about it. This research has shown that users put high value on feeling safe and secure on board the automated vehicles, and that most of them want to have a steward on board. This challenges the operators' goal of driverless operation to reduce operational costs. This fact is important to consider for operators when developing their operational model, as it might not be feasible to have a completely driverless operation. There are also several technologies

that can be applied to increase the experienced safety on board: for example, control towers that allow for remote operation (Mårtensson et al., 2018), and social robots that can inform and interact with passengers (see, e.g., Furhat Robotics, 2020).

On the users' side, given that people are exposed to an unknown technology, it is important to allow people time to learn, to develop their understanding and to adjust their expectations towards the technology. This is not only for the passengers who use the service, but also for the other road users who share the same road space. This highlights the importance of having a design thinking approach (Veryzer and de Mozota, 2005) in designing a new (public) transport service with new and unusual technologies. In doing so, the choice of the locations of future automated vehicle pilots will play an important role in elevating user acceptance and, potentially, their willingness to adopt the technology.

9.4.2 As a Possible Tool in Supporting a Human Scale, Happy, City

In the last few years, big transport and economic organizations, such as the International Association of Public Transport (UITP, 2017), have consistently argued that automation of the transport system would give benefits of reductions in road fatalities and environmental impacts, and improvements of road traffic parameters such as average travel time and road capacity; the same promises which the World Economic Forum (2018) and many other authorities (e.g., OECD, 2015; EU, 2017) also promoted; that is, as a solution in creating a 'human scale city', 'liveable city', 'sustainable city', 'inclusive city', and the like.

The results described above provide different views, which highlights the importance of deeper reflections from both industries' and stakeholders' points of view. The technology is still very premature, and far from satisfying. Upon technological maturity, increase of speed and safety of the automated buses, future deployment should take into account the needs, the demand and cognitive elements of those demands, as those elements are crucial in attracting and establishing the market of the given service. The study highlights the fact that there will be no single service delivery strategy that fits all groups of users. Different user groups appreciate different quality service attributes, which are also influenced by their level of adoption of the given transport technology. How this aspect will be addressed by the stakeholders in reality will be an interesting subject to follow and observe.

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NOTE

1. The dataset consists of measured distance from the LIDAR sensor on the corner of the bus to surrounding objects, measured via pulse laser sensor(s) which illuminates the target surrounding the moving bus.

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10. Smartphone challenges to stimulate cycling: clues from a living lab in Enschede

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10.1 INTRODUCTION

During the past century, population and wealth growth have led to the creation of large urban areas in which people and goods are mainly connected by road transport. This has led to urban problems such as congestion and pollution. Public transport can reduce road transport, but the question is whether mass transit can transform cities to a human scale. Together with walking, cycling may be indispensable to develop liveable human scale cities. Through cycling, people can in principle access all locations in neighbourhoods, and thus will be able to connect with their urban environment physically. It is a local activity in itself, it is healthy, and it is more than simply travelling from A to B. It is therefore important to stimulate cycling.

Positive interventions or ‘soft measures’, such as personal travel planning, subsidies, providing feedback, rewards, public transport (PT) discount could stimulate the use of sustainable transport options (e.g., Bamberg and Schmidt, 2003; Cairns et al., 2008). In the age of big data, mobile phones and software platforms are becoming useful tools to collect travel behaviour data and deliver interventions. Global Positioning System (GPS) data from smartphones can be used to estimate travel modes and travel routes accurately (e.g., Biljecki et al., 2013). Moreover, several research projects have used smartphones to deliver interventions (e.g., Bie et al., 2012; Poslad et al., 2015). These interventions include personalized feedback, self-monitoring, challenges and goal-setting, social comparison and rewards.

Regarding cycling, Weber et al. (2018), for example, have shown that cycling campaigns in the United States, United Kingdom (UK) and Australia can attract many (potential) cyclists using gamification in smartphone apps. There are also several cycling apps that have a seamless server to end-users,

attracting thousands of users over a longer period of time (sometimes years). For example, Strava (www.strava.com) works as a fitness app that tracks and analyses cycling or running trips, explores new routes and provides the social network to compete with friends. Apps such as BetterPoints (www.betterpoints.uk/page/qr) and SMART (www.smartintwente.nl) explicitly reward users when they travel (more) sustainably. Although the latter apps are not only focused on cycling, they also attract occasional cyclists who only cycle now and then. Their aim, therefore, is to encourage behaviour change among all travellers.

Unfortunately, there are few scientific studies about the effects of rewards on cycling. Most studies in this field focus on avoiding rush-hour travelling (e.g., Kumar et al., 2016; Yang and Tang, 2018), and some studies have looked into the effect of rewards on PT ridership (e.g., Abou-Zeid and Fujii, 2016). There are a few exceptions. In separate studies in Palermo (Di Dio et al., 2018) and Vienna and Birmingham (Tsirimpa et al., 2019), apps were used to reward sustainable transport, including cycling. The amount of cycling almost doubled or even more than doubled, respectively, as a result. Although both studies have a clear experimental design, including a baseline measurement, the samples are relatively small (77 commuters and 64 individuals, respectively). The drawback of these experiments is that participants know they are participating, which could affect their behaviour. Moreover, self-selection could be an issue, because participants are more likely to have a positive attitude towards the aim of the experiment, that is, encouraging cycling.

In this study, we take another approach. We observe the behaviour of all users of the SMART app in the Dutch region of Twente. In this chapter, we focus on multiple and targeted challenges that are provided monthly. The advantage is that users are not influenced by an experimental setting and that the sample is much larger (an order of magnitude, that is, about a factor of ten) than in the studies mentioned above. Moreover, the measurements are done over a relatively long period. Some of the challenges have been repeated, and as a result, we are better able to establish which type of challenge is effective. As this study is not a real experiment, there are some drawbacks that will be discussed as well. The most important results from observation between March 2017 and February 2018 are summarized in this chapter.

10.2 METHOD

SMART tracks travel behaviour change of users, similar to BetterPoints. Modes are deduced using probabilistic Bayesian mode deduction models, which were trained on a complete training set (consisting of all types of users and types of trips) of about 3000 trips. The success rate of mode detection is 82 per cent (Thomas et al., 2018), which is comparable to similar applications

(e.g., Rasmussen et al., 2015). Note that wrong detections are hardly an issue among SMART users, and will not influence the results, because the detection errors are not systematic (such as too few or too many detected bike trips).

The positive incentives were provided through the SMART app. The app is not only rewarding sustainable travel but also has a wider scope, which is illustrated by the four main functionalities in Figure 10.1. The left panel of Figure 10.1 depicts the SMART app dashboard. From top to bottom, the figure depicts feedback on historical travel patterns, challenges, rewards, and social/group incentives. Users can explore all functions of the app from this page. The figures in the right panel are screenshots from other pages of the SMART app. The first functionality is travelling information. This can be actual traffic information in which users are notified in case of road works or large-scale events, but the app also provides the actual historic travel pattern of the user (upper panel). This information makes users more aware of their current behaviour, which could be a trigger for behaviour change. The second functionality (second panel) are challenges which users commit themselves, that is, they need to fulfil a challenge during the challenge period. The commitment to fulfil a challenge may be enhanced when users get rewarded upon completion of the challenge. When the challenge is fulfilled, the system will immediately give the corresponding amount of points. The earned points can then be redeemed for various discounted products and services (third panel). Incentive providers include local shops such as cafeterias, restaurants and bike shops, but also leisure attractions such as the local ice rink. Finally, social incentives to encourage cycling (bottom panel) are also in the SMART app. This includes a competition with rankings to compare behaviour with others, and group challenges in which participants can invite friends to fulfil challenges together.

In this chapter, we explore the effect of monthly bike challenges. We included three main types of choice challenges with a challenging period of 14 days. These are location challenges, that is, number of cycling trips to a fixed location; cumulative challenges, that is, number of total cycling trips or cycling kilometres; and rate challenges, that is, number of days to ride at least 10 kilometres by bike or number of kilometres to be ridden by bike on at least ten out of the 14 days. The different types of challenges were designed and distributed throughout the year to see which type is more effective.

There are different ways to design challenges. One approach is to reward users when they cycle more compared to the baseline. This stimulates real change, as participants have to improve to be rewarded, but this may also discourage participation (Matushkina and Nevalennaya, 2010). Moreover, it only rewards behavioural change, which is unfair to travellers who already cycle a lot. Another approach is to reward users for each mile they cycle (for example, BetterPoints). The burden for the user is relatively low. However, some studies showed that targeted and challenging goals led to higher per-

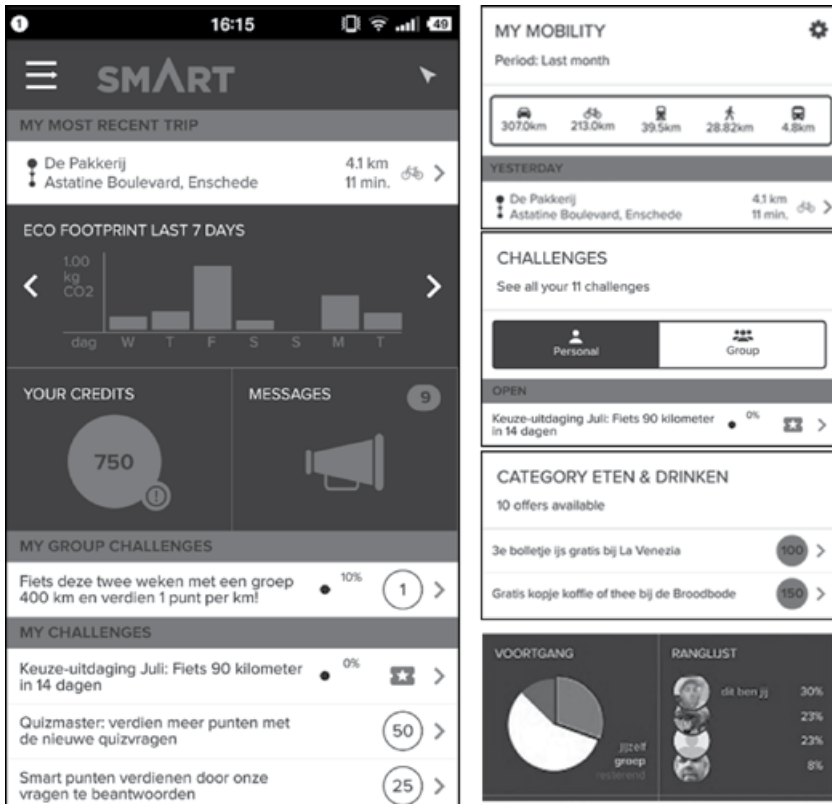


Figure 10.1 SMART dashboard (left) and functionalities (right)

formance than easy or ‘do your best’ goals (Locke and Latham, 2002). In our design, we tried to combine the advantages of both approaches by introducing choice challenges. Users themselves have the option to choose one out of five levels, from very easy to very difficult. This enables us to provide equal opportunities for everyone and at the same time personalize the challenge level in which participants can challenge themselves. As participants can choose their own level, it is also less likely that they will be discouraged to participate because a challenge is too difficult.

One of the drawbacks of choice challenges is that users can still choose a challenge and win points without changing their behaviour. In that case they choose a level that is too easy for them. To stimulate the choice of difficult challenges, participants get higher rewards when they accomplish more difficult challenges. The reward is proportional to the required number of bike trips

(12 SMART points per trip longer than 2 km) or total required bike kilometres (4 SMART points per km). However, for each challenge 30 SMART points could also be earned to motivate car users to join the (easiest) challenge. No reward is given if the participant cannot complete the chosen challenge. Therefore, participants have to choose between an easy challenge with relatively fewer points but a greater chance to be rewarded, or a difficult challenge with relatively more points but a higher chance of failing.

In the results, we compare trips within and outside the challenge period. It is important to emphasize that every month one monthly choice challenge was offered, but that the duration of the challenge was only 14 days. Therefore, a comparison during the challenge and outside the challenge period is possible for each month. We evaluated the difference between inside and outside challenge periods in terms of distance-based mode share. This is the percentage of the total distance that is covered by each mode during each measurement period. We used distance rather than trip frequency, because the latter might be disproportionately influenced by people shifting from walking to cycling for the shortest trips. To avoid the disproportionately large contribution of long car trips in the distance-based mode shares, we only included trips below 20 km. For larger distances, cycling is not considered as a viable option (Fioreze et al., 2018).

Based on individual mode share differences (between inside and outside challenge period), we estimated the standard error in the average mode share difference (weighted by the total covered distance per participant) as the standard deviation of the mean. In the results, we illustrate the uncertainties by two times the standard error.

10.3 USERS

Most SMART users are inhabitants of the city of Enschede, which is a medium-sized Dutch city with about 160 000 inhabitants. The modal split (based on trip frequency) of Enschede is quite representative for the Netherlands (55 per cent car, 26 per cent bike, 15 per cent walk, and 4 per cent PT according to EPOMM 2020). We recruited users via specific campaigns, such as the Enschede Cycle City campaigns, Charity campaigns (to cycle for a charity), Bike2Sport campaigns that stimulate teams to use the bike to sports events, and the SMART green campaign in which SMART cyclists get a faster change to a green light when they approach a certain set of traffic lights. However, there is also a general inflow due to various media and recommendations by friends.

Once new users have installed SMART, they could immediately use all functionalities and participate in challenges. They also did not need to provide extra information (such as age or gender). In other words, they were not

recruited for an experiment, but simply used the app because they wanted to. Thus, we created a realistic real-life context to analyse travel behaviour. However, as a drawback, we have no demographic information of the users, and we were not able to do a ‘before’ measurement to establish the baseline behaviour.

In Figure 10.2, we show the number of active users per day and month. Active users are defined as users who have at least one recorded trip per day (number of daily users) or during ten days in a month (number of monthly users). Note that some people may not make a trip at all during a given day (zero trips), and therefore do not record a trip even when they use SMART. The darker gray upper line shows the number of daily users when we correct for this effect. The figure shows some interesting results. The many dips in the number of active daily users correspond with the weekends in which the rate of zero trips is larger than during workdays. Except for these dips, the number of daily and monthly users is quite stable and increases rapidly at the start of 2018. This rapid ascent can be attributed to the success of the Cycling City campaigns. One of the attractive parts of the campaign is that users get automatically one point per cycling or walking kilometre without the need to participate in cycling or walking challenges.

About 50 per cent of the users participated at least once in a monthly challenge. Although the turnover is quite low, some users dropped out during this period. If we also include those users, in the end about 1000 users participated in a challenge. This is quite a substantive sample (compared to other studies). However, users do not always participate. They sometimes skip monthly challenges or stop participating in them. On a monthly basis, about 30 per cent of the users participated on average. There is also a difference between participants and non-participants, indicating a self-selection effect. Car share (distance-based for trips shorter than 20 km) is 52 per cent among users who did not participate in monthly challenges. This is quite comparable with the car share of the population. However, outside the challenge period, the car share drops to 35 per cent among users who participate in challenges. Even so, the participants still have a significant car share, that has the potential to get further decreased. Note that it is important to realize that there are few pure car users in the Netherlands: almost all Dutch people are occasional cyclists, that is, the bike share of an individual is seldom zero or 100 per cent. Therefore, the bike share could still be further increased for most of the participants.

10.4 EFFECTS OF DIFFERENT CHALLENGES

In the upper panel of Figure 10.3, we show the difference in modal shares between the challenge period and the outside challenge period. The figure clearly shows a significant increase in the bike share and a reduction in the car

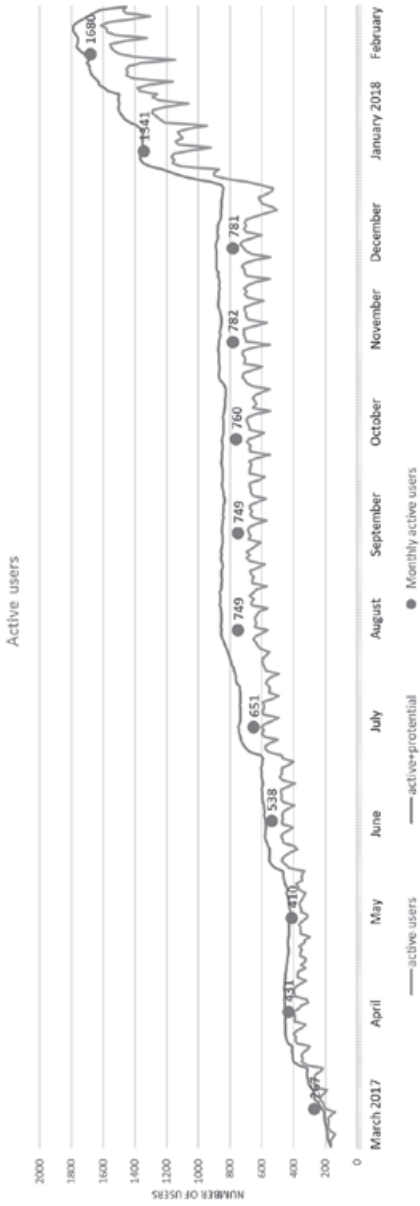


Figure 10.2 Number of active users per day and month (recorded trips for ten days)

share during the challenge period, except for the location challenges. Note that location challenges could be perceived as untargeted when participants have to visit a location they have never visited before. Because we consider many months, we can safely attribute observed changes to the challenges and not to other external temporal effects such as weather. We checked this by using the non-participants as a control group. Unsurprisingly, they did not show any significant change in modal shares between weeks when most participants were in the challenge period and the weeks outside the challenge periods.

The figure shows that challenges with high completion rates are not less effective. On the contrary, although not statistically significant, Figure 10.3 indicates that challenges with the highest completion rates also yield most of the behavioural change. The error bars illustrate two times the standard error in the difference of the mode shares. Interestingly, easy and difficult challenges (relative to the baseline) yield more or less the same behaviour change. For the completed challenges, the increase in cycling is almost twice as high for difficult challenges. However, when challenges are not completed there is almost no behaviour change. While almost all the easy challenges are completed, almost half of the difficult challenges are not completed. The fact that behavioural change is relatively significant when participants complete a difficult challenge is compensated by the fact that difficult challenges are completed much less frequently.

This result was not expected in advance. Participants who choose easy challenges do not need to change their behaviour to complete the challenge. The fact that they did suggests that the challenges in themselves encourage participants to change their behaviour. Perhaps participants are more aware of their behaviour when they participate in a challenge, and therefore are more likely to change their behaviour even when they can complete the challenge without behavioural change. This result is promising for challenges in which users can choose the difficulty level themselves.

Compared with Di Dio et al. (2018) and Tsirimpia et al. (2019), the behavioural change appears to be quite moderate. In Palermo, the cycling share increased from 5 per cent to 9 per cent (Di Dio et al., 2018). While the changes in percentage points are comparable, they start from a much lower base. Relative changes in bike shares are much larger in those two studies. Of course, it is harder to achieve large relative changes from a higher base. Therefore, it is hard to compare results from the Netherlands with those in the UK or Italy. However, their observed effects still appear to be quite strong compared to ours. As mentioned earlier, it is possible that self-selection is more of an issue in those types of studies, which results in overestimating the potential effects.

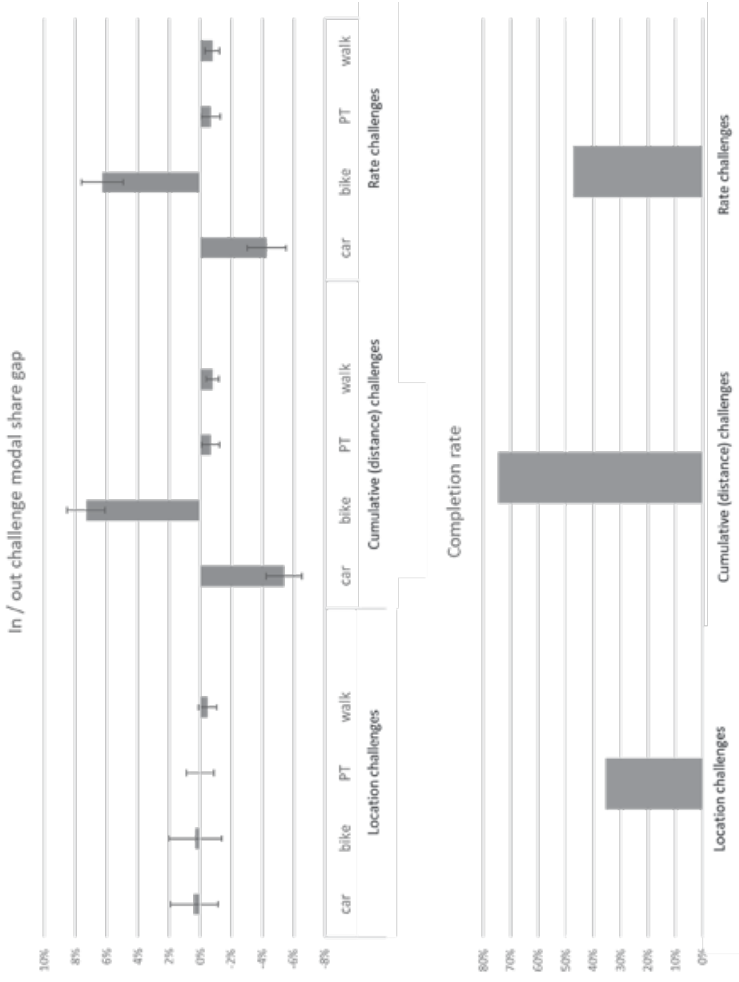


Figure 10.3 The difference in modal share between in and outside challenge period (upper panel) and average completion rate of the challenge (lower panel) per type of challenge

10.5 CONCLUSION

We conclude that monthly choice challenges can be an effective way to encourage cycling, although effects may be more moderate than expected based on other small-scale experiments. Challenges that are easy to accomplish do not necessarily yield less behavioural change. On the contrary, our result suggests that it is not necessary to request users to improve their behaviour compared to a (historic) baseline. However, these results are still on a highly aggregated level. In the next step, we will use an individual data and modelling approach to improve our analysis. One of the important remaining questions is whether the behavioural change will be sustained when no challenges are provided. Or do people fall back towards their former behaviour, even if they say they will continue cycling more? In other words, do people cycle more over time, also outside the challenge periods? And how long should we provide users with these types of challenges to obtain sustained behaviour change? To answer this question, we not only need to look at individual data, but probably also need to extend the total observation period beyond one year.

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11. Integrated mobility concepts in residential areas: challenges and opportunities of measures for sustainable urban mobility

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Julia Oehlert**

11.1 INTRODUCTION

Many people are used to the current car-oriented transport infrastructure. Thus, transforming transport requires the acceptance of sustainable transport policies by the general public (Banister, 2008) and, hence, local-scale planning for human beings, not for cars (Banister, 2011). This research focuses on an ‘integrated mobility concept’ (IMC), which is a coordinated plan for both urban development and transport planning on the neighbourhood scale, as opposed to a more strategic scale, and to concepts such as transit-oriented development. IMCs are typically applied in low-car and car-free neighbourhoods and include a wide range of measures. In theory, an IMC relies on a combination of alternative transport modes which mutually balances each mode’s advantages and disadvantages and thereby address specific transport needs that traditionally require a personal vehicle (Mayer, 2018; Topp, 2017). Based on a review of several international and German housing projects, we can conclude that in practice IMCs often feature the following key elements: residential car (sharing) clubs, bike sharing, mobility-as-a-service such as transport planning apps, the physical integration of transport offers via so-called mobility hubs, the planning restriction and concentration of parking spaces in neighbourhood and collective parking garages,¹ limited car accessibility, very good access to public transport, a high density and mix of land uses, as well as bicycle and pedestrian infrastructure.

The aim of developing an IMC is to minimize motorized personal transport and strengthen public transportation and active modes using systems of policies (for instance, measures and services) that aim at influencing the

demand for mobility (Ammoser and Hoppe, 2006). In the context of growing urbanization, IMCs ideally reduce the traffic volume and speed, and promote space-efficient neighbourhoods by reducing the amount of land devoted to car infrastructure and repurposing it for active transport and other uses. Besides achieving positive effects on wellbeing, IMCs result in a decrease in costs for housing developers incurred by the construction of parking spaces, especially underground car parking (Topp, 2017).

Although IMCs appear to have many positive impacts, few studies analyse their effects on resulting transport, and no study has explored their effects on land consumption. Researchers have investigated IMCs implemented in car-free and low-car neighbourhoods either by examining overviews of several case studies at once (Baehler, 2019; Foletta and Henderson, 2016; Kushner, 2005; Melia, 2014; Scheurer, 2001; Nieuwenhuijsen et al., 2019) or by performing a more detailed analysis of single examples (Borges and Goldner, 2015; Loo, 2017; Ornetzeder et al., 2008; Nobis, 2003; Foletta and Field, 2011; Moser and Stocker, 2008). The results suggest that IMCs have positive effects on mode shares of public and active transport and decrease car ownership levels. However, the methods used in these studies rarely obtain information and statements from the actors involved in the development process of an IMC. Furthermore, they mostly investigate the effects of the concept as a whole, but not of the contribution of single measures. To our knowledge, Scheepers et al. (2014) were the only scholars who reviewed several studies analysing mobility interventions targeted at fostering more active transport. They found that such policies often have a positive impact, but they only investigated a limited number of measures.

What is more, the implementation of mobility interventions poses several challenges for the actors involved, which can hinder the success of IMCs. Local authorities, housing companies and planning agencies may face different issues and also might have different motivations for realizing mobility measures, leading to conflicts of interests.

Thus, the main question addressed by this research is: what do the practitioners think about the importance and contribution of these concepts, and what is required for their successful implementation? To address this research gap, we carried out a quantitative survey among three different groups of actors influencing urban mobility systems. The survey investigates expert knowledge on the importance of IMCs and different mobility-related measures in residential areas, on the effects of these measures on both traffic reduction and space efficiency, and on the reasons for implementing an IMC and the associated challenges. Following this brief introduction, section 11.2 provides a short overview of the survey methodology. In section 11.3, the results of the expert survey in terms of general experience, the expert assessment of measures as well as motives and challenges are described. Finally, we critically

reflect on the results and the applied methodology and derive implications for policy and future research.

11.2 SURVEY METHODOLOGY

To acquire an initial understanding of the success factors and challenges associated with the realization of IMCs, we carried out a survey among German experts representing different stakeholders: local authorities and administrative bodies, housing companies, planning agencies and project developers (Oehlert, 2019). The survey sought to answer the following research questions:

1. What roles do IMCs play for practitioners, and to what extent do they already have experience in realizing them?
2. What are the expected impacts of IMCs and related measures on traffic volume and space-efficient land use according to the experts?
3. What challenges and opportunities are related to implementing IMCs in residential areas?

The questionnaire consists of 17 questions (Oehlert, 2019, p. 6). For most of these questions, a list of predefined items derived from literature and project reviews was provided (cf. Oehlert, 2019). The first part of the questionnaire asked for basic information on experts and their activities, such as institution, activity type, size of the city, and federal state. This was followed by a filter question on whether or not the respondent actually had experience with the planning and the implementation of mobility measures in new residential areas. If the answer was positive, the expert was asked to identify areas with previous experience, such as perceived impact of mobility measures, formal transport management tools, and reasons for the implementation of IMCs in new housing areas. Only respondents with experience in planning or developing mobility interventions were specifically asked to rate the contribution of different measures and neighbourhood mobility services to promoting space-efficient urban development and reducing traffic. In the final part of the questionnaire all experts were asked to answer questions on challenges of planning and implementing IMCs in new housing areas, and the impact of IMCs at the city level. The survey was conducted in May and June 2018 by emailing local authorities and housing and planning associations directly and via mailing lists. In total, 194 persons responded. Most participants represented public administrative bodies (40 per cent), planning agencies and project developers made up 27 per cent of the sample, and 20 per cent of the experts worked in housing companies. The remaining 13 per cent consisted of practitioners from research and other institutions which were not included in the evaluation.

11.3 RESULTS

11.3.1 General Experience in Implementing Mobility Measures

In total, 135 experts (70 per cent of the respondents) were involved in projects implementing mobility measures in general. More specifically, more than half of the surveyed persons (56 per cent) were planning related developments when answering the questionnaire, and more than one-third (35 per cent) had already finished projects with IMCs. Among the analysed groups, about 60 per cent of experts either had implemented or had implemented and at the same time were planning further interventions. More experts from the housing industry than from the other groups had no experience at all related to IMCs. These results and, in particular, the high percentage of experts planning such projects at the moment show that neighbourhood-oriented mobility services are a recent and relevant topic for all of the actors surveyed.

Among the implemented measures mentioned (Figure 11.1), bicycle racks scored the highest and had been previously implemented or planned by 96 experts (75 per cent). This is because German building regulations require property developers to build bicycle racks with new buildings. Measures for reducing or mitigating the negative effects of personal motorized transport had been realized almost as often: carsharing for residents (66 per cent), charging infrastructure for electric vehicles (65 per cent), reduction of the number of parking spaces per housing unit (63 per cent) and parking management (60 per cent). Half of the respondents also had experience with mobility hubs. Fewer experts had implemented projects involving measures promoting bicycle and foot traffic such as bike and pedestrian paths, bicycle garages, bike sharing and cargo bike rental. While freight transport solutions are highly relevant and extensively discussed, measures such as central parcel collection points and micro-consolidation centres have only rarely been implemented to date. Fewer than 40 per cent of the experts had planned and implemented such measures in their urban logistics solutions.

11.3.2 Assessment of the Impact of Mobility Measures on Transport and Space Efficiency

Figure 11.1 shows the proportion of experts perceiving the measures to contribute positively to improving space efficiency and lowering traffic volume according to their personal assessments. Among all measures, reducing parking, car sharing stations for residents, and neighbourhood and collective parking garages were named by the highest number of experts as having a positive impact on space efficiency. The experts' statements show that the

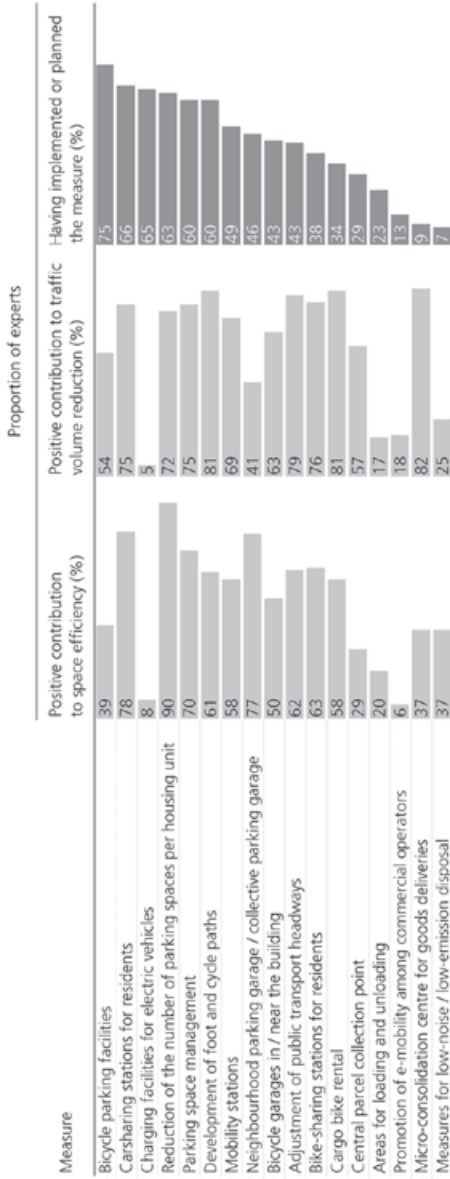


Figure 11.1 Expert assessment of the impact of mobility measures

measures that most reduce traffic volume aim at promoting environmentally friendly modes or are related to freight transport. About 80 per cent of the experienced respondents ascribed a positive impact to adjusting bus frequency, increasing the number of pedestrian and cycle paths and implementing micro-consolidation centres and cargo bike rental. Bike sharing and car sharing stations as well as parking management are also considered to reduce traffic, with about 75 per cent of the experts seeing them as contributing positively. An interesting finding is that measures for promoting electric mobility, a highly topical aspect, are at the bottom of the ranking regarding their effect on land use efficiency or traffic volume, as almost no expert saw them as contributing positively. However, electric mobility may be associated with other potential positive impacts, such as the reduction of emissions, which were not investigated in this study.

The survey also revealed that often measures increasing space efficiency do not seem to help reduce traffic volume, as is the case for neighbourhood and collective parking garages. On the other hand, some measures that contribute to reducing motorized transport require space, such as micro-consolidation centres or bicycle garages. However, many experts recognize that some measures – such as car sharing stations, reduction of parking facilities, parking management, the extension of pedestrian and bicycle paths as well as the adjustment of public transport headways – contribute positively in both regards. The survey results indicate that there is not one single measure for developing sustainable neighbourhoods, but rather that a combination of measures restricting car usage and providing alternatives is important. In the survey, this is confirmed by 75 per cent of experts who agreed or agreed somewhat with the statement that mobility measures only work if applied together and not individually. Two-thirds also think that neighbourhood-related mobility offers and services should be part of an IMC. IMCs are associated with several positive impacts, while some effects are seen critically by many practitioners. Over 80 per cent of the experts agreed or agreed somewhat that these concepts can promote environmentally friendly modes, enhance quality of life, increase equity in mobility, reduce the negative effects of transport and decrease the level of motorization. The experts are more sceptical about whether such concepts can reduce parking shortage or costs (30 per cent disagreed somewhat or disagreed), increase building density (38 per cent) and, particularly, reduce freight traffic volumes (62 per cent). Finally, integrating a mobility concept into the planning process of new neighbourhoods from the start is important to prevent residents from relying on car-oriented mobility. However, our survey showed that only 47 per cent of experts agreed or agreed somewhat with the statement that ‘Mobility measures should be part of each new residential development’, although 78 per cent of the experts said that they are usually included in the planning process of new projects.

11.3.3 Implementation of IMCs: Motivations and Challenges

In order to analyse the general conditions for IMC implementation, we asked experts to name their five main motivations and challenges when implementing IMCs (Figure 11.2). All experts from the three different groups pursued the goals of improving the quality of life in residential neighbourhoods and finding solutions to parking problems by implementing mobility measures and services. Respectively, 70 per cent of the respondents in each group were motivated by these goals, although the latter goal is more important for housing experts (Figure 11.2a). In contrast, local authorities want to shift motorized personal transport to environmentally friendly modes and satisfy the mobility needs of all population groups (90 per cent and 63 per cent respectively), while this is not so important for experts from housing companies. For the latter, it is more important to provide additional services for tenants and thereby increase the attractiveness of the housing (60 per cent), in comparison to other actors (less than 40 per cent).

Contrary to our assumption in the introduction, saving costs is not as an important factor for the experts. According to our survey, less than half of the experts in each group were motivated by this goal, for which there are several possible underlying reasons. Firstly, companies might not be aware of the cost reduction that can be achieved by dispensing with the construction of parking spaces. Secondly, the residential real estate market in Germany is currently driven by demand. Thus, more expensive apartments with parking spaces can still be let, and there is no need to reduce costs.

A closer look at the challenges that experts named reveals the factors that may prevent them from implementing IMCs in residential neighbourhoods or delay their realization (Figure 11.2b). The most frequently mentioned challenges differ more than the motivations mentioned by the experts. More than 50 per cent of the experts in each group of actors, with the exception of actors from housing companies, see major problems in the lack of will to realize measures. The results also reveal that planning agencies perceive the unclear legal framework as a major problem. Finally, 40 per cent of the experts from the housing sector see themselves mainly challenged by insufficient incentives, high costs and a lack of flexibility of local authorities.



Note: USP – unique selling point.

Figure 11.2 (a) Experts' motivations for implementing mobility measures; and (b) Challenges associated with IMC implementation

11.4 SUMMARY AND IMPLICATIONS

IMCs combine several mobility measures and services within a coordinated plan and are a core element for planning transport on the human scale, for instance in car-free and low-car neighbourhoods. Such concepts and related measures are expected to contribute to the sustainability of new residential neighbourhoods in terms of reducing traffic and efficiently using space. We conducted a survey, interviewing 194 experts to collect data on the experience of practitioners involved in developing IMCs. In general, the results of our survey corroborate the findings from other studies, pointing to recommending similar measures. According to the experts, some interventions decrease transport and improve space efficiency to a similar extent and should therefore be considered first in IMCs. However, most experts think that there is no single measure that both reduces traffic and improves space efficiency; rather, that measures might even have contradictory effects. Hence, the surveyed experts stress the importance of combining several measures in an integrated concept. In particular, restricting the number of parking spaces, on the one hand, and providing alternative mobility options, on the other, seems to support sustainable mobility behaviour. Surveyed practitioners mostly share the same motivations for implementing IMCs, but public authorities see IMCs as an instrument for shifting transport to more active modes, while housing companies view them as a marketing instrument. Regarding challenges, many respondents from housing companies perceive a lack of incentives and high costs as the main problems, whereas local authorities tend to mention a lack of will to implement them and the high demand for coordination. Moreover, it seems that, although actors have similar or complementary motivations, there are also conflicts of interest. Improving their collaboration, communication as well as the coordination of their activities could help to more effectively address challenges and eventually successfully implement projects.

This study corroborates other findings which have shown that in order to transform mobility, restrictions on the possession and use of cars are needed, combined with the provision of environmentally friendly alternatives (Nieuwenhuijsen, 2020). When designing such concepts, it is important to monitor them with empirical analyses such as residential surveys, data analyses and transport modelling, as well as to include expert views such as those reported here (Nieuwenhuijsen et al., 2019). Bringing expert knowledge and public ideas together to create IMCs can increase the acceptance of policies and interventions and contribute to transforming mobility to the human scale.

An additional learning from these findings is that when developing IMCs, stakeholders should first think about their objectives and then choose the corresponding mix of interventions. Depending on the measure, not all actors have

the same scope of action, thus requiring them to collaborate. An additional underlying issue is that departments of transport and urban planning have often been separated in local jurisdictions for historical reasons (Bertolini, 2012). However, new planning positions have been created to bridge these gaps, such as climate protection and mobility managers. Furthermore, since only half of the surveyed experts think that residential projects should include IMCs, it seems important to include elements of IMCs not only in local planning instruments and regulations, but also in more general ones such as sustainable urban mobility plans. As IMCs combine different aspects with a new and complex approach, this could also help to solve problems with a legal framework and clear assignment of responsibilities.

This study has some limitations. The majority of the sample of experts came from cities and urban agglomeration areas, in particular from Berlin where local conditions differ from many other cities, particularly medium-sized cities, due to the city's high population growth and rising housing prices. This may have had an impact on the assessment of measures. Due to the federal system in Germany, the legislation regarding different measures, such as parking requirements for new housing, also varies. Besides the local specifics, the survey did not collect sufficient information on the experts, such as their experience, age, position or role, which would help to contextualize the results. Finally, measures that were not specified in the lists of items in the survey could not be rated, and thus the survey might be somewhat biased, although the choice 'other' was not frequently used.

Acceptance of sustainable mobility by the public is necessary for people to change their mobility behaviour. This can be achieved by demonstrating interventions and individual marketing on a local scale (Banister, 2008, 2011). Future studies should thus address whether and to what extent including residents in the planning process can increase an IMC's acceptance, for example by showing residents the available alternatives for their daily mobility as well as ways of using saved space differently. Studies obtaining expert knowledge should analyse whether the experts' responsibilities in institutions and level of experience influence their assessment of measures and IMCs in general. More qualitative research such as focus groups or experimental games could bring further insights into the actors' underlying motivations and perceived challenges. The complex interactions between the stakeholders should also be further investigated by applying social network analysis to the planning process of an IMC (Eräranta and Mladenović, 2020). Finally, we would learn much from a broad international expert survey or review in order to understand how IMCs are treated in different cultural contexts.

NOTE

1. Throughout the text we use this term to refer to multi-level parking garages that cater to the needs of neighbourhood residents (German: *Quartiersgarage*). Visitors can possibly also use such facilities temporarily; however, their purpose is to provide long-term parking for residents near their homes.

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PART IV

Potentials for developing planning processes for human scale cities

12. Channelling human scaled modes to build repurposed street networks

Kevin J. Krizek and David A. King

12.1 EMERGING LANDSCAPES AND PRIORITIES IN FUTURE TRANSPORT PLANNING

City leaders are pressed to consider how emerging transport technologies will change existing urban transport portfolios. New types of vehicles – automated cars, scooters, electric bikes – will continue to emerge in innovative new forms. Yet any new vehicles will need to integrate with existing transport modes on the streets, which are currently dominated by large cars and sport utility vehicles (SUVs). This leaves fundamental questions of how to appropriate space in streets to different forms of movement. Any transport planning decision, ideally, would ensure future conditions with high levels of accessibility (King and Krizek, 2020), while also stewarding the environment and promoting justice. This chapter posits how and why planning for bicycles and bicycle-like vehicles can be used as a guiding principle to enhance both mobility and cities' overall welfare.

We argue that many urban settlements, even most North American cities, belie their bicycling potential. They are closer to being set up for easy bicycling than most people recognize; a change that is much needed is based on designing streets differently. In this chapter we present a perspective drawing largely from North American contexts but with applicability elsewhere, to describe a rationale and strategy that underscores the merits of bicycle-like transport in future considerations and its feasibility. The last section outlines a strategy built on network development to seed changes that can spark a transport revolution in many cities across the globe.

12.2 CURRENT CONTEXT RELATIVE TO NEW TECHNOLOGIES

Private automobiles have historically dominated the transport landscape in cities since World War Two (WW2). Expressing concern for streets was

synonymous with looking after the needs of cars. Planning and engineering institutions have followed suit by installing rigid design guidelines and manuals. Decades-long practices to engineer streets favouring cars is a well-documented phenomenon (Norton, 2008). Planning was boring, lacking shake-up from new innovations, and for a prolonged period (post-WWII to the turn of the 21st century), quietly supporting cars while punishing other modes. Notwithstanding periodic flashes, largely in the 1970s with experimental forms of vehicles or a bicycle boom (Reid, 2017), not much has changed outside of the Netherlands and Denmark and a few other communities in Northern Europe. Lack of change is particularly noticeable in American cities and suburbs.

This staid context, just described, serves as a backdrop for ideas where innovative technologies are being promoted with much excitement and smaller vehicles are increasingly seen in a new light. New vehicles are cleaner and smarter. Some are backed with breakthroughs in electric battery power technologies. Other ways in which they vary from their predecessors, both cars and bikes, are in terms of size, speed or navigational requirements. Innovations might be as small as a hoverboard, or larger than the biggest car on the road. In terms of speed, they might have limited capacity, or rival the fastest of sports cars. The user may or may not be required to engage with the vehicle, for example in terms of navigation. Furthermore, some of these vehicles can provide revolutionary solutions to existing mobility problems in cities.

However, at least three issues arise from these prospects. First, transport futures based on any one of these innovations are speculative: as is the case in projecting any future, rates of adoption are built on prospect, while benefits and costs are unknown. Second, the size and shape of many of the innovative vehicles (such as versions of automated vehicles) are modelled after existing cars; more car-sized vehicles denigrate the built environment because of the space they require. Third, the manner in which new vehicles will integrate with existing fleets and the fabric of street systems is complicated to plan for (Gössling, 2020). The prospects for any vehicular invention are likely to be less revolutionary than proponents promise. We suggest that prudent transport planning practice does not hold out hope for unproven forms of technology.

These types of uncertainty permeate several dimensions of transport planning (Bertolini, 2012; Marsden and McDonald, 2019). This uncertainty should not stifle or preclude planning efforts to create transport systems different from the current ones, however. Our purview directs the conversation to designing future urban streets. Absent from most conversations about how to plan for the future of streets, we argue, are compelling ideas derived from sound planning principles, based on known technologies; actions that preserve the health of cities and are able to be acted on tomorrow. The idea draws from lessons gleaned from one of the oldest, most environmentally friendly and equitable

modes of transport: the bicycle. It means drawing into focus an opportunity that awaits should new and safe networks for short trips be developed; networks that favour human scale modes.

12.2.1 Bicycles are Valuable Modes to Plan For

Bicycles represent vehicles that prize human scale dimensions while also satisfying wide-ranging mobility needs. The type of vehicle to which we refer might be a bicycle in the truest definition. Alternatively, it might represent a vehicle with ‘bicycle-like’ characteristics in terms of speed, size or character. It would go faster than simply walking and might top out at roughly 30 km/h. A 20 minute trip averaging 21 kph, for example, would cover a range of 7 kilometres. In terms of size, the vehicle could encroach upon but not egregiously exceed the size of existing cargo bikes. This would help to ensure increased efficiency for how valued street space is used. In terms of operation, the vehicle would demand human qualities for some power and navigation. This would help ensure some human characteristics, rather than relegating everything over to technological advances.

Beyond fundamental characteristics of the vehicle, bicycles can benefit in that they are a known product, having been around for a century. This condition has allowed an established base of knowledge to accrue about their use, one that has been quickly burgeoning in recent years (Krizek et al., 2018; Pucher and Buehler, 2017).¹ Burgeoning research, for example, helps planners and researchers to understand bicycling’s role in satisfying different travel markets. Matched with past knowledge, this research provides even more certainty to the already known environmental determinants that help to spur more bicycle use (Nello-Deakin, 2020). This research provides ample guidance on how to design streets and the factors that undermine cycling safety. We know the knock-on effects of having more bicycling in terms of air pollution, physical activity, liveability, and more (Götschi et al., 2016). We know what bicycles can and cannot do, particularly in Europe, where many cities have enthusiastically embraced cycling.

We do not suggest that bicycles should be the only vehicles allowed on city streets. Rather, new vehicles should be developed that increase access and mobility, so long as they mostly subscribe to the bicycle-centred characteristics mentioned above. Electric bicycles, scooters, modified golf carts and other small vehicles can all co-exist with other street users, provided the rules of the road are guided by cycling. As bicycles and bicycle-like vehicles require space on city streets to operate safely, our focus here is to expose the rationale for their value and then describe a process to steward that space. For the remainder of the chapter, in the interest of parsimony, we use ‘bicycles’ as a label that is inclusive of all human scale vehicles.

12.3 SETTLEMENT PATTERNS AND BICYCLING'S POTENTIAL

Fuelling the rationale and potential for a focus on bicycles hinges on understanding three phenomena: the patterns of settlement, bicycle trip distances and the imminence by which bicycle networks could be developed. We overview factors addressing the first two, with a focus on describing a strategy to address the third.

The distance to most destinations for which urban residents travel provides a first point of evidence. Every other time a driver in a United States (US) city gets in a car they travel less than 6.5 kilometres (Krizek and McGuckin, 2019). Simply put, urban settlements have origins and destinations that are reasonably proximate to one another. This finding applies to both cities and suburban environments, recognizing that the latter are characterized by separated land uses and auto-centric streets (Hess et al., 1999). Yet, walking trips are rarely more than 1.5 km (Yang and Diez-Roux, 2012), and travel less than 6.5 km is not so far as to require the type of motorization afforded by automobiles. Alternatively, consider an inventory of 86 000 residences from Tempe, Arizona (USA), a typical suburb in a sprawling region (Capasso Da Silva et al., 2020). Close to 80 per cent of these homes have most services reachable within 6.5 km from home. This leaves open rich prospects to satisfy a market of urban trip-making using modes other than automobiles.

More than 1 km but less than 7 km is the range where bicycles thrive. Analysing data from bicycle use sourced from the Netherlands, China, India and the US reveals Figure 12.1. The shape of the curve is largely similar across all modes;² what is notable is the x-axis, measuring trip distance (Arasan et al., 1994; Harms and Kansen, 2018; Iacono et al., 2008; Zhang et al., 2014). Bicycling use drops quickly with initial distance gains. But the integral of the curve between 1.5 and 6.5 km presents a 'sweet spot' as the majority of all cycling trips fall within this range and roughly three-quarters of all bike trips are less than 4 miles (6.5 km).

A major challenge in realizing more bicycling stems from the safety of conditions provided for their use. While many streets might be low-stress most of the time, characterized by having few cars or slowly moving ones, they fail to connect people to where they want to go. Otherwise, bicyclists are mostly relegated to high-stress travel environments, at least in most North American cities. The importance of streets can be further gleaned by examining how many jobs are available by bicycling in the 50 largest US cities. Using any street (low or high stress), more than 15 000 jobs are available, on average, within a 20 minute bike ride. In using only low-stress streets, a cyclist can reach a third of those (Owen and Murphy, 2019).³ While these measures speak

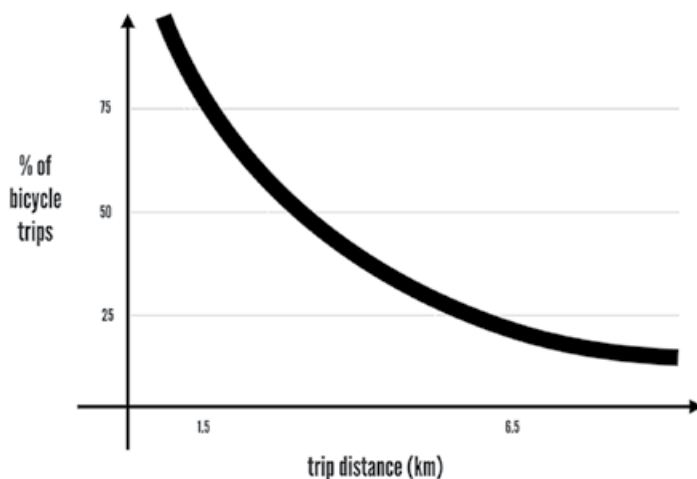


Figure 12.1 *Distance decay curve for the distance of cycling trips from localities around the world*

only to employment, it is not too far of a reach to apply similar logic to other purposes of travel. Most urban settlements could be set up for bicycling.

12.3.1 Streets can Change their Use

Streets can and do change character. The marks that automobile-based practices have etched into the canvas of streets are not indelible. The primary hurdle in realizing the above gains is to ensure safe networks for bicycling; networks which are lacking in most cities. Redesigning street networks for better transport extends to how cities could support new vehicle types, those with size and speed similarities to bicycles, which will maintain high levels of access to jobs and opportunities, but at far less cost to society.

Consider the past post-industrialization period, where streets, including many still familiar to us all, have seen walking, omnibuses, streetcars, bicycles and, ultimately, cars and trucks. Former layers are embedded and are exposed as streets are repaired and torn up: vestiges of earlier lives, tracks from streetcars, horseshoes, and even ruts from Roman chariots. Some progressions, from one dominant mode to another, occurred in only a few years. They might change character with the diurnal cycle. During a rush hour compared to the middle of the night, streets might go from full and slow to nearly empty, yet

speedy. Or a traffic lane in a street can change based on the direction of travel.⁴ Streets have high potential to be swayed away from further auto-based practices. When considering potential futures that are different from what currently exists, this is helpful to keep in mind. Globally, many cities pursued strategies to change the nature of their streets – temporarily or permanently – in response to COVID-19, usually resulting in ways favouring bicycles. Many of those applications were relatively ad hoc, changing streets that were relatively easy to change. We now turn to describe a process of repurposing street space to prioritize the application of new networks.

12.4 HOW NETWORKS GROW

12.4.1 Positive Externalities

We first reflect on existing street networks and contextualize them against broader thinking. Street systems have structural properties that are embodied in all networks. They convey matter or energy from one point to another through nodes that are connected by links. These nodes and links develop based on inputs from each, and information external to the network. Natural networks such as plant leaves, for example, receive inputs from the amount of natural light or, alternatively, soil moisture. Rivers or streams may grow from conditions affecting the amount of water running off the landscape. Communication networks are based on how quickly new nodes in the network (for example, new users) acquire that mode of communication. Extending these principles to transport networks is limiting, however, because transport networks respond to political and economic triggers. Transport networks develop by responding to some forces that can be analogous to natural systems, but they are more influenced by available funding or land use planning, each of which carry highly political dimensions.

12.4.2 Feedback Loops

Still, there are meta-level patterns. A property that holds across the growth of transport networks is that links and nodes grow based on the positive externalities that are generated when a link or a node is improved. Any upgrade makes that part of the network more valuable to existing and potential users. Additional users of the network spur demand for more upgrades, thereby initiating a positive feedback loop. Should there be a demand to use the network concomitant with an improved link or node, the improvement spurs more demand (e.g., Levinson, 2008).

Many factors moderate the strength and speed of the feedback loop, and we turn to discussing the opportunity to stimulate that loop for bicycling. A first

factor stems from knowing the latent demand to use the network; evidence for this was explained above (that is, the amount of trip-making in urban areas that is less than 6.5 km). Next, important factors involve knowing the location and size of any improvement, together with the stage of the development of the network (that is, whether it is nascent or mature).

Most mature cities have mature street networks. In a mature automobile-oriented street system, it is more difficult to realize an individual improvement from a system-wide perspective. For example, should a problematic intersection be improved, its impact on the network overall is slight, because the improvement applies to only one of thousands of intersections in a city. For a nascent, emerging network, the reverse is true. Each improvement has a higher impact owing to its relative contribution to an improved system. For example, should there be only one bicycle lane in town and another is added, that network becomes twice as strong. To heighten the impact of a second bicycle facility, it is best to ensure that the second can play off the first. This underscores why it is important to strategically locate improvements. An example drawn from prior writings (Levinson and Krizek, 2018) helps to explain this.

Suppose a city aims to strengthen its bicycling network. It begins changing the street near an elementary school by painting it to indicate the school traffic zone. For this improvement, the primary benefactors are the children who frequent the school, as the reach beyond this population is limited (similar to having a single fax machine but no one to fax with). Should city officials improve a segment of street a few blocks away near the recreation centre, a network is born. Two links are formed – school to recreation centre ('rec'), and vice versa – benefiting two different populations. Should an improvement be realized in front of the grocer that is three blocks north, the network now serves six markets: school to rec, rec to school, grocer to rec, rec to grocer, grocer to school, and school to grocer. Each improvement on the network provides benefits to users travelling for different types of trips. Should more improvements come online, for example next to the library, the number of markets grows from six to 12. More nodes and links with improvements bring higher value for these improvement as recognized by community members, loosely following a growth dynamic that resembles Metcalfe's law (Gilder, 1993) and broader network effects: more users of the service provides a value of the product to others, and the value of the product increases according to the number of others using it.

In a growing network, plotting the number of improvements (that is, users or market penetration) versus time typically reveals an S-shaped curve (Figure 12.2). Following a nascent period where improvements are slow to pick up (Hall, 2004), continued improvements help to trigger a rapid acceleration phase. This point, also referred to as take-off, is the location in the curve with

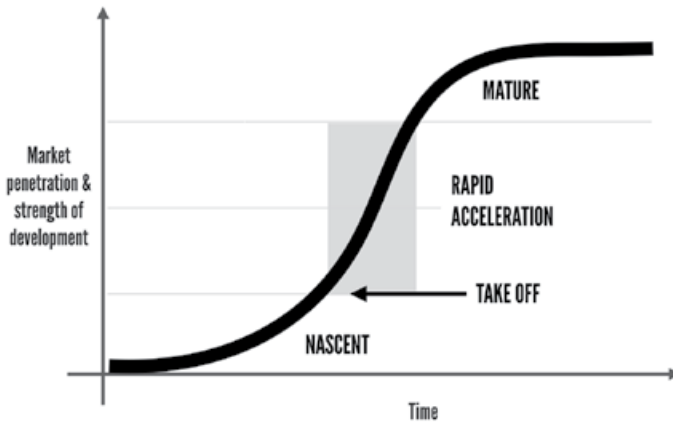


Figure 12.2 Transport networks develop based on improvements which vary by stage of development for the network, as depicted in an S-curve

the greatest inflection relative to the initial growth rate, and getting to this point is most important (Golder and Tellis, 1997). Growth continues until the network reaches a mature status or a saturation point. Given that cycling networks are currently nascent in most cities, this can work to bicycling's advantage in terms of quickly attracting new users (e.g., Félix et al., 2020). Efforts to grow the network can be quickly realized, thereby moving past the take-off phase. Another important factor working in bicycling's favour is that most streets are already built and paved. Legal rights of way have already been preserved; there is minimal need to find resources to lay the road surface. Streets can be inexpensively repurposed through minimal signage or re-marking efforts.

12.4.3 Locations to Sow Seeds

The above rationales point to the following: streets can change the types of vehicles they support, and a bicycle network can be swiftly built from existing streets. Yet, the speed at which the network develops depends on where seeds are planted. This means strategically improving links and nodes to street networks that have high potential for attracting cyclists. It is a crucial step to initiate and strengthen the point of take-off. First places to target are locations in cities where many short trips start or stop, those less than 4 miles. These locations vary by city and it is necessary to contend with long-standing equity

concerns about which streets, in which neighbourhoods, to change (Tucker and Manaugh, 2017). Our efforts here identify and briefly describe some generalities of these places – schools and campus environments, neighbourhood retail and the first/last stage of trunk transit service – each of which serve as attractions for many short trips.

Owing to the size and characteristics of the population affected, streets near schools and campus environments provide the first areas to target. School travel is an issue that varies considerably in culture. It often starts with which type to attend (for example, public or private); other factors quickly follow suit. The public education school system in the US provides only one frame to view this issue, albeit a large one, and we rely on it here as an example. More than 50 million children in the US attend school; three-quarters of them travel less than 8 km to do so, thereby roughly translating to 75 million school trips, two per day, for 160 days. Recognizing that 8 km is a healthy distance, if one were to assume that two-thirds of those might be within comfortable cycling distance, this equates to 50 million school trips per day. Primary explanations for why children do not cycle to school start with unsupportive conditions on streets. Therefore, improvements through programmes such as Safe Routes to Schools have demonstrated progress along these lines. Making streets safer around schools has yielded an 18 per cent uptick in the number of children walking or bicycling there (McDonald and Aalborg, 2009); exactly the type of dynamics referenced here. Campus environments such as universities provide other good locations with high proportions of travellers without cars and lots of short-distance travel.

Trips near neighbourhood retail mark a second location. Within 6–7 km from most homes, urbanites and suburbanites alike have many services available. Acknowledging that nearby services are not always the ones that are frequented by residents, the geographical distribution of such establishments suggests that most are being supported by people travelling no more than a few kilometres to do so.

Bicycle-like vehicles, however, are not suited for longer-distance passenger trips in cities; such travel might be better relegated to train or bus. Locations along the trunk service, possibly terminals or other popular stops, is where many short-distance trips to final destinations begin. Passengers can disembark transit and use bicycles for the last stage (or vice versa for the first stage). This strategy increases the overall trip shed (the area that can be served) by transit, and helps further to strengthen the market for short-distance transport. Furthermore, it allows faster service along the line haul (trunk) portion because of fewer stops. One need look no further than the power of the shared bicycle system offered by Dutch rail to understand the possible impact in this respect; that system of 15 000 bicycles has grown to accommodate 3 million rides per year, all of which start or stop at train stations.

12.4.4 Completeness

Mounting improvements to support bicycling near the above locations is a first step. Changes to one part of the network have multiplicative effects: a fundamental principle that helps networks to grow quickly. But any network is only as strong as its weakest link. Researchers have a much-needed role here to identify locations that serve the above criteria, particularly those that connect key nodes and then link those subnetworks to form a larger one. Consider how dedicated bicycle lanes on key links of networks often vanish at intersections. Think about how each turn away from dedicated land may or may not be met with a facility that supports bicycling. Beyond individual links, bicyclists often find themselves exposed to high-stress environments at nodes. The need to cross just one troubling intersection, following the weakest link principle, has paralyzing effects for even dedicated cyclists.

12.5 CONCLUSION

Owing to emerging types of vehicles, city leaders will be increasingly challenged to prepare their streets to best serve future transport needs. Transit and pavements (and cafes) will continue to vie for attention. These needs will compete with other demands on streets such as storing utilities, providing conduits for emergency services, and picking up rubbish. Given that the rights of way are largely fixed – expansion, reduction or relocation is unlikely – all of this underscores the demand for finding space-efficient and low-cost options that offer high mobility. Prior eras of transport planning found many answers in prioritizing car use. But these decisions made decades ago are insufficient to solve the present generation’s problems. In times of high uncertainty, planners and city leaders will need to experiment with furnishing new types of streets (Bertolini, 2020). They will benefit from a well-grounded and evidence-driven theory to test.

This chapter presents a rationale and strategy to prioritize actions that favour bicycles as a proxy for human scale vehicles. Doing so advances the public interest with the fewest negative consequences. It means not holding out hope for unproven mobility interventions, or furthering the status quo, largely featuring cars, which denigrate characteristics of human scale cities. Enabled by the framework offered here, cities can experience how small successes coalesce to create substantive gains.

NOTES

1. Papers that address bicycling, according to the Web of Science (from 1991 to 1995 relative to 2011 to 2016), have seen a thirteenfold increase, including systematic catalogues of the emerging knowledge base (e.g., Handy et al., 2014).
2. Gathering data from these studies and plotting thresholds using the exponential function provides the aggregated function shown in Figure 12.1.
3. The average number of jobs reachable in 20 minutes via any street for the 50 largest US cities is 15 191; using only low-stress streets, it is 5364. The differences were less in Oklahoma City, Philadelphia, Richmond and Louisville, which revealed less than 50 per cent difference; the biggest differences were in Tampa Bay, Columbus and Las Vegas.
4. For example, reversible lanes that are used for high-occupancy tolls lanes (for example, Minneapolis) or Phoenix's 'suicide lanes' on 7th Avenue and 7th Street, which are reversible centre lanes on arterials with limited left turns.

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13. The Gross Potential for Cycling: planning for human scale urban mobility

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and Ana M. Dias**

13.1 INTRODUCTION

The (re)turn to human scale cities is inseparable from the shift of mobility paradigms towards sustainable modes of transport. As car dominance steadily transformed what was once public space into road space (Sheller and Urry, 2003), growing congestion and pollution have decreased the quality of life and equity among citizens. Non-motorized transport, and especially cycling, is associated with higher levels of happiness and emotional wellbeing (Zhu and Fan, 2018). It has been framed as a means to democratize the city (Cox, 2019) and as a convivial tool that increases opportunities for social relationships (Illich, 1973, 1974), in addition to other widely recognized environmental and economic benefits. Cycling, therefore, establishes and ensures mobility on a human scale (Quee and Bijlsma, 2018). Nevertheless, despite the growing policy and academic interest in cycling, when compared with other modes of transport little attention has been paid to it (Heinen et al., 2010), and analysis and planning methods have not kept pace with demand (Kuzmyak et al., 2014).

Promoting a modal shift towards cycling is a complex process, particularly in cities dominated by the car-centric paradigm, which cannot reproduce the path of champion cycling cities such as Amsterdam and Copenhagen. Starter cycling cities combine poor cycling conditions with low cycling rates (Dufour, 2010), where the lack of cycling culture and technical know-how limits strategies to sporadic interventions (such as hastily planned infrastructure or symbolic bike sharing systems). Long-term commitment is also weakened as cycling provision lacks the high profile of other infrastructure investments (such as, for example, the metro) and is associated with being ‘cheap’ (Aldred, 2013).

Nevertheless, cycling has entered the global urban mobility agenda, pushed by a widespread commitment towards the transition to post-carbon societies. Portuguese cities, which have extremely low bicycle rideshares – only 0.5 per cent of commuting trips, according to 2011 census data – now face the target raised by the National Strategy for Active Mobility, launched in 2019, to increase urban bicycle modal share to 10 per cent by 2030.

Within this context, project ‘BooST – Boosting starter cycling cities’ aims to integrate current knowledge with the needs of such cities by developing a planning support system for cycling. The shared know-how would substantiate future cycling strategies and facilitate the transition to implementation in planning practice. This chapter draws on research conducted for this project and presents the assessment framework of one of the developed tools, the Gross Potential for Cycling (GPC). It starts with a short review of planning support tools for cycling (section 13.2), followed by the presentation of the GPC tool (section 13.3). Section 13.4 details an application to the municipality of Matosinhos, located in Porto’s Metropolitan Area. The chapter finishes with some remarks on the potential of GPC to assist the development of cycling promotion strategies.

13.2 PLANNING SUPPORT SYSTEMS AND TOOLS FOR CYCLING

Research on cycling travel behaviour in the last decades has strengthened the empirical evidence on some of the most relevant factors influencing commuting mode choice. A complex array of explanatory factors, including psychological and socio-demographic characteristics, the built and natural environment and land use patterns (Heinen et al., 2010; Kuzmyak et al., 2014) has supported the development of tools focused on cycling policies and planning.

Planning support systems (PSS) have been developed to support evidence-based policy and decision-making processes in land use and transport planning (Klosterman, 1999; Te Brömmelstroet and Bertolini, 2008). Cycling-specific PSS include: (1) a set of broad measures evaluating the overall cycling environment in the city, such as the Index of City Readiness for Cycling (Zayed, 2017); (2) tools analysing the potential demand, through spatial and socio-economic analyses, for bicycle commuting, such as the Propensity to Cycle Tool from the British context (Lovelace et al., 2017) and the Analysis of Cycling Potential in the city of London (TfL, 2010, 2017); (3) micro-scale indicators assessing the usability of specific streets for cycling, such as the Bicycle Safety Index Rating (BSIR) and the Bicycle Compatibility Index (BCI) (Schwartz et al., 1999), the assessment of Levels of Traffic Stress for cycling (Mekuria et al., 2012) and bikeability indexes (Hoedl et al., 2010; Winters et al., 2016); and (4) frameworks to prioritize investment in infra-

structure based on the evaluation of predefined parameters weighted by expert judgement (Glavić et al., 2019).

Starter cities raise specific challenges to existing approaches. Those based on street-by-street analysis require vast amounts of micro-scale data, making it impossible to assess large areas, while disregarding relevant socio-economic factors. Others only provide city-wide averages, impeding the identification of the areas with the highest cycling potential, which is key to decide on where to prioritize investment. Certain tools focus on existing cycling infrastructure or rely on data on travel patterns or stated preference surveys (Cox, 2019), which is less relevant when there are no previous cycling habits.

The literature has also identified an implementation gap between the development of PSS and tools and their operational use in planning practice (Kuzmyak et al., 2014; Saujot et al., 2016; Vonk et al., 2005). In order to bridge this gap, assessment tools and models have to be understood by planners, making a claim for more bottom-up participatory approaches that consider planners' objectives and general needs (Te Brömmelstroet and Bertolini, 2008).

The GPC provides a user-friendly PSS whose main novelty is the assessment of the gross potential for cycling, rather than just previous travel patterns, the level of existing cycling infrastructure or user satisfaction, as is commonly used for 'champion cities'. It also entails a participatory process through a call for the participation of Portuguese municipalities.

13.3 THE GROSS POTENTIAL FOR CYCLING

The GPC builds on a literature review exploring the multiple factors influencing the choice of commuting by bicycle (socio-economic, built and natural environment, attitudinal and social factors) and on existing tools. A previous version of the tool (the Potential for Cycling Assessment Method by Silva et al., 2018), has shown the ability to test different scenarios, prioritizing on the location of new infrastructure and complementary bicycle promotion measures. Based on geographic information systems, the GPC employs a two-dimensional approach, combining the assessment of the target population according to their predisposition to cycle, based on socio-economic factors, with the target areas more suitable for cycling categorized by their geographical and built environment characteristics. The model is calibrated according to traffic conditions – comprising topography, road hierarchy, car parking pressure, average congestion, number of car accidents and current cycling infrastructure – which are incorporated into cycling and driving speeds.

13.3.1 Target Population

The first dimension, target population, relates to the spatial distribution of different population segments and is built by assessing four socio-demographic indicators: age, potential demand density, employment density and motorization rate. Age (P1) identifies the population groups more prone to cycle. Most of the literature shows that bicycle commuting tends to be more frequent among younger ages (Dill and McNeil, 2013; Goldsmith, 1992; Litman et al., 2018; Plaut, 2005). While some studies did not find age to be significant (Geus et al., 2008; Parkin et al., 2008), these are target-specific contexts, particularly ones where bicycle usage is already a mainstream behaviour, or focus specifically on work-based trips, excluding students from the analysis. It is our understanding that students and younger adults should be seen as the major target group for promoting the shift of travel behaviours and long-term changes when there is no established cycling culture.

Potential demand density (P2) aims to measure the concentration of prospective users, using travelled distance as a proxy, seen as having a direct negative impact on cycling (Goldsmith, 1992; Stinson and Bhat, 2004; Parkin et al., 2008; Heinen et al., 2010; Fraser and Lock, 2010; Handy et al., 2010; Handy et al., 2014; de Souza et al., 2014; Heesch et al., 2015; Litman et al., 2018). An 8 km threshold was used to filter out those who perform trips, on any transport mode, that can switch to cycling. Employment density (P3) focuses the density analysis on an accessibility perspective, identifying the hotspots of job opportunities. Motorization rate (P4) is a variable provided by census data (car drivers per 1000 inhabitants), based on the question on the main mode of transport used for commuting trips, with the results being used in comparison with the national average. This variable, a proxy of car ownership, follows a consistent pattern in the literature, having a negative effect on cycling levels (Buehler and Pucher, 2011; Heinen et al., 2010; Hoedl et al., 2010; Litman et al., 2018; Parkin et al., 2008; Plaut, 2005; Stinson and Bhat, 2004). As all car trips are addressed in this indicator, the risk of collinearity with indicator P2 is minimized, which filters those based on distance and combines it with other transport modes.

13.3.2 Target Areas

The second dimension identifies the most suitable areas for cycling in terms of accessibility to main centralities, education, and public transport, as well as connectivity and land use mix, while also comparing the relative performance of the bicycle with the car. Accessibility targets three types of destinations considered primordial for the promotion of cycling. Accessibility to education facilities (A1) combines two factors associated with higher propensity to cycle.

Empirical evidence indicates that starter cities should prioritize cycling promotion and infrastructure-based measures in areas with higher proportions of young people, such as schools and universities (Marqués et al., 2015; Whalen et al., 2013), which at the same time are important trip generation nodes.

Accessibility to centralities (A2) measures the city's compactness, as denser urban areas (in population and employment) allow shorter distances between multiple locations (Baltes, 1996; Stinson and Bhat, 2004; Parkin et al., 2008; Fraser and Lock, 2010; Heinen et al., 2010; Heesch et al., 2015; Litman et al., 2018), reducing the attractiveness of car use due to increased driving and parking difficulty (Parkin et al., 2008) and encouraging higher cycling levels.

Accessibility to transport interfaces (A3) takes advantage of the integration of cycling and public transport, significantly extending the catchment area of both, and making intermodal mobility more competitive than car travel (Doolittle and Porter, 1994; Kager et al., 2016; Pucher and Buehler, 2009). In these three indicators, accessibility was measured through predefined cycling travel isochrones towards the considered facilities.

Relative accessibility (A4) identifies the areas where the bicycle is more competitive than the car, comparing the distance reachable by both modes in five minutes' travel time from each census tract centroid. Here, the time spent for parking, based on existing parking pressure on each street, was incorporated as a penalty for the car's catchment area. Bicycle parking provision was not addressed, as the impact of parking on the overall travel time is residual.

Connectivity (A5) relates to how efficiently a road network connects destinations and to the importance of minimizing commuting trip lengths, especially relevant in the case of active mobility (Cantell, 2012; Dill, 2004; Handy et al., 2003; Tresidder, 2005). The GPC measure is the average block size, considering that smaller blocks increase physical connectivity, hence cycling potential. The reference values are inspired by the guidelines and good practices of urban design (Barton et al., 2003).

Occupation Diversity (A6) relates to the spatial distribution of services and facilities and the variety of functions within an area. While the car mobility environment is associated with high functional separation (low diversity) and low density, the cycling (and walking) environment is characterized by higher densities and diversity of uses (low functional separation) (Bertolini, 2017; Heinen et al., 2010; Litman et al., 2018; Ma and Dill, 2015). The index considers the diversity of nine types of activities at 500 metre radius buffers, selected by their high frequency of use in the Portuguese context: primary education institutions; secondary education institutions; restaurants; supermarkets and food shops; other shopping; pharmacies; health centres; services of public interest (banks, post office, public and administrative services); and leisure/culture (theatres, showrooms, museums, libraries).

Table 13.1 Weight structure of the GPC

Indicator	Weight
P1 Age	3
P2 Potential demand density	3
P3 Employment density	3
P4 Motorization rate	2
A1 Accessibility to education	3
A2 Accessibility to centralities	2
A3 Accessibility to transport interfaces	2
A4 Relative accessibility to car	3
A5 Connectivity	1
A6 Occupation diversity	1

13.3.3 Data, Weights and Aggregation

Data is provided by the municipalities, online databases and national planning organizations. Each indicator is represented on a scale from 1 (lowest potential) to 5 (highest potential), represented spatially at the census tract level. The individual scores are combined into an aggregated score, using weighting factors (see Table 13.1). These weights were determined based on their relevance and representativeness in the existing literature. Finally, a single municipality-wide value is computed for both indicators and the aggregated score, weighted by population.

13.4 GROSS POTENTIAL FOR CYCLING OF MATOSINHOS

In this chapter we use the city of Matosinhos, in northern Portugal, as an illustrative application for the GPC. Matosinhos is a municipality of Porto Metropolitan Area, the second largest urban area in the country, and has a population of around 175 000, with a density of 2 811 inhabitants per km², according to 2011 census data. The city has a high motorization rate (61.9 per cent), against a residual bicycle share (0.4 per cent), therefore it is a starter cycling city. The modal share distribution is inseparable from the city's land use patterns, characterized by a heterogeneous occupation and by a strong dependency on neighbouring municipalities (absorbing 40 per cent of daily commuting), especially Porto, with which Matosinhos shares its entire southern border. In recent years, the discourse on sustainability has entered Matosinhos's agenda. While the city's recent mobility plan has introduced a package of measures targeting the bicycle, describing the first steps towards

the implementation of a network of cycling infrastructure and traffic calming measures, those results have not been captured yet by the available data. Globally, Matosinhos has a medium potential for cycling, due to its GPC score of 3.5, with above average values in what concerns accessibility to education, urban centralities and the age potential of its population. This justifies the focus on younger age groups as ‘cycling ambassadors’. On the other hand, the reduced connectivity of most of its urban structure and a high motorization rate are the biggest impediments to a stronger performance. Each indicator has a unique physical configuration, which is a testament to the particularities of starter cities (Figure 13.1).

A significant portion of the territory is highly ranked when considering the accessibility to education facilities (A1). Still, most of the remaining area-based indicators reflect the territorial asymmetries between the north of the municipality, with lower densities and reduced provision of facilities and employment, and the south, which concentrates most of the population, services, activities and relevant infrastructure in a denser urban setting. This is particularly noticeable when addressing access to centralities (A2) and, although less noticeable, at occupation diversity (A6). The reduced congestion and parking pressure due to the sparser urban occupation of the less dense territories lead to a natural increase of the car’s average speed, which is reflected in a weaker competitiveness of the bicycle (A4). Public transport accessibility (A3) accompanies the metro network’s ‘J-shaped’ axis, while connectivity (A5) identifies the location of more ‘human scale’ urban configurations, roughly coinciding with the core of urban centralities, albeit far from the optimal levels.

The geographic distribution of younger residents (P1), while generally favourable, is marked by abrupt shifts reflecting ‘elderly-dominated’ neighbourhoods. As potential demand density (P2) accompanies the location of residential density hotspots, this signals that most of this city’s residents do indeed perform daily trips that could shift to the bicycle. The analysis of employment density (P3) identifies three key potential areas, deviating from the north–south dichotomy, while motorization rate (P4) reflects the presence of five major areas clearly marked as ‘car-centric’.

The spatial configuration of the GPC score (at the top left of Figure 13.1) attributes higher scores to most of the southern portion of the municipality, especially its western edge, coinciding with the central city area. While maintaining the north–south unevenness, the Matosinhos’ GPC pattern deviates from the sole consideration of population, employment or services hotspots. The areas with the maximum cycling potential are therefore the prime candidates for initial cycling infrastructure investment and where the benefits of policies will be felt more swiftly. While this might accentuate the territorial

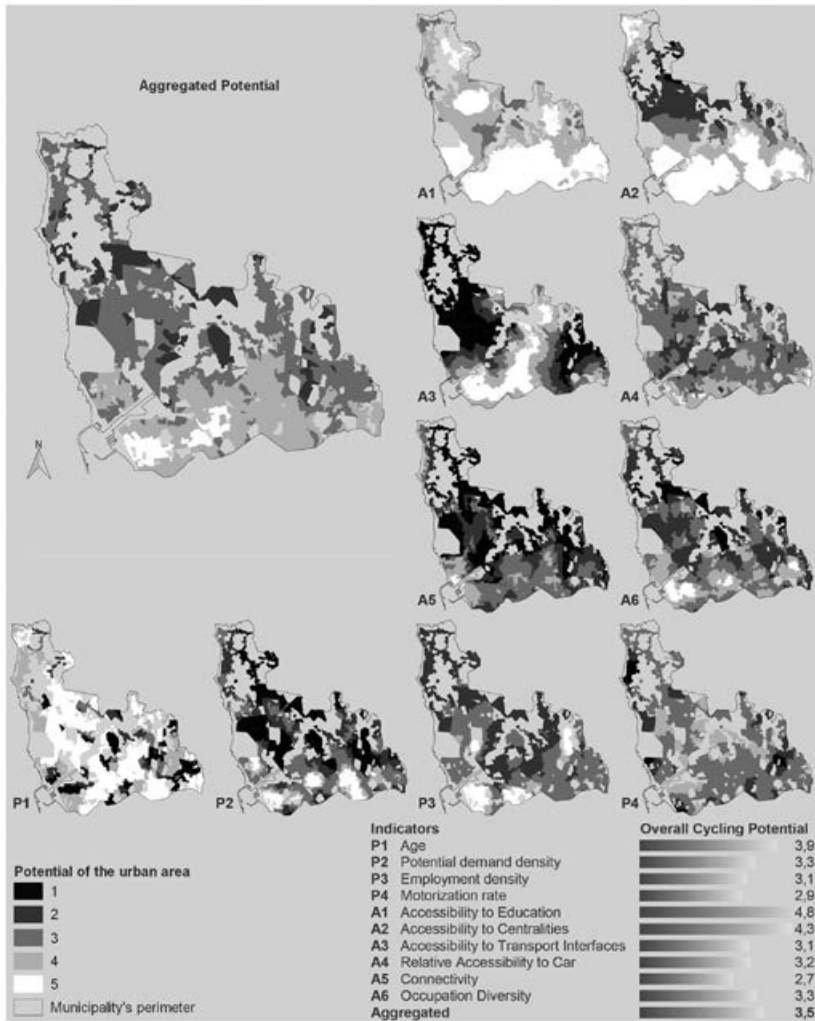


Figure 13.1 Overall Gross Potential for Cycling

asymmetries, such is a necessary step to build the initial momentum in starter cycling cities.

13.5 FINAL REMARKS

The GPC is an evidence-based tool, which aims to be both scientifically robust and usable for planning practice. By assessing the areas with higher potential for cycling, supported by visual maps and numeric outputs, it provides easy-to-interpret information for urban planners, decision-makers and the general public. It breaks the initial resistance often associated with bicycle promotion strategies, and especially investment, increasing the initial chances of success, while also allowing targeted and customized policies for areas with differing potential within the same city. This is crucial to foster the development of a progressive strategy that addresses the constraints of specific areas, towards an integrated and inclusive city-wide cycling network. By addressing the spatial and functional specificities of starter cities, the GPC provides a basis for transformative thinking and planning. Future research will also focus on the application of the GPC to cities in more advanced stages of cycling usage, and comparing such results with other existing tools.

As highlighted by the GPC rationale, cities planned for cycling are compact, dense, connected, accessible and with mixed land uses, all features that are inseparable from the human scale city. Nevertheless, further research is needed on the links and tensions between the cycling city and the human scale city, engaging in the debates on mobility justice, affordability and the contradictions inherent to capitalist societies. Planning for cycling entails reclaiming public space and putting people back into the centre of transport planning, contributing to making cities more sustainable, equitable and convivial, while enhancing the quality of life and wellbeing of its inhabitants.

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BooST provides support instruments for cycling starter cities: the Starter City Roadmap. It provides technical know-how and support to local authorities and urban planners, comprising three main tools: (1) an assessment framework of the Gross Potential for Cycling (GPC), identifying the areas that present greater potential for cycling; (2) an assessment framework of the Economic Value for Cycling (EVC), providing estimates based on the bicycle industry value chain (a niche in Portugal), the economic impacts of reduced fuel consumption, health gains and environmental and energy savings; and (3)

a Cycling Measures Selector (CMS), supporting the identification and packaging of packaging mobility management measures suited to stakeholders' needs.

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14. Comparing spatial data sources for cycling studies: a review

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14.1 INTRODUCTION

Cycling is considered one of the core travel modes for developing human scale cities. With zero emissions and pollution, cycling has also been shown to increase physical activity levels and foster social connectedness (Garrard et al., 2012; te Brömmelstroet et al., 2017; Kroesen and De Vos, 2020). Compared to car travel, cycling saves space for other urban functions and acts as an important feeder mode for public transport (Geurs et al., 2016). Consequently, urban planning practice and mobility research now widely promote cycling as a sustainable transport solution (Martens, 2007; Pucher and Buehler, 2017). Wider acceptance and technological development have diversified the modes of cycling. Innovations such as electronically assisted bikes (e-bikes) and bike sharing systems (BSS) are rapidly being adopted, replacing the use of conventional bikes and, to a lesser extent, car trips (Bigazzi and Wong, 2020; Ma et al., 2020). Smart cycling technologies are getting more attention at different levels of governance, as they alter how this mode of travel is experienced,

understood and governed (Nikolaeva et al., 2019). Urban planning practice and mobility research share a growing need for understanding better the spatial, temporal and social aspects of cycling to respond to the rapidly changing scene in cities and attract more people onto bikes. To foster human-scale transportation, cities need to shift emphasis from the focus on understanding motorized transport to understanding cycling and active travel.

Despite the increasing need, lack of cycling data and access to it is still a common challenge. Absence of applicable data has been recognized as a limiting factor for transport and urban planning in many studies, also in mature cycling countries such as the Netherlands (Iacono et al., 2010; Aultman-Hall et al., 2012; Nello-Deakin and Harms, 2019; Aldred et al., 2019). While data collection processes with motorized transport are typically well established by transportation agencies, cycling-related data has rarely been included in these processes (Aultman-Hall et al., 2012). Aultman-Hall et al. (2012) note that the lack of established processes has led to this data being collected on a project-by-project basis at isolated locations, precluding system-wide extrapolation. Part of the challenge lies in the traditional ways of collecting data using travel diaries, surveys, interviews, static bike counters and various statistics. While these sources are useful, there are limitations in their availability and comprehensiveness. Some common challenges include laborious data collection, small sample sizes, insufficient spatio-temporal coverage, route and travel chain detection, and reliance on self-reporting (Bird et al., 2013; Handy et al., 2014).

The rapid development of sensor technologies has enabled mobility data collection from a variety of sources that uncover mobility patterns and daily movements of people (Kitchin, 2014; Romanillos et al., 2016; Pritchard, 2018). Cycling data sources originating from sensors and location-based services (Huang et al., 2018) include a variety of examples such as BSS (O'Brien et al., 2014; Fishman, 2015; Klingen and Van Ommeren, 2020), eye-tracking (Rupi and Krizek, 2019), GPS positioning through various devices or mobile applications (Romanillos et al., 2018; Rupi and Schweizer, 2018; Dane et al., 2020), social media (Das et al., 2019), street view imagery (Goel et al., 2018), video recording (Pokorny and Pitera, 2019) and virtual reality simulators (Leeuw and Kruijf, 2015). Furthermore, tracking the use of bikes is increasingly integrated into the Internet of Things (IoT) fabric of smart cities through smart applications and devices such as smart wearables (Nikolaeva et al., 2019), which further add to the increasing data flux.

However, like traditional cycling data, novel data sources have biases and usability challenges that relate to availability, cost and insufficient spatio-temporal coverage of data, and mode and route detection (Goel et al., 2018; Lee and Sener, 2020; Sun and Mobasher, 2017). There are also other challenges limiting novel data sources' potential, such as privacy

issues, demographic representativeness and generalizability, and requirements for computational processing capacity and know-how (Oksanen et al., 2015; Romanillos et al., 2016; Médard de Chardon, 2019). Despite a rapidly growing body of literature exploring the possibilities, a comprehensive view on how different novel cycling data can best benefit planning and research is still missing. Fostering such understanding can help researchers and planners to better evaluate and choose the most fitting data for different needs, which in turn can lead to saving resources and efforts in data collection and acquisition, and ultimately to more reliable and representative outcomes that support the growth of cycling in cities.

The present chapter provides a comparison of contemporary data sources available for cycling research and planning, building upon the expertise of a broad group of cycling experts. We review common data sources in the literature in relation to their capability to answer some of the most common questions on cycling asked by urban and transportation planners, including:

1. Where are people cycling (spatial patterns)?
2. When are people cycling (temporal patterns)?
3. Who are the cyclists (user demographics)?
4. What are their cycling types (work, leisure, and so on)?
5. Why do people choose to cycle (the motivations for and barriers to cycling)?

With each data source, we review separately different aspects such as availability; spatial, temporal and user information; and typical biases. First, we identified different empirical data sources from the recent cycling-related scientific literature. Next, we implemented an expert survey with a short questionnaire among researchers and practitioners with experience in using empirical cycling data sources. The survey was distributed among the Network on European Communications and Transport Activities Research (NECTAR) researchers, and their own networks of experts. The questionnaire allowed respondents to assess the strengths, weaknesses and usability of data sources, to give justifications and to point out relevant literature. Additionally, we asked respondents to assess different data sources on a five-point Likert scale (from very poor to very well) on how well the data sources fit for ‘where’, ‘when’, ‘who’, ‘what’ and ‘why’ types of questions. A set of example questions like those presented above was provided to direct evaluations. The responses allowed us to map the applicability of each data source. The questionnaire was completed by 58 respondents who provided 71 distinct assessments of cycling data sources. To test an open and co-creative writing process, every respondent was further invited to review the manuscript in a collaborative platform Authorea.

Before continuing, it is necessary to highlight some limitations of our approach. First, there are various cycling-related questions in planning and research that do not fall into our categories. Yet, the questions reviewed here represent the basic information typically needed by planners and researchers, being a prerequisite for more applied questions. Second, scale is a challenge. For example, a data source may excel at capturing spatial patterns at street level, but not be applicable for monitoring broader areal cycling patterns, which both nevertheless fall under the jointly evaluated ‘where’ category. Third, some of the reviewed data sources suffer from the small numbers of expert evaluations, which adds uncertainty to their evaluation.

14.2 DESCRIBING DATA SOURCES FOR CYCLING

Data sources mostly used in cycling analyses include three categories: (1) bike counters and manual observations; (2) BSS, Global Positioning System (GPS) tracking, sports applications; and (3) surveys, interviews and public participation geographic information system (PPGIS). These sources are described briefly below, and in more detail in Table 14.1 where their characteristics are divided into components of availability, typical attributes, spatial, temporal and user information, and finally providing literature examples for each data source. The list of the reviewed sources (Table 14.1) is by no means exhaustive and there are various other data sources that can benefit cycling research. Yet, the reviewed data sources represent commonly collected and available data, and were assessed by at least three different experts in our survey. Within the categories, the data sources are ordered by the number of expert evaluations.

14.2.1 Bike Counters

Counters are a simple way to collect data on cycling levels and to monitor bike traffic longitudinally. Automatic bike counters use a variety of detection techniques ranging from infrared and radar waves, pneumatic tubes, inductive loops to video or thermal imaging, magnetometers and piezoelectric detectors (Alta, 2016). Counters are statically attached to a specific location and commonly located in the hotspots of bike traffic. Typically, counter data includes the coordinates of the counter, and the data is collected by a fixed interval (for example, minute, quarter-hour, hour, day).

14.2.2 Manual Observations

Manual observations refer to a variety of data that is collected by an observant from single or multiple locations at a single occasion or at regular intervals. This type of data can include simple cyclist counts, subcounts (by age, gender,

Table 14.1 Typical characteristics of the reviewed cycling data sources

Data type	Accessing the data	Typical attributes	Spatial accuracy and coverage	Temporal information	User information	Example studies
Bike counter data	Through data portals of public sector agencies or through measuring campaigns	Counter ID, bike count, time	Spatial coverage is limited to the counter locations. Spatial accuracy is good when the exact locations of counters are known. No track records.	Automatic counters provide year-round continuous data with good temporal resolution.	Aggregated cyclist counts by time intervals, no individual user data.	Nordback et al., 2011; Rupi et al., 2019
Manual observation data	Through observation campaigns	Observation ID, lat./long. coordinate, time, observation count / description	Spatial coverage is limited to places the observers are located or visit. However, the locations/routes can be selected to suit the study purpose.	Temporal coverage is limited to observation periods, repeated observations possible.	Detailed individualized data in active ride-along observations; user counts and basic description of subcounts in passive observations.	Fraboni et al., 2018; Gamble et al., 2017; Van Duypen and Spierings, 2013
Bike sharing origin-destination trip data	Through the system operator or from open data portals	Trip ID, depart/return station, depart/return time, user ID	Typically OD records without route information. Spatial accuracy is high as it is linked to the station locations. Coverage bound to the station network.	Time stamps available for hires. Data collected throughout the system operation period, often data available from continuous years.	Typically anonymized individual-level data, sometimes enriched with basic demographic variables (e.g. age, gender) or subscription type.	Klingen and Van Ommeren, 2020; Médard de Chardon and Caruso, 2015; O'Brien et al., 2014

Data type	Accessing the data	Typical attributes	Spatial accuracy and coverage	Temporal information	User information	Example studies
GPS-tracking data	Through GPS-tracking campaigns or survey apps	User ID, track ID, lat./long. coordinates timestamp	High and accurate spatial coverage, track records show exact routes; potential data gaps or location errors due to app late start, irregular frequency of data collection, signal loss or multipath signals in urban canyons.	High temporal resolution depending on the data collection settings, typically from 1 second to 1 minute.	Detailed individualized data may be collected separately in the data collection campaign or survey app.	Dane et al., 2020; Romanillos et al., 2018; Rupi and Schweizer, 2018; Rötzer et al., 2019
Sports application data	Data products accessed by purchasing or through collaborations with responsible companies or public-private sector hybrid collaborations	Segment ID, time, cyclist count, cyclist count by trip types	High spatial accuracy with street segment-level data. Spatial coverage is typically good, but depends on the number of users of the given sports application in the study area.	High temporal resolution and coverage (raw data can contain minute-by-minute cycling counts of street segments).	Either aggregated user counts or limited anonymized user information (e.g., age, gender) depending on the data product.	Hochmair et al., 2019; Oksanen et al., 2015; Sun and Mobasheri, 2017

Data type	Accessing the data	Typical attributes	Spatial accuracy and coverage	Temporal information	User information	Example studies
Survey data	Through survey campaigns, open data portals or public sector agencies	Respondent ID, answers, comments	Typically limited spatial coverage (e.g. main origin and destination location, sometimes route characteristics). Population-level travel surveys include spatial data on a coarse level (e.g. postal code or census tract).	Limited temporal coverage. With recurrent surveys, longitudinal analyses possible.	Anonymous and detailed individual-level data.	Nello-Deakin and Harms, 2019; Nielsen and Skov-Petersen, 2018; Silva et al., 2019
Interview data	Through interview surveys	Respondent attributes, answers to questions	Generally limited spatial coverage and accuracy. May still provide detailed individual descriptions on specific areas or routes.	Generally limited temporal coverage and accuracy. Longitudinal data possible if interviews are repeated.	Detailed individualized data.	Freudendal-Pedersen, 2015; Nello-Deakin and Nikolaeva, 2020; Médard de Chardon, 2019
PPGIS data	Through PPGIS-survey campaigns, open data portals or public sector agencies	User ID, marker ID, answers, comments	Based on markings/drawings on a background map. Spatial accuracy and coverage typically varies by user. Spatial data quality is uncertain.	Limited temporal coverage unless the PPGIS survey is designed to capture variation in time with specific questions.	Anonymous individual-level data, data collection incorporated to survey questions.	Pritchard et al., 2019; Snizek et al., 2013

Note: OD = origin-destination. ID = identification.

BSS user/regular, and so on) or bike type counts (for example, regular, sport, cargo bike), recognizing whether people cycle in groups or alone, or evaluating cycling behaviour, for example at an intersection to recognize potential hazard risk. Manual observations can also take the form of ride-along observations where the observant is cycling with the study participant.

14.2.3 Bike Sharing Trip Data

BSS have become commonplace in many cities. Typically, these systems collect information on bike rental trips with each trip as an individual record. These records typically reveal the origin and the destination station, depart and return time, and the user and bike identifications (IDs). Depending on the data provider and the system registration settings, trip-level datasets may be linked to basic user variables such as age, gender, postal code and subscription type. Trip datasets from docked systems do not contain exact routes between the stations unless the GPS data is separately collected. Application-based dockless BSS, in turn, track users' movements through positioning, but these datasets are rarely publicly available.

14.2.4 GPS Tracking

GPS tracking is increasingly integrated into various cycling data sources. Here we refer to GPS tracking that is recorded with a separate GPS device or a specific location tracking application on a portable device (for example, mobile phone or tablet) even though GPS tracking can also be integrated to other sources of data reviewed in this chapter, such as to BSS and sports application data. GPS tracking records spatially and temporally precise location track points or line sequences. GPS devices can be handheld and carried by the cyclist or be attached to the bike frame. Tracking data is linked to a particular user and contains time-stamped geographical coordinates for every track point or line sequence, measured typically with a short interval ranging from seconds to minutes.

14.2.5 Sports Applications

Activity, sports and health monitoring applications such as Endomondo, Strava or Sports Tracker are increasingly used as a source of cycling data. Depending on the purpose and the sophistication of the application, they allow users to track their movements, heart rate, altitude, travelled speed and distance, and set up performance goals and share achievements with fellow users (Piwek et al., 2016). As the data is almost exclusively collected by private organizations, derived data products have variation in relation to availability, data type, form,

pricing and variable characteristics. Due to privacy concerns, most datasets are aggregated. For example, the Strava Metro data product consists of street geometries with minute-by-minute aggregated user counts, but without individual user information.

14.2.6 Surveys

Survey data on cycling can vary from short and targeted questionnaires focused on a single issue to large country-level mobility surveys focused on general travel patterns of the population including cycling. Survey data are primarily collected in a disaggregated form; however, when shared through intermediate sources, survey data are often aggregated to protect respondents' privacy. Surveys are increasingly implemented with online forms, which has made it easier to distribute them and collect data from wider groups. National travel surveys are typically collected yearly or every 2–3 years during a few days of extensive data campaigns.

14.2.7 Interviews

Interviews provide qualitative data in the form of shared experiences and stories, typically from a small sample of people. Interviews can take place individually between the interviewer and the interviewee, or in a group environment where multiple interviewees come together. Structure of interviews varies from non-structured and free-flowing discussions to semi-structured and structured interviews with standardized questions presented to each interviewee. In the cycling context, interviews can shed light, for example, on the reasons and incentives for as well as the barriers to cycling.

14.2.8 PPGIS

Public participation GIS (PPGIS) mapping refers to geospatial techniques that allow the collection of both qualitative and quantitative data through active involvement of individuals (Brown and Kyttä, 2014). Using a typical PPGIS application, participants can map places (points), routes (lines), areas (polygons) or combinations of these, together with responding to survey questions. In the cycling context, PPGIS can be used to collect information on, for example, origins and destinations of trips, route choices or areas of interest, and to link this information to individual place-related experiences and preferences attached to the mapped entities.

14.2.9 Other Sources

Other sources of cycling data mentioned in the expert survey include cycling statistics, BSS station count data, Google Street View images, eye-tracking and video recording of cyclists, travel diaries, social media posts extracted from platforms such as Twitter and virtual reality (cycling simulators). While many of these may be potential for studying cycling, we do not review them here due to the small number of responses.

14.3 ASSESSING DATA SOURCES FOR CYCLING

Our survey respondents assessed the cycling data sources' applicability for different types of analytical questions. The results, shown in Figure 14.1 with radar charts, present a clear distinction between more quantitative sources (BSS trip data, bike counters, GPS tracking, manual observations and sports applications) and qualitative sources (surveys, interviews and PPGIS). The radar charts are ordered by the number of assessments, starting from the top left. All data sources in the former category exhibit better applicability to spatio-temporal 'where' and 'when' types of questions, while the latter category of data sources has the opposite patterns with strong points in 'who', 'what' and 'why' types of questions. The results point to a trade-off with using sources that are able to measure precise spatio-temporal locations or even cycling routes, but often lack individual and semantic information; and correspondingly using sources that are richer and more nuanced in user profile and information on motivation, but may lack spatio-temporal coverage and accuracy.

We further asked the survey respondents to report strengths, weaknesses and biases with different cycling data sources based on their experiences. Table 14.2 summarizes the results of these responses. The results capture similar differences of analytical capability between the data sources as Figure 14.1, but bring forward challenges of data collection and availability. The availability of data or the ease of data collection is listed as a strength for bike counter, BSS, PPGIS and survey data. This implies that these sources are either commonly available openly or for research purposes, or can be collected with a relatively small effort. As with GPS tracking, interview, manual observation and sports application data, data access or collection effort is considered as a weakness requiring considerable human or financial resources and therefore limiting their use.

Notable aspects in relation to reported biases are the user-related biases inherent in many data sources. Assessments show that GPS tracking, bike sharing trips and sports application datasets often suffer from participation bias, as most of the data is recorded by active users who may represent only



Figure 14.1 Expert assessments on the fitness of cycling data sources for answering different types of cycling-related questions

Table 14.2 Expert-reported strengths and limitations of cycling data sources

Data	Main strengths	Known biases/limitations
Bike counter data (n = 11)	<ul style="list-style-type: none"> – Unbiased data – Reliability typically good – Temporally comparable data – Increasingly available data 	<ul style="list-style-type: none"> – Lack of spatial coverage – Lack of user information – Accuracy of counters varies depending on the counting method – Poor reliability with some counters when snowing – Data gaps typical – Maintenance can be costly – No semantics (e.g., trip purpose)
Manual observations (n = 4)	<ul style="list-style-type: none"> – Particularly useful for conflict observation or hazard identification – Can be carried out anywhere – Variety of different kind of observations can be captured at once 	<ul style="list-style-type: none"> – Limited spatio-temporal reach – Only samples – Subjective measurer bias inherent – Designing a successful observation campaign, which captures targeted issue at the right time and place is challenging – Requires lot of human resources
Bike sharing OD trip data (n = 14)	<ul style="list-style-type: none"> – Large sample sizes, records may contain even millions of trips – Potentially high spatial coverage (with extensive systems) – High temporal resolution and coverage – Individualized, yet anonymous data – Increasing availability from many cities – Shows activity (i.e., single trips can be distinguished) 	<ul style="list-style-type: none"> – Lack of socio-demographic data – No route information – User demographics often biased to certain groups – Super-users and/or residents near stations may generate majority of data – No semantics (e.g., trip purpose)
GPS tracking (n = 10)	<ul style="list-style-type: none"> – High spatial and temporal coverage and detailness – Reveals cycling routes and route choices – Differentiation of cyclists' types (e.g., commuters, leisure) possible with enough data – Speed information included – Can be collected through mobile phone apps 	<ul style="list-style-type: none"> – Difficult to collect large data samples – Requires dedicated data collection campaigns that need resources – Participant bias (e.g., by age or gender or enthusiasts only) – Privacy issues – No semantics (e.g., trip purpose) – App malfunctions may impair results

Data	Main strengths	Known biases/limitations
Sports application data (n = 4)	<ul style="list-style-type: none"> – Large masses of data – High spatial and temporal coverage and preciseness – Street segment-level cycling count analyses possible – Some data products can differentiate between different activities (e.g., commuting, leisure) 	<ul style="list-style-type: none"> – Data products typically aggregated, no individual data – Data not openly available as collected by private actors – Typically heavily biased to athletic cyclists and male users – Active user bias – No semantics (e.g., trip purpose)
Survey data (n = 10)	<ul style="list-style-type: none"> – Can be targeted to specific groups – Provides understanding on perceptions, motivations and barriers, i.e., unmeasurable issues – The data readily available if official survey – Easy to collect online – Comparability with other survey data 	<ul style="list-style-type: none"> – Response bias (e.g., by age or gender or enthusiasts only) – Sample sizes often limited – Answers might not reflect true behaviour – Trip chains and short trips often not reported – Poor temporal and spatial coverage and resolution
Interview data (n = 7)	<ul style="list-style-type: none"> – Rich contextual information on behaviours, experiences, choices and perceptions – Uncovers complexity (e.g., interplay of actors, realities of transport services) – Unbiased sample – Emphasis on human experience 	<ul style="list-style-type: none"> – Small sample sizes – Subjective bias – Expensive and time-consuming to collect and process – Difficult to obtain exact spatio-temporal data
PPGIS data (n = 3)	<ul style="list-style-type: none"> – Can distinguish spatially exact information together with rich user information – Easy-to-collect online – Can be targeted to specific groups/ areas 	<ul style="list-style-type: none"> – Typically small sample sizes – Uncertainty of data quality – Subjective bias – Uneven spatial coverage and resolution: most users map only a few locations/routes, disproportionate data from active users – Poor temporal coverage and resolution

certain population groups. To some extent, these biases are produced by uneven cycling demographics common in many places, but they may also be attributed to the uneven use of mobility tracking technologies among different demographic groups. Some respondents refer to sporty and male users being over-represented in sports application data, while among BSS users over-representation may be related to groups for whom the system is accessible. There are still ways to mitigate these biases. For example, with Strava data, Fischer et al. (2020) show that using only the trips labelled as commuting may better represent ridership patterns of population. User-related biases are differently present in interview, manual observation, PPGIS and survey data,

which may suffer from small sample sizes and subjective biases, which impair the generalizability of results obtained from these sources.

14.4 DISCUSSION

Emerging data sources have facilitated the increasing body of cycling research and broadened the research perspectives. However, our results highlight the need for careful consideration of data availability, representativeness and fitness for different analytical needs. Difficulties in data collection, lack of suitable data and poor accessibility to it were identified as the main limitations of several reviewed data sources, causing analytical complications in understanding cycling. Some of the critical data needs include representative information from large populations on detailed cycling routes and trip chaining behaviour, as well as the representation of people in the survey data who are less active as cyclists or do not cycle at all. In order to avoid the biases of single data sources, it is often crucial to combine multiple data sources, both traditional and novel (Tenkanen and Toivonen, 2020).

Many transport and planning agencies share cycling data that is often limited to counter or survey data. Increased data sharing such as making BSS trip datasets accessible might provide a good strategy for cities as it can generate novel research from them and therefore benefit the public policy (Willberg et al., 2021). Similarly, publishing anonymized or aggregated research data sets by researchers would benefit the understanding of cycling through new research opportunities. A few open data initiatives such as the European Cycling Challenge (2017) and Bike Data Project (2020) have also motivated citizens to share their cycling data, but coordinated efforts by cities to collect comparable, socially representative and longitudinal data are mostly lacking.

However, cycling data with necessary spatio-temporal detail and coverage is mostly collected by private companies. In many cases, individuals share their data with the companies via free sport or navigation applications, but getting access to this data for research and transport planning purposes is possible only at high cost or not at all. Developing transparent, privacy-respectful and sound data products as well as ways to access these could bring new opportunities to fill some current cycling data gaps.

Similarly to other types of personal data, collecting individual-level data on cyclists' behaviour requires balancing between privacy protection and the benefits that detailed data offers for understanding cycling patterns. For example, linking BSS records with user-specific health and socio-demographic data would be useful for revealing specific social, behavioural and health associations (Romanillos et al., 2016). In addition, detailed semantic information collected on top of quantitative trip data enables obtaining a more complete picture on the situational, socio-spatial and economic aspects of cycling.

However, due to the sensitivity of these joint datasets, collecting and linking various individual-level data requires well-justified reasoning, obtaining consent from the individuals, setting strict access rules to raw data and ensuring full compliance with research ethics. Thus, it is not possible to share rich individual-level data with the research community, and shared data products need to be either fully anonymized and limited in scope or aggregated.

Increased standardization of approaches could systematize cycling data collection and sharing, and facilitate comparative studies. Despite some efforts (e.g., Alta, 2016; Toole Design, 2019), the cycling data standards are not similarly developed as with motorized transport. Critical aspects for standardization include finding meaningful aggregation levels to retain privacy without compromising sensitiveness, explicitness of the spatial and temporal attributes, and inclusion of categorized demographic information when possible. Cycling data standards should also focus on data findability and accessibility. One interesting recent example is the ‘Talking bike’ initiative by the Dutch national government, which intends to create General Data Protection Regulation (GDPR) compliant and coordinated cycling data market for governments and municipalities to purchase standardized cycling data from selected private partners (NDW, 2020). In general, docking station-based BSS trip data is a good example of a solid and privacy-respectful cycling data type. In addition to being longitudinal and having a decent sample size, BSS data are inherent in spatial anonymity as docked stations seldom represent the true trip origin or destination. However, BSS data tends to be available mainly in cities in which the system is managed by a public sector institution. Public interest may still open new horizons in collecting contextual information on cycling such as equipping shared bikes with environmental sensors.

While any current cycling data source alone cannot provide comprehensive knowledge on cycling, novel datasets have increasingly helped to fill some gaps, especially in the spatio-temporal corners of cycling research. Yet, traditional data sources are still indispensable, especially in shedding light on the underlying reasons and motivations for cycling. By reflecting the dynamics of current cycling practices, novel and traditional datasets together empower transport and land use planners in their efforts to increase cycling and to transform urban transport systems to more sustainable, healthier and essentially more human scale systems. There is still a long way to go in bridging the gap in cycling data availability to facilitate the use of the most fitting data according to the need. We call upon everyone collecting and studying cycling to contribute to responsible data sharing and open science practices whenever possible.

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15. Urban traffic and health risk: what is the role for citizen participation in transport planning?

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15.1 INTRODUCTION

One of the challenges of human scale urban planning, including transport, is that citizens feel more engaged and responsible for processes and outcomes of planning decisions, mainly in view of liveability of cities. This new engagement seems increasingly to be happening where traffic is at high volume and density, causing serious noise annoyance which may come with several health risks. These risks may include cardiovascular diseases such as hypertension, arteriosclerosis and ischaemic heart disease (Babisch, 2014; Basner et al., 2017). Addressing the issue of noise in urban traffic is not new. Some cities have already installed measurement systems to assess noise exposure for citizens. However, there is a more general trade-off in policy-making; for example, facilitating transport demand growth to promote economic development at the expense of noise exposure or low air quality for citizens. As a result, not much of the knowledge gained on citizens' exposure has been actually applied in urban policies for noise management.

In some cases, however, citizens have taken the initiative to measure and address high noise levels or other health risk by themselves, aimed at increasing quality of life in places that suffer from such risk (Goodchild, 2007). Such citizen initiatives can be called 'citizen sensing'. Citizen sensing initiatives have recently become increasingly popular, not only through improved sensor technology and mobile devices owned by citizens or collectively owned, but also, in particular situations, by a common feeling among citizens of distrust towards the actor(s) responsible for noise or low air quality (Gabrys et al., 2016; Berti Suman, 2018). Distrust may follow from the feeling of not being taken seriously; in particular, in calls for transparency in measurement undertaken by the responsible actor(s). Given these aspects, citizen sensing can

be seen as a grassroots-driven initiative, not only aimed at improving understanding of the problem through measurement, but also taking steps towards reducing noise or other traffic annoyance.

In contrast, 'citizen science' is organized by established institutions, such as universities, to create or improve large-scale databases and modelling through the support of citizens (Berti Suman and Van Geenhuizen, 2019). Often involved with biodiversity cooperative studies, citizen science initiatives may also focus on high noise levels or any other traffic annoyance; however, in a more institutionalized way. In this context, we mention that terminology such as 'citizen sensing' and 'citizen science' is faced with blurring edges and swift changes. Accordingly, citizen sensing may also be seen as part of larger citizen science initiatives, referring to all participation of citizens (Eitzel et al., 2017; Heigl et al., 2019). In this vein, citizen science has been recognized as contributing both to scientific measurement and to policy-making (Van Brussel and Huyse, 2018). In more detail, Kullenberg and Kasperowski (2016) identify a strand within citizen science which is particularly overlapping with citizen sensing: namely, that related to the monitoring of health and quality of the environment. In this chapter, however, we draw a borderline between citizen sensing and citizen science.

The number of evaluation studies on influence of participatory citizen initiatives on urban planning solutions has remained small over the years. This situation may reflect various practical constraints to evaluation. For example, the aims of the participation are often not sufficiently clearly stated; the time dimension is difficult to take into account due to large time-lags; and the approach to evaluation may be an obstacle, due to an increased need for evaluating not only the end-results but also processes and new technology use underlying the end-results (e.g., Jiang et al., 2016). Accordingly, 'proofs' of evidence for benefits from participation tend to be limited to projects that are relatively simple, such as new bicycle lanes, or non-controversial, such as accessibility of buildings, such as shopping malls for wheelchair users (Kehayia et al., 2014).

In response to this, the chapter provides an approach to evaluation of citizen sensing/science by presenting a performance matrix. The approach draws on detailed case study results (Eisenhardt and Graebner, 2007; Emerson and Nabatchi, 2015), while the focus is on factors that influence how citizens' participation may contribute to solving urban transport problems. The research question is as follows: Which factors in citizen participation influence solutions to unwanted traffic impacts, and which work positively and which negatively in achieving such solutions?

In our contextualization of citizens' initiatives and design of the performance matrix, we draw on analysis of Amsterdam Schiphol Airport (AMS) (citizen sensing and noise) in the Netherlands and CuriousNoses in Antwerp/Flanders

(citizen science and air quality) in Belgium. The case studies are part of a mixed data approach to grasp multifaceted dynamics and context-dependency. Thus, interviews were performed concerning citizens' participation in planning on bicycle lanes and functional change of city centres (Manchester, United Kingdom and Montreal, Canada), workshops included needs for and potentials of citizen initiatives, for example, 'Citizen Science – Gamma Radiation, Noise Annoyance and Air Quality' at the Netherlands Ministry of Infrastructure and Environment, November 2017, Utrecht (Netherlands), and 'Citizen Science and Environmental Monitoring: Benefits and Challenges', November 2018, Joint Research Centre, Ispra (Italy). Case literature included, for example, Carton and Ache (2017) on AMS, and Van Brussel and Huyse (2018) and Meysman and De Craemer (2018) on CuriousNoses, whereas detailed information on solutions was drawn from websites such as the Alderstafel advice (AMS) (Omgevingsraad Schiphol, 2020) and traffic measures in cities in Belgium (e.g., ELTIS, n.d.).

The chapter continues by highlighting societal trends that support the development of active participation by citizens (section 15.2). Attention then moves to a further conceptualization of citizen sensing and citizen science (section 15.3). In section 15.4, how this citizen participation has been applied is analysed in the two case studies. The performance matrix is presented and discussed in section 15.5. Section 15.6 concludes.

15.2 TRENDS SUPPORTING CITIZENS' PARTICIPATION

The emergence of citizen initiatives and the issue of citizen participation are rooted in or act in parallel with trends emerging since the mid-1990s (Nabatchi et al., 2017; Nesti, 2018). Firstly, there is the recognition of increased complexity and uncertainty in society, and the need for new qualities of local governance in solving urban problems and designing adequate services. Answers to such situations were already addressed in the seminal work of Ostrom (1990), emphasizing the need for co-production in an era of planning of urban services that was monopolized by officials, while users acted as passive consumers (e.g., Pestoff et al., 2012; Nesti, 2018). In the years that followed, active participation of citizens as users started to be seen as a way of increasing public service quality and delivery and, in a broader sense, as a kind of democratization of power and shift to participatory problem definition and solving (Emerson and Nabatchi, 2015; Ansell and Torfing, 2016; Holtmann and Rademacher, 2016). With the acceptance of active involvement of citizens (individuals/groups) in public service delivery and a route to active citizenship and communities (Osborne et al., 2016), policy-makers started to be regarded

as having the important duty of understanding the needs of citizens as users, with concomitant influence on urban governance (Davidson et al., 2019).

Secondly, the increased attention for bottom-up initiatives and active citizen participation also fits two consecutive trends in science and knowledge production. One emerged in the early 1990s, when knowledge production tended to become more socially distributed, application-oriented, transdisciplinary, and subject to multiple accountability (Gibbons et al., 1994). The other one is more recent, bringing an even more prominent position of public sector and civic society actors in knowledge production, namely, as participants in solving societal challenges, including citizen science and open science (EC, 2014; Hecker et al., 2018). Accordingly, in a trend of democratization of science, citizens' influence has increased in agenda-setting in public research and participation in scientific data collection.

Thirdly, in the meantime, in innovation studies, users have become recognized as an important source of knowledge on innovation, with the customer active paradigm subsequently fostering various models of customer co-creation in the business sector (Prahalad and Ramaswamy, 2004; Kantola et al., 2014; Von Hippel, 2017). Likewise, citizens are increasingly considered as supportive in policy-making, by co-creation of practical solutions (OECD, 2020).

15.3 CITIZEN SENSING AND CITIZEN SCIENCE

In this section, we discuss the conceptualization of citizen sensing and citizen science in more detail. We emphasize that the terms are currently also used as popular buzzwords indicating many overlapping (grassroots-driven) practices, as well as shifts of terms between groups of actors involved (e.g., Turreira-Garcia et al., 2018). The discussion below evolves around origin and aim, and selection of participating citizens (Table 15.1).

Citizen sensing can be seen as an initiative of citizens (as lay people) who are triggered by their exposure to a risk (which may be a health risk) and intend to challenge the accountable actor(s) to recognize and solve the problem (Berti Suman and Van Geenhuizen, 2019; Berti Suman, 2020; Liu et al., 2014). The sense of being at risk, or the wish to gain a more immediate sense of environmental conditions (Gabrys, 2016, 2017), builds an urgent need among these citizens to access first-hand data on the problem situation. This holds true in particular if data from the actors causing the risk are not trusted by the citizens. As a result, citizens utilize networked sensor technology in measuring the exposure on their own account, thereby challenging institutional data (Boulos et al., 2011). With regard to participants' selection, self-selection takes place as layman and concerned people. Due to the grassroots and spontaneous character

Table 15.1 Features of participatory initiatives: citizen sensing and citizen science

	Citizen sensing	Citizen science
Origin/drive	<ul style="list-style-type: none"> – Distrust of institutional actor due to information monopoly and low transparency – Emotional triggers from health risk 	<ul style="list-style-type: none"> – Need for scientific data among institutional actors (university), sometimes along with public authorities
Aim(s)	<ul style="list-style-type: none"> – Producing citizen-sensed valid data and visualization to challenge institutional data – Recognition of the health risk – Creating convergence and problem-solving 	<ul style="list-style-type: none"> – Producing valid scientific data and large-scale models; eventually inform public authorities in planning to reduce negative impacts – Creating trust in and credibility of data – Support to citizens in achieving behavioural change
Selection of citizens	<ul style="list-style-type: none"> – Self-selection as laymen concerned about health risk, but question mark over ‘representativeness’ 	<ul style="list-style-type: none"> – Selection often performed by institutional actor

Source: Adapted from Berti Suman and Van Geenhuizen (2019).

of the initiative (not planned by other actors), there may be a question mark concerning ‘representativeness’ of the citizens involved (Table 15.1).

Regarding the sensing component, various authors put emphasis on the need for producing high-quality data and maps, satisfying important data validity criteria as well as high resolution and ease of communication of real-time results, all of them increasing credibility and legitimacy (Keseru et al., 2019; Peckens et al., 2018). Other authors emphasize value added from deeper (contextual) understanding by citizens, as a result of their involvement in the practice of measurement. In the case of airports, this includes detailed information on the site of measurement, weather conditions (wind) and types of aeroplane causing peak noise (Gabrys et al., 2016; Jiang et al., 2016).

Citizen science can be described as the active participation of lay people in scientific research, often initiated by scientists and sometimes also by public authorities (Den Broeder et al., 2017). Citizen science tends to be more targeted to scientific data and knowledge production, rather than problem-solving or policy-making. The aim of citizen science can be understood as supplementing scientific analysis by measurement; for example, increasing detail in place (scale) and time, among others, to enable improved modelling. Many projects are in biodiversity research, such as monitoring bees for the sake of human subsistence, but also other species (Hallow et al., 2015; Cooper et al., 2017). An important supporting strategy in citizen science is building trust and credibility among citizens and among users in science on the quality of the data involved

(Freitag et al., 2016). A secondary aim may be achieving steps towards mitigation or prevention of unwanted environmental impacts, among others by behavioural change of citizens. Further, unlike in citizen sensing, participants are often selected through an institutional procedure. While participation and co-creation by citizens tend to increase the legitimacy of the knowledge gained and solutions proposed, a nuance regarding the selection of participant citizens needs to be noted. Participants would often be ‘the usual suspects’, from the middle or rich class, well educated, already politically knowledgeable and highly sensitive to responsibility. Such a situation may weaken the legitimacy and democratic value of participation (Michels and De Graaf, 2017). Selection of participants and the connected data representativeness is a major concern for all participatory sensing initiatives (Keseru et al., 2019). What would be an appropriate principle for selection of citizens, however, is not clear, because of the many available principles, such as an appropriate range of (conflicting) interests in the process, sufficient representation of those who are affected by the risk, best quality data by educated (information and communication technology skills) citizens, and an easy-going process without delay, thereby excluding users with ‘obstruction power’ (Bryson et al., 2013).

15.4 CASE STUDIES

The analysis is centred on factors in citizen participation that contribute to reaching solutions to environmental risks. Both case studies – AMS and CuriousNoses – can be seen as representing successful developments, in that steps towards solutions have been taken, though the ways of doing so are different, and solutions may be temporary.

15.4.1 Amsterdam Schiphol Airport: Citizen Sensing

Amsterdam Schiphol Airport (AMS) is the main airport in the Netherlands and the third-largest in Europe for passenger transport, following London Heathrow and Paris/Charles de Gaulle (Eurostat, 2019). Today, 71 million passengers are handled at AMS per year (as of 2018). In the early 2000s, worried citizens launched a sensor system on noise in response to AMS’s plans to create an additional runway (the fifth). The main complaint at that time was the dogmatic attitude and lack of transparency of the institutional (AMS) noise measurement system connected to an information monopoly, and lack of recognition of the health risk of (peaks in) noise annoyance (Carton and Ache, 2017; Berti Suman and Van Geenhuizen, 2019). Important steps towards solving the problem were recognition of the health risk and of the citizens’ monitoring results, ultimately opening the door to constructive dialogue in co-production of practical solutions with the institutional actor

AMS. In more detail, it appeared that strong performance factors have been the creation of a high-quality citizen monitoring system providing strong data validity and reliability that enabled contesting the information monopoly, and broader public and societal support through the adoption of this noise monitoring system even in other situations (for example, municipalities across the Netherlands).

Though causality cannot be proved, AMS decided in 2013 in collaboration with citizens and various authorities and governments to implement a plan to reduce and/or mitigate noise production. This plan on ‘norms and maintenance’ (Alderstafel, 2013) included selected runway use, specific flying techniques and routes for take-off and landing, preference in allocation of landing rights to airlines using relatively quiet and clean airplanes, and specific day/night schedules. In addition, plans were made to mitigate ground noise from departures by specific landscaping (for example, noise-reflecting ridges).

The measures to be taken, however, do not limit growth in air traffic. It seems plausible that, when there is still room for mitigation or prevention of noise annoyance, citizen sensing may indeed work. This is particularly salient today with the national government’s intention to increase the growth of air traffic above a limit that has been respected for several years, namely 500 000 flights per year. When it comes to more drastic decisions, such as a halt to airport growth, room for citizens’ input may be more limited.

15.4.2 CuriousNoses: Citizen Science

CuriousNoses (CN) started more recently (2017) and has been undertaken in cities in Flanders (Belgium), after a successful pilot in Antwerp. The scientific aim of CN is to accurately measure nitrogen dioxide (NO₂) concentration on a large scale that has never been done before, namely using 20 000 measurement points (impossible without citizens’ participation). The intention is in particular to test and increase the predictive capability of a more sophisticated model (ATMOSYS) that will inform policy-makers on air quality. Additional aims are to increase citizens’ learning, and to inform and support citizens in behavioural change. In contrast to the AMS case, the project is rather institutionalized, initiated by the University of Antwerp and Flemish Environment Society, among others, and also including activity of the media (Meysman and De Craemer, 2018). The major task for participating citizens was fixing devices (tubes) on a street-facing window of their house measuring the concentration of NO₂ in the ambient air. With almost 90 per cent of the measurements satisfying validity criteria, and with results indicating relatively high levels of NO₂, such as in urban corridors between high buildings and near start–stop traffic at intersections, the project as a measurement project in environmental pollution can be considered an important achievement (META-EEB, 2018; De

Standaard, 2019). As further results, the project has increased the plausibility and legitimacy of earlier measurements, and thereby could confirm policy urgency for authorities to reduce traffic.

It is noteworthy that at the start of the project there was already common ground for change, in which both design of urban traffic circulation plans and implementation of CN could be realized. The municipality of Ghent introduced a new traffic management plan in early 2017, that ‘cuts’ streets in the city centre to discourage all through traffic. In addition, the municipality of Antwerp in 2017 opted for a Low Emissions Zone that targets the most polluting vehicles, with most recently (early 2020) the introduction of more stringent norms (ELTIS, n.d.).

In a next stage of CN research, dynamic exposure of citizens to NO₂ is measured, including exposure at home, at work and during home-to-work travelling. And finally, research will be carried out on societal benefits of the project, in terms of influence on the behaviour of the participating citizens and influence on the policies of local and regional authorities (CuriousNoses, 2019; De Standaard, 2019).

15.5 PERFORMANCE MATRIX

We develop a performance matrix by focusing on factors that influence how citizens’ participation contributes to problem-solving of traffic annoyance that citizens experience. Before we discuss the different factors, we mention that it is difficult to reveal direct causality between citizens’ sensing and achieving problem solutions. This can be illustrated with AMS, where citizens have been included with other actors on a board or platform that supported the comprehensive plan on norms and maintenance in 2013 (section 15.4), while other citizens remained sceptical and continued being active in measuring noise annoyance. This development points to a particular role of a narrow/broad organizational layer between the citizen sensing activity and the design of envisaged solutions.

We distinguish five sets of factors, mainly inspired by citizen sensing initiatives because of their comprehensiveness: nature of the problem, organizational features of citizens, organizational features of the setting of public/policy actors, actions/processes adequacy, and translation of measurement results into actionable solutions. In this way, we adopt and extend the approach by Emerson and Nabatchi (2015), Voorberg et al. (2015) and Berti Suman and Van Geenhuizen (2019), and acknowledge that factors may mutually interact and may change in the course of the process.

Table 15.2 displays the matrix, which we would qualify as preliminary, as it needs testing on main lines and requires refinement, using additional case studies, eventually on slightly different citizen participation.

Table 15.2 Preliminary performance matrix

Critical factors	
Nature of problem	<ul style="list-style-type: none"> – Type of definition (e.g. measurement, recognised risk) (++) – Available ‘room’ for solutions of problem (+)
Organizational: Citizen action	<ul style="list-style-type: none"> – Strength of involvement (++) – Strength of capabilities (e.g. in sensor technology) (++) – Representativeness (democratic content) (+) – Self-reward as incentive (++)
Organizational: Policy-making	<ul style="list-style-type: none"> – Extent of public/policy involvement (+) – Compatibility with citizens (++) – Providing citizen incentives (+/-)
Actions/steps’ adequacy	<ul style="list-style-type: none"> – Convincing power of data quality (++) – Problem recognition by actors causing a risk (++)
Actionable solutions	<ul style="list-style-type: none"> – Embedding a final solution, e.g. legally (++) – Working with experimentation (++) – Working with temporary and partial solutions (+) – Use of new technology (radical/incremental) (+)

Note: Indicative strength, from modest (+/-) to very strong (++) .

On the problem side, we mention first the problem definition. If citizens or the driving organization define the problem as a measurement issue, the situation is different from solving a problem (for example, a health risk) that is initially not defined and recognized by actors causing the problem. If the problem definition is multisided, already accounting for complexity, it may support quickly reaching a beneficial solution. Conversely, if the problem definition is simplified, delay may arise. Next are strength of controversy and complexity, and room for solutions. If (actor) complexity is high and difficult to deal with, delay may happen and steps towards solutions may not be gained in the short term, or not at all. Also, if room for solutions is small in a situation of priority for traffic to grow, steps towards solutions tend to be more difficult to achieve.

On the organizational side concerning citizens, reaching beneficial solutions tends to critically depend on strong personal involvement (for example, connected to personal health risk), strong capabilities and strong representativeness of citizens for the problem situation. Furthermore, with regard to the organizational setting, there seems less direct influence by policy actors in citizen sensing in the beginning. Compatibility may increase in the course of the process when citizens and the responsible actor, as well as authorities/policy-makers, have achieved common recognition of the problem and can work on constructive dialogue. In terms of incentives, self-reward for citizens through solving health risks seems to work stronger compared to any other incentive.

Next, we address adequacy of actions/processes. As indicated above, well-running constructive processes are crucial for citizen sensing, such as creation of credibility, achieving common problem recognition (including recognition of citizens' data) and building constructive dialogue (Berti Suman and Van Geenhuizen, 2019). Strong adequacy is particularly important if citizens need to tackle large (dynamic multi-actor) complexity and uncertainty. We would qualify influence of the different adequacies as positive but also as negative, dependent on the situation. If adequacy is not sufficient, progress in building constructive relationships may be very slow.

And finally, we address translation into actionable solutions. Such translation is important as solutions often encompass much more than simply removing the cause of negative traffic impacts; for example, due to multi-causality, multi-actor interests and power, attention is needed to embed final solutions (e.g. in a legal sense), and to use experimentation and temporary and partial solutions as well as benefits from technology in the development of new solutions. In a negative situation, speed of action may be reduced by several years, if there is doubt about effectiveness of solutions, and extensive negotiation and experimentation need to be undertaken (such as two years of experiments in the case of AMS). It seems that citizen sensing is quite vulnerable to the influence of such factors. Using partial/temporary solutions, as well as experimentation and collective learning on novel solutions, such as in living labs (Van Geenhuizen, 2018; ELTIS, n.d.), may however limit the constraining influence. In addition, application of new technology in the solution seems important, and if incremental change is involved it may improve solutions' effectiveness. Application of radical solutions may work quicker but may also cause the risk of failure. Finally, what has been difficult to judge, and therefore has been excluded from our analysis (a study in itself), is how an additional organizational board (platform) may contribute to achieving solutions that are wanted by the citizens.

15.6 CONCLUSION

This chapter has explored evidence on problem-solving potentials of citizens' participation initiatives in urban transport planning. In particular, the chapter presented a performance matrix displaying mainly strong factors in achieving transport planning solutions. Strong influence tends to be exerted by characteristics of the problem; citizens' risk-based motivation, capabilities and representativeness; compatibility with the policy context (mainly in the later stages); and by adequacy in actions and processes. If the quality is high, such as through multi-sided problem definition, rich citizens' capabilities, multi-faceted validity and coverage of data produced, and achieving problem recognition and constructive dialogue with actors/authorities, the contribution to

beneficial solutions tends to be large. Furthermore, translation into actionable solutions comes with other questions, due to responding to needs for effectiveness and (legal) embedding, which may cause delay. All in all, factors that may be detrimental in reaching beneficial solutions for citizens include strong actor and other complexity (as a problem feature), priority for continued growth of traffic, and doubt about translation into actionable solutions.

The design of the matrix has been inspired mainly by a citizen sensing initiative. Regarding future research, there is the need for analysis of slightly different types of citizen participation, with the aim of testing and refining the matrix. In detail, there is the need to learn more about data validity and selection bias of participating citizens, motivation of citizens to participate, as well as citizen selection criteria that would be adequate in different problem and organizational settings. Positive influence of the establishment of boards and platforms could also be the subject of further research.

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16. What could transport planning practice learn from public participation GIS method?

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16.1 INTRODUCTION

Steps away from the ‘predict and provide’ transport planning paradigm have been recognized since the 1970s (Hensher, 1979) and increasingly in the last two decades (Bertolini et al., 2008). This ongoing paradigm change should lead to human scale transport planning where mobility solutions are planned from the perspective of people and are based on improved understanding of the lifestyles, mobility choices and experiences of individuals (Weckström et al., 2019; Glavić et al., 2019). Today, transport planning practice is gradually recognizing the limitations of the solely quantitative approach, emphasizing the political dimension in the process of breaking out of car dependency (Banister, 2008; Kennedy et al., 2005; Sustar et al., 2020). Contrastingly, in planning theory, public engagement has been seen as an important aspect of planning processes, benefiting not only the procedural or outcome justice, but also improving the quality of decisions and enabling transformative process development (Healey, 1992; Innes, 2004; Ward, 2001; Willson, 2001).

Despite efforts in practice and theory, mainstreaming public engagement also remains one of the crucial factors for the evolution of transport-planning practice. This is evident in the development of Sustainable Urban Mobility Plans (SUMP), the common European Union urban transport planning framework (May, 2015), where citizen and stakeholder involvement is essential. In addition to this exemplary institutionalization of participatory transport planning within SUMP, the topic has attracted researchers’ attention, for example to understand value conflicts (Barnes and Langworthy, 2004), assess inclusivity of participatory processes (Booth and Richardson, 2001), choose target participants (Comeau and Rodriguez, 2000), measure participation

performance (Bailey et al., 2015) and recommend cost-effective strategies and procedural improvements (Casello et al., 2015; Lee et al., 2017).

Despite the range of efforts aimed at advancing participatory planning practices, the need for further development of public engagement methods and participatory planning practices remains (Bickerstaff et al., 2002). The palette of traditional methods, such as public meetings, exhibitions and focus group sessions (Ibeas et al., 2011), has been extended during the last two decades with a variety of digital and web-based tools (Luna-Reyes et al., 2012). These tools have been developed as a response to several challenges in the dominant planning practice: face-to-face participation can only involve a handful of activists; participation often focuses solely on resisting changes; public engagement is typically initiated too late into the planning process and the collected data might remain invisible (Kahila-Tani et al., 2019). Responding to these challenges, agencies nowadays have at their disposal a range of digital tools, including for example online discussion portals (Lowry, 2010), visualization tools (Cheu et al., 2011), social media (Evans-Cowley and Griffin, 2012) and crowdsourcing applications (Misra et al., 2014).

Public participation geographic information system (PPGIS) methods are among the most widespread web-based methods. PPGIS methods have a rich and diverse conceptual history that draws upon several intellectual traditions including critical theory, community development, liberal democracy and social justice theory, anthropology and ethnography, political ecology and philosophies of science (Kahila-Tani, 2015). PPGIS methodology enables residents to communicate localized experiential knowledge about their place-based experiences, behaviour patterns or suggestions for planning alternatives. This georeferenced input can be in the form of point, line or area map-based markings, allowing large datasets to be collected (Figure 16.1). Thus, an advantage of using georeferenced data is the possibility for direct conversion into standard GIS formats (Brown, 2012; Brown and Kyttä, 2014), and an opportunity to link user knowledge to existing infrastructure or proposed planning solutions. Moreover, PPGIS methods enable an objective assessment of the distribution, type and/or intensity of values that individuals deliver (Brown and Raymond, 2014). In Finland, PPGIS methodology has been developed in a close cooperation with planners, thus allowing the methodology to have a direct relevance for planning and decision-making processes (Kahila-Tani et al., 2016).

So far, despite some isolated efforts (Prevost, 2006; Schlossberg and Brehm, 2009; Tang and Waters, 2005; Zhong et al., 2008), the development and implementation of PPGIS tools has been mostly on the fringes of the transport planning field (Ganapati, 2010). In addition, previous reviews of PPGIS methods have focused on the use of PPGIS in research (Brown and Kyttä, 2014), in urban planning practice (Kahila-Tani et al., 2019) and in natural resource management (Brown et al., 2020). However, a review that can provide lessons for

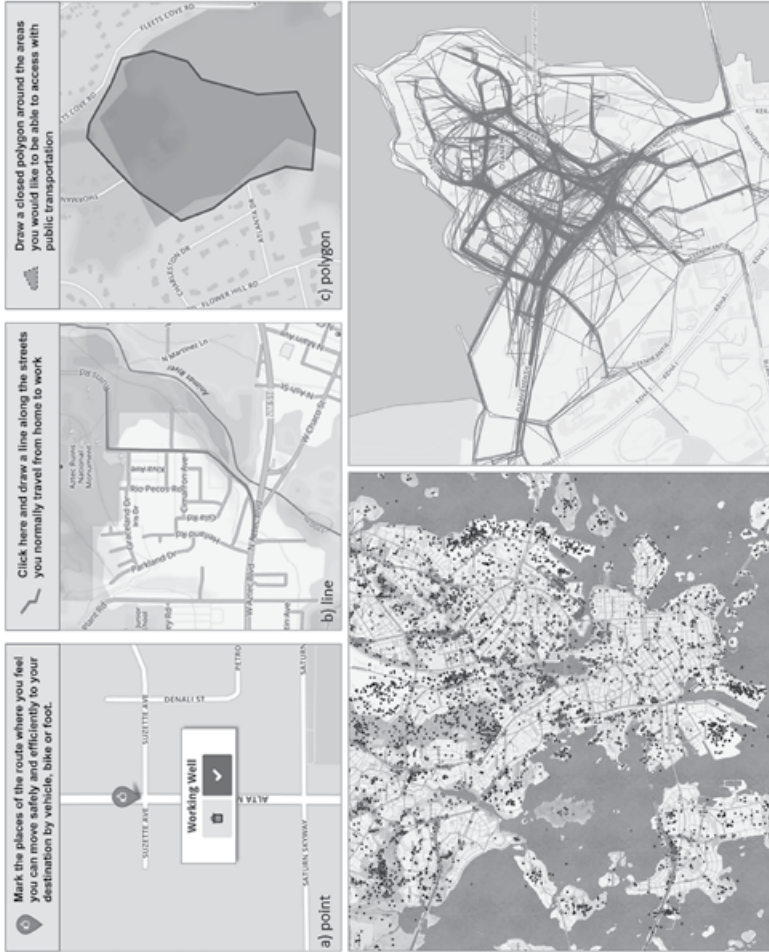


Figure 16.1 Examples of PPGIS data collection input (upper part) and data representation types (lower part)

transport planning practice is missing. This research aims to fill this gap. This chapter reviews actual PPGIS experiences in transport planning processes from the United States (US), the United Kingdom (UK), Finland, the Netherlands, Australia and New Zealand. An analysis of PPGIS questionnaires used in 47 participatory transport planning projects, together with questionnaires of experts utilizing the questionnaire tool, reveals some essential pros and cons of PPGIS methodology in transport planning. In particular, we discuss whether the PPGIS methodology promotes effective arrangements of public participation, helps to reach a broad spectrum of participants, or produces high-quality and versatile knowledge.

16.2 METHODOLOGY

Previous reviews of PPGIS methods inform us that purpose, geographic context, data quality, sampling approaches, data collection, data ownership and dominant mapping technology vary depending on the project (Brown and Kyttä, 2014; Kahila-Tani et al., 2019). The methodology used in this review consists of two complementing parts. The first part is an *ex post* evaluation of 47 transport projects that have implemented the Maptionnaire PPGIS method for public engagement. Maptionnaire is an advanced example of PPGIS methodology developed originally at Aalto University, and the authors had access to the data of projects realized using this tool.

To start the review process, over 400 planning projects using Maptionnaire for public engagement were identified through forward and backward snowballing. The search focused on the period between November 2013 and May 2017, and was stopped when a saturation point was reached, that is, when no new projects could be identified. From this set of projects, those that focused on transport planning were selected, resulting in 47 projects, which were implemented in Finland (49 per cent), the UK (21 per cent), the US (15 per cent), New Zealand (9 per cent), Australia (4 per cent) and the Netherlands (2 per cent). The review of projects includes analysis of transport modes in the project's scope, project type, area scale, structure of questionnaire used, and number of respondents, data and points collected.

The second part of the study included an *ex post* expert questionnaire, aimed at reviewing additional experiential lessons from the persons responsible for organizing the questionnaire, which cannot be drawn from project evaluation itself. This questionnaire was sent to the identified individuals responsible for public participation in the organizations leading the aforementioned 47 projects (total 32 organizations), and was open during June 2017. The questionnaire included questions related to organization type, experts' position in the organization and their educational background. The questionnaire used mostly open questions about the following topics: Why did you want to have online

participation in your project? What were the surprising results from your data collection, if applicable? What were the benefits for the project from using online participation? What were the challenges in using online participation in your project? Would you recommend this tool to a fellow transport planner?

16.3 ANALYSIS OF IMPLEMENTED PPGIS PROJECTS

16.3.1 Overview of Implemented Projects

The project types where PPGIS questionnaires were used varied from the development of strategic transport visions of whole cities to providing comments about detailed road designs. Most of the projects (55 per cent) focused on improvement of transport services, such as connectivity of bus lines. In addition to that, PPGIS questionnaires were used to collect background information for development of transport strategies and visions of cities (21 per cent), with a purpose to create guidelines; for example, on how to support walkability and cycling by urban design, or how to improve safety of the cyclists. Fifteen per cent of the projects related to land use planning, where opinions were asked related to road projects. Topics classified as ‘other’ (9 per cent) were related to, for example, mapping the interests of specific stakeholders (for example, companies) regarding road building projects. Regarding the transport modes of the 47 reviewed projects, the most frequent type (47 per cent) was multimodal transport. The focus of many questionnaires was on pedestrians and cycling (19 per cent), or public transport planning (17 per cent), while questionnaires were rarely created about plans solely for vehicular traffic (9 per cent) or rail (4 per cent). The group ‘other’ (4 per cent) includes questionnaires that did not deal with any mode in particular, but rather focus on a certain objective, such as traffic safety. Regarding the geographic scope of the questionnaires, most of the projects were city-wide (66 per cent). The second group of projects related to a larger scale (19 per cent), such as intercity or state-wide projects, while the smallest number of projects focused on a smaller scale, such as neighbourhood (9 per cent), city centre (4 per cent) or detailed design (2 per cent).

16.3.2 Questionnaire Structure in Implemented Projects

The analysis of questionnaire structure shows that the length of the questionnaire varied between two and 20 pages, with median being seven, and the most frequent number of pages was 14. This kind of high variation is possible because the transport experts designed the questionnaires themselves and thus the quality and content of the questionnaires varied a lot. The questionnaires were implemented using a range of traditional question types, such as radio

buttons, open answers and dropdown lists. These question types were used to gather background information about the respondents as well as about the project, or for rating the project ideas or the connections.

An essential element of map questionnaires is options for map-based answers, in the form of point, line or polygon. Point markers were used in almost all questionnaires (44), line strings in 23 and polygons in one questionnaire. In total, 226 point questions, 54 line strings and 3 polygon questions were used in the questionnaires (Table 16.1). Points were used to mark positive and negative issues on the map, strings for routes, while polygons were used to define areas that need improvement or development. Average and median for each map answer types per questionnaire were five for points, and one for both line and polygon questions. The questionnaire developers had also used additional geographic datasets, most often in geoJSON or shapefile formats, sometimes raster overlays, to mark additional map features – for example, planned infrastructure – to provide additional contextual information for respondents.

16.3.3 Respondents and Data Points in Implemented Projects

The analysis of respondents and data points of map questions from the 47 projects shows that there were 50 904 respondents, who marked 80 052 map data points in total. A questionnaire had an average of 1126 respondents. The summation of the number of respondents, data points, and their ratio are classified by transport modes and project types in Table 16.1. The ratio between the number of respondents and the number of data points collected reveals that there are projects that have a small ratio value (for example, 0.31), meaning that a high number of respondents have not provided answers to the map-related questions. On the contrary, there are projects, such as those on public or multimodal transport that have around two data points per respondent (1.91 and 1.94, respectively). Further analysis revealed that the relationship between the number of pages and the number of respondents/data points was not linear, and there are other factors contributing to the amount of collected data than the length of the questionnaire.

16.4 EXPERT QUESTIONNAIRE ANALYSIS

Out of the 34 experts who received the questionnaire, 21 responded (61.8 per cent). With regard to organization type, six respondents were from transport planning, six from consultancy, five from city planning, and six from other types of organizations such as governmental organizations. Most of the respondents identified themselves as city planners, and only a few as transport planners or project managers. Nevertheless, most respondents had their background in transport engineering and only a few in planning geography,

Table 16.1 Various types of elements used in PPGIS questionnaires and different types of projects and transport modes

Element	Distribution of various question types used in questionnaires					Respondents and data points per transport mode and project				
	Total	Median	Max	Min	% of questionnaires	Count	Total respondents	Total data points	Data points/respondent	
<i>Traditional questionnaire questions</i>										
<i>Transport modes</i>										
Radio button	279	5	27	1	7.2	8	19,928	38,083	1.91	
Checkbox	210	4,5	64	1	1.1	22	15,620	30,259	1.94	
Range	157	7	11	1	8.9	9	12,189	12,847	1.05	
Text	104	3	11	1	8.1	4	2,967	3,057	1.03	
Grid	57	6	12	1	4.7	2	1,144	356	0.31	
Select	66	3	18	1	6.2	2	1,073	389	0.36	
Integer	10	1	1	1	1.3					
<i>GIS-based map questions</i>										
<i>Project types</i>										
Point	226	5	25	1	93.6	26	29,482	60,006	2.04	
Line	54	1	17	1	48.9	10	14,874	16,400	1.10	
Polygon	3	1	1	1	6.4	7	7,391	8,145	1.10	
						4	1,174	440	0.37	
						47	52,921	84,991	1.61	

architecture or spatial planning. The respondents were asked whether they would recommend the tool to a fellow planner, with a ranking from 1 to 10 (maximum). The responses varied between 8 and 10, with the mean being 9.33, and the median 10. Consequently, respondents would highly likely recommend PPGIS method to another expert, although there might be positive bias from those answering the survey.

16.4.1 Benefits of PPGIS

Experts stated a range of reasons for using online methods in public engagement. For some, community engagement is an essential element of the current organizational practice, and many stated that their agency had extensively used web tools before to complement face-to-face engagement. The possibility to achieve a high total number of respondents and high diversity of participants was among the main benefits of the PPGIS method. Several experts highlighted the ease of using the tool: for residents to answer online questionnaires and to provide input as opposed to other methods; for demonstrating plans and other visual features on a questionnaire map; for utilizing data that is already collected in a digital format; for marketing a web-based questionnaire using social media or other means; for importing georeferenced data into GIS analysis software; and for developing questionnaires by using ready-made PPGIS tools together with different organizations within the municipality.

Further benefits identified included the possibility to collect opinions beyond standard questionnaire answers, including individual experiential understanding, wishes, unexpected positive/negative effects or more straightforward plan recommendations. Experts also valued the possibility to collect feedback in a geographic context, taking into account other spatial information such as the built environment, as well as a possibility to collect input about multiple locations or a wide area. In addition, the flexibility of implementation in different project stages was highlighted because this helps in refining the planning process itself, and allows a follow-up study in a particular neighbourhood. Several experts stated that the number of map answers and their statistical significance, the number and depth of open answers related to everyday experiences, and the differences in answers based on location, surprised them after completing the data collection and analysis processes. Some experts also expressed their surprise with the conflicting aspects in the citizens' answers. PPGIS datasets often provided support for the agency's analyses and interpretations and helped in validating and defending planning decisions. Experts also highlighted the benefit of reaching different target groups using questionnaire customization. Finally, online participation was sometimes seen to increase public interest in ongoing plans and development thanks to the good user

experience with PPGIS tool. For some experts this meant utilizing the PPGIS questionnaire as a way to increase the reputation of the municipality.

16.4.2 Challenges of PPGIS

In addition to benefits from using PPGIS methodology, experts also identified some challenges. While some experts valued a high amount of data, others found challenges in analysing large datasets. Especially, the analysis of large numbers of open comments from citizens has been deemed to be difficult and time-consuming. Several experts identified the challenges participants face when using the questionnaire tool, especially questionnaires with many geo-referenced questions and map-based questions that require input in the form of route or area. Besides the above-mentioned challenges that are especially related to the PPGIS tool, there is a set of challenges that can be considered generalizable for all web-based questionnaires. Here experts mentioned that lengthy questionnaires or answering options might lead to respondents dropping out. As in the general case of stated-preference questionnaires, experts highlighted the limits to what respondents can suggest based on the descriptions of hypothetical situations in the built environment. Another general challenge emphasized is that respondents' input is highly dependent on the way questions and information are formulated and presented online. Many experts expressed concerns that the use of digital tools might exclude some potential respondents. The anonymity of respondents may make it impossible to know whether the answers are from the same respondent, especially in longitudinal studies. Some experts were afraid of the preparation effort and the need to coordinate the agency's communication and marketing processes to attract respondents. These lead to challenges in estimating total costs, but also in learning how to implement new methodology, which is in turn related to actors involved and previous knowledge in the agency.

16.5 DISCUSSION AND CONCLUSION

This research aimed to provide an overview of efforts using the online public participation GIS method for public engagement in transport planning. The review of 47 implementation cases and expert questionnaire provided an insight into arguments pro and contra this public engagement method. This section provides reflections on lessons for participatory transport planning processes, with recommendations on implementing digital public engagement tools and developing participation planning practices.

According to the study, the advantages and challenges of the use of PPGIS methods in transport planning are very similar to those identified in participatory planning projects in urban and regional planning more widely. The pros

and cons represent three perspectives that Kahila-Tani et al. (2019) identified as essential in participatory urban planning cases: (1) ability to reach a broad spectrum of people; (2) effective arrangements of public participation; and (3) the production of high-quality and versatile knowledge.

According to the experts surveyed in this study, among the main advantages of the PPGIS method is the capability to collect large data volumes with little effort and to facilitate the inclusiveness of wider and new groups. The average number of respondents of a PPGIS questionnaire in the studied transport planning projects was over 1100 participants. Although the number could be still higher, it is clearly more than take part in a typical traditional public hearing or focus group meeting. The PPGIS method is quite flexible to accommodate different requests for public engagement, thus being highly transferable. This was evidenced by a wide variety of elements used in the questionnaires. When using PPGIS questionnaires, conflicting views can also be identified, to the surprise of the experts. An advantage identified in the PPGIS literature (Brown, 2015) is that the method provides an opportunity for individual input, allowing the opinion diversity to emerge, as people can share their personal, experiential, georeferenced knowledge, while not being affected by direct interaction with other people. In addition, the experts were concerned about the digital divide, as online methods can exclude some participants. This is related to one of the greatest challenges of the PPGIS method, namely the danger of skewed geographical and socio-economical representativeness. According to Kahila-Tani et al. (2019), it seems that the data collection strategy matters. Large datasets and personal invitations that are based on random sampling seem to promote good representativeness in PPGIS questionnaires, while open marketing of questionnaires typically creates problems in reaching a balanced respondent profile.

The experts found the PPGIS method easy to implement, and the method supports data collection at various geographical scales, various phases of the planning process and in projects related to different transport modes. PPGIS method implementation is highly dependent on the effectiveness of an agency's planning processes, and coordination with other processes such as marketing. Thus, challenges of integrating PPGIS data into an agency's practice and decision-making processes can be significant, and can consequently involve much time and cost, even if the participatory method itself is intended to be cost-efficient. The experts saw that the PPGIS method is well suited for enhancing the agency's and city's reputation, as well as for supporting the development of participatory culture in both the agency and civil society. Despite its advantages, technology is not the sole answer to issues of participatory planning. The PPGIS method should be integrated with other public engagement activities, especially face-to-face activities, because wider inclusion of both collective and individual participation methods is needed to

reach a broader spectrum of people, embracing a plurality of societal voices (Staffans et al., 2020). Nonetheless, the focus on implementation should be in the early phases of planning process, allowing for the benefits from data volume and method flexibility to improve both the decisions and the process itself.

From an agency's perspective, the PPGIS method has also the advantage of providing new types of knowledge that are usable in decision-making. The data format supports data sharing and collaboration with various sectors, and it allows easy integration into existing systems, especially into GIS and statistical analysis platforms. On the other hand, based on the type of data, there is room for expert misuse, for example through cherry picking to support existing presumptions. Moreover, some agencies may not have competent analysis or visualization skills to analyse large quantities of data. Despite the highlighted ease of creating PPGIS questionnaires, an agency with little previous experience in creating web-based questionnaires should dedicate special attention to understanding the necessary requirements for a successful questionnaire design and outreach. Agency challenges with big and qualitative data can be partially answered through opening data, organizing hackathons, as well as encouraging collaboration on co-analysis with citizen advocacy groups. Accounting for citizens as central actors in participation processes, the focus should also be on data utilization, as opposed to focusing on data collection as an end in itself.

PPGIS methodology does not only support human-scale transport planning as a tool for public participation. Place-based methodology is also valuable in deeper research on everyday practices of people, such as regarding emerging mobility services (Weckström et al., 2018), everyday mobility patterns (Ramezani et al., 2021), active living and the related health impacts (Laatikainen et al., 2018), and in the identification of various urban mobility lifestyles (Kajosaari et al., 2019). Here the notion of expanded urban planning (Wallin, 2019) comes onto the scene. To realize truly human scale planning it is not enough to invest in public participation, since the self-organized actions of inhabitants and their everyday life practices also play a crucial role. Ultimately, we will have to ask a question about knowledge integration in dynamic planning processes, if planning processes are to aim at including more, rather than less, participants (Eräranta and Mladenović, 2020).

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17. Participatory evaluation in transport planning: the application of Multi-Actor Multi-Criteria Analysis in co-creation to solve mobility problems in Brussels

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17.1 INTRODUCTION

Transport is the eighth leading cause of death globally, with 1.35 million deaths and 50 million injuries each year (World Health Organization, 2018). Proposed solutions to transport problems are usually solved by transport planners who often approach problems with what Healey (1992) calls narrow scientific rationalism in which economic concerns trump social and environmental ones. In this type of planning, citizens often have no say in decisions that have a direct impact on their lives. Instead, it is politicians that take decisions based on plans drawn by transport planners. This top-down, expert-led approach to transport planning is being challenged by public participation (Booth and Richardson, 2001). To what extent the public can participate, is indicated by the level of participation. Arnstein's (1969) ladder of participation ranges from manipulating the public to accept a solution, to allowing citizens to take decisions. Public participation in transport planning, however, is often limited to informing and consulting (Gil et al., 2011).

Citizens should be at the centre of human scale cities. In recent years, co-creation has been coined as an umbrella term for the higher levels of participation in which citizens have decision-making power. However, transport-related co-creation processes often lack a participatory element in the evaluation of the co-created outcome, that is, when possible solutions have been identified but a decision needs to be made on which solution(s) should be implemented (Pappers et al., 2020). This chapter seeks to address this research gap by proposing the involvement of citizens and stakeholders in the

ex-ante participatory evaluation of co-designed solutions using Multi-Actor Multi-Criteria Analysis (MAMCA). The proposed integration of co-creation and participatory evaluation is demonstrated by evaluating co-designed solutions to improve traffic safety in Brussels, Belgium. This chapter addresses the following research questions:

1. How can participatory evaluation using MAMCA be applied in a co-creation process?
2. What are the benefits and limitations of participatory evaluation using MAMCA in a co-creation process?

17.2 LITERATURE REVIEW

Participation of the public in a planning process is a double-edged sword. Public participation is said to increase the legitimacy of and support for decisions, lead to more innovative solutions by drawing from citizens' knowledge, and increase citizens' knowledge and interpersonal skills (Holden, 2011; Larson and Lach, 2008; Schroeter et al., 2016). However, public participation can also slow down the decision-making process, and decrease the legitimacy of a decision when participation is limited to certain groups (Holden, 2011; Transplus, 2003). Furthermore, different levels of participation have different levels of involvement from the public, ranging from manipulation of people to giving people full managerial control (Arnstein, 1969). Co-creation can be seen as a form of public participation that is situated on the highest rungs of the ladder of participation, and focuses on creativity and innovation (Pappers et al., 2020).

Participatory planning is defined as 'the involvement of any individual, group or community' in the planning process (Smith, 1973, p. 279). Involving citizens in the planning process can provide planners with detailed and local information and can increase citizens' competences. Whereas the legitimacy of a planning process may increase by including groups with conflicting points of view, this can also reduce the adaptiveness of the planning process (Smith, 1973). Furthermore, if all points of view are taken into account, the outcome of any participation process will necessarily be the middle ground. This 'tyranny of the median' will prevent radical solutions that are necessary to tackle problems, because they are not supported by the majority (Kaza, 2006). However, Stagl (2006) shows how this 'tyranny' can be overcome when citizens change their point of view during the participation process.

Evaluation in transport planning is often carried out using formal evaluation methods such as cost-benefit analysis (CBA) and multi-criteria analysis (MCA). The outcomes of these methods are used to inform decision-makers of the impacts of different alternative solutions to a problem. CBA shows the

costs and benefits of alternative solutions to all members of society and allows for a ranking of the solutions based on the costs and benefits (Boardman et al., 2018). However, the evaluation method is heavily criticized for its reliance on economically quantifiable measures and its unsuitability for complex planning problems. MCA uses quantitative and qualitative criteria to evaluate alternative solutions and allows for a ranking of the solutions based on their impacts on the selected criteria. The priorities in MCA depend on the context in which it is applied (Te Boveldt, 2019). MCA is increasingly applied to evaluate the impacts of transport projects (Macharis and Bernardini, 2015).

Evaluation is participatory if there is active engagement of multiple stakeholders, including citizens (Mathie and Greene, 1997). Whereas evaluation using traditional methods such as CBA claims to be objective by using quantified methods, participatory evaluation cannot be neutral as the evaluator's interventions cannot be value free (Plottu and Plottu, 2009). For example, when making evaluation participatory, issues arise such as how to correctly identify stakeholders and how to correctly obtain preferences from them (Harrison and Qureshi, 2000). Furthermore, when there are too many stakeholders participating in an evaluation, the diversity of opinions may make reaching a consensus impossible (Mathie and Greene, 1997).

There are different degrees of participatory evaluation using MCA, depending on whether an analyst or the stakeholders themselves are responsible for the generation of alternative solutions, the priorities (that is, criteria and weights) against which alternatives are evaluated, and evaluating the impact of the alternative solutions on the stakeholders' criteria (Dean, 2018). A rather low-key form of participatory evaluation is to ask citizens and stakeholders to rank alternative solutions, as has been done for energy policy in the United Kingdom (Stagl, 2006) and sustainable mobility policies in Italy (Marletto and Mameli, 2012). Muñuzuri et al. (2016) and Macharis et al. (2010) go beyond asking stakeholders to rank alternative solutions by looking at the impact of these solutions on stakeholders' objectives and ranking the alternative solutions on this impact. In the participatory MCA to assess potential rail investments in England conducted by Dean and Hickman (2018), stakeholders were also responsible for the evaluation of the impact of the alternative solutions on their own criteria.

17.3 METHOD: MAMCA

Multi-Actor Multi-Criteria Analysis (MAMCA) is used to analyse how the priorities of different stakeholders are impacted upon by alternative solutions that aim to improve the current situation. Knowing how different stakeholders are affected by alternative solutions gives an indication of the level of support from each stakeholder that can be expected for each alternative solution (Macharis

and Bernardini, 2015). The aim of MAMCA is thus to provide insight into the priorities of different stakeholders and not to ‘simply’ select and implement the alternative solution with the highest ranking (Macharis et al., 2012).

MAMCA consists of seven steps. The methodology starts with the identification of the problem and the definition of the alternative solutions (step 1). This is followed by the identification of the relevant stakeholders and their key objectives (step 2). The objective of each stakeholder is translated into criteria and weights, that is, the relative importance a stakeholder attaches to a criterion (step 3). In order to measure the impact of alternative solutions on a stakeholder’s objective, one or more indicators is constructed for each criterion as well as a measurement method for each indicator (step 4). Using the criteria and indicators, an MCA is performed for each stakeholder in order to find out the impact of the alternative solutions on the stakeholder’s objective (step 5). The outcome of each stakeholder’s MCA is combined by visualizing how each stakeholder is affected by each alternative solution (step 6). This step not only shows a ranking of the alternative solutions based on their impact on the stakeholder’s criteria, but also indicates which stakeholders and which criteria are critical in order to come to a consensus on which alternative solution(s) will be implemented. The final step in the process is the implementation of the chosen alternative solution (step 7) (Macharis, 2007).

The novel approach proposed in this chapter is the link between the co-creation process and participatory evaluation using MAMCA. First, the alternative solutions are co-designed by citizens. In previous evaluations using participatory MCAs such as MAMCA, the alternative solutions were pre-defined by the analysts guiding the evaluation (Almeida, 2019; Macharis et al., 2009; Turcksin et al., 2011) or suggested by stakeholders (Bana E Costa, 2001; Macharis et al., 2010; Macharis and Januarius, 2010; Verlinde and Macharis, 2016). Second, although citizens’ ideas have been collected and sometimes implemented in other transport-related co-creation projects, there was no formal *ex ante* evaluation of the alternative solutions (Pappers et al., 2020).

17.4 APPLICATION OF MAMCA IN A CO-CREATION PROCESS

17.4.1 Participatory Evaluation using MAMCA

The participatory evaluation using MAMCA took place in a living lab on traffic safety in Brussels. The explicit involvement of citizens and stakeholders was at the core of the co-creation approach used in this living lab. Awareness of the living lab was raised via posts on the project website and social media, the network of the local non-governmental organization (NGO) tasked with

the organization of the living lab, and the newsletter of the municipality in which the living lab was located.

Citizens identified traffic safety as one of the most urgent problems in the municipality, and set up a data collection campaign during three workshops. The data collection campaign included a survey about the mobility preferences of residents, a mobile application through which citizens could indicate places where there are traffic safety hotspots, and participatory data collection to count traffic and measure the speed of cars. The traffic count showed that traffic in the neighbourhood is mostly small vehicles such as passenger cars as well as pedestrians; large vehicles and cyclists are only a minority. During the speed measurements, 33 per cent of all measured vehicles ($n = 618$) were driving over the speed limit of 30 km/h.

Citizens and stakeholders could submit ideas (that is, alternative solutions) to improve traffic safety in the neighbourhood via an online platform (brussels.looperproject.eu/idea) as well as during the previously mentioned workshops. The 43 submitted alternative solutions were then narrowed down to five by citizens during a fourth workshop. The remainder of this section will discuss the five selected co-designed solutions and their evaluation following the steps of MAMCA.

17.4.2 Step 1: Definition of Alternatives

The alternative solutions that improve traffic safety were co-designed by citizens. The following co-designed alternative solutions were selected during the fourth workshop:

1. Improve signalization at a dangerous intersection.
2. Indicate alternative cycling routes to avoid a busy high street.
3. Set up an awareness campaign to inform road users of children in the streets.
4. Reduce road width using temporary installations.
5. Speed meters that visualize the speed of road users using smileys.

Besides these five co-designed alternative solutions, a sixth alternative called ‘no intervention’ was added. This was to see the impact of maintaining the current situation on the stakeholders’ objectives.

17.4.3 Step 2: Stakeholder Analysis

The relevant stakeholders to be included in the evaluation of the co-designed alternative solutions were identified by citizens during the workshops. During interviews held by the researchers with the identified stakeholders, the inter-

viewees were asked which other stakeholders should be included in the evaluation process. This led to the identification of the following stakeholder groups: citizens; the Ministry of Mobility of the Brussels Capital Region; the cycling NGO GRACQ; the Brussels public transport operator STIB; the Mobility Department of the municipality of Schaerbeek; and the police. The police were excluded from the evaluation because they could not obtain permission in time to participate.

17.4.4 Step 3: Definition of Criteria and Weights

Each stakeholder group defined their own criteria and weights (that is, the level of importance a stakeholder group attaches to a criterion). This was done during interviews with stakeholder representatives. Each interview with a stakeholder representative started with an introduction of the living lab, followed by an overview of the five co-designed alternative solutions. The stakeholder representative could then share their thoughts on the solutions as well as traffic safety in general. The interviewer – a researcher of the living lab – then compiled a list of criteria and verified these with the stakeholder representative. Lastly, pairwise comparison was used by the stakeholder representative to attach weights to the selected criteria. An overview of the criteria and weights of each stakeholder group can be found in Table 17.1.

A different approach was necessary to define the criteria and weights for citizens, because there was no representative identified for this stakeholder group. Citizens' criteria had been identified during discussions in the four co-creation workshops of the living lab, by talking to citizens on the street, and through a neighbourhood-wide survey on the citizens' priorities regarding traffic safety. Due to the voluntary nature of participation in the living lab, the sample of citizens that participated in the MAMCA is not representative of the wider population. A survey showed that participants were mostly female, highly educated and used sustainable modes of transport (that is, bicycle and public transport) most often.

The 123 respondents of the neighbourhood-wide survey mentioned the following criteria most often: air quality, traffic safety, cycling infrastructure, noise pollution, availability of parking places for cars, accessibility of public transport stops. In a second survey, 36 citizens attached weights to these six criteria using pairwise comparison. The average weighting of the citizens responses was calculated using Goepel's (2018) tool that uses the analytic hierarchy process (AHP) to calculate average weights of multiple respondents within one stakeholder group. Viewing citizens as one stakeholder group does obscure the different viewpoints within this group, however.

Table 17.1 The criteria, indicators and weights per stakeholder group

Stakeholder group	Criteria	Indicator(s)	Weight
Citizens	Traffic safety	Number of accidents	34.0%
		Perception of safety	
	Availability of cycling infrastructure	Availability of separated cycling lanes and bike parking	22.9%
	Air quality	PM2.5 emissions	13.1%
		NO _x emissions	
	Noise	Perception of transport noise	11.0%
		Exposure to transport noise	
Produced noise			
Availability of car parking	Availability of parking spaces for cars	3.5%	
Accessibility of public transport stops	The average distance to a public transport stop	15.5%	
Brussels public transport operator	Reliability of public transport system	Percentage of metros, trams and buses that are on time	50.2%
	Traffic safety	Number of accidents	23.7%
		Perception of safety	
	Accessibility for people with special needs	Level of fully accessible services	14.6%
Public funding of transport	Level of transport subsidies for investments	11.5%	
	Level of transport subsidies for operating costs		
Brussels Ministry of Mobility	Liveability	Walkability and pedestrian friendliness	37.8%
		Quality of urban space	
	Traffic safety	Number of accidents	22.7%
		Perception of safety	
	Accessibility for people with special needs	Level of fully accessible services	21.4%
Circulation	Flow of traffic for all road users; in order of importance: pedestrians, cyclists, public transport and private transport	18.1%	

Stakeholder group	Criteria	Indicator(s)	Weight
Schaerbeek municipality	Traffic safety	Number of accidents	63.5%
		Perception of safety	
	Accessibility for people with special needs	Level of fully accessible services	17.0%
	Air quality	PM2.5 emissions NO _x emissions	15.4%
Cycling NGO	Noise	Perception of transport noise	4.1%
		Exposure to transport noise	
		Produced noise	
	Quality of cycling infrastructure	Infrastructure such as separated cycling lanes and bike parking	45.7%
	Traffic safety	Number of accidents	38.3%
		Perception of safety	
	Air quality	PM2.5 emissions NO _x emissions	10.8%
Cost-effectiveness	Investment costs Operating costs Revenues	5.2%	

Note: NO_x: nitrogen oxides; PM2.5: particulate matter 2.5.

17.4.5 Step 4: Criteria, Indicators and Measurement Methods

Table 17.1 gives an overview of the criteria and indicators per stakeholder group. All stakeholder groups identified traffic safety as a criterion, and four out of five stakeholder groups mentioned air quality. The three institutional stakeholders – municipal and regional governments and the regional public transport operator – also mentioned accessibility for people with special needs.

17.4.6 Step 5: Overall Analysis and Ranking

This step determines the impact of the co-designed solutions on the stakeholders' criteria. Since MAMCA is done *ex ante*, the impact of a co-designed solution on a criterion was predicted by experts who based their judgement on their knowledge. Moreover, modelling or measuring the change in the indicators was not possible in this case. The experts who performed the evaluation were traffic safety experts of the Belgian Road Research Centre, mobility researchers at the Vrije Universiteit Brussel, and employees of the Brussels urban sustainability NGO BRAL.

The Preference Ranking Organisation Method for Enrichment Evaluation (PROMETHEE) developed by Brans et al. (1986) was used to evaluate the impact of a co-designed solution on a criterion. A seven-point impact scale

ranging from very negative to very positive was applied. If a solution did not impact a criterion, the fourth point on the scale was chosen, that is, 'neutral'. Then, the evaluation score of each alternative for each stakeholder was calculated using the weighted sum method. This is done by determining the overall score of an alternative (V) by calculating the sum of all performance scores (v) on the criteria (i) multiplied by their respective weights (w) (Dodgson et al., 2009):

$$V(a) = \sum_{i=1}^n w_i v_i(a)$$

17.4.7 Step 6: Results

The results of the evaluation show that there was consensus across the stakeholder groups in terms of their ranking of the proposed alternative solutions. Improving the signalization at the intersection had the highest evaluation score for all stakeholder groups; that is, of all five co-designed solutions it would have the most positive impact on the criteria of all stakeholders. This solution is followed in ranking by the awareness campaign for the presence of children in the streets and the narrowing of the streets. The speed measurements ranked lower, and the alternative cycling routes had the lowest ranking. Because all alternative solutions rank higher than the 'no intervention' scenario, resistance from the different stakeholder groups towards implementing the co-designed solutions was therefore not expected. Figure 17.1 visualizes the ranking of the different alternative solutions. The x-axis shows the stakeholder groups and the y-axis shows the evaluation score between -1 and 1 (that is, the impact an alternative has on the stakeholder's criteria).

17.4.8 Step 7: Implementation

Although improving the signalization at an intersection was ranked highest by all stakeholder groups, this alternative solution was not immediately implemented. This decision was taken by citizens at a workshop where the results of the MAMCA were discussed. Instead, consensus was found between stakeholders and citizens to implement the street drawing which MAMCA also found to have a positive impact on stakeholders. This decision was based on the evaluation scores as well as practical considerations: redesigning an intersection is a lengthy and costly process and may not be completed in the short term, that is, before the living lab end. Nevertheless, the municipality started the procedures to redesign the intersection. The implementation of

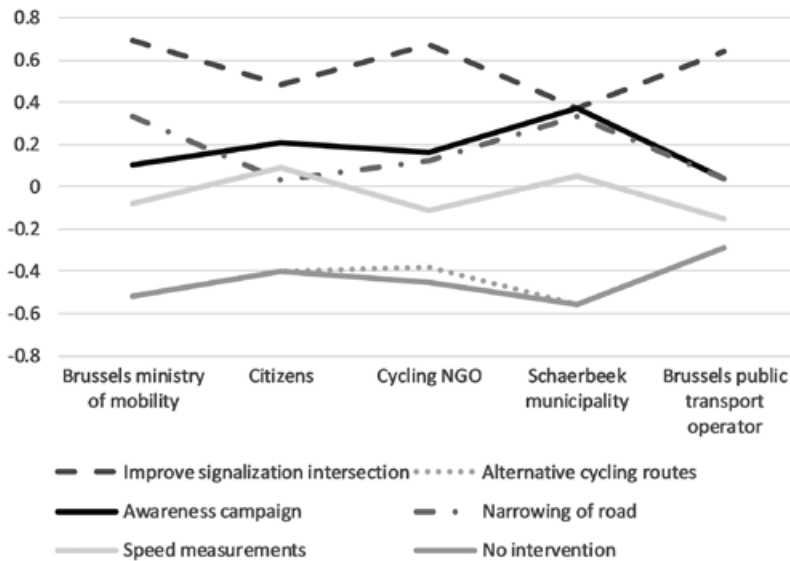


Figure 17.1 The multi-stakeholder ranking visualizing the ranking of the co-designed alternative solutions

the co-designed solution took place during a local NGO’s annual street party. A local artist drew the outlines of a traffic safety themed drawing on the intersection in front of the NGO, which children then coloured in. In order to measure the drawing’s impact on traffic safety, speed measurements were done one week before and one week after the implementation. No significant impact on the traffic speeds was found, however.

17.5 DISCUSSION

Combining participatory evaluation using MAMCA and co-creation was found to influence both the MAMCA process as well as co-creation. When looking at the impacts of co-creation on MAMCA, two advantages were found.

First, co-creation increases the opportunities for citizen engagement in the evaluation of the co-designed solutions. In participatory evaluation, citizens are often included only after the problem as well as the alternative solutions already have been identified. In co-creation, citizens identify the problem, for which they co-design solutions. Citizens are thus involved at an earlier stage, thereby increasing their engagement in the evaluation.

Second, citizens not only have valuable knowledge of the problems in their neighbourhood and ideas for possible solutions, but also know who is impacted upon by the problem and who will be impacted upon by alternative solutions. This helps in the second step of MAMCA, the identification of stakeholders, and could lead to the inclusion of stakeholders previously not identified. The representativeness of the participating citizens needs to be considered, however. Finding the right communication channels and networks is crucial when wanting to include groups such as the elderly and migrants.

Three disadvantages of applying co-creation to the steps of MAMCA were found. First, co-creation may result in more alternative solutions than can be evaluated. When selecting which solutions will be evaluated, a balance needs to be struck between citizens' wishes, the requirements of MAMCA, and the time and resources available to conduct the evaluation. MAMCA requires the alternative solutions to be significant enough for an impact on criteria to be expected, as well as sufficiently distinct to detect a difference in impact.

Furthermore, in order to make a useful comparison, the solutions should address the same issue at preferably the same location. In Brussels, the evaluators assisted citizens during a workshop in selecting solutions that were comparable and sufficiently distinct. Five out of the 43 proposed solutions were selected for evaluation, which is a manageable number; between four and eight seems to be the norm. Furthermore, citizens were found to be understanding when it was explained why their idea was not selected.

Second, identifying citizens as one stakeholder group does not do justice to their diversity and reduces the representativeness of this stakeholder group. The same can be said about involving stakeholder representatives for other stakeholder groups, who may also not correctly voice the views of the group they are representing. Future research should therefore investigate how citizens can be represented differently, for example by dividing them into distinct stakeholder groups based on their selected criteria and given weights, or by looking at socio-demographic data such as age or car ownership.

Third, the representativeness of the citizens' criteria and weights can be questioned. The selection of criteria was done by more and different citizens than the weighting. Furthermore, only 1 per cent of the neighbourhoods' residents participated in the evaluation. Involving more citizens or using a representative sample of citizens could increase the representativeness of citizens as a stakeholder group, but would also require more resources.

We found five advantages of applying participatory evaluation using MAMCA to co-creation. First, MAMCA extends the 'co' of co-creation to evaluation. This participatory or co-evaluation engages citizens and stakeholders, making them feel more invested in the co-creation process, which in turn can facilitate the implementation of co-designed solutions. This was the case in Brussels, where one co-designed solution has been implemented.

Second, MAMCA allows each stakeholder to define and attach weights to their criteria. This makes stakeholders reflect on their priorities instead of their perceived preference for certain alternative solutions. When there is no *ex ante* evaluation of alternative solutions – which is often the case in co-creation projects – the impacts of the co-designed solutions on stakeholders and thus the possible stakeholder support for the co-designed solutions is unknown. This lack of evaluation could reduce the support for the implementation of solutions due to a (perceived) lack of stakeholder support or conflicts with stakeholders' interests. For example, the municipality and the public transport operator perceived the improvement of the signalization at an intersection to be a controversial solution, because they believed other stakeholders would be negatively impacted upon. However, this solution turned out to have the highest level of stakeholder support.

Third, the consensus-making step of MAMCA intertwines with the decision-making in the co-creation process about the solution(s) to be implemented. The outcome of MAMCA is a ranking of alternatives based on their evaluation scores. Visualizing this multi-stakeholder ranking in a graph (see Figure 17.1) helps citizens and stakeholders to understand each other's preferences, can be used as input for discussion in the co-creation process, and helps to identify the solution(s) with the highest level of support from stakeholders. Therefore, the rankings provided by the MAMCA are not to be considered as the ultimate prioritization of the solutions. In Brussels, for example, the discussion led to the implementation of a solution which was second in the overall ranking.

Fourth, for decision-makers, MAMCA brings objective evaluation into otherwise 'fuzzy' co-creation and offers a structured way of ranking alternative solutions which can facilitate decision-making. Fifth, involving participants in evaluation may increase their knowledge of evaluation methods and thereby reduce the 'black box' feeling that traditional expert-led evaluation methods may evoke.

Two disadvantages of applying MAMCA to co-creation were found. First, the evaluation in MAMCA requires expert knowledge, time and effort that citizens or NGOs may not have. While involving stakeholders in the evaluation may reduce the 'black box' feeling, expert knowledge is still necessary to correctly assess the impact of the alternative solutions on the stakeholders' criteria. Furthermore, collecting criteria and weights from stakeholders requires a series of interviews or surveys with significant organizational efforts involved.

Second, deciding which alternative solution(s) will be implemented ideally happens during a consensus-making workshop attended by citizens and stakeholders. In Brussels, the evaluation results were published online,

and a consensus-making workshop was organized, but not all stakeholders attended.

17.6 CONCLUSION

This chapter has shown how citizens and stakeholders participating in co-creation can be involved in the evaluation of co-designed solutions using Multi-Actor Multi-Criteria Analysis (MAMCA). Applying MAMCA in a co-creation process involves citizens and stakeholders in the evaluation of co-designed alternative solutions. The involvement of citizens in the evaluation of co-designed solutions to traffic safety problems in Brussels was found to have an overall positive impact on the co-creation process. Furthermore, MAMCA makes evaluation – which is traditionally a top-down and expert-led exercise – participatory. This approach fits well with the aims of citizen involvement and empowerment integral to co-creation.

Although co-creation and participatory evaluation have been researched individually, the intersection of these two topics is the main contribution of this chapter. The experiences of combining MAMCA and co-creation are promising, but adaptations should be made for their integration to work better in other contexts. Based on the experiences in Brussels, we make two recommendations:

1. The selection of alternative solutions that will be evaluated should be done openly, based on stakeholders' input and guidance of the evaluators.
2. Citizens should be divided into different stakeholder groups to integrate their diversity into the evaluation. Differences in views will become more salient in projects that are larger in scale and/or more complex.

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18. Implementing a metro project: a political economy perspective from Lima

Katy Indira Huaylla Sallo and Robin Hickman

18.1 INTRODUCTION

The vaunted revival of railway systems (Banister and Hall, 1993) has reached various contexts, and different forms of rail-based transport systems have become an attractive means of transport aspired by many. In Latin America only a few cities have implemented such systems as yet, often with difficult stories of implementation. The Metro of Lima is the first metro project in Peru, and has a history of decades of problematic planning, construction and controversy. Initial project planning started in the 1970s but completion, of Line 1 only, occurred 40 years later. The current Line 1 opened in 2011 and was extended in 2014; at 35 km in length it is the longest elevated metro in South America.

This chapter seeks to explore the political economy of new transport systems, examining the barriers that transport projects have to overcome to be successfully implemented. Line 2 of the Metro of Lima has subsequently been planned, with construction starting in 2014. The first section was due to be operational in 2020, and the full Line 2 in 2024. The planning of Line 2 is assessed using a political economy framework (Feitelson and Salomon, 2004), which focuses on the analysis of interests of actor groups, suggesting that the adoption of innovations will depend on the coalitions that adopt or oppose the project. The aim of the research is to understand the complexity of the decision-making and implementation process and to better inform planners and stakeholders. Many metro projects are difficult to implement, and by examining the complexity of project development, including the different actors and viewpoints involved, lessons can be derived for future project planning.

The analysis suggests that the political discussion is critical to project planning, not because economic and social barriers are insignificant, but because the political discussion and management of this can be critical to the successful

delivery of the project. Other important factors include the development of the sanctioned discourse and the mediation of interests of affected groups. Traditionally, technical design issues attract most of the attention in transport planning, and social and political issues are overlooked. This research demonstrates that social and political dimensions are critical areas during project implementation, and if not considered, they can stop or delay progress and even cause abandonment. The political economy approach hence contributes to a widened understanding of the myriad of factors involved in project planning. The successful delivery of metro projects is not always straightforward, with issues extending beyond the technical case. However, metro projects can be very important in the development of sustainable mobility systems and human scale cities. Indeed, effective public transport systems are the only way that large numbers of people can be moved to and around city centres. The analysis has also opened up new areas for future empirical research, which are summarized in the conclusion of this chapter.

18.2 CONTEXT AND THEORY

Many recent studies seeking to understand change and innovation in transport use a socio-technical perspective. This helps us to understand the framework within which projects may be developed: socio-technological transitions are not outcomes solely of technical developments; moreover, they require more extensive social changes including norms, regulations, industrial markets, institutions, social habits, and politics (Kline and Pinch, 1996; Geels, 2004; Hekkert et al., 2007; Geels, 2010). The advancement of this type of research challenges our traditional transport planning practices, suggesting that infrastructure needs to be planned within a broader understanding of societal structures. Socio-technical studies categorize these as elements of the regime and landscape (Geels, 2010).

Socio-technical studies, however, overlook issues of agency and politics, and often these are critical in major infrastructure projects. The political economy framework from Feitelson and Salomon (2004) helps to assess the implementation of transport projects relative to key actors and different interests. The mediation of the different viewpoints on a project can be critical to its successful delivery. Metro projects are still new in Peru, the location of the case study, and are highly visible and political projects, often controversial and difficult to deliver. The coalitions for or against the project (even following project approval) influence implementation. The political economy model helps us to understand these combined societal and political factors, alongside the technical case for a project.

A metro system is a major infrastructure project, including much complexity and high cost in planning and delivery (Allport, 2011). This further attracts

high attention from numerous stakeholders (Flyvbjerg et al., 2003; Priemus and Van Wee, 2013). These systems are seen as safe, environmentally friendly, efficient and likely to provide wide benefits to society; yet such outcomes are not obtained by default and often projects can be contested (Hickman et al., 2015). Metro projects are highly visible infrastructures and are often viewed as highly desirable by sections of the public, yet controversial by others; hence there can be much debate. Implementation processes are complicated and projects can take several years to plan and build. The implementation phase comprises a key element of the whole project planning process, even following a positive decision to go ahead. Such large projects typically have numerous stakeholders with different interests and power which all need to be carefully managed (Priemus and Van Wee, 2013; Greiman, 2013). It can be relatively easy to block or delay a metro project, and building supportive coalitions to manage opposition is important (Allport, 2011). Besides, a metro project's implementation occurs over many years, which generates more uncertainty as political priorities might change.

Transport planners also tend to focus on the technicalities of a project and overlook the differing views and impacts of different actors in the process. Long-term implementation leads to turbulent timescales with many political periods, changes in priorities, political agendas, social changes and new social discourses (Feitelson and Salomon, 2004; Allport, 2011). These types of factors influence the quality, amount, delivery and efficiency of transport infrastructure; yet, often the literature on decision-making processes does not cover actor views and their mediation in any depth (Straub, 2008). Furthermore, empirical analysis on political economy in developing countries is significantly limited, with no examples in Latin America (Straub, 2011).

18.3 RESEARCH FRAMEWORK AND CASE STUDY

18.3.1 Case Study

The Metro of Lima and Callao is used as the case study, the first metro project in the Peruvian context, consisting of a network of six railway lines, with a total of 158.5 km. Line 1 (34 km) was initially planned in the 1970s, but was only completed in 2014, 40 years after its conception. In the same year (2014), Line 2 (34.5 km plus a section of 7.65 km of Line 4) was granted as an integral concession to a consortium for design, construction, operation and maintenance for 35 years (AATE, 2015).

Line 2 aims to connect the east and west of the city, and was expected to start operation of the first phase in August 2017 (Peru 21, 2014). The ambitious project is all underground, and is expected to provide significant benefits to around 2.5 million people at a cost of US\$5346 million (Ositrán, 2014).

In March 2014, the consortium Nuevo Metro de Lima won the concession amidst criticism, as it was the only bidder for the mega-project. ‘The biggest infrastructure in Peru’s history has to be more competitive, how is it possible that such amount of money is given when there is only one bidder?’ (Peru 21, 2014). Despite the controversies, the signing of the contract was celebrated as a historic success. ‘The critics only show us that the Line 2 is on the right track’ (Cuevas, 2014).

Over the next two years, Line 2 faced significant issues during its implementation. In December 2014, construction started, and issues related to land acquisition, expropriations, interference release and bureaucratic procedures generated delays (Mariluz and Olano, 2016), and a sudden stoppage of the building works for nearly two years. In 2016, a survey showed that only 56 per cent of the population agreed to the continuation of the project (*La Republica*, 2016). Also, in 2017, the concessionaire consortium presented an arbitration request against the country due to delays in land delivery and claimed payment of US\$260 million (Gestión, 2017). Deadlines were not met, and in 2018 the new Minister of Transport stated that: ‘the project was franchised with unreal schedules’, while millions are still waiting for the first phase opening of the Line 2 metro project.

18.3.2 Research Methods

This research is qualitative in approach, using 13 in-depth interviews (see Table 18.1) complemented by secondary data. Interviews were conducted between June and July 2018 with local stakeholders including planners (government), business groups (investment bodies and industry), and non-business groups (policy entrepreneurs, academia and community groups). Secondary sources of data included relevant information from institutional reports, presentations, academic studies, newspaper articles and online documents. The respondents were chosen in a purposive manner to gain expert views on the project alongside different user views; no representativeness of views is claimed.

The political economy framework (Feitelson and Salomon, 2004) is used to analyse actors’ views and uncover competing views. This framework focuses on the analysis of interests of social groups, suggesting that the adoption of projects will depend on ‘the coalitions that adopt or oppose the innovation’ (Feitelson and Salomon, 2004, p. 22). Therefore, the political economy framework views a project’s adoption as combined social and political processes. These are critical for the implementation of long-term, large-scale and highly visible innovations, such as with the Metro of Lima and Callao. A disadvantage is that the analysis is a snapshot of a specific moment in time, meaning that changes over time in the adoption process appear not to be considered (Vervoordeldonk, 2013).

Table 18.1 List of respondents

Interviewees	Institution/social group
Respondent 1	GyM Ferrovías – Línea 1 operator / business group
Respondent 2	Sociedad Concesionaria Línea 2 – concessionaire company Line 2 / business group
Respondent 3	Banco de Desarrollo de América Latina (CAF) / investment bank
Respondent 4	Banco Interamericano de Desarrollo (BID) / investment bank
Respondent 5	PROINVERSION (supervision institution of the Metro of Lima) / Government
Respondent 6	Planning division at AATE (institution in charge of the planning, implementation and operation of the Metro of Lima) / government
Respondent 7	Operations division at AATE
Respondent 8	High-income resident
Respondent 9	Cyclist
Respondent 10	Taxi driver / low-income
Respondent 11	Universidad Nacional Federico Villareal / academia
Respondent 12	Pontificia Universidad Católica del Perú / academia
Respondent 13	Universidad del Pacifico / policy entrepreneur

The adapted framework includes a number of elements. There are, firstly, the technical requirements of the project, which includes issues such as project design, engineering and urban design. Alongside these is also the economic and financial case, including funding arrangements. There are a range of actor views that need to be mediated, concerning perceived problems and opportunities, effectiveness and distribution of benefits and costs for the project. These lead to social barriers and political barriers to the adoption of the project. The sanctioned discourse is the views that become dominant on the project, and these have to be mainly positive for the project to go ahead successfully. Hence, the delivery of a project is viewed as much more than the technical case: there is also an extensive mediation and management of actor views. The interviews are used to discuss the different elements within the framework, to uncover the differing views on each part.

18.4 UNCOVERING CONTEXTUAL ISSUES

18.4.1 Mistrust in Politicians

Politicians are critical to the delivery of projects, helping to shape opinion and lead particular perceptions on projects. Yet, according to most interviewees, politicians are sometimes mistrusted as not having a real interest in serving society; instead, they have their own interests and blame others to push their own agendas. ‘Each political period criticises the previous one, which

generates a pernicious circle' (Respondent 6, interview). And, if a highly visible project is not performing well, politicians who want to gain notoriety could criticize the project to attack the government (Respondents 13 and 4, interview).

It seems that the recent political and institutional crisis in Latin America and in Peru has increased such negative perceptions. 'Under the current situation there are several reasons why citizens have greater distrust about what politicians do' (Respondent 9, interview). Indeed, the Odebrecht scandal has affected most Latin American countries, including Peru, showing up the biggest corruption network in history in Latin America (BBC Mundo, 2018). Corruption investigations in Peru have also increased considerably in recent years and most recent presidents were found to be involved. Over 90 per cent of the population distrust half of the politicians, a number that grew between 2014 and 2017 (Peru 21, 2018), which is a very high proportion.

18.4.2 Contested Views are Affected by Misinformation

Planners highlight that the population support the metro due to its benefits (Respondent 7, interview); yet, it appears that a large part of the community ignore the project and are not putting forward their views. 'Campaigns about the project have been poor; benefits have not been transmitted. People do not know that a subway is being built' (Respondent 11, interview).

In theory, any project should include a communication strategy alongside its development process; nonetheless, in practice, communication is not valued as a critical aspect, and it may be only partly or minimally implemented. The annual reports on the project discuss the informative events and social programmes conducted with municipalities in the area of influence (AATE, 2015). However, limiting the information only to such small areas around the infrastructure certainly does not give wide communication and ensure widespread support, as a large population is ignored.

'How is it solved economically? We do not know the economic means how it is paid' (Respondent 10, interview). The public was not informed about the economic aspects of the metro, which is promoting misinformation (Respondents 5 and 6, interview). Certainly, the society needs to know how their taxes are used and how the infrastructure built around their neighbourhoods is paid; yet, it appears that such information was not provided, which creates high misinformation and uncertainty around the implementation of Line 2.

18.4.3 The Current Institutional System Limits the Development of the Metro

Poor coordination and different visions from the numerous institutions involved in the development of the metro appears to affect its progress enormously. ‘The conflict in Line 2 is generated by the diverse opinions of the institutions involved’ (Respondent 5, interview). ‘Institutions have different visions; they do not communicate and coordinate for a common objective’ (Respondent 7, interview).

Transport in Lima is currently managed by several institutions at various levels (Alegre, 2016), and the complexity of Line 2 required the involvement of many, in addition to the consortium company in charge of the concession. Each institution has limited competences, different priorities and visions, which creates large challenges for coordination towards the achievement of a common goal.

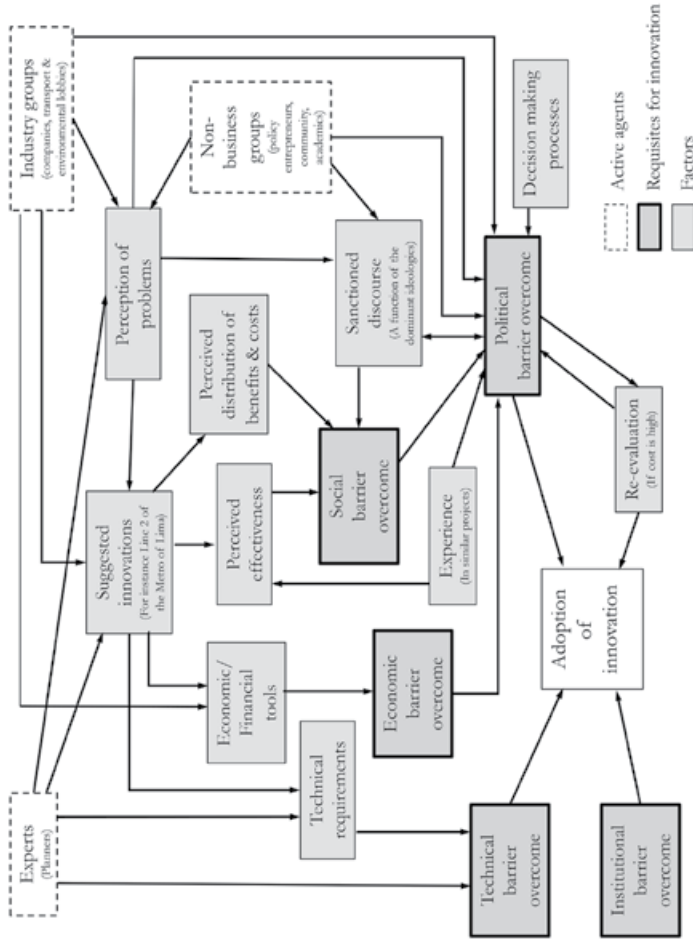
Also, the constant change of state officials affects technical capacity: ‘Technical expertise, knowledge and experience of professionals who worked on Line 1 have been lost’ (Respondent 7, interview). Certainly, periods in national political office last only five years, and periods in regional office just four years. Thus, state professionals are usually moved according to changes in politics (Bensa, 2017), generating a loss of technical capacity over time.

18.5 POLITICAL ECONOMY ANALYSIS

18.5.1 Political Barriers

Contrary to the vast political support that rail projects usually have (Hall, 1980; Allport, 2011), the Metro of Lima faces weak political backing. Rail projects are highly visible investments and often highly attractive to politicians as they try to obtain maximal exposure while they are in power (Feitelson and Salomon, 2004). Yet, this is not the case of the Metro of Lima; therefore, it is important to investigate what factors are causing such a lack of political support.

Figure 18.1 shows the relationships between factors. The dashed line shows the factors that are contributing to the weak political support and consequently creating a strong political barrier to the development of the metro. The economic and social dimensions, as well as active agents, the sanctioned discourse and decision-making processes, present critical obstacles adding to the political difficulties.



Source: Adapted from Feitelson and Salomon (2004).

Figure 18.1 Factors contributing to the political barriers

18.5.2 The Economic Controversy

Polarized perspectives are a common feature among actors, primarily due to concern about the implementation of high-cost infrastructure in a country with financial constraints, which is likely to benefit only a part of the population. 'These are expensive projects in a context of budgetary constraints, because you have to choose between a costly project in a city that produces almost 40 per cent of the national GDP [gross domestic product], or some other projects that are more 'social' but with less impact on the global economy' (Respondent 3, interview). 'This level of investment in Line 2, and without generating more benefits in the city than only along one route, we are missing opportunities' (Respondent 11, interview).

Clearly, the transformational impacts that a metro project can generate are not universally perceived. Transport investments are not only a link between an origin and destination, but also they can create economic development, diminish carbon emissions and reduce social exclusion (Banister and Thurstain-Goodwin, 2011; Hickman et al., 2015). Indeed, Line 1 generated some of these impacts; however, these were limited and not informed extensively to the public; thus, the impacts of the metro are perceived to be only the number of trips carried relative to the cost. Yet, Line 1 only carries 4.1 per cent of the total trips across the city (Lima Cómo Vamos, 2018), a small number compared to the economic investment. This indeed appears to be illogical. In practice, such mistaken perception affects public opinion concerning Line 2, as an absurd project with minimal future benefits. Allport (2011) indicates that a metro project should generate considerable benefits to a significant number of people to be politically feasible; thus, considering its current situation and social perception, Line 2 is not politically feasible.

18.5.3 Social Perceptions and Affected Groups

Despite the high number of people who rate the metro as providing a 'good' service (Lima Cómo Vamos, 2018), it has very uneven impacts for some relative to others. 'Line 1 does not provide me with benefits, I usually go from east to west' (Respondent 9, interview). For instance, in 2017, Line 1 was used only by 33.5 per cent of the population (Lima Cómo Vamos, 2018); thus there is indeed a significant group not using the project.

Besides, Line 1 currently shows a decrease in its performance, which impacts upon public opinion about its effectiveness. 'People say, ok, I will use the metro; however, at what expense? I have to travel squeezed and stand in long queues' (Respondent 11, interview).

Line 1 has reached its capacity limit and carries an additional 33.5 per cent of trips that might be alleviated by the enhancement project being carried out

(AATE, 2015); yet the system does not have complementary modes for the last mile, nor physical or fare integration with other modes (Respondent 11, interview). This affects people's perception of effectiveness.

Moreover, some groups could be adversely affected by construction works, and thus block implementation if their views are not heard. 'Those who organize the population and start marching against the transportation systems are the ones that operate the buses' (Respondent 6, interview). Bus riders who might be affected are not a small group; for example, the number of people who depend on the conventional bus system is around 650 000 (Mendiola et al., 2014). However, this potential risk is not seriously addressed, nor have clear mitigation plans been put in practice so far, which clearly indicates that these factors are overlooked.

18.5.4 Sanctioned Discourse and Other Factors

The sanctioned discourse is critical to the implementation of the metro: if there is a general positive view on the project then it is likely to be supported by politicians and decision-makers. The sanctioned discourse can be seen as the result of the interaction of interests that build a consensus on an issue, that is, concerning what is acceptable and what is not (Jägerskog, 2003). The sanctioned discourse needs to be a positive discourse, providing support to the project, otherwise implementation becomes problematic (Jägerskog, 2003; Feitelson and Salomon, 2004). Politicians decide which projects or policies to promote, or not, according to the sanctioned discourse and concurrence with their views and aspirations (Allan, 2001). The media often characterize mega-projects, including Line 2, as costly, delayed, blocked or even abandoned infrastructure (Paz, 2018). Moreover, many projects are currently investigated by the Controller General's office (RPP, 2018) due to their high cost and delays: 'News about Line 2 was more about how costly the project is and delays in its construction' (Respondent 9, interview); 'The media generates negative opinions in the population; it can destroy the image of any project' (Respondent 6, interview).

Some information propagated in the media is not well evidenced, but due to its power and coverage it can change people's perceptions greatly, or cause misinformation. The Metro of Lima, as a highly visible project in an urban area, attracts much attention from stakeholders. Therefore, it has become a key topic in the media and political debates. Unfortunately, with numerous difficulties in implementation, it is clearly not as appealing now as it was initially. 'The Line 2 is not attractive anymore, the politician who says I'll support the project and I'll finish it, nobody will believe that' (Respondent 11, interview). Therefore, there is some rationale behind politicians currently not actively supporting the Metro of Lima. It has negative perceptions and high visibility; thus, supporting

a problematic project is unlikely to be an option that politicians choose unless they can see longer-term benefits that may be realized.

The analysis shows that institutional and technical barriers significantly affect the development of the metro. Achieving the wider benefits of a mega-project largely depends on an integral vision and a cross-sector intervention (Banister and Berechman, 2000), which is difficult to achieve if institutions are divided and efforts for coordination are not efficient (Respondent 11, interview). As a result, the institutional barrier could be a missing element in the vicious circle, where institutional constraints and limited technical capacity lead to narrow objectives, low-performance innovations, poor balance between demonstrated costs and benefits (hence economic controversy), negative social perceptions, actor opposition, lack of political support and, finally, a highly modified or abandoned project. A greater understanding of the wider impacts of public transport investment, beyond performance against narrow economic efficiency goals, can help to demonstrate the benefits of investment. This stronger evidence base can be used to gain support by politicians and wider interest groups, hence the mediation of actor groups can be managed more effectively.

18.6 CONCLUSION

The implementation of major infrastructure projects is complex, particularly in a context such as Lima where there is a long history of insufficient technical resources in city authorities, poor project planning, low funding levels, corruption and mistrust in politicians. This research aimed to explore the decision-making process and identify barriers in the implementation of the Metro of Lima. The analysis has shown barriers in five different aspects: political, economic, social, technical and institutional. It has demonstrated, with empirical evidence, that the political barrier is the primary challenge and the most complex obstacle to overcome, mainly due to the lack of political support for the project. This, in itself, is a result of a range of factors, including poor project planning over decades. Highly visible projects require strong technical evidence-gathering, a case made for the wide benefits of investment, which can help to generate support, including with different actor groups and politicians.

Several societal factors are generating a significant political barrier to the implementation of the metro. Among those, economic concerns are one of the biggest threats, as the metro is perceived as an absurd project that requires massive funds with minimal benefits. Negative social perceptions are increasing as only a minority of the population has experienced the service so far; the majority are not using the project. The sanctioned discourse has become negative and does not promote the project due to the continuous adverse news

in the media. This includes corruption investigations around mega-projects in the country. As a result, these elements are adding to the political barrier and blocking project implementation.

We can reflect on changes to the process, which may enable better implementation of the metro. First, enhancing communication and engagement strategies might turn negative perceptions into positive perceptions and shape the sanctioned discourse into a positive driver for the project. Also, institutional and technical strengthening can lead to more robust projects and the demonstration of more benefits across all dimensions (economic, social and environmental). Indeed, institutional reinforcement is not a straightforward task, but action now might enable a greater positive impact of the metro in society. As an exploratory analysis, it was beyond the scope to propose solutions for the obstacles found; but we hope that this analysis contributes to an area where research is scant, particularly in the Latin American context (Straub, 2011).

There is a need for more multidisciplinary work within planning offices. Planners of different backgrounds can lead to more robust projects in all aspects, including engineering, urban planning, urban design, social and environmental impacts. This type of evidence-building and project development is critical to effective project planning. Planners also should be more open to hear people's feedback, and communicate to the society in a more comprehensive and transparent way; building support for a project is often difficult, but more effective communication and participatory processes can help to provide support for the critical moments where the politicians may waver and even withdraw their backing. People are indeed more likely to support a project that they know and have been involved in throughout the project planning process. Supportive coalitions can assure that projects are implemented. Such coalitions have to be carefully built, as many threats might appear along long-term implementation timelines, as in the case of the Metro of Lima. Besides, we should change how we conceive long-term projects. They are live projects and should be able to change and adapt to the context as they progress. As they require many years to plan, to implement and also to operate, they have to be flexible along their lifecycle.

The political economy framework helps us to understand how the different factors and interests interact and affect political feasibility. Such factors are usually considered as secondary elements, or even overlooked. However, this analysis has shown the importance of managing different actor views in the process, and has opened up new avenues for future research. A political economy analysis can be included in practice as part of the initial project planning process; it can help to understand the different views in the process and to frame the participatory process. This can be revisited through the project appraisal process, to ensure that a positive sanctioned discourse is maintained. An understanding of different actor views, alongside technical planning, will

help to identify current and potential future risks. Its usefulness goes beyond the identification of factors that cause barriers; it also enables us to find pathways concerning how to mitigate particular risks. In this sense, it would be interesting to conduct empirical analysis on how the political economy framework can help to find mitigating elements to overcome barriers, that is, how the different actors perceive solutions. Besides, this analysis was qualitatively focused and restricted to a particular point in time. Future research can use quantitative data and focus on different time points in the process.

In the end, transport projects need to be developed so that they support public policy objectives. The Metro of Lima should help to deliver sustainable travel behaviours, in environmental, social and economic terms. But it needs to be more effectively planned and delivered through the project planning and implementation processes. A metro project can support many objectives in human scale planning; it will allow more people to be delivered by environmentally positive means of travel to different parts of the city; it can support a vibrant city centre with high levels of pedestrianization and high-quality public space. Yet, metro projects, such as the case in Lima, are difficult to implement. A more thorough development of evidence and participatory processes, and management of different interest groups, can greatly assist – and lead to more effective public transport planning in Latin American cities.

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PART V

Conclusion

19. On the journey of transforming transport systems for human scale cities

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The ultimate end is not knowledge, but action. To be half right on time may be more important than to obtain the whole truth too late. (Attributed to Aristotle)

SELECTED FINDINGS FROM PART II AND RELATED REFLECTIONS ABOUT HUMAN SCALE URBAN TRANSPORT SYSTEMS

Without any intent of conveying all the messages from the 18 preceding chapters, here we would like to summarize some selected findings in relation to the need for transformation of urban mobility systems. Part I has brought us a handful of important insights for moving away from the *Homo economicus* model and embracing the multidimensionality of the mobile human being in the city. With that in mind, the first point ahead, as Chapter 2 informs us, is that we need to allow for multiple meanings of what human wellbeing is and how it can be achieved through built environment and policy interventions. Current conceptions of subjectively experienced wellbeing grounded in hedonic and eudaimonic perspectives cannot be always taken as universally applicable in the domain of urban transport. Understanding of wellbeing for the individual has to be put in the context of a socially contracted and constructed common place that a city is, where furthering selfish benefits for some, such as allowing the use of large passenger cars, should not be allowed to the significant detriment of others. Drawing from findings of Chapter 3, we have to recognize that our cities have often provided a significant discrepancy in an essential mode for human wellbeing: walking. All too often, walkability is only a feature of city centres, and the most economically deprived people face a lack of pedestrian facilities, further restricting their use of public transport. Furthermore, Chapter 2 underlines that since wellbeing has multiple meanings, this requires us to move away from straightforward and linear causalities, and to extend our

understanding towards relational and co-constitutive nature of human beings in the urban environment.

The findings from Chapter 4 and Chapter 5 allow us also to return to the often-used assumption of ‘average’ humans whose primarily commuting needs in the morning and return from work is what we need to mainly care about in shaping our transport systems. Aiming to achieve a modal shift away from private cars for commuting trips requires us to further expand the understanding of *Homo mobilis*. Such expanded understanding is essential to help us make better decisions regarding planning public transport systems. At the beginning, as Chapter 4 informs us, we should recognize that commuting is not simply a functional activity, where changes in accessibility can by themselves influence breaking out of the unsustainable habit of car driving. From the stance of rehabilitation processes of everyday activities in the context of the Global South, we see that income and poverty aspects are important for habit preservation in mode choice. In particular, low-income individuals depend on public transport, regardless of their accessibility conditions; while high-income individuals do not use public transport, for reasons that are not associated with accessibility. Similarly, gender issues are at the forefront, where women are generally more likely to use public transport, ultimately leading us to ask the question of masculinity norms associated with car use. Thus, the question of distributive justice and burdens on particular least advantaged groups is something we have to connect back to transformation of our mobility-related norms and values. Certainly, an additional relationship to include is the one between commuting and work–life satisfaction, an essential aspect of human wellbeing, as Chapter 5 underlines. In addition, we have to ask a question: where should we look for improvement to our public transport systems beyond the immediate focus on the least advantaged? These two chapters point towards urban areas with a middle-income population. Besides extending operating hours to cater for diverse commuting needs throughout the day, an important aspect of focusing also on the middle-income population is further habitual public transport use support, which can tip the balance of deeper norms in the long term.

Turning our gaze towards the elderly, Chapters 6 and 7 provide us with an interesting set of similarities and complementing contrasts between the south and north of Europe. Despite the obvious climate and urban form differences between Portugal and Norway, the concern for wellbeing of a growing population of the elderly is something in common. As having an active lifestyle with physical activity and social interaction is essential for the wellbeing of elderly people, we need to find ways to enable and encourage moving away from car-dependent everyday mobility. On the one hand, Chapter 6 argues that we need to understand the classical integration of walking and public transport through the needs and preferences of the elderly. On the other hand, Chapter 7 argues that we should also design new mobility sharing services, such as car

sharing, through the perspective of the elderly, as they should enable an active lifestyle. To improve our understanding of the ageing population on the move, we need to look for functional factors such as lack of infrastructure or its deteriorated state of maintenance, but also to understand the relationship between material infrastructure and competences and meanings. One important window of opportunity for behavioural change is a dilution of meanings associated with private car ownership happening over recent years. Such a change in meaning stems partially from environmental concerns for future generations, as well as from reducing competencies for car driving itself that elderly people experience due to cognitive or even economic reasons. Thus, even with the focus on a specific group of people, Chapter 7 shows us how understanding interdependencies between infrastructure–competences–meanings, understood through application of social practice theory, would pragmatically lead to highlighting additional aspects for improvement from the narrow definition of functional mobility. For example, further understanding and shaping competences and meanings in relation to infrastructure would lead us to look for possibilities on how to improve public transport driver training, how to improve security through non-digital and lighting solutions, how to improve the visual appearance of transport vehicles and the surrounding environment, and how we use opportunities for combining learning and social interaction across generations in designing urban mobility services.

SELECTED FINDINGS FROM PART III AND RELATED REFLECTIONS ABOUT RESPONSIBLE INNOVATION PRACTICES FOR HUMAN SCALE CITIES

As the urban mobility landscape is undergoing a period of rapid and dynamic pace of new services emerging and being experimented with, there is certainly a need to draw some key lessons from Part III of this book. As these technologies are in formation, one of the essential challenges is how to adequately take into account users' perspectives about the hypothetical future choice situations. With a focus on Mobility-as-a-Service, Chapter 8 provides an example of stated adaptation methodology, useful for understanding the mode choice adaptation process of travellers in response to a hypothetical subscription. Such methodology should be particularly useful for reducing the often conflicting hypothetical and cognitive bias in surveying stated preferences. Expanding the focus on human scale further, Chapter 9 informs us about discrepancies between people's and technology developers' expectations for vehicle automation in rubber-tyred public transport. In this particular case, people place a high value of both safety and security on board the vehicle, as most of them would prefer to have a human steward on board. Such a conclusion can be found in many previous attempts to automate public transport vehicles even

for rail-based systems, as in practice many such vehicles still do have stewards on board. Thus, we take this as a firm warning that the technology is still premature and unsatisfying, despite the great desire to reduce operating costs in public transport systems. Underlying the message against technological determinism, Chapter 9 ends with an encouragement for the further embrace of design thinking in developing new transport services. Similarly, Chapter 9 recognizes that planners and policy-makers have the responsibility to steer mobility innovations. Ultimately, extending from findings in these chapters, our suggestion is that developing responsible processes requires moving away from understanding humans as merely the adopters of technology, but rather understanding them as learners over time, and eventually even as co-creators of the technology itself.

Having in mind that innovation processes often require experimentation in the urban commons, in order to help build a transition pathway from niche to regime, Chapter 10 provides important lessons in relation to supporting behavioural change. The conclusion that this chapter reaches is that monthly choice challenges can be an effective way to encourage cycling behaviour. In particular, experimentation often involves a question of how difficult challenges should be, and this research concludes that it is important to let users choose the challenge level, but that even easy challenges do not necessarily yield less behavioural change. Such findings further underscore the communitarian aspects of human beings, who also appreciate being part of a larger endeavour in and of itself. However, we have to recognize that innovations in mobility systems often face the challenge of need for larger-scale systems integration, in contrast to some other domains of digital innovation. In Chapter 11 this brings us to a neighbourhood-scale integrated mobility concept, packaging a range of mobility measures and services. The conclusion here is that measures and services should not be observed in isolation to understand their impact, but that their combination can also have undesired effects. Moreover, this research also informs us that such combination is not always based on actants aligning their goals, but they could actually be in contradiction even if there is an agreement about some measures. Thus, this chapter leads our reflection to further question of conflicts of interest, challenges in cooperation and communication, and the need for new integration actants established in governance networks.

SELECTED FINDINGS FROM PART IV AND RELATED REFLECTIONS ABOUT POTENTIALS FOR DEVELOPING PLANNING PROCESSES FOR HUMAN SCALE CITIES

Part IV of the book provides a set of lessons focused on urban and transport planning processes. The common thread across Chapters 12, 13 and 14 is that

planning our cities to enable travelling by cycling is inclusive of all human scale transport modes. From here, we would further argue that, similar to the point made in Chapter 12, we should not be holding out hope for more digital interventions that further strengthen car dependency. In addition, Chapter 12 furthers systems thinking approach to the application of street design, where most urban settlements could be set up for cycling, relying on positive feedback loops. This understanding of cities as complex systems is in line with the previous arguments, especially those from Chapter 2. Pragmatically, planners need to embrace the dynamics of cycling network growth when prioritizing actions, focusing on locations where many short trips begin or end, and focusing on completing unconnected parts of the network before expanding coverage further away. As some have argued before, Chapter 13 recognizes that we have not been developing many planning support systems for cycling-related decisions, which is an even greater problem for resource-constrained cities that lack existing infrastructure, cycling norms and organizational capabilities. Thus, one of the key aspects we need is development of both scientifically robust and usable planning tools that would support making decisions of where to begin any cycling investments at all. As planners would often need to defend their choices for such investments in front of policy-makers, they need higher chances for initial success if they can gain support for further long-term strategy development of the city-wide network. Geographic information system (GIS)-based tools can thus be useful in accounting for spatial measures while also providing visual outputs for communicative sessions. In addition to useful tools using existing databases of population, Chapter 14 argues that we should do a better job in collecting quantitative and qualitative data from various novel and conventional sources. However, 'more data' is more easily said than done, and thus we need a careful reflection on strengths and weaknesses in finding the most useful data for the given problem at hand. Such reflection on usefulness goes hand in hand with considerations of data availability, representativeness, and associated ethical challenges such as privacy.

Expanding our scope of potential data sources, Chapter 15 argues for a greater inclusion of citizen-based data collection. This is certainly not only about additional data sources, but also poses a question of the roles of citizens in planning processes. Thus, if we are to remain constrained to the domain of better expert decisions, we would run into a conflict with value diversity and ultimately a need for democratic nature of built environment planning in general. Focusing on place-based web questionnaires, Chapter 16 provides reflections for developing public participation activities in planning processes, if we are to understand further existing mobility behaviours or perceptions on proposed alternatives. Here, the question of data validity expands to questions of problem legitimacy and the need to support communicative planning activities that should be based on transparency and accountability. Pragmatically

speaking, although initially this might be a large step, including people in participatory processes can only benefit the organization of planning processes in the long term. Besides understanding existing mobility behaviours or perceptions on proposed alternatives, Chapter 17 provides a framework for further engagement of a wider range of stakeholders in the development and evaluation of plan alternatives. When organizing such activities, urban residents can be included into different groups to integrate their diversity into evaluation. As a result, participatory planning activities should not solely benefit the learning of planning organizations, but can also be an investment into long-term civic learning and positive engagement. Reflection on participatory planning activities inevitably relates to the institution of modern democracy, whose strengthening is something that Chapter 18 can help us to dive into. As also highlighted in Chapter 11, the foundation of modern democracy is an irreducible web of common and conflicting interests stemming from societal pluralism. Especially conflicts of interest are obvious in long-term mega-projects of urban infrastructure planning, such as the Metro of Lima. Here, the constraint of funding sources does not make things easier by itself, but planning is usually an activity of dealing with constrained resources and technical possibilities. What is more or less common in planning processes is the level of trust established in the governance networks. Such trust-building processes require some essential aspects, such as creating conditions where a large proportion of the population can have first-hand experience of the changes in transport service. What we can further learn from Chapter 19 is that trust-building also requires not falling into the trap of perceiving negative news in the media solely as a threat. Sanctioning discourse is not the way out of the undeniable dimension of antagonism in modern pluralistic societies. Potential for emerging conflict is what democratic politics involves. The challenge then becomes how to legitimize conflicting interests, and create conditions for adversaries to co-create decisions, even if not having agreeable views. Participatory planning implies that the governance system has to be able to handle such – for some, paradoxical – tensions, allowing for an unquestionable right to present and defend views, but aiming for partly consensual decisions, acknowledging that some differences might remain unaddressed.

THREE KEY DOMAINS OF CHANGE FOR THE ONWARD JOURNEY OF TRANSFORMING URBAN MOBILITY SYSTEMS

The chapters in this book have provided us with a range of findings from around the world, from Peru, Brazil, the United States, Canada, Portugal, the United Kingdom, Germany, the Netherlands, Norway, Sweden, Finland, Australia and New Zealand. These lessons have been based on a range of meth-

odological approaches, from statistical and GIS analysis to well-supported and logical critical argumentation. It would not do a complete favour to all the individual chapters if we simply tried to list all of their suggestions for future action. Instead, in this section, we want to make a first step towards a more networked understanding, by establishing a framework for inspiring responsible future-making. In line with the opening quote from Aristotle, our ultimate concern is on the side of acting, despite all the importance of knowing.

Taking our proposal as a starting point for further learning and action, we propose three key domains of change: (1) changes in actions and virtues of diverse actants involved in future-making; (2) changes in governance and processes of these networked actants; and (3) change in the core conceptualizations used in understanding urban mobility.

Starting with the changes in actions and virtues of diverse actants involved in future-making, we would like to briefly reflect at the level of actions and virtues for diverse actants responsible for future-making, ranging from planners to innovators and academia itself. Several chapters in the book have highlighted the importance of wellbeing and diversity of the meaning of happiness, ultimately related to the richness of human everyday experience, from which we can draw lessons for changes in actions and virtues. For example, Chapter 2 has argued for experimenting with more context-sensitive, relational and process-oriented perspectives on human wellbeing and everyday mobility. Such experimenting is needed both in practice and in academia. Emphasizing such experimentation actions is especially important if we are to talk not just about human needs but also about changing human wants, and ultimately about behaviour in the urban environment. Our future actions should further seek to uncover many interdependent aspects of the routine everydayness of urban mobility practices. We can find many such concrete recommendations in Part II's chapters, including aspects such as more diverse population segments, safety and comfort, gender, age, employment, poverty, and long-term physical and mental health. In light of the ongoing COVID-19 pandemic, we should further draw lessons for anticipated similar events in the near and distant future. Future studies would benefit from even more mixed-method and longitudinal datasets, furthering the spirit of transdisciplinarity at the level of all future-making actors. In addition, we should act upon formalizing as many as possible of those methods in open access planning or innovation support tools. Here, it will not be enough to solely focus on humans in the city for future studies, but we in both practice and research need to pay more attention to diverse and changing experiences and responsibilities of humans in hybrid institutional networks. As we will argue further below, this is not just about a pragmatic purpose of furthering action research activities, and evolving redistribution of roles and responsibilities for future-making. Just as we would argue that we need to shift away from the narrow model of the human being on

the move in the city, a similar shift has to happen with our model of humans in the organizational processes. For such a shift to happen, there is an essential need to nurture a virtue of mutual care and empathy between people both in practice and in academia. Just as we should not treat humans on the move in the city as solely objects of study and change, so we should not fall into the same trap in our mutual relations involving academia and practitioners. Nurturing virtues of care and empathy will have a true power of developmental action, co-creating essential conditions of trust and support for systemic change needed in transforming our urban mobility systems.

Turning to the second key domain, changes in governance and processes of these networked actants, we would like to briefly reflect on interdependencies between organizational networks, processes and visions. Organized actions in changing our built environment emerging around the world at the time of the COVID-19 pandemic have shown us that our organizations are capable of adapting to shocks. However, can we achieve permanent structural change, both in our cities and in our future-making organizations? As the first step of structural change, we should certainly aim at having further development and use of adequate planning support tools for everyday mobility centred on integrated walking, cycling and public transport planning processes. Similarly, we need to improve organization-level data collection and sharing processes, balancing longitudinal accumulation and sensitiveness with privacy through consent and access restrictions, and explicating the used spatio-temporal and demographic attributes on the aggregate level when possible. Academic organizations should here act as role models, responsibly opening their own databases as much as possible. Similarly, academic funding bodies and publishing instruments should increasingly urge opening of data and transparency of methods through sharing of analysis or processing codes. In addition, it is important to continue responsibly testing various emerging technologies for urban mobility transformation, and carefully evaluating their priority for implementation in the wide range of technological actions we already have at our disposal for urban transformation.

Besides these aspects, if we are to talk about crafting human scale cities around the world, we have to account for governance contexts on a much deeper level of organizational processes and ideologies. Thus, if we are to be advocating for initiating and sustaining behavioural change in urban mobility, we have to aim for behavioural change in our own organizational processes. For such organizational behavioural change, we have to relate it back to knowledge integration and organizational learning processes. For enabling such learning, we need to increase the amount of comparative studies conducted across societal and governance contexts, relying on expert surveys and focus groups, simultaneously using analytical methods for understanding spatio-temporal mobility patterns. In addition to comparative studies, we also

need more longitudinal studies of dynamic patterns of interactions between diverse urban actants, if we are to learn from the structures and patterns of their complex interactions. As we have already seen in some of the chapters in Part IV, many unanticipated ways in which these multi-actant processes unfold can enrich our understanding. Following the lines of open science experimentation, we need further processes to widen the set of participating actants, further democratizing the collective imagination of both the built environment and emerging technologies. Starting with further understanding of why we have the potential selection bias in public engagement, such processes have to aim for building bridges between academic and practitioner activities. However, we should not be under the illusion that we can immediately have synergetic interorganizational ideologies in relation to future-making. Such mixed-actant processes have to depend on successful mediation of differing views, not falling into the trap of sanctioning fierce debate. This would certainly go against the pluralism of our societies, and would be in direct conflict with previous statements on the plurality of knowledge. Instead of antagonistic fear, we have to be comfortable with friction and the agonistic process of trust-building, where if actants are pointing out the challenges, they are not doing so to hurt, but rather to construct.

Nonetheless, we also recognize that change is not easy and often hurts. Looking in the mirror ourselves, we have to acknowledge that academic institutions also need to continue thinking about new professional roles and educational needs beyond existing disciplinary silos and identities. For that, we need direct institutional incentives for more mixed-methods, transdisciplinarity and action research, further normalizing the integration of social science knowledges. As we have seen clearly in some chapters, new perspectives (for example, social practice, political economy, complexity theory) can be rather useful in deepening understanding. Furthermore, as was experimented with during the Network on European Communications and Transport Activities Research (NECTAR) 2019 conference, future NECTAR and other previous academic conferences should be among these associations for testing new activities and agendas. Furthering research–practice collaboration and co-creation takes years and a lot of trial and error. Nonetheless, this will certainly be an important step for the future of NECTAR in both responding and actively steering the ongoing societal transformation.

Ending with the last key domain, change in the core conceptualizations used in understanding urban mobility, this book argues for the necessity of changing our anchoring conceptualizations. As already mentioned in Chapter 1, our overarching suggestion is that our new anchor point for knowledge-building should be a human scale city. It is to serve as a boundary object, allowing us to readjust our scale in understanding the multidimensional and ever-changing *Homo mobilis* existing within a multilayered and ever-changing urban envi-

ronment. Re-anchoring on a human scale city, we recognize the power of language in relation to thinking and identity at the level of individual learning, and at the level of organizations, in relation to organizational cultures and imaginaries. Moreover, such re-anchoring provides us with several points for hopeful thinking and action. We hope that this book has shown the potential power that such ideological conceptualization has in expanding the horizon of imaginable futures, constructing meanings of what built environment, technology or policy could be. We hope that this concept will help us in embracing the irreducible emergence of mobility commons, as ultimately a social–technical–environmental system. We also hope that it will help us to embrace the necessary complexity of social justice frameworks that can look beyond an opposing dialectic between utilitarian and distributive justice foundations. Hand in hand with those, we hope that such re-anchoring will be helpful to clarify further the moral limits of transport as a societal good, and application of solely economic principles for its evaluation. However, having in mind the relational beings that humans are, we want to clarify that human centrality in our understanding is not narrow anthropocentricity. We do not suggest that we should only consider narrowly defined human psychological or existential needs, and treat the environment as a separate entity or even just a resource to be managed. In fact, such a misconception is at the heart of our abuse of ecological systems in the past two centuries following the industrial revolution. Thus, if we negate our relational existence within other networks of life, it would not just be a question of injustice towards those beings, but it would essentially lead to a degradation of both our moral capacity and our authority. Such abuse raises the difficult challenge of our very collective survival on this bounded planet.

Returning to the Aristotelian idea also made in Chapter 1, that knowledge and action are one, we have to avoid falling into the trap of post-Enlightenment rationalist thinking that is still prevailing in transport studies. Just as there are many potential actions above, so there are many different kinds of knowing, and this knowing as a process of future-making is distributed across diverse actants in governance networks. Thus, we cannot claim that we have presented a complete alternative to the path-dependent knowledge–action structure of urban transport systems. Essentially, pretending to provide an ultimate structure of knowing would also go against the idea of pluralism of humanity. After all, each human has a slightly different cognitive model, just as the same is true for each planning organization. There is no one single essence, no one single knowledge–action structure. However, this does not diminish our stance in relation to relativism or, even worse, irresponsibility falling into the pitfall of determinism. Quite the contrary, it requires an even greater sense of responsibility and commitment for future-making. To question our own sense of responsibility and commitment, we have actively reflected on the potential for blurring the roles and boundaries between research and practice.

Pragmatically, our current answer is that we need more people with a dual cross-organizational role, to serve as knowledge integrators. This would be an important first step in reconceptualizing future roles and responsibilities by opening up possibilities for new identities. However, we hope that the chapters of this book will serve as inspiration for further encouragement of commitment to sustainable futures. Ultimately, we hope that our reflections presented here have shown a firm sense of the very commitment that such alternative futures are possible, and that for enabling those futures, the change has to start from all of us, in both practice and academia.

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