

The ICT revolution for more sustainable mobility? A long-run perspective

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NEW ICTs HAVE HISTORICAL PREDECESSORS THAT ARE WORTH CONSIDERING

New Information and Communication Technologies (ICTs) have been hailed to massively transform our economies, and potentially towards more sustainability. But will they? While the newest ICTs such as the Internet are in some respects unique, in other respects they have historical predecessors (telegraph, telephone) that are worth considering: they have also generated important expectations and impacts on their contemporaneous society, and in particular on the mobility regime.

OLD ICTs HAVE MASSIVELY TRANSFORMED OUR MOBILITY

The literature review in this paper shows that ICTs have transformed and keep on transforming our mobility in very massive, long and unpredictable ways. If one does not live yet in “electronic cottages”, as expected by some already a long time ago, “old” ICTs have modified our mobility radically by supporting and making more efficient new transport modes, by contributing to the geographical concentration and dispersion trends of cities and economic activities and by changing how and how much we connect to our families and friends. The interactions between mobility and ICTs, be they new or older ICTs, turn out to be massive, diverse and complex.

ICTs: A POWERFUL ENGINE OF TRANSFORMATION THAT HAS TO BE GIVEN A DIRECTION

Moreover, if the current ICT wave put forward by some authors opens many opportunities for building a more sustainable mobility system, it also raises many challenges. For ICTs to drive a more sustainable mobility and beyond that a more sustainable society, there are plenty of conditions to be met and of choices to be made, individually or collectively. This calls for integrating all the new options permitted by ICTs into mobility policies and governance, analysing their potential realistically.

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1. INTRODUCTION

To better understand the challenges of moving towards a more sustainable economy, many authors have recently used history and various analyses that provide a long-term perspective (e.g. Rifkin, 2011; Perez, 2014). They highlight that the current crisis is a symptom of a fundamental restructuring of our economy, and that we might be at the beginning or in the middle of a new innovation “wave” that will help build a sustainable world.

For some of them, the new innovation wave is driven by sustainable technologies and practices, and would logically lead to a more sustainable economy (see Figure 1). In a previous paper we have shed light and some doubts on this potential transformation (Demailly and Verley, 2013). For others we are still in a new Information and Communication Technologies (ICTs) wave—peer-to-peer exchange platforms, apps for smart

phones and social media, big data and the ‘Internet of things’, etc.—that has the power to reshuffle our production and consumption modes and to build a sustainable economy. The SMARTer 2020 report, for example, states that “new” ICTs have the potential to abate more than 9 Gt CO₂ by 2020 (GeSI, 2012).

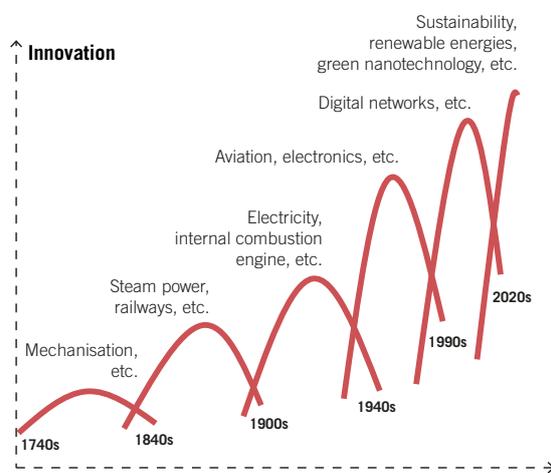
However, if new ICTs raise opportunities to reduce the ecological footprint of our economies, they also create many challenges (e.g. Berkhout and Gertin, 2001), if only because of the footprint of producing these technologies. Moreover, whereas the literature focuses on the impact of the newest ICTs such as Internet, these technologies have historical predecessors such as the telegraph or the telephone that have also generated great expectations and have transformed their contemporaneous society.

This paper provides a literature review whose objective is twofold:

- First, we investigate how old (telegraph, telephone) and new ICTs (“Internet”) have and keep on transforming our mobility modes (i.e. how we move) and patterns (i.e. how much and what for). We aim to provide a comprehensive overview of the linkages between ICT and mobility, for old and new technologies.
- Second, we illustrate how ICT can help—or not—building sustainable mobility, through more efficient modes of transport or through reduced demand for mobility.

Mobility looks like a good case study as it faces many sustainability challenges: energy scarcity and climate change mitigation, local pollution and noise, important needs for space in cities, biodiversity impact of transport infrastructures, etc. On the energy and climate dossiers alone, it is worth noting that the mobility (i.e. transport) sector (freight plus passengers) account for about a third of EU final energy consumption

Figure 1. Waves of innovation



Source: based on Natural Edge Project (2004).

(European Commission's Market Observatory for Energy, 2010) and about 25% of EU CO₂ emissions (EU Commission, 2014). To progress towards sustainable mobility, i.e. a mobility regime that addresses all the challenges we have just mentioned, the Avoid, Shift, Improve (ASI) framework has now been widely adopted. It is a structure with which the full range of sustainable mobility options can be adopted (Banister, 2014). These options include substituting or not making trips, shortening trip lengths through land use planning, the use of public transport, walk and cycle, and, finally, increasing fuel efficiency.

In short, our literature review highlights that ICTs, from the telegraph to the Internet, have had important impacts on mobility, but that their relationships are diverse and complex. ICTs have transformed and keep on transforming our mobility modes and patterns in very different ways, but also in very unpredictable ways. We also highlight that ICTs, old or new, are contributing to radically transform our mobility but that this is not automatically to the benefit of sustainability: there are conditions and consequently choices to be made and policy interventions to be designed.

Therefore, we consider in this paper the history of ICT and mobility in order to understand or at least illustrate the nature and the intensity of the linkages of the two.¹ History here is used to exemplify how diverse and complex are the linkages between ICT and mobility and how they can contribute or not to more sustainability.

Section 2 investigates the relationships between ICT and mobility from a quite conceptual perspective and provides a typology of the various promises and changes that new ICT may support towards a more sustainable mobility. Section 3 provides a review of the historical literature at the crossroads of ICT and mobility, and studies the impacts of the telegraph and the telephone on mobility. Section 4 digs into the promise that more communication (i.e. information transport) means less mobility (passenger transport) and investigates how new ICTs are transforming the ways we access work, services or leisure. We conclude in section 5.

1. Unfortunately, the literature at the crossroad of ICT and mobility histories does not provide much new to the analysis of "new" ICT impacts on sustainability, if only because this literature is poor and "new" ICT may be radically different from old ones.

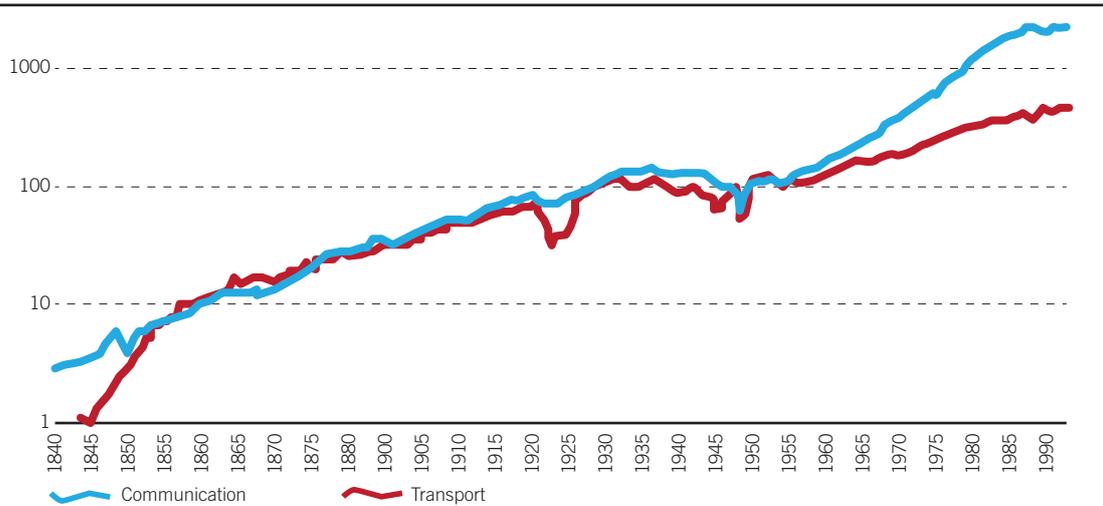
2. RELATIONSHIP BETWEEN ICTs AND MOBILITY

Taking a joint look at ICT and mobility is a meaningful approach. In fact, both are closely intertwined. ICT can be considered a broader definition of communications. Similarly, mobility relates to transportation. Accordingly, Thrift (1990, p. 453) states that "transport and communication cannot be split apart. Each relies on the other in all manner of ways".

Mokhtarian (1990) names four core dimensions in which they are related.

- First, using a conceptual dimension, ICT is a form of transportation (see also Choo and Mokhtarian, 2007). More specifically, ICTs transport information, while transport itself transports individuals and objects. However, it is an asymmetrical relationship because every form of communication intrinsically transports something, while transportation does not always have the goal of communication.
- Second, the physical infrastructure of ICT and transportation are often combined. That is, the new construction of ICT networks have often been superimposed on the transport networks that already existed. The telegraph and railways are a typical example of this phenomenon (we come back to this example below).
- Third, from an analytical perspective, both ICT and transport are characterised by their network structure. The Internet is the most recent network structure, but the same rule also applies to other ICT and transport technologies.
- Finally, there has been an interesting correspondence for the evolution of regulations for ICT and transportation. At first, both large parts of ICT and transport sectors were deemed to be natural monopolies. In many cases, a state company ran the ICT or transport network (e.g. railways). However, this point of view changed over time, and deregulation was the consequence.

These dimensions show the inherent relationship between ICT and transportation and confirm the relevance of considering both in a mutual framework. The relationship should not be exaggerated however: both communication and transportation have grown over the past centuries, as shown in Figure 2, and these trends are intertwined but up to a certain extent only. The increase in mobility for example is driven by factors that go much beyond communication, if only by the speed of transportation systems, allowing for example Americans to travel 50 km per day today versus only 50 m in 1800 (Urry, 2007; Mok *et al.*, 2010).

Figure 2. Growth of (passenger) transport and communication, France

Source: Grubler (1990), Mitchell (2007).

Note: Passenger transport (railway, aviation) is measured as passenger-km, communication is measured as total number of transmitted messages (mail, telegraph, telephone). Both trends are indexed to 100 in 1945.

As regards “new” ICT, it turns out that the promises for sustainable mobility are numerous. One may distinguish between three positive changes that ICT may bring to the current mobility regime (see Miroux and Lefèvre, 2012; Cohen-Blankshtain and Rotem-Mindali, 2014): less physical transport needed, a greater efficiency of the transport system, and a shift towards alternative transport modes.

From kilometres to bytes. A first prominent and overarching promise of ICT for mobility is that it will lead to a ‘death of distance’. In fact, one hypothesis is that ICTs such as telecommuting, videoconferencing or e-commerce will be a major step forward in reducing the dependence on the location in space for individuals, and consequently may imply less traffic because an important number of transactions do not need physical transportation anymore. The exchange and transportation of bits and bytes would then substitute physical mobility of people and goods with, allegedly, much lower environmental effects than their physical counterparts. ICT would help building a ‘dematerialised economy’ (or at least dematerialising economy).

A greater efficiency of the transport system. The transport system may use the newest ICT technologies to optimise the management and flow of transport. In particular ICTs are deemed to reduce congestion problems hence reduce emissions and waste energy. Congestion problems exist notably in cities, but also on major motorways in almost any country and the increased use of ICT may allow drivers to avoid these problems for example by informing individuals about

the current traffic situation and by indicating alternative routes. Ultimately, automated cars and highways would optimise routes themselves. ICTs are also expected to increase the efficiency of the public transport system through better management of flows, better information systems for passengers or more efficient pricing and payment methods. Lower costs of operation, better service and higher safety for travellers are seen as significant side effects.

Modal shift. Finally, ICT may support a modal shift from individual and car-based transport systems towards more collective modes. Not only increasing public transport efficiency may lead to higher use, but ICT could also support new modes of transportation such as ride-sharing or car-sharing and help switch from one mode of transport to another one (through better information or “single ticket” systems).

3. A HISTORICAL DETOUR

In many cases, historical means of communication were implicitly used to substitute for transportation (see Mokhtarian, 2009). The first means of communication were related to sound and sight, such as trumpets and flags. By using these forms of communication, it was not necessary anymore to travel to another location. However, the visual and auditive capacities of humans are quite limited, so that these very early “ICTs” could only facilitate communication for relatively short distances. The invention of writing and later printing

radically modified the possibilities to communicate. Communication became further de-personalised, as the sender of communication did not need to be in contact with the receiver of the communicated information in space or time. However, transport and communication were still closely coupled, as a physical messenger was always necessary (Mok *et al.*, 2010). Finally, the last step in forms of communication has been through electronic means such as the telegraph, the telephone and more recently the Internet.²

Below we draw some insights from the historical literature on the telegraph and the telephone. How have these technologies transformed or helped transforming our transports modes? Have they led to reduced demand by concentrating activities, or to more demand for transport by dispersing them? Have they “pushed” individuals to travel more or less? Obviously, there are no clear-cut answers. Therefore, we first note that the history of ICT is full of promises, failures and unexpected successes.

A history of promises, failures and unexpected successes

The history of the telegraph and the telephone is full of promises – and sometimes fears, that did not materialize. Standage (1998) shows that many believed that the telegraph would change the existing socio-economic regime. For example, contemporary observers expected a large democratisation of society, the breaking up of class barriers and a reduction in loneliness. Some contemporaneous authors also claimed the “annihilation of time and space” (Morus, 2000, p. 456).

Geels and Smit (2000, p. 868) note that the telephone introduction was “accompanied by vehement discussions about its impact on social life. Although transportation itself was not so much an issue in these discussions, some people expressed their fear that future generations might remain indoors, maintaining necessary contacts only via the telephone”. These authors also highlight that

2. It is worth insisting on a key difference among them and with the newest ICT. The telegraph was the first of these grand inventions of modern ICT: for the first time communication without face-to-face contact was possible. “In a historical sense, the computer is no more than an instantaneous telegraph with a prodigious memory, and all the communication inventions in between have simply been elaborations on the telegraph’s original work” (Marvin, 1988, p. 3). However the telegraph was not yet a very democratic ICT, if only because its use was quite expensive. Thus, it was mostly employed by organisations such as governments and businesses, and only used for private communication in the case of major life events (Pred 1973; Mok *et al.*, 2010). The telephone and later the Internet democratised access to communication to an important extent.

speculation about automated cars and highways was already around in the 1930s. In its Futurama exhibition General Motors toured visitors around through scale models, demonstrations and films, showing a future transportation system where almost everything would operate automatically. After people had pushed the buttons of their vehicle, and instructed its destination, an automatic electronic system, and roads with invisible rails and radar systems would take them there.

If the history of modern ICT shows many promises that have not materialized, it is fair to say that many contemporary observers have also underestimated the fundamental impact of ICT on society. The telephone, for example, was described as merely an “electrical toy” by Western Union officials when it was first introduced to England. Moreover, the cheapness of messenger boys was seen as a formidable reason why the still relatively expensive use of telephones would not have a great impact on society and the existing communication and mobility networks (Dilts, 1941; Mokhtarian, 2002). History proves that these hypotheses were wrong. It is also worth noting that the telephone industry itself resisted the so-called ‘trivial’ use of the telephone for social calls until the 1920s (Fischer, 1988) and kept focusing on commercial, industrial and even defence markets. According to Green and Adam (1998), this was strongly related to gender considerations as the main users of the telephone for social calls were women isolated at home.

ICT for a more efficient transport system

Whereas new ICTs are deemed to play a critical role in building a more efficient transport system, it turns out that older technologies such as the telegraph have played an important role in the growth of railway lines. Indeed, with increasing industrialisation and construction of the railway network, it was important to be able to control the transport network at a distance. For example, the increasing speeds of trains posed a challenge to the security of the passengers. Effective control of the transport system through the use of the telegraph was essential for the success of the railways (Spar, 2001).

According to Carey (2009), the telegraph was also fundamental to standardising time as such. Historically, every city (and many villages) had its own time, calculated from the movement of the sun and the stars. In the US state Wisconsin alone, there were 39 different time zones. Clearly, this multitude of time zones created trouble when the railways arrived. Passengers did not really know when the train was supposed to arrive at their city in their time zone, and led to accidents.

The speed at which information and time could be communicated through the telegraph enabled a more uniform system with the creation of standard time zones in the entire world. Thus, the telegraph allowed an impressive growth of railway lines, while the railway lines were also fundamental for the construction of the telegraph network (the telegraph lines usually followed already existing railway lines, as the ICT network was often superimposed on the transportation network, see Mokhtarian, 2009).

Obviously, it is not because the literature on the telegraph insists on its linkages with railways that we should conclude that the telegraph—and more generally, ICT—support more so-called sustainable modes of transport than unsustainable ones. If this literature does not insist on the impact of the telegraph on roads, it is rather because cars and trucks were invented much later than the telegraph. Thus, one may guess that the telephone has supported as much the functioning of railways as of roads.

ICT, geography and cities

The need for transport is determined by the spatial organisation of people and firms: where people live and work, where business offices and factories are located, etc. Many authors discuss the impact of ICT on this organisation, highlighting the role that they play in the concentration or dispersion of cities. Below we present this literature. Note that the concentration of people and activities in cities does not automatically mean lower transport needs. In fact, one can imagine big and powerful “global cities” inside of countries (Sassen, 2012) with shapes including highly transport-dense areas.

Do ICTs lead to a more concentrated or more dispersed organisation of firms and workers? The fact that cities exist indicates that agglomeration forces (e.g. beneficial contacts between economic actors, knowledge spillovers) can be very intense. Thus, concentration is “the most striking feature of the geography of economic activity” (Krugman 1991, p. 5).³ However, ICTs may well reduce

agglomeration forces by allowing many forms of contacts without requiring spatial proximity and, as noted by Graham and Marvin (1996, p. 326), “utopian and technology determinists point to the dissolution of the city”.

The history of the telegraph shows that this technology has indeed played a role in the dispersion of activities, by allowing a separation between offices and industrial plants, between headquarters and manufacturing processes. As highlighted by Tarr *et al.* (1987), few data exist however to show to what extent the telegraph actually contributed to the decentralization of productive facilities. It is worth noting indeed that the telegraph’s utility was limited by many factors as a communication device such as its cost or the inability to use it to engage in discourse. The telegraph prepared the way for the more flexible telephone and, ultimately, newest ICT that facilitated further the dispersion of activities across the globe.

Even though ICTs have contributed to the dispersal of some activities away from the city, they have not led to its disintegration. On the opposite, the telephone first further increased the concentration of activities in the centre of cities with an unclear impact on transport needs. As pointed out by Pool *et al.* (1977), before the telephone, businessmen needed to locate close to their business contacts: every city had a hatters’ neighbourhood, a fish market, a financial district, etc. Businessmen would pay a great deal for an office within a few blocks of their trade centre and, once the telephone was available, they could move to cheaper quarters while still keeping in touch. Then, at an early stage the telephone helped dissolve the solid knots of traditional business neighbourhoods and helped create large new downtowns. Interestingly, this association was initially not anticipated by contemporaries.

Strikingly, the relationships change with time and the level of telephone penetration. Although initially the telephone facilitated the growth of cities, “a parallel trend was also developing”. That second trend was a dispersion from the city “to suburbia and exurbia” (Pool, 1983, p. 453), with a massive impact on mobility needs. Dispersal was initially based on more efficient transport systems (mostly automobile and highways), which helped minimise the travel time especially associated with commuting. But the “ability to pick up a telephone and get a message through without moving was just essential as the car” (Pool, 1983, p. 454).

ICT and the “electronic cottage”

We have already seen above that ICTs have raised and keep raising hopes that people could work and have access to many goods or services without

3. Theorists such as Fujita and Krugman (2004) list a number of standard forces that lead to agglomeration or dispersion of firms and workers in space. Among dispersion forces, one may quote the land and housing prices that are lower in the countryside than in a city or commuting that enables individuals to live at considerable distance from their workplace. Main agglomeration forces are the beneficial contacts between consumers, producers and suppliers of goods, which are improved by spatial proximity, or the positive externalities that may arise from locating near other actors of the same sector and thus being in contact with the knowledge of others.

having to travel anymore. At the same time, ICTs have also raised social concerns that people might end up isolated in their “electronic cottage”. What lessons can we draw from the history of ICTs?

It turns out indeed that teleworking is not a new idea. As highlighted by England (2004, p. 272), “a US bank manager strung a telegraph line to his home so he could work at weekends almost as soon as the telegraph was invented”. Neither is tele-shopping: rail and telegraph made possible the development of catalogue sales (Tedlow, 1996), and the diffusion of household telephones further expanded its growth. But the fear of “electronic cottages” has not materialized (yet).

Whereas some expected the telephone to substitute physical contacts, it turns out that the relationship between personal communication and mobility is much more complex. This is best illustrated by the first phrase that was spoken on the phone by its inventor Bell. He said that “Mr. Watson, come here; I want you” (Mokhtarian, 2002, p. 45).

4. “NEW” ICTs AND THE REDUCTION IN MOBILITY NEEDS

Many authors predict a radical change in the geography of activities because of “new” ICT. Audirac (2005) assesses that cities will not be monocentric with one important cluster, but polycentric, and that the future metropolises will be more widely spread out and intensively interconnected by ICT and transportation with still important traffic. On the other hand, Cohen-Blankshtain and Rotem-Mindali (2014) see a further tendency towards concentration of activity that is linked to accessibility and connectivity.

Whatever the new geography of activities, one of the promises of ICT for mobility identified in section 2 is the reduction in transport needs for individuals through new systems of teleworking, tele-shopping or tele-leisure. This effect is commonly called the substitution effect. This would mean that there is a fixed amount of functions performed by the use of ICT and transportation, so that an increase in one variable necessitates a decrease in the other (Plaut, 1997).

Alternatively, ICT and transportation may also be complementary. This means that an increase in the use of ICT (or the invention of new ICT) will have a positive effect on the propensity to travel. Contrary to the substitution hypothesis, the volume of transactions is not seen to be fixed but variable, so that it may increase through more ICT or more travel. For example, the flexibility of working (in part) at home may incentivise

workers to choose a location of their home farther away from their work than they would if they had to go to work every day. In more extreme cases, individuals can even live in other countries than their employer, communicate by the use of different ICTs (e.g., emails, videoconferencing, etc.), and fly over thousands of kilometres once or twice a month.

For a number of years, most researchers have focused on the substitutes versus complements debate. Even if communication and transportation have both grown massively over the last centuries pushing people to think there is an overall complementarity between these two dimensions (see below), it turns out that there may be substitution in some fields of transportation. Adopting a micro-perspective, researchers have often made the distinction between three different trip purposes: subsistence (e.g., work), maintenance (e.g., shopping) and leisure (Mokhtarian *et al.*, 2006). Special interest has been given to the corresponding emerging tele-modes, that is tele-commuting, tele-shopping and tele-leisure. Cohen-Blankshtain and Rotem-Mindali (2014) review the literature on the effects of these new modes.

- First, evidence of tele-commuting (or tele-working) appears to show a substitution effect (e.g. Pendyala *et al.*, 1991; Balepur *et al.*, 1998), which is smaller than often anticipated (Mokhtarian and Salomon, 2002). However, it is not a pure substitution effect, as there are also relevant complementary effects. For example, business networks become larger and necessitate increased travelling. Still, this effect is smaller than the substitution of working, for example, at home.
- Second, tele-shopping is often considered to replace normal shopping because individuals increasingly shop digitally. Indeed, online shopping has been found to have substitution effects on in-store shopping (e.g. Anderson *et al.*, 2003; Fichter 2003; Mokhtarian, 2004). This has also the effect of increased home deliveries and thus higher freight transport (e.g. Cohen, 2000; Nemoto *et al.*, 2001). Still, a range of studies tend to show an overall limited or neutral impact on the combined personal and freight travel (e.g. Keskinen *et al.*, 2001; Visser and Lanzendorf, 2004). On the one hand, a part of shopping trips are simply done not as an exclusive aim of a trip, but rather alongside other affairs. At the same time, many purchases can be done within one single trip. The fact that shopping opportunities become more transparent online also gives increasing incentives to travel to formerly unknown and perhaps distant shops (Farag *et al.*, 2006).

- Finally, tele-leisure activities imply that one can entertain oneself easily at home and does not need to travel for it. However, leisure activities are very diverse in nature. According to Cohen-Blankshtain and Rotem-Mindali (2014), the evidence of substitution or complementarity effects is mixed, in part because the results depend on the kind of the considered leisure activity. The results for leisure are not trivial, as between one third and one half of all personal trips are related to it (Mokhtarian *et al.*, 2006).

In another review, Van Cranenburgh *et al.* (2012) find similar results for the working and maintenance categories but see a more complementary relationship between ICT and mobility in the leisure area. In contrast, the earlier study by Andreev *et al.* (2010) confirms the substitution effect for tele-working, while finding a complementary effect for shopping and leisure.

While the substitution vs complementarity debate has been popular in the past, it turns out that the relationship between ICT and mobility is more complex. The use of an ICT does not simply lead to more or less mobility: it modifies the way people move through space. For example, while a telephone call or the use of mobile Internet applications may not cancel a trip or lead to a new trip, they may modify the time or route or potentially the destination. Furthermore, while the direction of influence is often considered to run from ICT to transportation, one has to keep in mind that the impact may also be the other way round, i.e. that transportation may have a positive influence on ICT as well. For example, good pre-existing transport networks may be a positive stimulus to the development of ICT networks and technologies. One should also always bear in mind that there may be a neutral effect, i.e. no effect of ICT on mobility. Finally, although communication and mobility have closed relationships, one should not forget that there are many forces driving the rise in transportation other than communication, and vice versa. As discussed above, the massive increase in the daily travel distance of Americans—from 50 m in 1800 to 50 km nowadays—is mostly driven by the increasing speed of transportation systems from walking to automobile and rail.

5. CONCLUSION

Information and Communication Technologies (ICTs) have been hailed to generate a new world of prosperity, growth and sustainable development. However, we do not live in a brave new world where everything that we see has never been experienced before. While the newest ICTs such as Internet are in some respects unique, in other respects they have historical predecessors such as the telegraph or the telephone that have generated important expectations and impacts on its contemporaneous society and mobility regime.

The literature review in this paper shows that ICTs have transformed and keep on transforming our economies and societies in very massive, long and unpredictable ways. If one does not live yet in “electronic cottages”, as expected by some already a long time ago, “old” ICTs have modified radically our mobility by supporting and making more efficient new transport modes, by contributing to the geographical concentration and dispersion trends of cities and economic activities and by changing how and how much we connect to our families and friends. The interactions between mobility and ICT, be it new or older ICTs, turn out to be very diverse and complex.

Moreover, if the current ICT wave put forward open many opportunities for building a more sustainable mobility system, it also raises many challenges. For ICT to drive a more sustainable mobility and beyond that a more sustainable society, there are plenty of conditions to be met and of choices to be made, individually or collectively. This calls for integrating all the new options permitted by ICT into mobility policies and governance, analyzing their potential realistically. Generally speaking, ICT is a powerful engine to transform how we move and live but this engine has to be given a direction. As Perez (2014, p. 11 & 12) puts it: “the particular trajectory followed by a technological revolution is not endogenously determined only. All that a technological potential can do is set the stage for the social actors to take their decisions and shape the favored direction from within the new range of the viable”; “social values, policies, regulations, taxes, costs and relative prices will be the ultimate drivers of the speed and depth of the shift.” ■

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