

The background of the top half of the page is a dynamic, futuristic image. It shows a road with white arrows pointing forward, receding into a bright light at the horizon. The sky and road are filled with vibrant, multi-colored light trails in shades of blue, green, yellow, and red, suggesting high-speed motion or data flow.

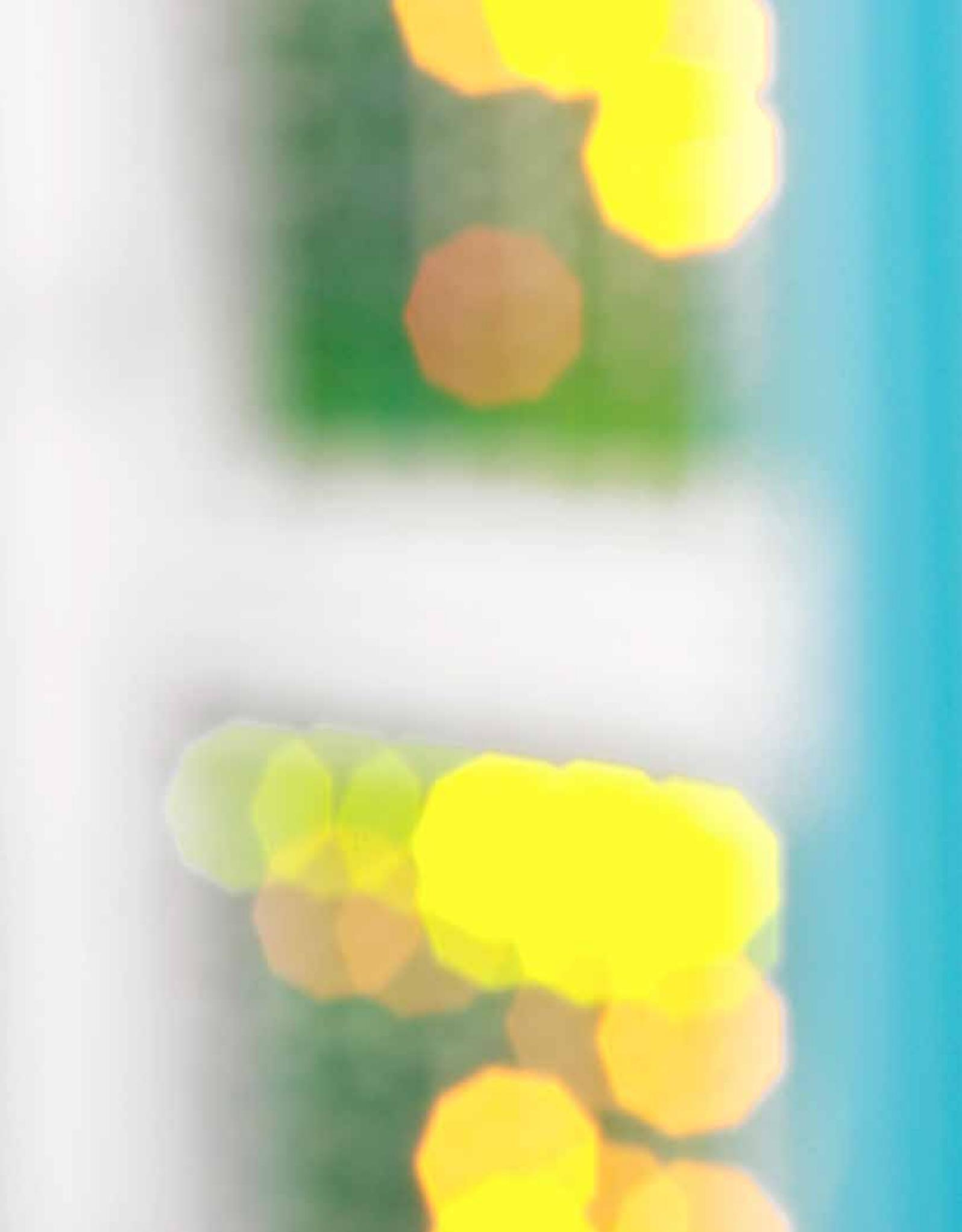
ifmo

Institute for Mobility Research

ICT AND PHYSICAL MOBILITY

State of knowledge and future outlook

Jacek Pawlak, Scott Le Vine, John Polak, Aruna Sivakumar, Johanna Kopp



This document summarises the results of a baseline study on the future perspectives of ICT and physical mobility.

This research was sponsored by the Institute for Mobility Research (ifmo) and conducted by Imperial College London, UK.

STUDY PARTNER:

**Imperial College
London**

Imperial College London
South Kensington Campus
London SW7 2AZ
United Kingdom
tel: +44 (0)20 7589 5111
Webpage: www.imperial.ac.uk

Design: Bernhard Moosbauer, www.exsample.org

© Copyright 2015 ifmo

Foreword

Since the 1980s, transport professionals have been tackling the issue of how information and communications technology (ICT) affects physical mobility. Thirty years on, the Internet and mobile devices that access it form an integral part of our everyday lives. ICT is continuing to revolutionise the way we shop, and social networks make it more possible than ever before to be connected to people in all corners of the world.

One thing is clear: ICT is a moving target. Empirical transport research can barely keep up with present-day technological and commercial developments. By the time it is published, travel data is close to being obsolete, referring as it does to the world of a few years previously.

Meanwhile, the availability of smartphones - and with them of mobile Internet use - has increased dramatically. The growing proportion of activities carried out online, together with the easier provision of travel-related information - which in turn enables better real-time assessment of transport alternatives - has great power to change travel behaviour.

This baseline study maps the current situation and provides a conceptual framework for understanding the interactions between ICT and physical mobility. It also raises another question: how will ICT influence physical mobility in the future? Discussions undertaken with experts, and with young adults, give indications about likely developments to come and inform the setting of priorities for further research.

Prof. Kay Axhausen
ETH Zurich
Chairman of the ifmo Board of Trustees

Executive Summary

Information and communications technology (ICT) is rapidly evolving and is penetrating more and more aspects of people's everyday lives, including how they travel. This study establishes the current state of knowledge regarding the relationship between ICT and physical mobility, and gives specific guidance for avenues of future research. To address these objectives, we first conducted a detailed review of the academic literature, followed by a Call for Evidence, an Expert Workshop and two Young Adult (Teenage) Workshops.

We identified five distinct yet interrelated themes around which the discussion in this report is organised. We recognise that the state of knowledge is advancing very quickly in this area of research, and at present the field is characterised by many theoretical, methodological and empirical challenges. Commercial decisions and policy measures relating to ICT and physical mobility must therefore be made with explicit recognition that the current state of knowledge is continuously evolving and sometimes fragmentary. Notwithstanding these limitations in the available evidence, the following conclusions can be drawn:

- **Will the need for physical proximity (and hence travel) continue to exist?**

Despite the growing sophistication of ICT, the need for activities undertaken in physical reality, and hence the requirement to travel, appears likely to continue. Nevertheless, time-use patterns and the way people organise their lives will continue to evolve as ICT becomes ever-more deeply integrated within people's routines.

- **Does increasing use of ICT lead to changes in mode choice and car ownership decisions?**

The role of ICT in people's mode choices (e.g. bus, car, walking) and in car ownership appears to be, at most, secondary. Classical considerations such as prices, travel time, reliability, convenience, and prestige appear to persist as dominant factors in these decisions.

- **Is time use and travel planning becoming more spontaneous?**

ICT appears to provide scope for quicker, more accurate and more personalised travel arrangements, rather than making time use and travel planning more spontaneous. Furthermore, there is evidence of individuals relying on portable ICT to adapt their travel plans during travel disruption.

- **Will disparate social groups follow the same pathway of ICT/mobility interactions?**

The mechanisms through which ICT and physical mobility interact appear to vary between different demographic groups and from country to country. Developments in ICT can therefore be expected to have unique consequences for physical mobility specific to various socioeconomic, cultural and geographical contexts.

- **What will become of concerns regarding privacy implications?**

Privacy is increasingly relevant to the sphere of ICT/physical mobility relationships. People appear to understand that significant benefits can be derived from voluntarily sharing personal details and preferences. It is unclear whether the typical consumer is fully aware of the amount of economic value they are voluntarily donating, and how ICT services would adapt if this willingness to share were to change.



Introduction

The desire to acquire, process and communicate information is one of the most basic elements of human behaviour and social organisation. Technologies that enhance these capabilities have therefore always been amongst the most powerful drivers of behavioural and social change, from the Babylonian abacus to Twitter. What is exceptional, however, about current developments in ICT is their pace and ubiquity - we have already reached a point where few aspects of our lives are not penetrated by the influence of ICT. This is reflected in the continually growing penetration of the Internet (Figure 1) as well as the proliferation of mobile phones and the growth in their capabilities (Figure 2). In the latter case especially it is evident that despite high penetration of such technologies, there is still a significant scope for growth, especially among the developing countries.

A somewhat separate issue is to do with the direct incorporation of new types of ICT into transport network management. The latter is of great interest to transport researchers, and the implications remain far from a settled matter. For the purposes of this study, however, it was decided to specifically exclude these types of ICT from consideration, and to focus instead on the impacts of consumer use of ICT for online activity participation. So, we did not consider, for instance, ICT that makes it easier to manage a road network (e.g. real-time video feeds or sensors), nor did we consider the consequences of self-driving (autonomous) automobiles. Such ICT raises genuinely important research questions, but they are not the focus of the present study.

This study was designed to investigate the impacts on personal mobility¹ that are attributable to people incorporating ICT into their lifestyles. We recognised the need for a holistic approach, drawing on the respective strengths of both qualitative and quantitative methods. We also recognised the need to take into account various contextual factors, such as the affluence of societies, the availability and quality of transport and ICT infrastructures, and attitudinal and cultural factors, which can all play an important part in shaping ICT/physical mobility relationships. Finally, this issue also has a multifaceted temporal aspect, as the dynamic nature of fundamental developments in ICT and also the way in which different generations of users employ such technologies both unavoidably affect the relationship they have with their physical mobility.

This report serves as a summary of the study - it seeks to convey the key findings, provide a synthetic overview of the state of the knowledge in the field, and present an outlook for future research. Thus we firstly give a brief background to the study's research, before moving on to a number of different thematic areas:

- **Will the need for physical proximity (and hence travel) continue to exist?**
- **Does increasing use of ICT lead to changes in mode choice and car ownership decisions?**
- **Is time use and travel planning becoming more spontaneous?**
- **Will disparate social groups follow the same pathway of ICT/mobility interactions?**
- **What will become of concerns regarding privacy implications?**

¹ In this context, we understand mobility as the 'ability to travel from one point to another' and 'actual physical travel'.

These topics comprise distinct yet interrelated research questions which emerged from the study. This is followed by a synoptic overview of the study and suggestions of possible directions in which future research might be pursued.

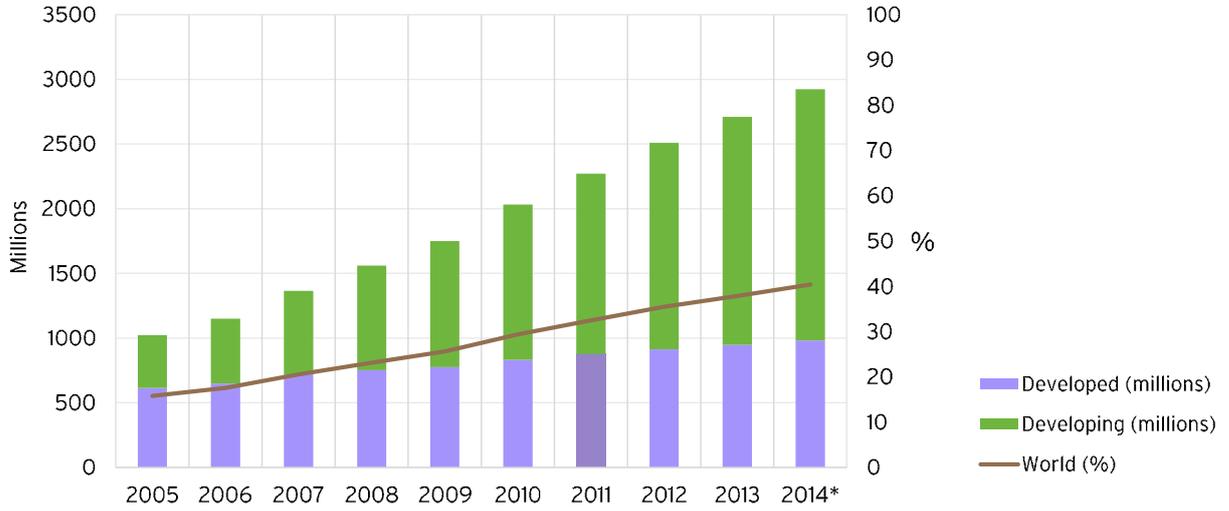


Figure 1. Individuals Using the Internet in Developed and Developing Countries (Total and Percentage, 2005-2014)

SOURCE: The World in 2014: ICT Facts and Figures (International Telecommunication Union).

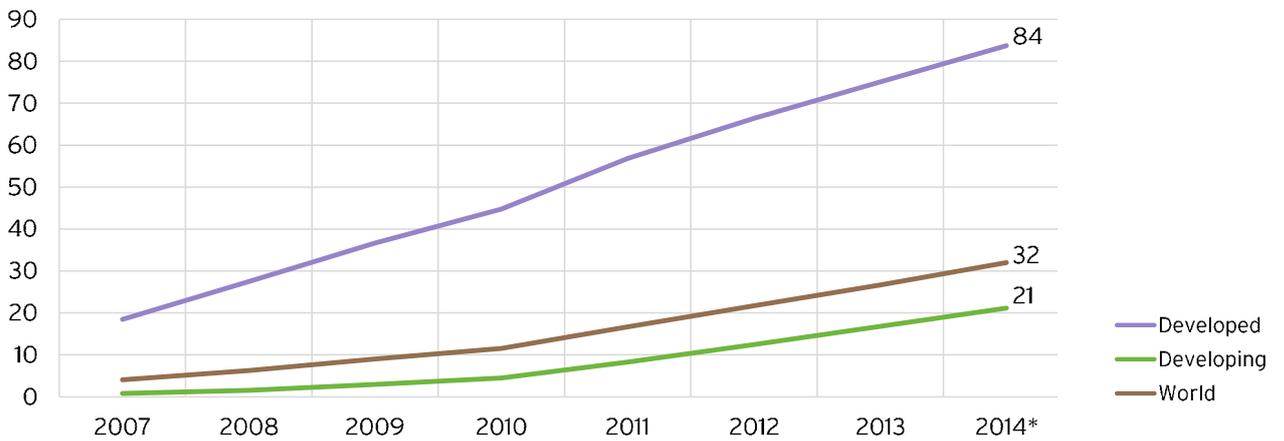


FIGURE 2. Active Mobile Broadband Subscriptions per 100 Inhabitants, 2007-2014

SOURCE: The World in 2014: ICT Facts and Figures (International Telecommunication Union).

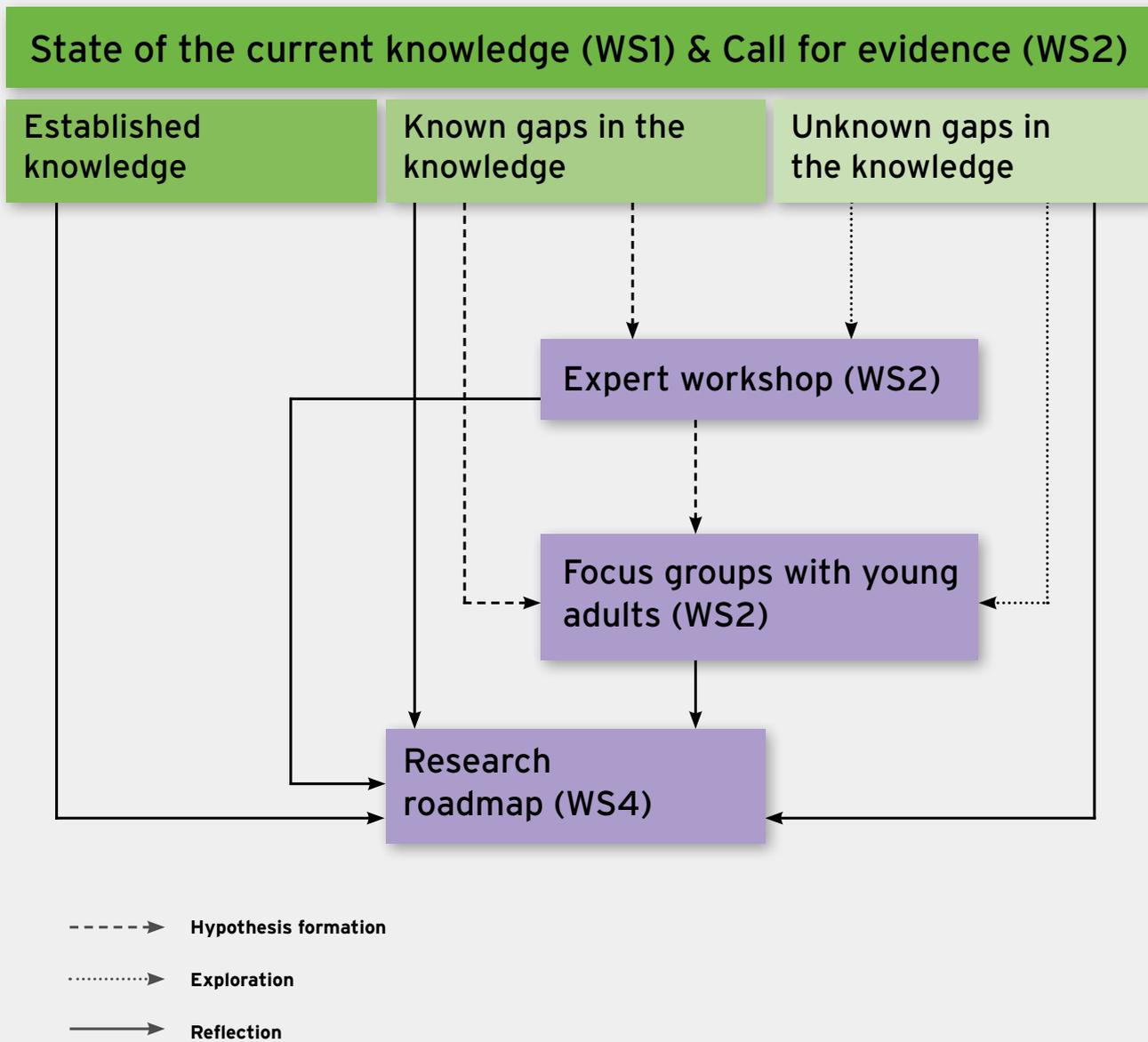


Figure 3. Structure of the project

SOURCE: Authors' representation.

In order to address these challenges, we structured the study into four work streams (WS), leading to a project structure that is outlined in the forward-looking research roadmap (see Figure 3). In particular, this study therefore consisted of the following lines of enquiry:

- **Work stream 1** involved investigation of the state of current knowledge, exploring the relevant scholarly literature which addresses the interaction between ICT and physical mobility. This was based on both published material in the public domain and 'grey literature' documents that were otherwise accessible to the research team (e.g. conference proceedings that are not formally published). This provided a means of establishing an awareness of the level of knowledge and confidence - or lack of confidence - about the relationship between ICT and physical mobility.
- **Work stream 2** focused on engagement with the current leading thinkers in the field through two mechanisms. Firstly, a Call for Evidence (CfE) was disseminated in spring of 2014 intended to bring in outside perspectives and recent research that goes beyond existing written sources. This exercise served to identify current research that has yet to proceed through the full publication life cycle. A total of 18 submissions were received in response to the CfE, which enhanced the scope of the published literature review. Second, following the CfE, we invited 15 recognised experts to a workshop. Participants included a combination of promising early-career researchers and distinguished leading thinkers; moreover, the attendees had a range of expertise in different fields of study (some within the transport domain, some outside it). The workshop provided an opportunity for participants to exchange views interactively regarding the impacts ICT is having, particularly relating to travel behaviour. The workshop followed a semi-structured agenda based on themes, as key issues of concern, that were identified during WS1 and the CfE.
- **Work stream 3** involved two workshops with a diverse cross section of young adults (between 16 and 20 years old) in the South East of England (one workshop in London and one in Brighton, a smaller city an hour outside of London)². In contrast to the Expert Workshop, these workshops comprised members of the public, and were designed with a different aim. We sought to understand the ways in which young adults relate to ICT, how they view the interaction of ICT with physical mobility, and how ICT and physical mobility fit into their expectations and aspirations for the future. We believe that having a grasp of these aspects of young adults' lives is key to understanding the possible future trajectories which the relationship between ICT and physical mobility may follow in the future.
- **Work stream 4** involved drawing from and reflecting on the results from the previous work streams in order to generate a roadmap for directing future research efforts.

² This piece of research was conducted with support from Social Research Associates, London.

Research Background

Understanding the implications of ICT for physical mobility requires, in turn, an understanding of how the two sectors are interrelated (Figure 4). Innovations in ICT can result from exogenous impacts (e.g. new technology) or from the identification of needs related to the way in which activities or travel are presently undertaken (e.g. inefficiently, too expensively, too unhealthily). Thus ICT innovations can lead to changes to the way that traditional activities are undertaken, e.g. in virtual as compared to physical reality, or in new places. ICT can also stimulate the emergence of completely novel activities that do not have physical-world counterparts, such as microblogging. Such changes in behaviour may then translate into impacts on physical mobility, in terms of (amongst other possibilities) the purpose, amount, cost, mode, or timing of travel. The new lifestyle thereby emerging may itself result in additional needs which in turn further stimulate ICT, creating a feedback loop.

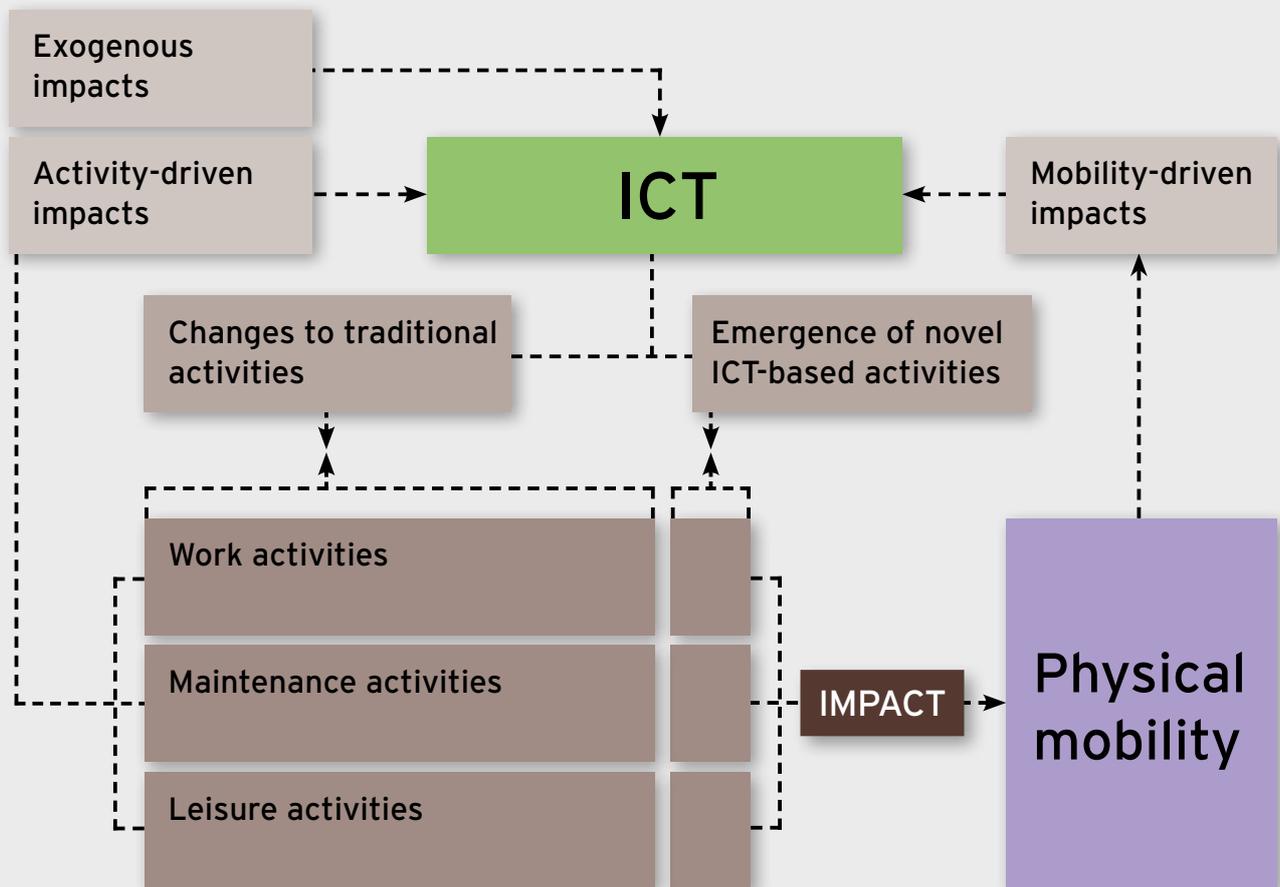


Figure 4. A Simplified Conceptual Framework for Understanding the Interaction Between ICT and Activity/Travel Behaviour

SOURCE: Authors' representation.

The structure depicted in Figure 4 is clearly a simplified view of what is a complex system of interactions. In an attempt to instil order within this rapidly growing field of research, early work by Ilan Salomon³ and Patricia Mokhtarian⁴ the latter of whom we were privileged to have both as a respondent to the CfE and a participant in the expert workshop put forward what has proven to be the seminal, and still authoritative, taxonomy of the relationships between ICT and travel behaviour, in terms of types and levels of interaction (Figure 5).

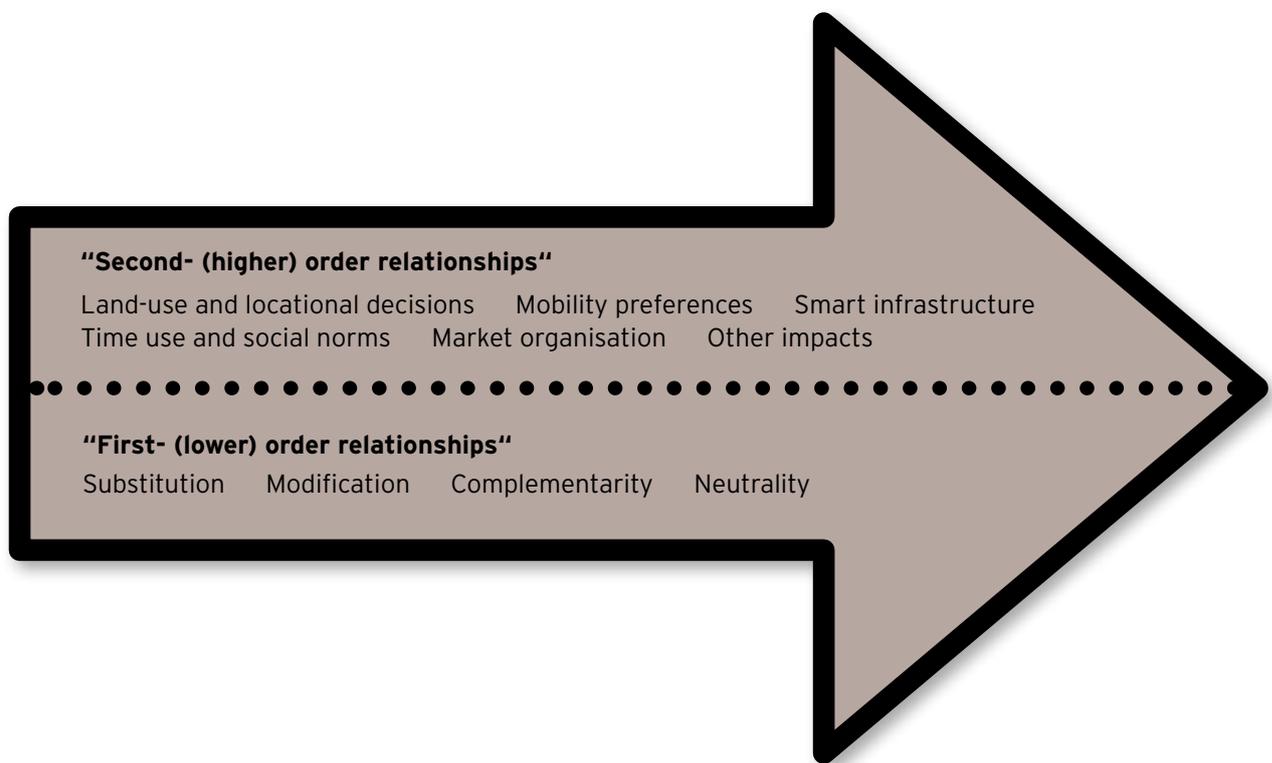


FIGURE 5. Different Levels of Interaction between ICT and Physical Mobility

SOURCE: Based on Salomon (1986) and Mokhtarian (1990).

³ Salomon, I., 1986. Telecommunications and Travel Relationships: A Review. *Transportation Research Part A: General*, 20(3), 223-238.

⁴ Mokhtarian, P.L., 1990. A Typology of the Relationships between Telecommunications and Transportation. *Transportation Research Part A: General*, 24(3), 231-242.

In the Salomon/Mokhtarian taxonomy, ICT/physical mobility interactions at the lower level (the first order) involve changes affecting specific journeys and the activities that motivated the travel. These include:

- **Substitution** - this is when an individual chooses to make use of ICT to conduct an activity (or, rather, its virtual 'tele-activity' equivalent) which results in a trip not taking place. As such interaction would result in some travel being eliminated, such a solution has long been desired as a panacea for traffic problems, especially congestion.
- **Modification** - this classically includes changes to trip timing (departure and/or arrival times), destination (e.g. choice of shop), mode of travel/route chosen, and range and productivity of activities which can be undertaken while travelling. It is also worth noting that (ICT-based) real-time travel information is strongly linked to the modification in travel patterns encompassed in this category.
- **Complementarity** (also generation) - this is a polar opposite effect to substitution, and refers to the generation of additional travel (additional trips) which would not take place without ICT. This may take place as a result of increased awareness of activity opportunities, leading to additional generated travel.
- **Neutrality** - this is a limiting case where none of the three effects occur, though depending on the interests of the stakeholder, one may wish to differentiate between pure neutrality, where no effect occurs, and net neutrality, where effects cancel each other out when aggregated.

The higher (second) level encompasses the indirect influence of ICT on other aspects of life that eventually lead to modified travel behaviour pattern. Such modifications include land-use and location-based (e.g. residential) decisions, changes in mobility preferences, emergence of smart infrastructure, changes to accepted social and professional norms (e.g. acceptance of remote work practices), market re-organisation and introduction of new business models (e.g. car sharing).

In general, the higher the level of relationship, the greater the inertia, and the longer the time interval before actual impacts take place (and are thus observable to researchers). In other words, substitution of a given trip can in principle occur instantaneously, whilst residential decisions would involve longer timescales, with societal changes possibly taking decades to fully express themselves.

The conventional wisdom expressed by many researchers in the late 1970s and 1980s was of electronic communication as a simple and convenient substitute for physical travel. This view has been quite resilient and can still be observed today in public discourse. Such an effect is most likely to be found when impacts are viewed narrowly or on a short timescale directly following an intervention (i.e. the introduction of an ICT-enabled teleworking scheme). This observation has been noted in some cases by journalists. That such a view can in fact be too narrow/short-term is exemplified by the experience of southern California, where following the introduction of compressed work schedules (which aimed to minimise the number of days that workers commute to their job) in the early 2000s, long-term monitoring found that people “drive like crazy” on their days off, negating the overall reduction in car-driving mileage that motivated the project in the first place.⁵

Most studies on interactions between ICT and physical mobility to date have concentrated on tele-activities, i.e. virtual analogues of real-life activities. This is because ability to undertake a particular activity without the need to bear the cost of travel (in terms of money, time and stress) has been argued to lead to changes in patterns of activity/travel behaviour. The conventionally identified tele-activities include tele-working and tele-commuting, tele-conferencing, tele-leisure, and tele-services. In the past years, this taxonomy has been under increasing pressure to accommodate instances of newer ICT-based activities which may themselves involve a number of conventional tele-activities – for example, social networking may include elements of tele-working, tele-leisure and tele-conferencing.

The available evidence is incomplete, is subject to structural limitations, and is far from being entirely satisfactory. However, we can conclude, based on the available data, that the naïve expectation that ICT is serving to replace physical mobility is unsupported by either theory or the empirical evidence in the public domain. Leading scholars demonstrate that, depending on one’s interpretation, the results are either indeterminate in their conclusions or tend to, on balance, refute this ‘replacement hypothesis’. The exact nature of the relationship typically depends on the specific instance of ICT and the prevailing travel conditions of the physical mobility, contextual factors such as institutional flexibility in employing ICT-based forms of interaction, individual preferences and skills, and the available infrastructure. In view of this, interactions rarely take place in isolation from one another: the stream of evidence emerging from studies which examine such relationships simultaneously, using (for example) structural equation modelling, points towards the existence of dynamic – and possibly intractable – complexities which are the explanation for the ambiguities in this field.

Being mindful of the nature of the empirical evidence available, we identified the key challenges which ought to be considered when drawing conclusions and making business and policy recommendations. We recognise that the value of explicitly identifying these challenges lies not only in enabling a critical assessment of the existing knowledge, but also in guiding research strategies towards more complete results concerning specific aspects of interaction between ICT and physical mobility:

⁵ Bae, C.H.C., 2004. Transportation and the Environment. In: Hanson, S. & Giuliano, G. (Eds.). *The Geography of Urban Transportation*, 3rd edition. Guilford Press, New York. P. 356-381.

- **Causality issues** - it is frequently taken (explicitly or implicitly) that it is the adoption of ICT that influences physical mobility. The early studies were, arguably, justified in doing so given the early stages of ICT developments and their low penetration into the lives of the populace. However, in the age of omnipresent ICT, its adoption might be motivated by travel conditions, in which case the direction of causality is either reversed or bidirectional. Such instances have, to date, been comparatively underexplored despite potentially far-reaching implications for the results of data analysis, and hence for the conclusions drawn and recommendations made. In addition, the majority of studies have been based on cross-sectional datasets, which do not provide as rich information as datasets collected over time (from longitudinal studies) during which the precedence of ICT adoption or travel behaviour can change, and hence the direction of causality could be determined more robustly.
- **ICT as a moving target** - given the fast pace of changes in the ICT sector, the use of generalising terms such as 'ICT' may be misleading. Clearly, the technologies of the mid-1990s and mid-2010s possess different capabilities and are, moreover, available to different segments of the population. The question arising, then, is about the extent to which yesterday's research results are valid for use as a reference for future investigations.
- **Measurement** - one issue associated with defining ICT is how it can be delineated in such a way as to capture the aspects of behaviour that are most relevant to studies looking its interactions with physical mobility. Is it frequency of access of social media, or total time spent on it, that is the relevant metric? Should the measurement take place over a day, a week or a month? How should one define metrics which can be applied to the population regardless of the available technology, so that data can be collected robustly over time?
- **Context specificity** - the majority of the studies examined were conducted in specific contexts, be they economic, geographical, occupational, or cultural. As a result of the comparatively low number of cross-national studies seeking to understand the extent to which such results are transferrable from one nation to another, the results are rarely readily comparable. Last but not least, the context-specificity implies that broad generalising statements may not be justified.

“[There is] empirical evidence of [an] increasing degree of user-selected (not pervasive) ‘reachability’ via mobile phones; reachability correlates positively with both professional and [gendered] family responsibilities”

ANNE AGUILÉRA
Université Paris-Est, IFSTTAR, LVMT, France

“We find that possession and use of ICT are strongly associated with fragmentation of paid work; ICT represent[s] highly differentiated categories of devices and services, and [the] effects of each technology should be examined separately”

ERAN BEN-ELIA
Tel Aviv University, Israel

ALISSA D. TOLSTOKOROVA
Independent Expert in Gender Issues, Ukraine

“There is increasing recognition [in the scholarly literature] of the importance of ICT as an essential element of transnational familial relations. Scholarship emphasises technology’s positive role in maintaining connected relationships, and even virtual intimacies... [however] ICT [is] not always helpful or reliable, especially in [an] emergency”



Main Questions

Will the Need for Physical Proximity (and Hence Travel) Continue to Exist?

Background

As more and more ICT functionalities become increasingly elaborate in their ability to deliver the virtual equivalents of physical activities, simple extrapolation may suggest that travel will ultimately disappear altogether. However, ICT and physical mobility have also been identified as complementary, for instance when ICT provides more detailed information regarding social and leisure opportunities and hence travel increases. This interaction suggests that whilst the need for travel will always remain, its purpose, mode, or timing may change as a consequence of ICT.

Experts' Views

The experts anticipated that activities which are not inherently enjoyable will be those that people seek most keenly to replace by means of an ICT equivalent. Such activities may include visiting a bank, perhaps seeing a doctor, dealing with governmental authorities, and even doing non-leisure ('maintenance') shopping. Work was expected to remain an essential component of activity/travel behaviour, but it is expected to become less clearly defined in terms of both space and time (a phenomenon known as fragmentation). As a result, the question was raised of the quality of such arrangements in terms of both productivity and well-being of employees.

The experts also emphasised that much of the research to date had involved efforts to investigate work-related activities - and their relationships with increased ICT use. Non-work activities have, on the other hand, received less attention. This is despite them accounting for a significant proportion of everyone's daily time and in particular of their ICT use. The conclusion that appeared to emerge from the debate was that since activities which are not pleasant are most likely to be those for which ICT will substitute, the associated travel will diminish too. At the same time, travel for 'pleasant' purposes may increase. Yet it was felt that the awareness of new leisure opportunities (enabled through ICT, e.g. social networks) may stimulate leisure travel.

Young Adults' Views

During the focus groups, the participants were asked to indicate which social and economic trends they expected to prevail in the future; the results are shown in Figure 6. The evident trend is that individuals identified the need (or requirement) to travel in parallel to the possibility of flexible work arrangements (working from home, working while travelling, working from a local business centre, etc.). This is because young people recognise the need for face-to-face contact with their peers, and consider ICT-based contact

as supplementary to real-world relationships, rather than a substitute for them. People will also be more independent in terms of working alone or relying on self-employment, and hence their travel patterns may become less stable than the historical morning and afternoon commuting travel patterns. Interestingly, the participants thought that ICT skills would be essential in achieving success in their future professional careers, and a number of people mentioned already employing social media for their professional development. While the skills gap was not a concern for the participants, they have admitted the possibility of prolonged levels of high unemployment, and the later initiation of a professional career, owing to the need to acquire further skills. Only a few participants expected to see early retirement and part-time job opportunities become more prevalent.

Conclusions

The need for activities that require one's physical presence at particular places appears likely to remain, regardless of the degree of sophistication of ICT. However, ICT is being incorporated increasingly into everyday practices, leading to changes in time-use patterns and lifestyles that are more varied.

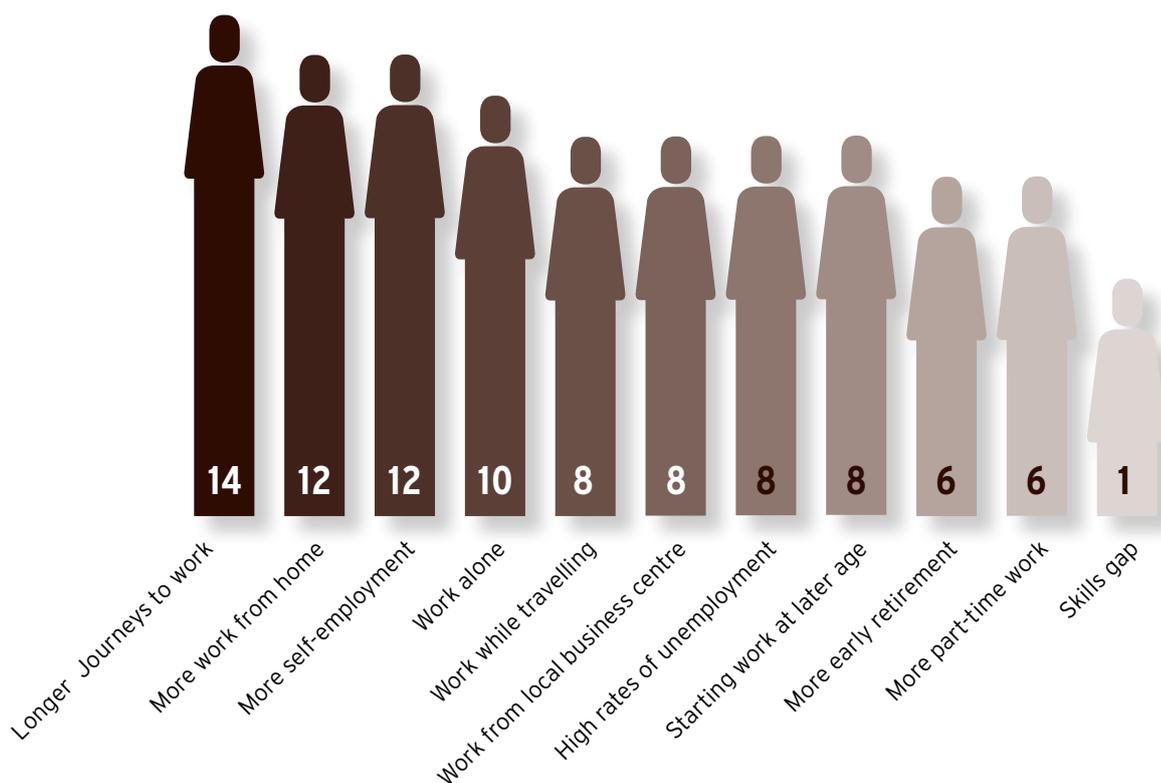


FIGURE 6. Support for Future Social/Economic Trends among the Focus Group Participants (out of 20)

SOURCE: Authors' representation.

*
"I think people will work further away, travel longer to work, but not go so often."

*
"The working day will be counted from when you leave home not when you get to the office."

*
"I wouldn't want to work entirely remotely - it's important to meet people face-to-face."

*
"My mum and I do car boots and fairs, and we use Twitter to tell people where we're going to be each month."

*
"I use Facebook a lot to recruit people for festivals and clubs - I've got three different accounts, depending on the group profile. It's building to more than a part-time job."

*
"You have to go to college sometimes but not as often - what with Skype and so on. The problem at the moment is that teachers want to control you - how you dress and so on - which they can't do if you're not in college."

"An ICT development that improves [electronic] connectivity could reduce the need for physical mobility. However, there is limited evidence for this shift - there is much wishful thinking, but in reality the stubbornness of congestion and driver numbers suggest these new solutions might not yet be responding sufficiently to the needs of people who drive"

"ICT is having a significant effect on the manner in which travel time is perceived"

ERAN BEN-ELIA
Tel Aviv University, Israel

PAUL MINETT
Ridesharing Institute, USA
MARCO SCHAEFER
Erfurt University of Applied Sciences, Germany

Does Increasing Use of ICT Lead to Changes in Mode Choice and Car Ownership Decisions?

Background

The classical assumption prevailing in the field of transport research and appraisal is that of 'empty' travelling time which is lost. This vision has been underlying the struggle for reductions in travel time by finding speedier modes. However, the use of time for productive and/or enjoyable purposes is a hardly a new phenomenon - the time spent on a journey has always been used to do something, whether that be sleeping, reading a newspaper, meeting someone or dealing with paperwork. The arrival of modern ICT has, however, extended this phenomenon by providing travellers with unprecedented portability of computing resources. The set of activities that can be undertaken while travelling has been greatly widened.

This recognition that time spent while travelling is, at least in certain circumstances, a potential source of utility (or at least a reduced rate of marginal disutility) has stimulated claims that ICT may even be responsible for shifting modal preferences, and hence lead to changes in ridership across various transport modes. For example, it has been argued that provision of wireless Internet on board public means of transport may make people use such modes more, and reduce their use of the car. At the same time, the emergence of the autonomous vehicle (AV) concept creates a specific hybrid environment enabling public-transport-like use of travelling time while retaining the intimacy of private vehicle.

An interrelated hypothesised effect of ICT has been seen in the relative deceleration or stagnation in the demand for car travel in developed countries, termed the 'peak car phenomenon'. This view sees adoption of ICT as one of the most important drivers for this trend, including the (negative) impact of ICT on driving licence acquisition. Whilst a number of studies have failed to identify empirical support for such a claim, the debate regarding car ownership and travel behaviour in our increasingly digitised world is ongoing, with the emergence of autonomous vehicle technologies further complicating the picture.

Experts' Views

The experts identified developments in vehicle automation and the ability to engage in car sharing as the two most important determinants of the future of car ownership and travel behaviour. The possibility of mass ownership of AVs was seen as potentially facilitating an increase in the traffic-moving capacity of existing networks on the one hand, while on the other being likely to stimulate traffic growth, which would be in opposition to the usual aims of policies that promote public transport in urban areas. Participants noted that AVs may turn out to represent a hybrid between the intimacy and freedom of a private vehicle and the environment afforded by fixed-route public transport, but with less personal freedom of mobility than car driving currently offers.

The experts acknowledged that ICT-enabled use of time spent travelling had been an important trend towards improvement in the quality of journeys. In terms of the productive use of travelling time in AVs, the experts expressed the view that transport researchers had widely assumed this to be characteristic of certain public transport modes, notably rail services, but not applicable to car driving. In view of this, the proposition discussed was that of the AVs constituting an exchange of freedom: by giving up the opportunity to drive (and the very high degree of freedom of mobility which that entails), one acquires more freedom of time use. The prevailing view among the experts was that the popularity of AVs would ultimately hinge on (presently unknown) personal preferences, unless top-down policies are implemented which would seek to achieve optimal performance of the network by requiring that all vehicles be autonomous. In the latter case, however, concerns about civil liberties, were indicated by the experts as areas requiring attention in the years to come.

With respect to car-sharing services, participants' views differed widely regarding the extent to which they can and/or will accept substitutes for car ownership, i.e. access to a car versus ownership of one. There was, similarly, no consensus regarding whether car sharing should be seen as means of relaxing the current limitations of car-based transport, or rather increasing the efficiency of the existing supply of automobiles. This was seen as an important point by the experts, who felt that whilst these two views may in fact be different manifestations of the same underlying phenomenon, political or public perception of increased motorised supply versus increased efficiency could significantly differ.

Young Adults' Views

Among the focus group participants, walking and bus were the most frequently reported modes - partly on the grounds that they are low-cost. Car travel was generally undertaken as passengers - mainly driven by parents. Regarding the use of ICT, listening to music was seen to be a positive aspect of all these modes, especially for walking. The participants also saw provision of free-to-user Wi-Fi on urban buses and inter-city coaches as substantially increasing the attractiveness of such modes. However, such on-board amenities were viewed as second-order considerations that augment rather than replace traditional concerns about journey times and increases in ticket prices. In addition, the participants complained about the poor reliability and low bandwidth of such services, which could limit the scope for ICT use.

Only one participant in the focus groups reported usually travelling by driving a car, whereas all others travelled as a passenger. Even amongst participants holding driving licences, access to a car was only occasional as the vehicles were used by the parents on a daily basis. The participants were also aware of possible safety implications resulting from using ICT while driving or riding a bicycle.

To explore the participants' future aspirations for the desired kind of mobility in reference to car, the young adults were asked to indicate their first preference out of six vehicle types: a modern premium limousine, a classic 1960s microbus, an older inexpensive car (described in the question as an 'old banger' - a colloquial term), an upmarket bicycle, a 'smart car', and a motorbike. Overall, the most popular preference (with 8 responses out of 20) was for an older inexpensive car. Participants in the Brighton workshop were more likely to get 'something [a car] affordable' in the near future, while those in London were more willing to buy a more expensive car, accepting the trade-off that such a purchase would be further into the future for them, because of the cost. Nevertheless, the use of ICT was never mentioned as a first-order, explicit motivation for reducing or refraining from car-based travel.

Conclusions

ICT appears to play, at most, a secondary role in choices of transport mode and car ownership. Classical considerations such as prices, travel time, reliability, convenience, and prestige appear dominant in mode choice and car ownership decisions



*
"If I had a car I'd want it have character - but overall I'd rather have a nice place to live."

*
"I don't like travelling in the car with parents - they can look over to see what you are doing on your phone or listen to your conversations."

*
"When I'm walking around I can rely on a signal more than driving in cars or on the train. I don't mind walking a long way now as long as I've got music and contact."

*
"I wouldn't judge someone by their car - I'm more interested in what networks they use and the music they like."

*
"Trains are bad for reception so I tend to prefer buses. It's not fair that trains only provide Wi-Fi in first class."

*
"I went to Cornwall in the coach and they had Wi-Fi all the way - it was brilliant."

*
"I cycle occasionally but my parents insist I can't take my phone if I do and I guess they're right - you shouldn't wear headphones and cycle so I prefer to walk or go by bus."

"ICT has the potential to considerably modify the space-time constraints of physical mobility and human activities... ranging from longer-term decisions such as migration to everyday shorter-term decisions on activity engagement."

GIOVANNI CIRCELLA & PATRICIA MOKHTARIAN
Georgia Institute of Technology, USA

Is Time Use and Travel Planning Becoming More Spontaneous?

Background

An additional hypothesised effect of ICT on physical mobility concerns changes to activity planning horizons. Given the spatio-temporally flexible nature of ICT-enabled activities, individuals, it is argued, no longer require to plan to the extent required by physical, spatially separated activities which involve travel and, sometimes, coordination with others (for example in terms of the need to be together, or for vehicle use). The ability to coordinate with others in real time may also translate into increased willingness to alter prearranged schedules and adapt them to constantly changing circumstances. Thus, the expansion of the on-the-spot choice set of (tele-)activities enabled by ICT may make the trips not only more spontaneous and unplanned, but also mean their constant evolution in terms of purpose and character. This is because individuals could try to accommodate emerging activity opportunities as well as adapt to unforeseen circumstances such as travel disruption on the go. Overall, the phenomenon appears to imply an increase in multipurpose and non-home-based trips, perhaps requiring a shift from transport modelling that relies on the assumption of symmetrical, pre-planned, home-based trips as the building block of models, towards modelling based on tele-activity and multitasking-inclusive activities.

Experts' Views

The experts acknowledged the increasing value, and therefore importance, of the growing 'smartness' of ICT enabling the provision of increasingly personalised information, leading to better choices - i.e. either cost-effective, or perhaps if not cost-effective then providing value in other ways. While the inevitable consequence of such growth in personalised services is demand for data, the experts pointed out that much of it is already being generated, in some cases made available through 'open data' policies. However, such information tends to be fragmented, superficial, and frequently rather difficult to analyse via traditional quantitative methods. It was thus felt that researchers or service providers are as yet merely scratching the surface in terms of leveraging big data to understand human desires and behaviour. The implications are firstly that a new generation of techniques for data enrichment through consolidation or pattern recognition methods is required, and secondly that incorporation of user feedback in understanding people's desires will be a crucial aspect of this new 'big data world'.

Young Adults' Views

Most workshop participants claimed to use ICT for the purpose of travel planning. In addition, the ability to access travel directions and other context-sensitive travel information as needed - both before and during travel - was seen as both convenient and reassuring to the participants. Unsurprisingly then, in the discussion there was no clear distinction between planning journeys in advance and replanning during travel. When disruption occurred, the ICT provided confidence in being able to quickly and successfully adapt their plans. At the same time, all participants admitted that the degree of pre-planning would normally depend on the purpose, with more formal and professional career-related travel being carefully planned as opposed to more spontaneous social and leisure-related activities.

Conclusions

ICT appear to provide scope for quicker, more accurate and more personalised travel arrangements, rather than making time use and travel planning more spontaneous. Furthermore, there is evidence of individuals relying on portable ICT to adapt their travel plans during travel disruption.

*
"Next Bus is brilliant - I can leave home literally a minute before the bus is due."

*
"I must admit people get too dependent on satnavs - my mum once drove completely the wrong way just because that's what her satnav was saying."

*
"I'd be literally lost without [Google] Maps - I use it all the time whenever I go anywhere outside Brighton."

*
"Once the trains were held up and the announcement at the station was wrong about what was happening, so I tweeted the train company and told them."

*
"My friends texted to say they'd gone to a different club so I changed trains at East Croydon instead of going to Victoria."

*
"I registered my journey in advance and they sent me a text to say the train was delayed, so I went by coach instead."

*
"I had an advance cheap ticket to Manchester, but when I got to Euston the trains were cancelled so I found out (via phone and website) I could go by coach instead; but I didn't have enough money and I couldn't get an immediate refund at the station."

“Finland’s National Information Society Strategies [1995, 1998 and 2006] do not fully take into account the human and social aspects of the information society”

SAKARI TAIPALE
University of Jyväskylä, Finland

Will Disparate Social Groups Follow the Same Pathway of ICT/Mobility Interactions?

Background

The studies exploring the relationship between ICT and physical mobility are frequently placed in very specific geographical and occupational contexts. This constraint immediately raises the question of the extent to which such context-specific results are applicable under conditions different from the original ones. For instance, can research on the use of ICT in relation to the travel needs of a skilled professional operating in a knowledge and service-oriented economy be used as a reference point for exploring the implications of ICT-oriented policy for the travel behaviour of a manual worker in an industrial economy? In addition, the knowledge regarding what trajectories such relationships may follow is almost non-existent, despite a considerable amount of empirical studies spanning more than three decades. A similar set of questions could be asked of the transferability between various segments of population, especially when one of the segments is one frequently seen as more vulnerable to exclusion - disabled people and ethnic minorities would be examples.

Experts' Views

The experts have noted that many technologies today thought of as futuristic are in fact already available, albeit not widespread. In addition to supply-side constraints, the pace of adoption of such not-yet-widespread ICT is strongly influenced by preferences and perceived benefits, intentions and costs - in a word, the demand side. Certain segments of users are either unable - or strongly unwilling - to adopt many technological solutions. The existence of this population segment raises important policy and ethical issues, such as whether, and if so under what circumstances, it is appropriate to encourage inclusion, or even to include by default while giving users the choice to opt out.

The debate that emerged regarding this issue was illustrated by the tension between the exponential curve (apparently) describing technological advancement, and the classical S-shaped curve of consumers' adoption of product innovations. In this sense, the ultimate answer was expected to depend on the extent to which the current pace of technological innovation, both supply- and demand-driven, can be maintained. Whilst limits to ICT systems' evolution were seen as being plausible at some future time, they were not seen as a limiting factor within short- or even medium-term timescales.

Participants acknowledged that there are likely to be very substantial differences in the nature of the relationship between ICT and physical mobility when the specific national, regional, or even local context is varied. Such differences may in principle arise from various factors, including spatial conditions (e.g. degree of urbanisation, urban form), traditional preferences for specific forms of mobility (e.g. automobile culture

in the USA, public transport in Europe, cycling in China) and specific regulations (e.g. Saudi Arabia's ban on driving licence acquisition for women). In the case of Saudi Arabia, ICT was seen as a medium through which greater freedom of physical movement may someday be pursued via ICT-organised campaigns. The importance of freedom of action on the Internet was further emphasised by a recent research outcome from the Netherlands which indicated that young people value online freedom more highly than freedom of physical movement.

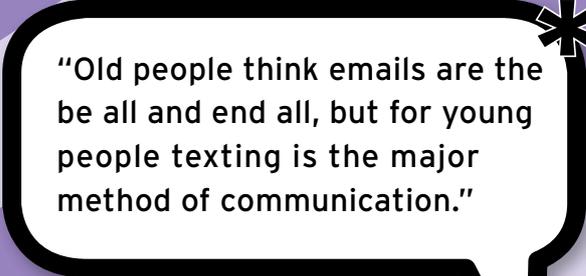
The experts were of the opinion that developing countries will not necessarily follow the same trajectory of ICT/physical mobility interaction as Western societies have, because they may skip certain generations of technologies. An example of this is cheap-to-construct mobile telephony networks being built in places where landline networks have never existed (e.g. parts of sub-Saharan Africa), and where transport infrastructure may be of poor quality. In such cases, ICT infrastructure may simply provide connectivity which has never been delivered by transport infrastructure in the first place. The overall conclusion was that whichever relevant insights may be applicable across societies, the findings and experiences from individual places, regarding ICT and physical mobility interaction, are likely not to be directly transferable to other contexts.

Young Adults' Views

The discussion of young adults in this subject area focused on the intergenerational differences in the relationship between ICT and physical mobility. The participants acknowledged that their parents or grandparents felt considerably less confident in using ICT than the participants themselves; this applied also to the ability to use mobility-related tools such as maps or navigation. At the same, the participants felt very reliant on technology and would be almost unable to function without access to their devices.

Conclusions

The ways in which ICT and physical mobility influence one another seem to differ between different demographic groups and from country to country. Future developments in ICT will thus probably lead to distinctive consequences for travel depending on the specific socioeconomic, cultural and geographical contexts.



*
"Old people think emails are the be all and end all, but for young people texting is the major method of communication."



*
"My granddad sent me an email and wondered why I didn't see it for four days. He thinks he's so trendy sending emails."

“Supporters of the ICT/physical mobility substitution theory wrongly assume that the pool of social practices and needs remains stable”

PAWEL BUGAJSKI
Mott MacDonald, UK

What Will Become of Concerns Regarding Privacy Implications?

Background

Given the growing penetration of ICT into lifestyles, significant interest has emerged among researchers and policymakers about the willingness to disclose personal information such as preferences, location, or current activities. Some evidence has emerged that age may considerably affect attitudes and practices, with younger generations being more willing to reveal what would traditionally be seen as private data in exchange for personalised services, including those related to physical mobility.

Experts' Views

The implications of the ability of ICT to track and monitor in real time, with a high degree of precision, and also frequently without awareness of the user, were seen as key areas of potential concern. Such technologies were seen as being able to increase the degree of safety (e.g. by ensuring more accurate navigation regardless of external conditions), efficiency (e.g. via improved monitoring and operation of ship/plane/lorry-driving, or quicker incident response) or security (e.g. through video surveillance, or RFID [radio-frequency identification] technology). Hence an important aspect of designing such services will increasingly be to make productive use of high volumes of passively collected data and to communicate clearly to end users the potential benefits; therefore, in this view, devising and providing suitably structured incentives is a forthcoming challenge for transport-related apps. However, it was considered to be uncertain whether members of the public are in general aware of the commercial value of information they possess, provide, and exchange.

Young Adults' Views

The participants were presented with a hypothetical scenario (see Textbox 1) and were asked to reflect on the potential benefits and concerns brought by various ICT-based tools related to physical mobility. The reaction to this scenario was general interest in some of the apps that would enable such collaborative working. There was, however, concern about the safety and security of collaborative (shared) travel, though we noted that the Brighton group were more likely to trust collaboration within the locality.

On the more general question of privacy, many participants did not realise the extent to which their ICT use was monitored and used by external parties. However, when this information was communicated to the participants, many felt that it was inevitable and that the benefits were likely to far outweigh any disadvantages. Still, in general they were rather unconvinced by the supposed advantages of receiving personalised and location-specific offers based on their personal data.

Conclusions

Privacy is increasingly important to the sphere of ICT/physical mobility relationships. People appear to recognise that they can derive significant benefits from voluntarily sharing personal details and revealing preferences. Yet it is still ambiguous whether the typical consumer can accurately estimate the amount of economic value they are voluntarily providing, and how ICT services would adapt if this willingness to share were to change.

Scenario

Elizabeth is studying to be a nurse and works part-time at a department store. She gets around mostly on trains and buses, but when she works late she hails a ride-sharing service on her smartphone, because she's had trouble on public transport late at night.

About once a month she hires a car from a car club (using her smartphone to make the reservation and to help her find the nearest available car), and drives to spend the afternoon with her granny in Essex. With the costs of insurance and maintenance, there's no way she could afford her own car. When she drives she uses an app to tell her how to avoid traffic. She also uses a ride-sharing service to find a lift with another driver for festivals via a social network page of a folk festival group.

Elizabeth also has trouble sleeping and wears a wristband that measures her heartbeat. She uploads this data to the Cloud. She also gets texts from a clothing store when she is passing its outlet.

Last year when she was not studying, for several weeks she did odd jobs through an online marketplace for micro-job outsourcing. She listed her skills on their website, and people would contact her when they needed something done sometimes spontaneously, such as picking up groceries, cleaning or dog-walking. She made about £100 a week during time that would otherwise just be wasted.

She has a formal reception to attend in several weeks' time. She could never afford to buy the expensive gown and handbag that she wants, so she is thinking of renting them from one of the online accessory-sharing services.

She knows that some of these apps use her smartphone's GPS to see where she is all the time and that other shared information is not totally secure, but she feels that the benefits outweigh the risk.

Textbox 1. Privacy Scenario Presented to the focus group participants

"I'd be wary of travelling with strangers, especially just them and me in a car. Also they might be really boring and you'd have to talk to them all the time."

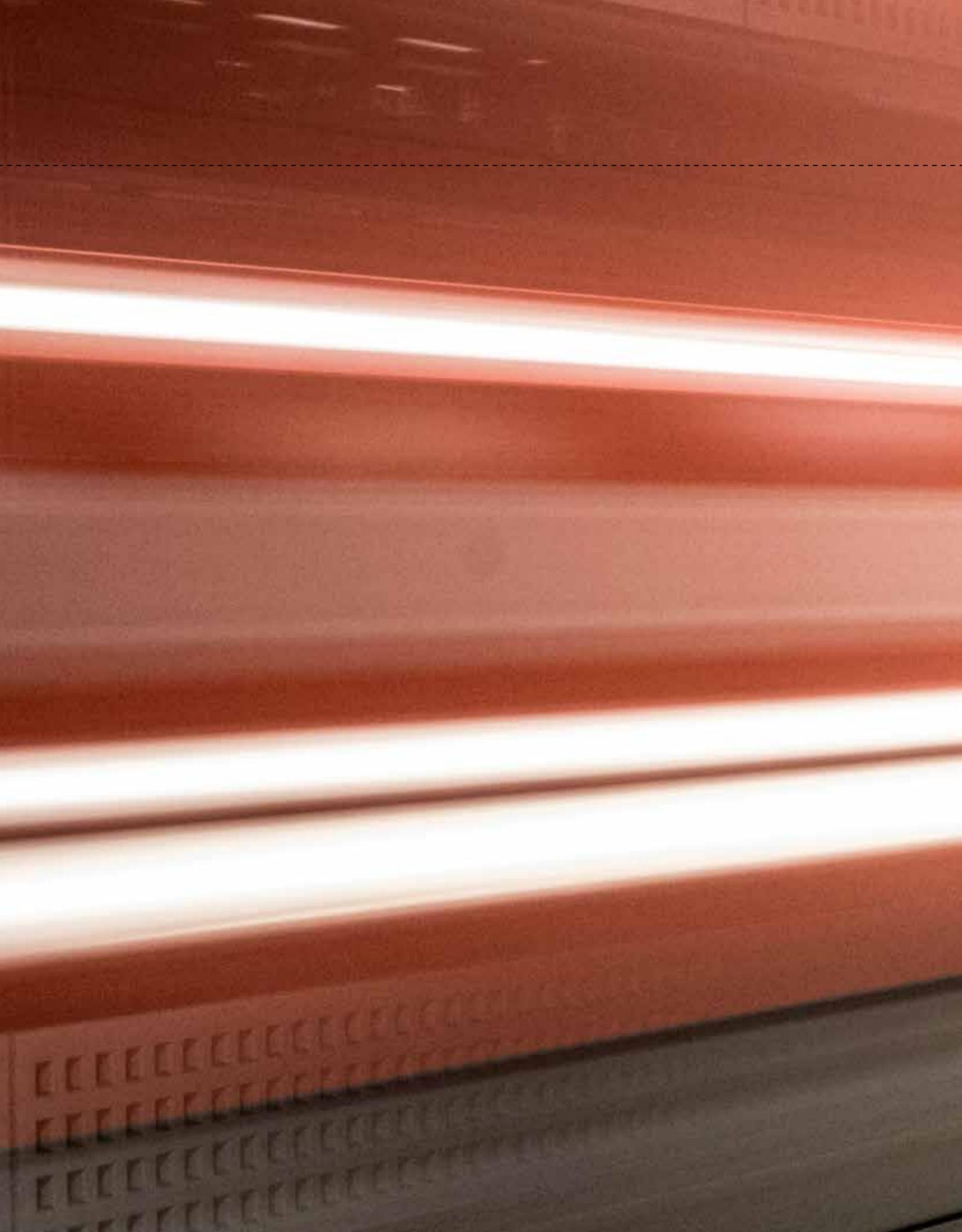
"It's a recipe for creeps."

"I can see sharing taxis would make sense but it'd be dangerous - bound to attract undesirables."

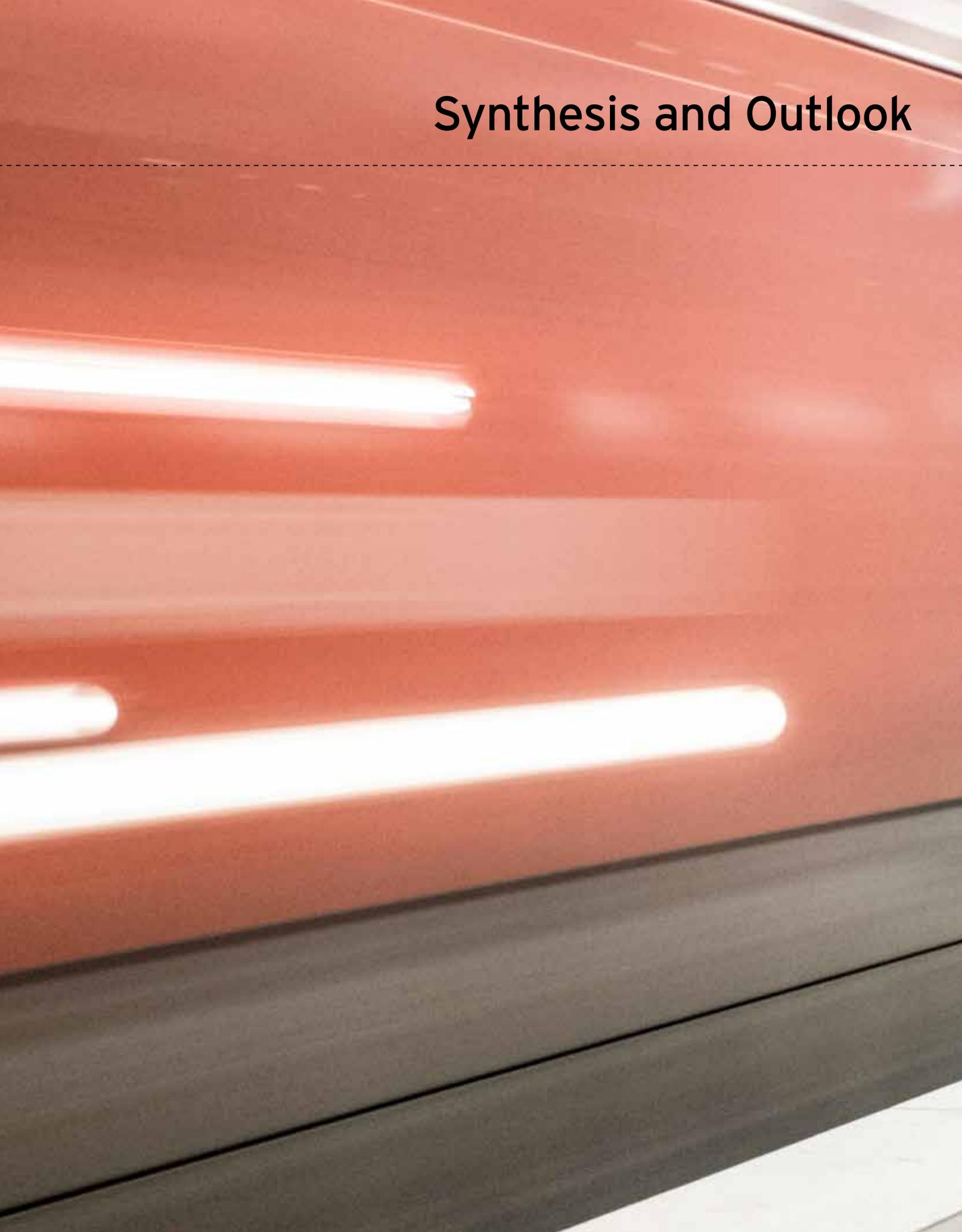
"I guess I'd share with people who lived locally [i.e. Brighton], especially who went to the same clubs or festivals as me, but not strangers from other towns."

"My mother wouldn't let me go out without knowing where I'm going and she tracks where I am all the time."





Synthesis and Outlook



Synthesis and Outlook

First, the existing literature is fragmentary, and in important respects remains immature. Empirical results from different studies frequently contradict one another, and in many studies results are descriptive with little formal theory. Many researchers note that the adoption and use of ICT are increasing, and suggest that this is causing physical travel to decrease. However, whilst there are mechanisms that could in principle lead to the substitution effect (ICT substituting for an actual physical trip), the scholarly literature suggests that so far ICT usage either has no net impact on the amount of physical mobility that one performs, or that ICT and physical mobility may on balance be positively related (in economic terms, complementary), or even have a mutually modifying relationship (through modal shifts, changes in trip timing, or use of travelling time). These relationships are currently changing rapidly and will clearly undergo further structural changes in the near future. While it is likely that the implications for travel behaviour will be profound, their precise nature of the changes is likely to vary widely from researchers' early expectations.

Second, the need for travel for the purpose of taking part in physical activities at specific times at given locations is likely to remain robust, in parallel with the growth of tele-activities. Time-use patterns and lifestyles will evolve as ICT is increasingly incorporated into everyday practices, but there is no evidence that participation in physical activities will simply decrease.

Third, it appears that the role of ICT in leading to modal shifts and impacts on car ownership is at most secondary. More traditional considerations such as prices, travel time, reliability, convenience and prestige appear to be much more important when it comes to choice of mode.

Fourth, rather than ICT causing time use and travel planning to become more spontaneous, it appears to provide for quicker, more accurate and more personalised travel arrangements. ICT allows people to efficiently adapt their travel plans to unforeseen circumstances.

Fifth, interactions between ICT and physical mobility appear to vary between different social groups, cultures and countries.

Finally, it appears that privacy concerns are becoming an increasingly important aspect of interactions between ICT and physical mobility. Various stakeholders, including consumers, appear to increasingly understand the value of their personal mobility and lifestyle data.

Looking into the future, the field is likely to be dominated by continuing evolution in the capabilities of ICT and the extent of its adoption, and the emergence of new services in the sphere of participation in activities and in travel. Societies seem to be transitioning to a future where the maturation of ICT takes place side by side with a growing scarcity, cost and unreliability of the resources required for physical mobility. In such conditions, ICT will play an ever-more important role in the better use of resources available to individuals, including their time and money, as well as of public goods such as environment or space. Our findings indicate that in this context, safeguarding against the misuse of data on which such services rely, and ensuring that vulnerable groups of society are not excluded from the benefits, will both remain important items on the agenda for business and policymaking. Continuing advances in knowledge in the field of interactions between ICT and physical mobility will play a vital role in ensuring that the proposed strategies are appropriately suited to the conditions of an evolving society.

Key Directions for Future Research

Given the state of knowledge established in the field, we believe that future research efforts should be concentrated on the following four areas:

1. Theory: Development of conceptual frameworks

As noted in earlier sections of this report, researchers have theorised several distinct mechanisms through which ICT might impact time use (and therefore travel behaviour). At present, there exists a reasonable agreement regarding the taxonomy of the lower-level relationships, while anything beyond that remains quite ad hoc. An important line of research is required to extend the current level of understanding of the higher-order interactions between ICT and physical mobility. Furthermore, the artificial distinction presently drawn between studies dealing with ICT and physical mobility from the activity and behavioural point of view on the one hand, and those dealing with intelligent transport systems on the other, should be abandoned, and integrated approaches should be promoted. The artificial character of such a distinction was especially evident during the Expert Workshop and focus groups with young adults - aspects of ICT encompassing both domains would emerge in the discussions jointly, signifying that rarely if at all is such a distinction made by the travellers themselves.

In parallel, new theoretical directions, together with statistical techniques to make the new theory operational, are required to analyse emerging - and frequently less tangible - issues such as privacy considerations, trustworthiness, satisfaction and well-being.

Development of new theory is, in general, a non-linear process requiring very specialised skill sets and exceptionally insightful thinking. Furthermore, success, and its principal metric (recognition from peers of the value of the proposed methods), are highly uncertain. Research projects which extend from existing theory are typically long-duration, lasting three or more years. This set of characteristics aligns best with strategic funders of fundamental research, such as national research councils, and not necessarily with industry, where clear vision of commercialisation of the research output is frequently a prerequisite for funding.

2. Technique: Development of new methodologies

A separate requirement, aside from developing new theoretical approaches, is the need to develop new methodologies, in terms of both how to analyse and how to collect data that meaningfully describe the ICT/physical travel relationship. An example of the latter category is the requirement to adapt travel survey methods to account for ICT usage. Some travel surveys collect only very limited information regarding access to (and/or usage of) ICT, such as whether a respondent is a user of the Internet and/or owns a mobile phone.

New techniques are also needed to harness the growing streams of passively collected big data, to enable light to be shed on aspects of ICT/mobility relationships which cannot be satisfactorily analysed with self-reported survey data. The challenges associated with using such data include their semantically poor content in terms of, for example individual attributes (e.g. gender, income, household characteristics) unless supplemented with traditional surveys, or the ability to otherwise infer such extra information. This direction, while promising, requires more intensive research before big data sources can be used as effectively as traditional datasets.

3. Empirical issues

Due to both the rapid pace at which ICT has been incorporated into a wide range of people's activities, and the context specificity of the existing studies, there remains much scope for research using prevailing best-practice methods (i.e. without the need for new techniques), to empirically establish the nature of these relationships. In many instances this will involve disaggregate analyses (with persons or households as the unit of analysis), though in other instances aggregate analyses will be warranted.

In some cases the data resources for this class of empirical research will come from continuous (or at least recurring) regional or national travel surveys, though in other circumstances bespoke data collection will be required. One example of an innovative research approach would be to recontact people who recently completed a travel survey, to ask them to participate in a follow-up survey which might, for instance, gather additional information on their ICT usage.

The crucial aspect of research on ICT and physical mobility which to date has been missing is that of longitudinal analysis. This is potentially a very powerful strategy, because it allows researchers to evaluate whether a hypothesised stimulus (i.e. cause) tends to precede a hypothesised effect or vice versa. A research challenge, however is that both ICT usage and the types of ICT equipment in use are changing very rapidly. This means that researchers face a difficult trade-off between consistency over time in survey protocols and capturing the most relevant aspects of ICT ownership/usage at different points in time. One strategy to deal with the absence of true panel (e.g. longitudinal) micro data is to develop pseudo-panel datasets, or pooling of cross-sectional data over a period of time. Such methods have seen applications in travel behaviour studies, yet surprisingly not those dealing with the interaction between ICT and physical mobility.

An important area in need of further empirical research is the relationship posited by some researchers between young adults' car ownership and their dependence on ICT use. In the short term, what is needed are studies that evaluate this relationship (such as it exists) in societies of varying levels of development (and of different groups within those societies). One additional line of inquiry that appears to be of value

concerns ICT usage whilst travelling, and its potential causal impacts on travel satisfaction, and thus mode choice and the value of time - this topic was covered during both the Expert Workshop and the Young Adult Workshop. Finally, more studies of a cross-national character would provide more knowledge regarding the transferability and validity of context-specific results, helping to form a consistent understanding of interactions between ICT and physical mobility. Such studies should also acknowledge the merits of both quantitative large-scale, as well as qualitative and local, approaches in eliciting complementary understandings.

4. Application and policy

The final avenue of research requirements relates to private-sector business decisions and public-sector policy measures. In general such questions may not be directly researchable ones in the strict sense, but they will influence the way that the research tasks outlined above are undertaken. On the question of regulation, if policymakers are to keep pace with the changes brought about by advances in technology, this will require careful consideration, as well as does the extent to which such mechanisms can be relied upon for protection of the public's interests. In addition, such policies, and wider best practice, must adequately reflect both the needs and the concerns of interested parties.

As with transport systems, ICT is recognised as beneficial when it operates correctly and under the conditions for which it was designed. But how resilient are ICT-based solutions for physical mobility in the face of unforeseen circumstances? And how resilient is the public's trust in technology, especially if there is a major failure due to a technological flaw. In addition, more thought needs to be given to the mechanisms (given various possible scenarios) for dealing with unexpected consequences of changes in technology, or misuse of it.

Another matter for consideration relates to the balance between the cost and benefits of widespread use of ICT. This widespread access to content is conventionally seen as beneficial, but under what circumstances might this view not hold true? And how are the technological benefits and costs distributed across societies, regions and countries? These questions are also important for the research community, which must investigate how the generation of data for research purposes translates into benefits to those who generate it - in the context of physical mobility, this means those who travel.

Finally, there are a number of important questions relating to the security, management and oversight of data, especially when it comes to the ownership and control of data streams that are - knowingly or unknowingly - generated by members of the public using ICT and physical mobility infrastructure. In an 'ecosystem of trust', the exchange of information assets and services will be fair, but what are the conditions for the emergence of such an ecosystem? Insights that help in understanding such exchange of information and data for services will most likely yield complex answers, but will also, it is to be hoped, lead to more transparent, secure and beneficial interactions between ICT and physical mobility.

Appendix 1: List of Respondents to Call for Evidence

Anne Aguiléra (Université Paris-Est, IFSTTAR, LVMT, France)

Corelia Baibarac (Trinity College Dublin, Ireland)

Rudi Ball, Kalan Nawarathne, Ajinkya Ghorpade, Francisco Pereira, Fang Zhao, Chris Zegras, and Moshe Ben-Akiva (Massachusetts Institute of Technology, Singapore/USA)

Eran Ben-Elia (Tel Aviv University, Israel)

Giovanni Circella and Patricia Mokhtarian (Georgia Institute of Technology, USA)

Pawel Bugajski (Mott MacDonald, UK)

Caspar Chorus (Delft University of Technology, Netherlands)

Matthew Coogan (New England Transportation Institute, USA)

Anthony D'Andrea (University of Chicago, USA, and University of Limerick, Ireland)

Bernard Gyergay (Rupprecht Consult, Germany)

Sarah Kaufman (New York University, USA)

Aharon Kellerman (University of Haifa, Israel)

Yoram Krozer (Twente University, Netherlands)

Eileen Mandir (Daimler, Germany)

Paul Minett (Ridesharing Institute, USA)

Ruth Rettie (Kingston University London, UK)

Sakari Taipale (University of Jyväskylä, Finland)

Nikolas Thomopoulos (London School of Economics and Political Science, UK) and Moshe Givoni (Tel Aviv University, Israel)

Alice Tolstokorova (Independent Researcher, Ukraine)

Appendix 2: List of Expert Workshop Participants

Anne Aguiléra (Université Paris-Est, IFSTTAR, LVMT, France)

Julie Alexander (Siemens, UK)

Eran Ben-Elia (Tel Aviv University, Israel)

Manny Chung (Department for Transport, UK)

Giovanni Circella (Georgia Institute of Technology, USA)

Caspar Chorus (Delft University of Technology, Netherlands)

Ulrich Fastenrath (BMW, Germany)

Johanna Kopp (ifmo, Germany)

Markus Ksoll (Deutsche Bahn, Germany)

Scott Le Vine (Imperial College London, UK)

Benedikt Lippay (MAN, Germany)

Patricia Mokhtarian (Georgia Institute of Technology, USA)

Claudia Nobis (DLR, Germany)

Jacek Pawlak (Imperial College London, UK)

John Polak (Imperial College London, UK)

Kulveer Ranger (Serco, UK)

Mike Short (O2/Telefonica, UK)

Aruna Sivakumar (Imperial College London, UK)

Nikolas Thomopoulos (London School of Economics and Political Science, UK)

Eric Yeatman (Keynote Speaker) (Imperial College London, UK)

