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"Nomads at last"? A set of perspectives on how mobile technology may affect travel

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ABSTRACT

This paper's goal is to propose a set of perspectives on how mobile phones and computers might affect travel: by tapping into basic needs of travellers; by affecting some preconditions for its spatial configuration; and by altering its costs and benefits. In the age of "digital nomadism," mobile technology is likely to play an important role for the new mobility and work-life arrangements put into practice by a multitude of creative knowledge professionals. What emerges from our multi-perspective exploration is the realisation that mobile technology might offer people numerous new reasons to be mobile: by making them more informed; more capable of using a larger variety of physical spaces and re-negotiating obligations in real-time; and potentially more efficient in the allocation of their travel time and resources. On the other hand, it also appears that mobile technology can impose new burdens on travellers and make travel *less* appealing in some ways. Additional research is called for to improve our understanding of the circumstances under which each of these opposing outcomes occurs. The findings from such research could be used to better calibrate traffic simulation models, as well as to weigh the implications of emerging forms of travel behaviour for the environment.

1. Introduction "nomads at last?"

An April, 2008, report from *The Economist,* titled "Nomads at last," referred to an alleged change in people's lives and mobility styles following the advent of mobile technology: cell phones, laptop computers, tablet PCs, personal digital assistants, and hybrids (The Economist, 2008). While acknowledging the business interests vested in promoting a buzz around the "mobile revolution" (Steinbock, 2005), the evidence is compelling that such technology is, in fact, evolving very fast. Not only are technologies unimagined only a decade ago widely available today, but a broad array of new work-life arrangements are being put into practice.

These transformations are often backed by employers, especially big corporations and global players, who increasingly allow their employees to telecommute, equip them with laptops, tablets, and mobile phones, and introduce ubiquitous Wi-Fi connectivity and hot desking.[1] Ultimately, they understand that, in a knowledge economy, the balance is changing. Fewer workers need to be where work and information are, while more often work and information can be where workers want to be. This makes sense if we consider that the raw materials of knowledge work are digitised rather than tied to physical locations.

Ongoing changes in people's mobility are difficult to track by means of traditional statistics. We are at the initial stages of "measuring the measurable" (Mokhtarian et al., 2005), which calls for much additional research. Consequently, we still don't know how to measure the alleged "nomadism" because of an inherent difficulty in defining and measuring it.[2] Rather, we talk about telecommuting or mobile work. Until recently most scientific research on the implications of technology for travel has focused on home and office computers, and less so on those (mobile) technologies that accompany us in the travel itself.

The very fact of having access to a portable device is likely to have repercussions for the way we move, as have other innovative devices that entered the travel realm in the past, from compasses to bicycles,

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[1] Wikipedia defines "hot desking" as an office organisation system that involves multiple workers using a single physical work station or surface during different time periods (Wikipedia, 2014c).

[2] In an article whose neutrality is disputed, Wikipedia defines "digital nomads" as "individuals that leverage digital technologies to perform their work duties, and more generally conduct their lifestyle in a nomadic manner. Such workers typically work remotely—from home, coffee shops and public libraries to collaborate with teams across the globe" (Wikipedia, 2014b).

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and from umbrellas to automobiles. Their common rationale is enhancing human capability in travel by providing orientation, protecting against the rain, increasing the speed and decreasing the effort of movement, (and now) allowing access to information and communication while on the go (see the concept of human extensibility in, e.g., Janelle, 1973; Janelle and Gillespie, 2004).

The advent of mobile devices stemmed from an economic and societal drive toward higher personal freedom, productivity, and efficiency in a post-industrial globalisation context (Castells et al., 2006). The ability to access communication and information resources "anytime, anywhere" not only is considered a means to liberate the individual from a dependency on specific physical places to carry out the desired activities, but also is viewed as a means to become more efficient in the allocation of scarce resources (i.e. time for work and leisure activities) – e.g., through more information and greater travel coordination – in order to be able to pack in a larger number of activities in the same amount of time (Lenz and Nobis, 2007). Thus, mobile technology offers an enhanced ability for individuals to choose where they want to be – to some extent, freeing themselves from the "yoke" of place-based constraints and the travel required to conform to them. At the same time (even aside from applications specifically designed to enhance *travel*-related information such as GPS, digital maps, and real-time traffic information, among others), mobile technology makes travel a richer experience and an easier one to pursue – but also a heavier burden due to the expectation that the traveller will now remain reachable and productive while away. The latter effect may not only apply to trips that would have occurred anyway, but could also facilitate *new* trips, given that those same expectations are supposed to ameliorate the effects of being physically absent, which may lead, for example, to an employer assigning more travel than the employee or the family desires.

If we are to understand the implications of technology for travel, we must grapple with how people balance these effects, both contradictory and complementary: freedom *from* travel, freedom *to* travel, and the bondage of travel. To do so, in turn, requires us to revisit a fundamental question: "what drives people to travel in the first place?" Only by a more thorough comprehension of those motives can we expect to understand why travel continues to increase (aside from short-term effects due to a global recessionary economy) at the very time it becomes easier than ever to forgo.

In this paper we first answer this question by assembling several different but useful perspectives on it, and then leverage those perspectives to help us better distinguish and comprehend the likely impacts of mobile technology on travel. This paper specifically has the travel of creative knowledge professionals in mind,[3] and some of our discussion pertains most cogently to that group of workers. However, many of the perspectives we present also apply (with varying degrees of strength) to people in other occupations and in realms of life other than work. By focusing on basic assumptions, we construct a number of hypotheses about how mobile technologies might be spatially reconfiguring the "playing field" of human travel. We ground these hypotheses in the preliminary evidence of which we are aware, and use creativity as a further source of informed speculation. Our hope is that this discussion will provide a lens (or set of lenses) through which this subject can profitably be viewed, and might inspire and inform future novel and creative research questions on the treated topics.

The paper is organised as follows: in the next section we review a selected set of conceptual frameworks, developed in the past and related to the primitive drives of travel behaviour. In Section 3 we use those frameworks to build a series of hypotheses and theoretical constructs on how mobile technology might affect travel: the way it addresses some basic human needs; the way it interacts with four distinguished classes of preconditions for travel; the way it impacts the spatial configuration of activities and trips; and the way it affects the costs and benefits of travel. We conclude the paper by recognising the need for empirical evaluation of the many hypotheses presented, in particular to identify which types of people are more receptive to mobile technology-induced behavioural change.

2. Drives and facilitators of travel: some anchors in the literature[4]

By drives of human behaviour, we mean broad and general categories of motivations into which a number of more specific reasons can be grouped. Typologies of such drives appear in a variety of disciplinary contexts, including psychology, sociology, geography, economics, and marketing research, as well as in several interdisciplinary fields. Drives should be distinguished from facilitators of (or constraints on) human behaviour. Drives are the fundamental motivations to act a certain way. According to Mokhtarian and Salomon (1994), the drives can be assumed to be generated largely from lifestyle orientations toward work, family, leisure, and ideology. Facilitators/constraints are factors that serve to make an alternative course of action either easier or more difficult to choose, respectively. The same factor (such as cost) can be either a facilitator or a constraint, depending on whether it is present in a positive (low cost) or negative (high cost) sense. But it differs from a drive in that, no matter how many facilitators are present (or constraints are absent), a behaviour does not occur unless there is a drive to do it.

In the following subsections, we briefly introduce three perspectives on the drives and facilitators of human (travel) behaviour. These perspectives are by no means mutually exclusive. However, they do exemplify alternative disciplinary views of motivations for human behaviour in general, and travel in particular, that we find useful in thinking about the impact of mobile technology on travel. In Section 3, we will argue that mobile technology interacts with the facilitators/constraints of travel (Section 3.1, on "needs of travellers" and Section 3.4 on "costs and benefits"). We also introduce four classes of "preconditions" of travel (involving both facilitators/constraints and drives) that are affected by mobile technology (Section 3.2).

2.1. Travelling to fulfill psychological needs

The discipline of psychology has long studied what prompts people to behave in a particular way. The best-known theory of motivation must be that of Maslow's (1943; 1954) hierarchy of human needs. According to Maslow's theory, human beings act to fulfill unsatisfied needs, which can be organised into a hierarchy or pyramid – in which the most primary level of needs (i.e. physiological needs) sits at the bottom and the most advanced (i.e. self-actualization) sits at the top (Fig. 1).

As shown in Table 1, Maslow's needs can be used to derive some of the most common motivations or drives for travel and mobility; i.e., forms of travel demand. However, as we will see in Section 3.1, those needs may also serve as facilitators to, or constraints on, travel.

The listed motivations that can be derived from Maslow's theory relate to the standard triad of travel purposes (Reichman, 1976):

[3] Florida (2002: 8) says that the Creative Class is a class of workers whose job is to create meaningful new forms, and is composed of scientists and engineers, university professors, poets and architects, and also includes "people in design, education, arts, music and entertainment, whose economic function is to create new ideas, new technology and/or creative content" (Wikipedia, 2014a).

[4] Portions of this section appear in a companion paper (Mokhtarian et al., 2014a). There is essentially no other overlap between the two papers.

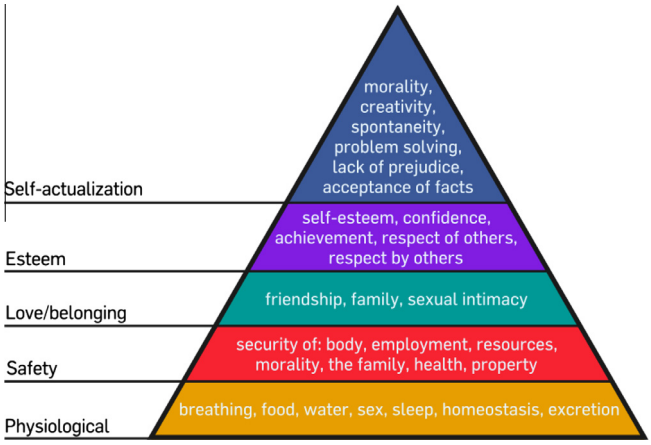

Fig. 1. A graphical representation of Maslow's (1943; 1954) hierarchy of needs. *Source:* Wikimedia Commons, <http://en.wikipedia.org/wiki/File:Maslow%27s_Hierarchy_of_Needs.svg> (accessed on June 30, 2014). Also in Wikipedia, 2014d.

- mandatory purposes (work, school, etc.);
- maintenance purposes (shopping, medical, etc.); and
- discretionary purposes (social, recreational, entertainment, etc.).

These three purpose categories can certainly be seen among the selected examples in Table 1, but it is noteworthy that they align predominantly with the lower three categories of Maslow's pyramid (i.e. physiological, safety, and social). Discretionary activities can reach the higher levels of the hierarchy (Salomon, 1985), and the table further helps us realise that travel itself is an activity that can meet a human need in its own right, particularly the higher-order needs of esteem and self-actualization.

2.2. Travelling to fulfill socio-spatial obligations

Recent years have seen the much-remarked-upon "mobility turn" in sociology, a paradigm shift toward the formal study of mobility led by Urry (2002). In one of his seminal pieces, Urry (2002: 256) explicitly addresses the fundamental question: "why do people physically travel?" He identifies six types of obligations that require co-presence:

- legal, economic, and familial obligations, including all work-related ones;
- social obligations, based on a need to meet face to face;
- time obligations, to spend quality time with family, partners, and friends;
- place obligations, to sense a place directly;
- live obligations, to take part in a live event; and
- object obligations, to interact with objects that have a specific physical location.

The listed obligations (which may not cover all possible motivations to travel) may also manifest in the form of preferences, in that they might be things that people want to do, rather than simply have to do. In either case, in order to do them, people are obliged to travel.

2.3. Travelling as the outcome of a utility-maximising choice

Mokhtarian and Salomon (1994) built a theoretical model to account for different travel drives or "motivators," linking them to facilitators and constraints. A key assumption of the model is that the absence of binding constraints is a necessary but not sufficient condition for travel to be chosen. That is, simply that travel is possible is not itself a motivation to do it; rather, the presence of an active reason for doing so is also necessary.[5] These active reasons thus function as the drives or motivators. Fig. 2 originally was developed to explain people's choice to telecommute from home versus travelling to work, and is meant to account for different elements of people's internal decision-making process vis-à-vis travelling. The model can be more generally applied to the choice to travel (or not) in a variety of contexts.

According to this model, different elements combine to define the individual choice to travel versus to not (e.g., to telecommute):

- life-style preference;
- contingent situation;
- perceived choice set of travel options;
- social and psychological attitudes; and
- perceived facilitators and constraints, including cost, type of technology available, and organisational support.

The model represents travel choices as complex decisions, in which travellers are, for simplicity, assumed to perform a rational and affective appraisal of numerous decision elements, and choose the alternative with the highest utility. An important role is played not only by their preferences and attitudes, but also by the type and quality of the information at their disposal.

3. How mobile technology might affect travel

In the previous section we considered different basic motivations for travel – i.e., to fulfill needs or obligations (Sections 2.1 and 2.2) – as well as different lifestyle preferences and contextual factors that might affect the choice to do so (Section 2.3). In this section we use those perspectives to explore how the advent of mobile technology might have affected travel. We argue that, by altering the facilitators of and constraints on travel, as well as by offering people new instances of the fundamental motivations to travel and be on the move, mobile technology might promote an increase in, and a spatial reconfiguration of, our daily mobility.

3.1. Impacts on needs of travellers

New information and communication technologies are likely to help fulfil basic human needs to the extent that they pave the way for new forms of communication and social activities (Ling and Yttri, 2002). As elaborated in Section 2.1, human activity is driven by one or more fundamental needs: physiological needs; need for safety; social needs; needs for esteem; or self-actualization needs. Mobile technology is not likely to affect those needs at the very bottom and very top of Maslow's (1943) pyramid, while it can have a significant impact on the safety and social needs of travellers:

- To the extent that mobile technology allows ubiquitous and instant access to information and communication with family, friends, and colleagues, it can contribute to addressing travellers' social needs (see, e.g., Mascheroni, 2007; White and White, 2007).

[5] To be sure, these reasons may not always be the traditional "derived demand" ones based on conceiving of an activity at a spatially-separated location and then travelling there to engage in it. A reviewer provided an example in which the motivation was simply to use frequent flyer miles, "anywhere" that could be visited without requiring double miles. In this case, the motivations are to "go somewhere", "make the most effective use of my frequent flyer miles", and possibly "get as much out of the airline's annoying frequent flyer program as I can", but they are still active reasons, not just the absence of constraints. There will be many people with the same number of frequent flyer miles, ample income, time, and so on, but without one or more motivations, who will therefore not make the trip.

Table 1
Maslow's (1943; 1954) hierarchy of needs, as applied to travel demand (drives).

Need	Type of travel generated by the need	Preferred way of travelling related to the need
1. Physiological	Travel for grocery shopping, eating out[a]	Preferring a travel mode that permits sleeping, or eating, while travelling; preferring a faster mode, or changing departure time to avoid congestion, so as to save more time for sleeping, or eating, while stationary
2. Safety/security	Travel for work, medical, exercise, banking/investments, religious services, therapy, escape	Avoiding certain mode(s), route(s), or departure time(s) out of safety considerations
3. Social (love/ belonging)	Travel for social activities, volunteer/club/religious activities, escape	Preferring a travel mode that facilitates social interaction
4. Esteem	Travel for status, independence, adventure seeking, spirit of conquest, escape	Preferring modes perceived to be higher-status
5. Self-actualization	Travel for curiosity, restlessness, variety-seeking, aesthetic appreciation	Experimenting with new modes or routes; choosing modes/routes suited to the trip purpose

[a] As Maslow himself notes (1943: 373), "any of the physiological needs and the consummatory behaviour involved with them serve as channels for all sorts of other needs as well. That is to say, the person who thinks he is hungry may actually be seeking more for comfort, or dependence, than for vitamins or proteins."

- Personal safety needs can be met through instant communication with police and emergency authorities, in case something goes wrong while on the move. Even the reassurance that assistance will not be difficult to obtain if something *were* to go wrong can assuage anxieties over the mere *possibility* of such problems arising (Katz, 2003; Nasar et al., 2007).

In synthesis, mobile technology is likely to make travel a less perilous and less lonely experience, ultimately making it a more attractive proposition to individuals (Jain and Lyons, 2008; Lyons and Urry, 2005). Note that this is a facilitation role, involving the lessening or removal of constraints.

3.2. Impacts on preconditions of travel

In this subsection we explore how mobile technology might have affected a number of contextual conditions that promote travel. To begin, we suggest that all inherent or situational preconditions of travel can be subsumed into one of the following four classes (cf. Stradling and Anable, 2008, pp. 179–180[6]):

1. *Capacity:* I travel because I can (i.e., because I am capable of doing so);
2. *Information/knowledge:* I travel because I know (i.e., because I know it exists and how to get there);
3. *Obligation:* I travel because I must (i.e., because I am required to do so);
4. *Preference:* I travel because I want to (i.e., because I actively desire to do so).[7]

Connecting these preconditions to the role played by mobile technology in travel, it may be asked: how does mobile technology interact with people's capacity, knowledge, obligation, and preference to travel? We suggest that the impacts on the first two preconditions are relatively predictable: in general, mobile technology increases our capacity to travel and knowledge of opportunities involving travel. The effects on the other two preconditions are more ambiguous, however. In some cases mobile technology may reduce our obligations and positively affect our preference to travel but, in some instances, it may have the opposite effects. We elaborate on each precondition in turn:

- *increased capacity:* To the extent that mobile technology enables us to be reachable and to access work resources everywhere, it permits us to spend time in places to which we would not have considered travelling otherwise. For example, Wi-Fi connectivity and laptop availability allow mobile workers to spend part of their work time in cafes or in hotel rooms (Vartiainen and Hyrkkänen, 2010).[8] Schwanen and Kwan (2008) remind us that mobile communication technologies themselves are bound by certain physical requirements (hardware, network infrastructure, the ability to recharge batteries, and so on), so the freedom these technologies confer is not without constraints. On balance, however, it seems that the liberty to move or stay is increased by mobile ICT.
- *increased knowledge:* Since mobile technology enables us instantly to access all kinds of information and communication resources, it makes us more informed about places we might consider going and things we might consider doing (Jensen, 2007), and the travel conditions involved in going there and doing them. This knowledge can serve two roles. When it affects travel that has already been contemplated, it becomes a facilitator of making that trip (or informs about constraints on making the trip). On the other hand, information obtained through Information and Communication Technology (ICT) in general, and mobile technology in particular, can create the desire for entirely new trips. In this case, ICT might be said to awaken or enhance the drive underlying the desire to Internet browsing session might make us aware of the existence of a certain event we might consider attending, or of new destinations to which we might consider travelling travel, not just remove constraints (O'Reilly, 2006.[9]). A text message or the modern phenomenon of flash mobs [see, e.g., Gore, 2010] are examples of this effect, but there are many other manifestations of it as well. Conversely, it could make us aware that the event we intended to attend has been cancelled (informing us of a constraint), thereby saving a trip. To be sure, traditional communication media (travel writing,

[6] "Why do we move around at all? 'Because we can, because we have to, because we like to' is the simplest formulation dividing out the different kinds of motive forces driving travel behaviours and transport choices…"

[7] The first precondition, i.e., capacity, is meant to subsume what Hägerstrand (1970) defines as "travel constraints": *capability* (i.e., physiological, biological, and instrumental limitations), *coupling* (i.e., interactional limitations), and *authority* (i.e., rules and law). The third precondition, i.e., obligation, is meant to subsume all types of obligations as described in Section 2.2 (Urry, 2002): legal, social, time, place, live, and object obligations. With respect to the model of Mokhtarian and Salomon (1994) described in Section 2.3, the first precondition relates to their facilitators/constraints, the latter two relate to their drives, and the second one relates to both.

[8] This enhanced capacity can sometimes *replace* travel, as when ICT (whether mobile or fixed) enables "accessing" a store outside of its normal hours of operation. This also represents the relaxation of a constraint, but our focus here is on the relaxation of previous constraints *on travelling* in particular.

[9] O'Reilly (2006: 1008), for example, refers to the role of "mediascapes" (mass media) and "technoscapes" (personal ICTs) in stimulating the imagination, which "is central to all forms of agency including travel – the creation of places and people as objects of desire, the means to fulfill that desire, and the self-identity that develops out of the practice of travel."

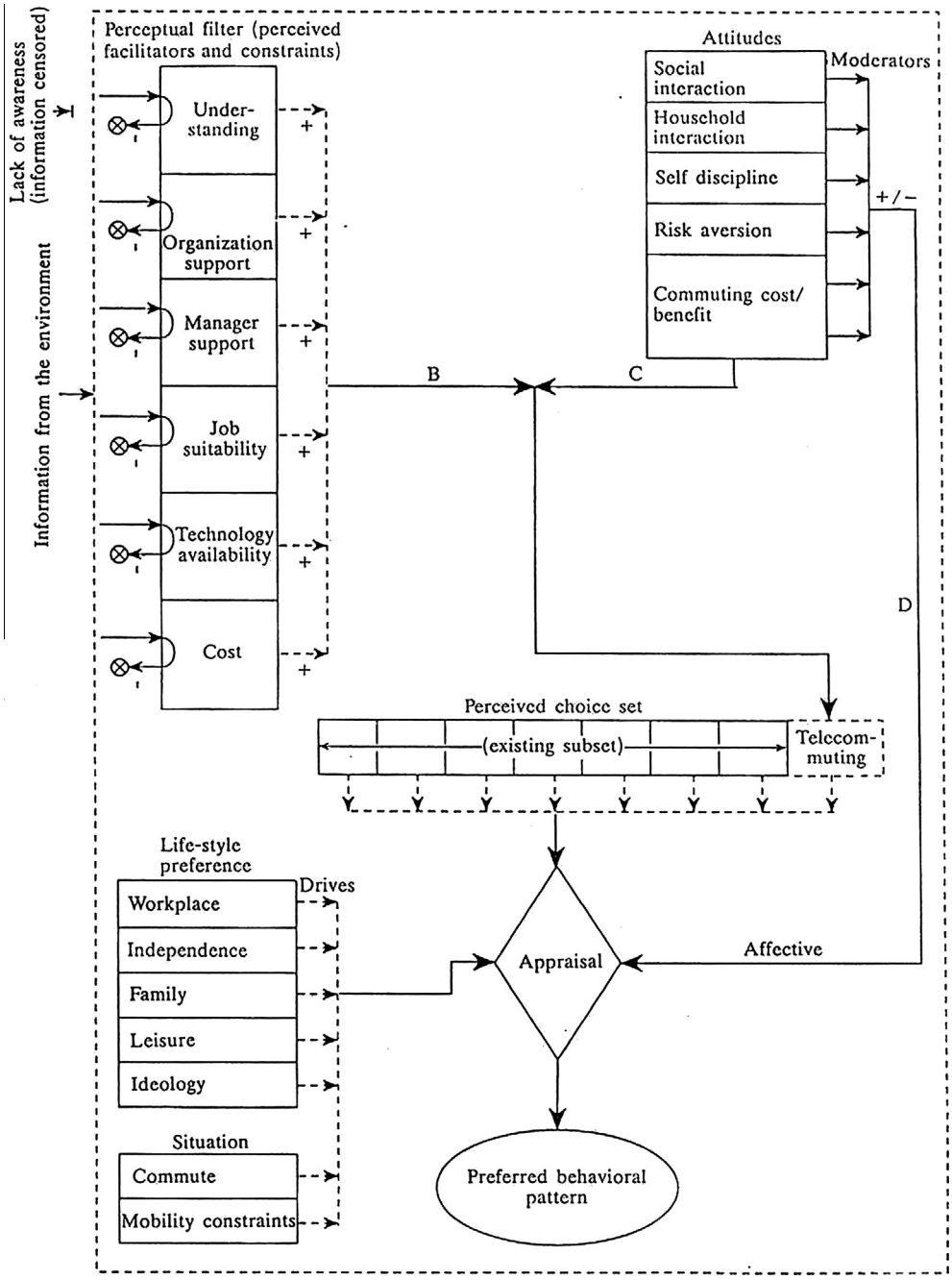

Fig. 2. A schematic model of the internal decision-making process involved in travel. *Source:* After (Mokhtarian and Salomon, 1994).

photographs, maps) have inspired travel for centuries (see, e.g., Spar, 2001; Perrottet, 2002). We suggest, however, that even if modern ICT represents only a change in degree rather than in kind for this role of information/inspiration (which is, itself, debatable), the change in degree is important. ICT multiplies and intensifies many-fold the reach of such inspiration through (1) the sheer amount and detail of information available, (2) the powerful impact of the information (e.g. full-motion, full-colour video, not just a still black-and-white photograph), and (3) its near ubiquity.

- *(perhaps) reduced obligations:* To the extent that mobile technology enables us instantly to communicate with our travel destinations and meeting peers, it delivers us more flexibility vis-à-vis our obligations towards them, typically in the form of cancelling, rescheduling, or changing the location of meetings (Kwan, 2007; Lee-Gosselin and Miranda-Moreno, 2009; Line et al., 2011; Kopomaa, 2000). For example, while delayed in congestion on the highway, we might be able immediately to renegotiate our meeting obligations and remove certain stops from our itinerary. Bowden et al. (2006) describe the use of mobile communications to reduce the need for an office-based team to travel to a construction site to resolve problems. More broadly, ICT in general (whether mobile or fixed) can reduce (even if not eliminate) many of the obligations described by Urry (2002) (Section 2.2), thus *lessening* the motivation to travel (for some people, at some times). For example, the ability to achieve "connected presence" (Licoppe and Smoreda, 2005) through frequent video calls or tweets to friends or family may, for some people and under

certain circumstances, obviate the need to travel to see them as often (for example, see Lee-Gosselin and Miranda-Moreno (2009) who suggest a degree of substitution between mobile phone use and face-to-face social activities). The increased digitization of information objects lessens the need to be physically co-located with them. Employers and other institutions are increasingly relaxing the obligation of physical co-presence, by enabling telecommuting and other ICT applications in medicine, commerce, justice, and so on. On the other hand, precisely *because* ICT has increased our capacity for travel as discussed above, new expectations and obligations may be generated, as when a mother expects her adult child living in another city to visit her more often, "now that you can work from anywhere."

- *(perhaps) increased preference:* To the extent that mobile technology improves our feeling of personal safety when travelling (Lemish and Cohen, 2005; Line et al., 2011; Nasar et al., 2007), or fulfils our social needs of maintaining contact while away (see Section 3.1), it might increase our preference to travel. The increased availability of information about places, events, and people of interest described above can also stimulate a preference for additional travel (see, e.g., Mokhtarian, 2009). On the other hand, the diminution of obligations just described could reduce the actual *desire* to travel: one may not feel as drawn to visit a friend as often as before, now that she is in frequent contact with that friend through ICT. Further, to the extent that new obligations arise, as discussed above, travel may become even more of a burden and thus less preferred.

A study of the influence of ubiquitous Wi-Fi connectivity on the daily travel habits of laptop-equipped MIT students (Dal Fiore et al., 2008) offers a number of anecdotal examples of how the four preconditions may be affected by mobile technology (Table 2).

All in all, the information and communication capabilities of mobile technology seem to offer people new reasons and capacity to travel to, and spend time in, a larger set of destinations. At the same time, through them people might gain new knowledge and freedom to be (or not to be) involved in activities that generate trips and stops. In this respect, mobile technology does interact with people's preference to travel and, ultimately, with their travel choices (Fischer, 2000). It is also likely to interact with the way people distribute trips over space, as described in the next subsection.

3.3. Impacts on the spatial configuration of travel

When merging a spatial and an activity-based view of travel (Axhausen, 2000), we can assume travel behaviour to be manifested in a bounded space: the "time–space prism" (Hägerstrand, 1970) if defined by what is possible, and the "spatial action field" (Zumkeller, 2000) if defined by what actually occurs. The adoption of ICTs, and the "affordance" (Gibson, 1979) they provide, may lead to the decoupling of activities, space and time, and result, among other outcomes, in the fragmentation of activities (Schwanen et al., 2008) and in more flexible space–time arrangements of activities (Kwan, 2002). Specifically, Schwanen et al. (2008) point out that the fragmentation of activities is a result of the ability of ICTs to enable splitting activities, which are then undertaken in multiple locations, at different times, and in a different order. Other researchers also point to a correlation between mobile ICT availability and usage and more dispersed travel (Miranda-Moreno et al., 2012; Yuan et al., 2012).

Within this framework, we hypothesise that – since mobile technology interacts with the four previously defined preconditions of travel (see Section 3.2) – daily activities will be spatially reconfigured as new stopping places might be "activated" in the mental map and spatial action field of travellers, while others "de-activated." For example, new stops might be added to a recurrent trip due to changing preferences as a result of increased information or increased capacity, while some previously necessary stops might instead be skipped due to removed obligations or (again) increased information. Fig. 3 exemplifies a possible reallocation of stops enabled by mobile technology.

The spatial reconfiguration of activities/stops modifies the spatial action field in form and dimension, with possible repercussions on the overall distance travelled. In order to predict the likelihood of a net increase/decrease in the number of stops, we would need to understand under which conditions the stops added would be counterbalanced by the stops removed.[10] But which path between stops would travellers follow? Would new forms of travel patterns be likely to emerge? In order to generate hypothetical answers to these questions, we need to consider three major likely implications of mobile technology on the spatial configuration of travel:

- given that they can count on a portable workstation at any time and place, users of mobile technology may take advantage of a larger variety of work settings (i.e. increased capacity, increased preference), based on considerations of geographical proximity, as well as personal convenience and preference;
- given that they can send and receive information everywhere (i.e. increased information, decreased obligations), mobile users may adopt a spatial behaviour that is less planned in advance and more emergent from contingencies (by means of just-in-time decision making);
- given that those individuals who are busier and more socially connected may have a greater need to be mobile (Kamargianni and Polydoropoulou, 2013), they might be especially keen to exploit mobile technology to optimise further their travel patterns.

Combining these three suppositions and assuming – at least in most instances and for most kinds of individuals – a rational tendency to economise movements (i.e., to forgo unnecessary, sub-optimal, or avoidable trips), we would expect mobile users to move more but also more efficiently (Aguiléra, 2008). By allowing the traveller to plan and rearrange activities from anywhere and at any time, mobile technologies' usage leads to more complex trips (Schmocker et al., 2010), in which origins and destinations of certain activities may no longer be regarded as fixed as the importance of large nodes and bases of operation for coordinating interactions is reduced (Kwan, 2007). The result is an increase in the dispersion of trips and a decrease in their eccentricity (Yuan et al., 2012). Fig. 4 graphically exemplifies the following two-step hypothesis:

1. Mobile technology and ubiquitous connectivity offer a chance to replace hub-and-spoke trips (more numerous) toward a central point of gravity (most typically, an office), with circular trips (less numerous) between the same destinations;
2. The saved travel time can be reallocated to more trips and/or to more distant but also more attractive destinations, possibly triggered by new information accessed through mobile technology (Zumkeller, 2000).

Having considered how mobile technology might affect the spatial configuration of travel, in the next subsection we explore how these technologies might impact its costs and benefits.

[10] In this respect, we speculate that the following variables are likely to play an important role: distances at stake; modality of travel; costs of travel; and travel behaviour styles (among others: individual efficiency in travel, measurable through the share of circular (vs. hub-and-spoke) trips over the overall number of trips; and individual tendency to spend a fixed versus a variable amount of daily time in travel).

Table 2
Examples of how mobile technology and communication may interact with the four classes of preconditions of travel behaviour, on the MIT campus.

Precondition 1: Capacity	Thanks to laptops ubiquitously connectable to the Wi-Fi network, students become capable of carrying out digital work also from libraries, cafes, and even during classes, so they could consider travelling to these places. Conversely, the need for trips to the library, or even to class (when it is podcast, for example), could also be reduced for the same reasons
Precondition 2: Information	Through their smart phones, tablets and laptops, students constantly receive new information about on-campus events which they could attend (i.e. to which they could travel, for example on the way home). Conversely, such information can also eliminate trips, as indicated above
Precondition 3:Obligation	Thanks to mobile devices, students could be able to renegotiate their obligations with peers, professors, and family members so as to avoid stopping at a given place or to travel to a different one
Precondition 4:Preference	By affecting the attractiveness of certain places on campus (i.e. libraries and cafés), ubiquitous connectivity might impact students' preferences to travel to and spend time in those places

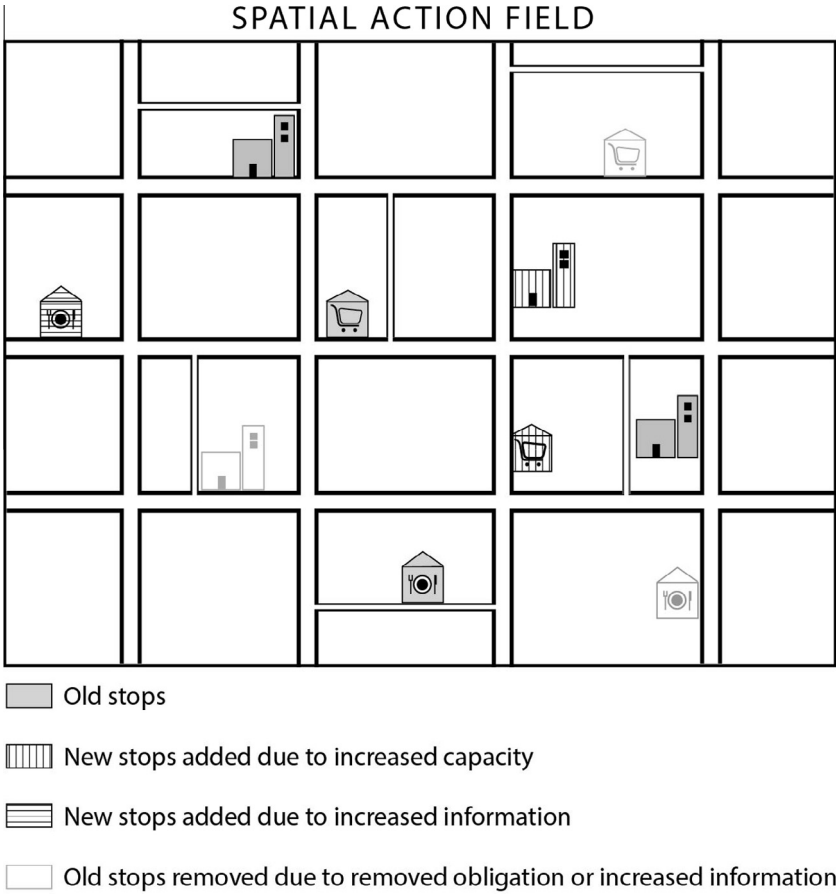

Fig. 3. Possible reallocation of stops in the spatial action field, thanks to ubiquitously connected mobile technologies.

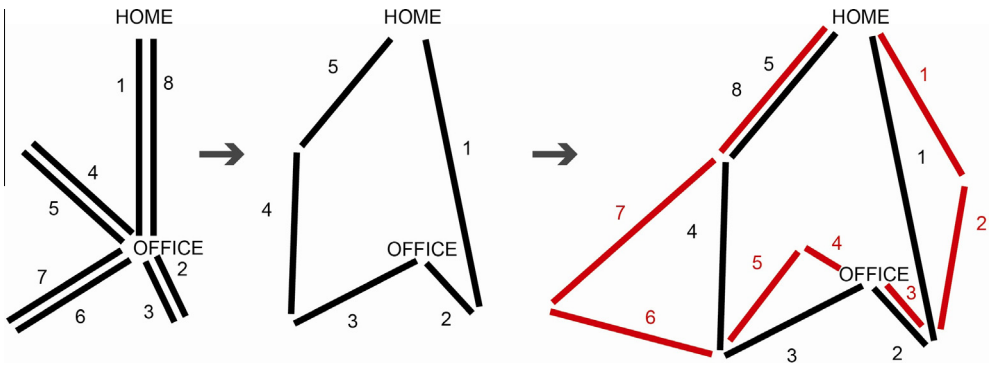

Fig. 4. A two-step hypothesis on the implications of mobile technology for spatial behaviour. Step 1: circular trips replace hub-and-spoke trips to and from a point of gravity; Step 2: the number of trips increases (and/or chosen destinations for existing trips change) due to increased efficiency and information.

Table 3
Likely impacts of automobiles and mobile technologies on some of the major costs and efforts associated with travel.

Type of travel cost	How impacted by the advent of automobiles	How impacted by the advent of mobile phones and computers
Direct monetary costs	The advent of automobiles replaced one-time ticket payments tied to distances (as in the case of trains and buses), with a sizable capital cost of acquiring the automobile, plus a number of occasional payments for gasoline and highways. The impact of this new system on travellers' *actual* costs is complex, but in any case it likely altered their *perception* of travel costs	To the extent that mobile technology gives travellers instant access to a wide-range of trip-related information (i.e. location-based apps, last-minute alerts, ticket offers, etc.), it might reduce the direct monetary costs involved in travel (Mokhtarian, 2009)
Indirect costs (i.e. unproductive time spent in travel, i.e. opportunity cost)	Most often, automobiles increase these costs, for people sitting in cars are generally not as productive as people sitting in trains or buses (because of a smaller chance to use one's hands and be fully attentive). Nevertheless, it must also be considered that automobiles may reduce the overall travel time	Mobile technologies most likely decrease these costs: portable phones allow individuals to be reachable and communicate (also in cars); portable computers enable digital work (Lyons and Urry, 2005)
Trip planning costs	Automobiles may have decreased these costs, in comparison to trips carried out by train or bus. A trip can now be planned at the last minute, with no dependency on schedules or reservations. Nevertheless, time and efforts have now to be spent planning the trip route, and checking it while on the go. Further, autos may have reduced some of the costs of uncertainty regarding travel time and other elements, although in congested conditions public transportation on dedicated rights-of-way probably has the advantage	Mobile devices most likely decrease these costs, for individuals can easily rearrange and renegotiate activities (Ling, 2004), and reduce the uncertainties of travel both by auto (Toledo and Beinhaker, 2006; Thompson et al., 2010) and by transit (Watkins et al., 2011), by accessing sources of richer information, as well as digital maps/GPS
Physical costs	Automobiles may decrease the overall physical costs of a given trip, for most often the automobile is available just a few steps away from the home	If heavy to carry around, portable computers and other ICT devices may increase these costs. On the other hand, by enabling travellers to find the most efficient means of reaching a destination, mobile technologies may reduce physical costs (e.g. by finding easier transfers)
Psychological costs	For certain people, automobiles may accentuate the loneliness of travel. In trains, buses and flights, travellers are surrounded by other people. Mental fatigue is usually higher for car drivers than for users of public transport (Mokhtarian et al., 2014b). Automobiles may also offer psychological benefits associated with self-esteem and self-actualization (see, e.g., Sachs, 1992)	Mobile devices most likely decrease the loneliness of travel, for travellers can find company and entertainment via phone calls and multimedia applications (see Section 3.1; 'equipped time' as described by Jain and Lyons, 2008). The same devices can reduce mental fatigue, e.g. through offering favourite music on demand (e.g. 'time out' as described by Jain and Lyons, 2008)
Personal safety costs	Automobiles increase safety costs vis-à-vis trains, buses and flights, even if the opposite may be perceived by travellers (e.g., Elvik and Bjornskau, 2005)	Mobile devices decrease these costs. In case something goes wrong, travellers are able to instantly communicate with emergency authorities or with family/friends/co-workers (Katz, 2003; Nasar et al., 2007). Nevertheless, usage of mobile devices while driving can be extremely dangerous (Wilson and Stimpson, 2010)
Costs related to uncertainty at destination	Little affected by automobiles, even if travellers by car could have more flexibility to cope with uncertainties	Mobile devices lower these costs (Katz, 2003). Real-time information allows travellers to know local conditions at the destination (i.e. for example: weather conditions, changed meeting schedules or availability of tickets for an event).[a]
Costs of trip change orcancellation	Automobiles decrease these costs. Not depending on schedules or tickets, travellers can more easily change their mind, including changing destination when they discover that this is problematic (sometimes, upon arrival)	Mobile devices decrease these costs. Travellers can instantly inform people at the destination, or be informed by them
Costs related to the quality of time spent at destination	Automobiles could increase these costs, e.g., if the trip is stressful and that frame of mind carries over to the destination. However, the same could be true of other travel modes as well. Similarly, autos could decrease these costs by making the trip easier, but other modes could do so as well	Travellers can potentially have a more fulfilling and productive time at the destination, thanks to multimedia and connectivity capabilities of portable devices (for example, at a business meeting, or for fun during the evenings spent at a hotel). On the other hand, business travel in particular can already be tiring (Aguilera, 2008; Beaverstock et al., 2009), and the increased expectations of connectivity while travelling may impose a greater burden on the traveller, leading to a "third shift" of exchanging messages with the home base after the "first and second shifts" of conducting the day and evening activities associated with the trip

[a] In this regard, Jensen (2007) presented empirical findings on how mobile phones allow Indian fishermen to know the real-time market prices of fish in different coastal cities. Leveraging this information, they can decide where to direct their fishing boats after making the day's catch.

3.4. Impacts on the costs and benefits of travel

The costs of travel are likely to play an important role in the behavioural change of travellers, as automobile drivers well know in times of rising oil prices. In this sub-section, new hypotheses are advanced on how mobile technology may affect travel costs. In the model presented, costs are not limited to the ones that are measurable by means of conventional economic indicators (typically, financial and time related), but encompass other types of costs that are more difficult to quantify, most notably social and psychological in their nature. As such, they are comparable to the constraints of Mokhtarian and Salomon (1994).

Table 3 presents a comparative review of the likely impacts of two major mobility innovations on the costs of travel: automobiles (when compared to previous forms of transport) and mobile technologies (when compared to previous forms of access to information and communication). Several types of travel costs and efforts are accounted for, including different individual perceptions of them[11]:

[11] Grotenhuis et al. (2007) elaborate on some of the costs presented hereafter, calling them efforts. Focusing on the usage of public transportation versus automobiles, they talk about physical efforts, cognitive efforts, and affective efforts.

- direct monetary costs;
- indirect (i.e. opportunity) costs;
- trip planning costs;
- physical costs;
- psychological costs;
- personal safety costs;
- costs related to uncertainty at the destination;
- costs of trip change and cancellation; and
- costs related to the quality of time spent at the destination.

It is important to note that all the listed costs can also be framed as facilitation benefits.[12]

It appears that the advent of mobile phones and computers might have greatly reduced the costs of travel (i.e. increased its benefits), except for physical costs (which would remain unimpacted or would possibly increase). The effects of automobiles might have been more equivocal, even if the likely decrease of trip planning and trip change costs (coupled with a perceived decrease in physical and monetary costs) could still play an important role in providing good reasons for people to use their cars versus public transportation.

4. Conclusions

In this paper we explored the possible impacts of mobile technology on human travel behaviour, at a theoretical level. A fundamental question (though one nonetheless often neglected by the literature) served as inspiration: what drives people to travel in the very first place? This question gave us the opportunity to take a step back and look into the preconditions of travel behaviour, in order to understand if and how the advent of mobile technology might have impacted them. We looked at Maslow's (1943; 1954) hierarchy of needs; we defined four classes of preconditions of travel; we explored the possible implications for the spatial configuration of trips; and we focussed on travel costs and (facilitation) benefits.

One observation based on this multi-perspective exploration is that mobile phones and computers might offer people numerous new reasons to be mobile. In theory, these technologies stimulate the various drives that underlie motivations for travelling, while reducing the constraints that would otherwise dampen the demand for travel. In sum, they can make people better masters of their travel behaviour, by making them more informed, more capable of using a larger variety of physical spaces, and re-negotiating obligations in real-time and, ultimately (but not necessarily), more efficient in the allocation of their travel time and resources.

Considering the trends of more and more traffic on the roads emerging from recent statistics[13] (Proost and Van Dender, 2011), we could conclude simplistically that the advent of mobile technology might have significantly contributed to this phenomenon, allowing people to be more mobile than ever. Nonetheless, even if mobile technology might have made travel a more seamless, secure, entertaining, and productive experience to pursue, a fundamental question remains about how much travel people are willing to undertake, under which conditions, and with what goals. After all, we must also consider that fixed (and mobile) internet connectivity allows us to accomplish an increasing number of activities without moving and/or to accomplish them with greater efficiency in travelling, so that strong counterbalancing effects on mobility should also be expected. Further, it is also clear that the same technology that can make travel easier and more fun can also make it more burdensome – potentially even both simultaneously.

These paradoxical and counteracting possibilities pose a challenge to empirical research in this area. As a next step, the numerous hypotheses advanced in this paper need to be empirically tested. Many causal mechanisms are conceptually plausible, but which are dominant, under which circumstances? We only considered the travel behaviour of generic individuals (thinking primarily but not exclusively of knowledge professionals): further research is needed to specify which categories of people might be more sensitive to travel behaviour change, and might in fact change their travel habits while adopting a new portable technology. Empirical research is also needed to investigate which kind of individuals might indeed exploit the efficiency potential offered by the new devices, vis-à-vis a more productive allocation of travel resources (time-wise and space-wise). For example, if it were to be empirically discovered under what conditions the saved travel time would be reallocated to additional (or more-distant) activities, hence stops (see Section 3.3), researchers could use the findings not only to better calibrate traffic simulation models, but also to weigh the implications of emerging forms of travel behaviour for the environment.

Disaggregate studies, with the individual as the unit of observation, are critical to understanding the true causes behind observed behavioural changes and, specifically, for disentangling causation from mere correlation. But aggregate studies are also essential to seeing the overall net impact of the numerous specific possible causal mechanisms identified here. Some older aggregate studies (Choo and Mokhtarian, 2005, 2007) provide useful examples of a productive methodological approach, but their findings are based on data only up to the year 2000.[14] Clearly, it would be valuable to repeat such studies with the extended time series that are now available, and to replicate them for other countries.

In any case, overall, the general hypothesis that mobile technology offers people new reasons for more and differently configured travel seems to be consistent with the very reason these technologies were introduced to the market in the first place. They were meant to deliver people more freedom and flexibility, unchaining their free will from the constraints of space and time. But, by making travel more controlled and productive, they might also have deprived it of part of its allure.

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[12] "Benefits" could be viewed as comprising two types, having in common that both types positively influence the utility of the associated alternative. *Motivation benefits* are derived from drives: we do something *because* we expect a benefit from it. By contrast, *facilitation benefits* are the opposite of constraints: when factors associated with our *ability* to do something are improved, we benefit (assuming we also have the drive to do it) because doing that "something" became easier. The benefits we discuss here are of the latter type.

[13] Aside from temporary dips associated with the recessionary economy.

[14] Applying structural equation modelling to U.S. data spanning 1950–2000, Choo and Mokhtarian (2007) found a clear complementary relationship between number of telephone calls and passenger vehicle-miles travelled, in both directions. However, when analysing number of mobile phone subscribers as the measure of telecommunications demand (Choo and Mokhtarian, 2005), the picture was less clear. A positive impact of travel demand on the number of mobile phone subscribers was found, but no significant impact of mobile phone subscribers on travel demand. The authors pointed to the limitations of the short amount of time that mobile phones had been widely available and the inability to use a more appropriate metric such as number of mobile phone calls or minutes, and also speculated that counteracting impacts of mobile phones on travel (both increasing and decreasing it) may have largely cancelled in this case.

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