Exploring the rebound-effect of information technologies on mobility systems: clues for a blueprint

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Abstract
It is commonly expected and announced that the information and communication technologies (ICTs) will relieve an enormous pressure from the transport investments and constraints in the future as less people should be inclined to travel (instead of "tele-doing" things) and less goods (in particular documents and written material of all kinds) should be released in the traffic. Environment will look better, regional development and flexible options for learning and working can finally be in our agenda.

This idealised perspective is exactly the contrary of what we can observe in most ICT-supported domains. As a matter of fact, our own research as well as other studies, in various areas, show that ICTs appear to play boosting role for mobility, building upon various development patterns, globally identified as the "rebound-effect". Beyond any form of ingenuity, it seems but urgent to understand and document this process, its features and stakes.

The domains in which we have carried out research, providing supporting results for the above-mentioned observation, are in particular: home automation and telematics, e-work, e-learning, e-voting, e-publishing (with main focus on personal mobility issues) and (for freight) the influence of ICTs on transport enterprises.

These mapping and documenting of cross-fertilising features and stakes should also lead to understand better the future of this issue, not only from the environmental point of view, which is often the claim for leveraging the hope that ICTs will diminish mobility (and therefore to restore a more realistic picture on this battlefront) but also economic (mobility is a resource and asks for organisational creativity) and societal points of view (let us consider in particular the pervasive or ubiquitous information technology horizon).

Our presentation aims at building upon our existing results and current debates in the matter, and at point out some key perspective for this problematic's close future, with special attention paid to both internal and external implications for transport.

Keywords
Information technologies – traffic induction – complexity

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1. A basic hypothesis

It is commonly expected and recurrently announced that the information and communication technologies (ICTs) will relieve an enormous pressure from the transport investments in the future as less people should be inclined to travel (instead of "tele-doing" things) and less goods, in particular documents and written material of all kinds, should be released in the traffic. Environment will look better, regional development and flexible options for learning and working can finally be high on our agenda.

This idealised perspective is exactly the contrary of what we can observe in most ICT-supported domains. As a matter of fact, our own research as well as other studies, in various areas, show that ICTs appear to play a boosting role for mobility, building upon various development patterns, globally identified as the "rebound-effect". Beyond any form of ingenuity, it seems but urgent to understand and document this process, its features and stakes.

The domains in which we have carried out research, providing supporting results for the above-mentioned statement, are in particular,

1. for personal mobility avoidance claims,

    - home automation and telematics,
    - e-work,
    - e-learning,
    - e-voting,
    - e-administration,
    - e-publishing,
    - e-commerce

2. for freight optimisation claims,

    - the influence of ICTs on SME in freight transport,

3. for both freight and passenger transport,

    - basic telematics scripts for mobility behaviour optimisation.

2. Nuances

The above-mentioned hypothesis on the relationship between ICTs and transport indicates only a general trend, but confirmed by empirical evidence[1]. However, there are contrary observations to be made, suggesting, for limited situations, a certain reduction (or at least containment) of mobility due to ICT use. We can categorise them according to three main mechanisms:

- substitution of physical mobility by ICT-supported communication,

- optimisation of transport configuration thanks to telematics application, refraining or even decreasing locally the level of traffic,

- risk monitoring and reliability improvement, thanks to ICT, allowing a better management of thresholds, regulations and limits in various sorts of traffic.

The most-researched of these dimensions is of course the substitution issue, the two other ones helping at best improve the quality of traffic flow and probably producing more new mobility induction than real containment.

The substitution concept was already in discussion in early ages of ICT developments or even before, with the modal problem of choice-making and behavioural patters observable in the "phone call or physical trip" dilemma (in the 80's). As a matter of fact, some key hypotheses on the substitution clues elaborated during the pre-Internet era, based mostly on phone, sometimes on Minitel or on early telematics applications, still define today the core approach for this type of research. The complexity added by ICTs is considered more as a series of increments in the theory, rather than the basis for a new approach (see for that Claisse and Row 1993)[2]. According to this tradition, there is real substitution taking place, but in a limited way or in niche activities[3]. Distance, in particular, can be one good reason for substitution choices, but with several associated co-factors (see for that, for instance, Mokhtarian and Varma 1998 and Buser and Rossel 1999). Several attempts have

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1 Most of our research in this domain has been up to now mostly qualitative, based upon observing real practises (and not only declared preferences), interacting on concrete problem-solving with specific socio-economic actors, eventually making explicit their reasoning in support of their modal or combinatory choices (see for that Buser, Rossel and Bosset 2000 and Buser, Poschet and Rossel 2002). Other approaches are possible and will become also part of our research activity. It will be discussed in the section on modelling the ICTs and transport relationship.

2 In Switzerland, the National research program MANTO, at the end of the 80s, dealt with this question in its early forms, prefiguring a Technology Assessment of the ICT-transport transaction, but with only preliminary visions of what ICTs could become. Nevertheless, this research programme, monitored by Martin Rotach at ETH Zurich, has been referenced as meaningful source during the next ten years; see for instance a Land-use planning analytical overview by Schrenk in 1997 and an IPTS survey (Kiriakou et alii 1998).

3 The nuance as regarding our hypothesis requires in its turn… a nuance: if an survey identifies, let us say, a 15 % substitution pattern, beside establishing clearly what substitution really means (status of telecommuters, duration of use, etc.), this does not imply that it is going to remain so forever, in a stable manner. This problem has been made explicit in particular by Varma, Ho, Stanek and Mokhtarian (1998). Another nuance comes from the perverse effect of the substitution behaviour of replacing travelling by ICT usages: new problems, deficits, conflicts, needs and specific mobility are generated as side-effects by a clear-cut substitutive modal choice, either at home or in tele-cottages (see for that Buser, Poschet and Pulver 2000).

been made so far to determine the level of substitution which can be accounted for in a reliable manner. Let us summarise here the Mokhtarian figures (1998), which for the United States situation[4]: the author indicates that "6.1 % of the workforce may be currently telecommuting[5], at least in California, 1.2 days a week on average, with the result that 1.5 % of the workforce may be telecommuting on any given day. It is estimated that the vehicle-miles eliminated by this level of telecommuting constitute at most 1.1 % of total household vehicle travel. When the limited knowledge about potential stimulation effects of telecommuting is incorporated, it is estimated that the net reduction falls to at most 0.6 % of household travel". As for the future, due to this stimulus factor, estimates are even more pessimistic.

Claisse has produced a long-term reflection on this matter, covering most technological developments of the last twenty years[6]. Nowadays, he speaks of "re-enchantment" of mobility by ICTs (Claisse 2000), but until the mid-90s he has worked at documenting the substitution and non substitution mechanisms. He produced a "elative substitution" theory (Claisse and Rowe 1993) and he substantiated the predominance of complementary usages of ICTs and transport technologies, with a non negligible induction effect of ICTs over transport and a specific type of development of ICTs with little or no transport effects. By induction, he means clear, direct, measurable induction. Let us stress, however, that, complementarity, through the global stimulus that it generates over mobility potential, has also, but indirectly, an induction effect.

In reality, the mechanisms through which ICTs boost transport in all its forms are numerous. For the moment, let us acknowledge the limited substitution impact of ICTs over mobility patterns[7]. The paradox comes from complementary modal usages: as the number and diversity of usages combining ICTs and transport increases year after year[8], it has at the samea time a more important mobility-reducing effect than mere substitution practises and an overwhelming induction effect over traffic of all kinds.

During the 90s the rhetoric gave the way to environmentalist preoccupations, keeping up with the idea that ICTs were going to help reduce traffic and nuisances. It seems that this vision, although still significant, has encountered some form of limit as more and more utility providers and vehicle manufacturers (for trains, cars, boats, planes or even smaller

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4 Buser, Poschet and Pulver (2000) are far less optimistic for Switzerland.

5 By the definition given by Mokhtarian after the Pacific Bell Guidebook (1996), "telecommuting is the partial or total substitution of telecommunications technology for the trip to and from the primary workplace, along with the associated changes in policy, organization, management and work structure".

6 We can start with a seminal work of the 80s (Claisse 1983) having quite a suggestive title: "transports ou télécommunications: les ambiguities de l'ubiquité" and select either actual current work (e.g. Claisse 2000) or the stimulating 30 years-ahead foresight on ICT and mobility interactions (Claisse and Rowe 1994), as upper horizon for his contribution.

7 The techno-euphoric rhetoric of some authors (see the Eurotechnopolis journal for instance) made it necessary to explore, document and explain the limits of the substitution paradigm (see for that Claisse 1997), just as it was necessary to analyse more specific issues in order to understand better the particular dimensions of the ICT-physical transport transaction. That is precisely what the above-mentioned "Telecommunications and Travel Behavior Research Program"(Univ. of California at Davis/Mokhtarian leadership), has done.

8 One of the main advantages of non-exclusive approach to telecommuting and ICT use in complementarity with moving physically is 1) flexibility and 2) potential for combination. This has been clearly identified in Bagley and Mokhtarian (1997).

vehicles) emphasise the interest of enhancing transport thanks to embarked ICT facilities (hence Claisse "re-enchantment" proposal).

We took here Gérard Claisse' career as a marker, but in the English-speaking literature, the work of the "Telecommunications and Travel Behavior Research Program", led by the Institute of Transportation Studies of the University of California at Davis, under the leadership of Prof. Patricia Mokhtarian, has gone through similar steps of digging, documenting and evidencing the evolving nature of the ICT-physical mobility relationship.

3. Complexity[9]

Each domain of activity involves to some extent a series of specific mechanisms tying ICT use and mobility schemes. Let us review briefly a few typical situations, taken from direct observation ("real practise" approach).

e-learning

There is no doubt that there are circumstances of time and distance disadjustment justifying distance teaching is as a meaningful substitute for either absence of accessible opportunity or classical distance learning. In some countries like Australia, Canada, China for their size, or France and England and a few other ones, for their colonial past, this situation is not new but just channelled today through ICT-supported solutions. In most cases, anywhere, however, e-learning proposals combine different knowledge-access features with more classical face-to-face encounters, both "vertical" (student-teacher) or "horizontal" (student-student), individually, teamlike or mediated by specialised mentors.

In reference to a static, classroom-like form of teaching and its mobility parameters, this new and somehow still emerging regime is characterised by its combinatory approach to knowledge-building. Although still maintaining, in many cases, a teaching staff, learning is becoming the pivotal activity (instead of teaching). In this new perspective, which comes along with significant institutional changes such as the Bologna agreement, helping students to move all across Europe after their bachelor's degree thanks to a hopefully functioning system of educational credits, ICTs are no substitute: complementary components to classical educational settings or even versatile platforms inducing new motivation to chase opportunities wherever they are located. The learner is more and more considered as an knowledge entrepreneur of his/her own, ICTs being merely a facilitating toolbox.

Complete course packages or specific technologies, except for very specific mass-products, become less and less frequent due to their high production cost, market narrowness and speed of obsolescence[10]. The generation of multiple forms and channels for knowledge sharing and acquisition is more the trend, with rather poor pedagogical conception but high accessibility and flexibility of update. As a general tendency, moreover, beyond isolated tools or applications, e-learning gets every year more

[9] This section is based primarily on our own research activity and findings.

[10] See for that Buser and Rossel (2000).

integrated in all the aspects of the organisation's functioning, whether a higher-education institution or an enterprise. We would like to stress here this multiplicative aspect of mobility (of persons and knowledge) thanks to ICTs.

e-work

Like e-learning, e-work, under different forms, represents the ideal dream of ICT use to transcend time and physical space limitations. Here again, much like in the previous domain, problems are complex and many, the mere substitute approach concerns only a tiny minority of situations (see for that Buser, Poschet and Pulver 2000). Most of the time, the side-effects of working at home are too numerous to be sustainable, except but for a very few specialists. On the contrary, partial tele-working is very frequent and can be observed in many fields of activity, following quite uneven level of intensity and flexible implementation patterns. Organisations can change their habits, delivering in real-time or almost, new types of services, in complementarity with fixed or home-based tasks[11].When doing so, they release extended mobility potentials (of persons, expertise, service, etc.), thanks to a combined model of physical travelling and ICT-supported activity. The scientific community is perhaps the most concerned by this multiplicative aspect of the ICT and transport relationship.

e-administration

Nowadays, a fast expanding domain, "e-administration" is incorporated in larger digital schemes like e-Europe and can take different forms. As a general standard, every town, region (in Switzerland, cantons), country and of course the European Community has a web site, through which is channelled information and also, more and more, tele-procedures to carry out some specific administrative tasks. We are currently part of two European research programmes on this subject (e-GOV-IST.5PCRD and e-governance/OFES-COSTA14).and what appears to be characteristic of this emerging pattern is 1) the extreme heterogeneity of situations, administrative procedures, technological platforms and website interfaces and 2) the difficulty of designing, developing and implementing a common or at least seamless one-stop access concept for European administrations. This last requirement is a necessary step to differentiate this multi-sprouting e-administration from a socio-technological jungle. The goal is not only to enable easy and relatively standardised access to information, but also allow going through simple electronic transactions. Part of a larger transparency assignment from the political arena encompassing its functioning and decision-making processes, this technological evolution has also generated here and there experimental e-voting trials (see for that Cotti 2002). What is critical in this trend is not so much that people can vote from home or a specific voting booth, but to see if new people, young people in particular, who may have otherwise some tendency to remain on the abstentionnist side, incorporate the public debate, as a normal activity, thanks to electronic information access (transparency) and transaction channels (simple effectiveness). The hidden agenda behind this kind of experiment is that the e-voting channel is in phase with the problem-solving culture of that generation. We still have to identify thoroughly and treat in the most appropriate manner the potential perverse effects of this type of governance, but as this evolution is not

[11] See the case of the Insurance sector, in Buser and Glassey (2001).

considered in a substitution but in a complementary perspective, time is available to carry out the necessary evaluation.

In this sector of activity, from the physical travelling/electronic solution trade-off, one can estimate as quite possible that some journeys are spared in the future but within a clear dual mode interaction scheme and a redundancy pattern between electronic and face-to-face solutions, likely to last for a long time.

e-publishing

Negroponte (1996), one the prophets of the multimedia age, made the reasonable hypothesis that bits are easier and cheaper to transport than atoms. Publishing is certainly one domain where the checking of such assertion should have been most stimulating to do. After some ten years of developments of both technologies and interfaces, the status of this claim is still quite uncertain. In the domain of e-books, the experimental tablets that have tried to replace either traditional newspaper support or books are still short of the readability of paper-made references, although they may have interesting additional features and are improving constantly. The precise future of this substitution potential is relatively unclear, however, and in all cases unsatisfactory. As far as e-press, the situation is different. 6-7 years ago appeared the first attempts to publish newspaper-type of media material on-line, either as side activity of well-known newspapers or electronic-only newspapers, with different types of vocations. First, the electronic version of newspapers was identical for the limited parts of the total newspaper diffused on-line. Then (but that was before the explosion of the new economy bubble), many newspapers tried to use their website platform to recruit new customers and to sell goods and services much beyond their traditional core competence (wine, insurance, cars, etc.). More recently, things got back in their original track and the deal seems now to be able to find the best kind of on-line material, interface and relationships that makes it complementary, not competitive, to the paper edition. It is part of the ongoing learning curve to identify, test and validate this new media mastering, very rarely in a substitute approach. In the scientific arena, the trend is to go on-line in order to diminish the importance of the paper distribution step. In the "lay market", solutions remain more complementary, perhaps even inductive of new reading and consulting practises that still need to be evaluated. In terms of moving bits rather than atoms, however, studies undertaken in an ecobalance perspective show that the situation is rather complex, the electronic channel being much more than just readers in front of their screens (see in particular Faist and Kytzia 2001 and Reichart and Hischier 2001) suggesting for the moment, as multi-channel access to information is still dominant, a global trend towards a mobility increase supported by ICT developments. This needs to be evaluated more finely, of course.

e-support for freight transport

Quite obviously, the objective in this domain is not to provide a virtual substitute to freight but to optimise and monitor the various facets of supply-chain so as to produce, thanks to ICTs an overall value-added effect. We have observed SMEs in freight transport in Switzerland for a French research programme dedicated to the study of ICTs in good transport (PREDIT II, DRAST-MPE)[12]. The unequal status, in terms of investment

[12] See for that Buser, Poschet and Rossel (2002).

capacity, of SMEs in the supply-chain, make them quite dependant upon big players and they tend to express what has to be identified as a resistance behaviour when coping to technological newness. They have good reasons as ICTs are not always up to the expectation, in particular for niche market and last mile traveling. When dealing with proximity for instance, fieldwork knowledge may be better than a traveling assistant. Software packages to load and unload may be perceived as less efficient than long-term experience. For very short term changes in all aspects of transport, phone calls between actors who most of the time know each other seem an easier solutions than fancier ones. However, for EDI type of tools, they are imposed by big firms (when you have less than 20 bills a day to process, you do not intrinsically need it). Altogether, however, things are changing and new channels are likely to constitute learning facilitators most SMEs (Internet dimensions on mobile phones, measuring box of the RPLP real-time taxing system for trucks, shared software allowing to check profitability of decisions in the value-chain, etc.). As a general trend, ICT help manage, monitor, coordinate better freight transport and therefore improve economic offer and the overall mobility potential it represents. Unable to measure its specific contribution in several types of situations, one could summarise saying that ICT participate "convergingly" to the increase of traffic taking place in freight transport.

4. Towards an explanation

To a great extent, the observations presented for the sample domains of the previous section are also valid for complex settings like the diverse telematics applications in transport, either for freight or passenger. Telematics allow to increase reliability, traceability, fluidity, safety and overall monitoring quality of traffic, but only to release potential for more traffic on any given track serviced by such technology. This paradox, which is but the same as always (in transport, new bandwidth tend to increase traffic), needs to be documented and somehow explained.

Altogether, authors like Claisse (see op. cit.) and Massot (1995) have proposed to conceive, as a general understanding of the ICT-physical mobility relationship the idea that it is at the same time generating susbstitution, induction, complementarity and modified travelling models. As stimulating as it is, this "cuandrangular" assumption still leaves us short of understanding what is going on and we will thus suggest our own grid, combining direct and indirect factors.

1. Any ICT support, without the traveller or the transporter having an global mobility overview (and they do not need it, like politicians and concerned citizens should), of what is really going on when taking an ICT-helped mobility decision (systemically and statistically speaking), tends just to facilitate all actors contribution in the consumption-push and competitive economic arena, traffic increase having been for decades one of the measurable effects of that much shared injunction.

2. People just do not do one thing at a time. Motivations, trajectories, sectors (industry, service, leisure and residence), activity status (e.g., non work and work), intermingle to constitute a permanent combinatory perspective for the mobile actors that we all are. Cross-fertilisation by extension of a practise from

one domain to the other and interplay between various types of opportunities are typical of real lifestyle and mobility schemes. Drawing upon existing resources, travellers are creative in their combination practises and suggesting for entrepreneurs and policy makers new services and niches to be harnessed. Without a sustainable vision of what all this leads to, the normal evolution of this concurrent processes is congestion and pollution. However, before that or meanwhile, combining inhabitants, travellers and consumers knit their web and mobility increases. The ideal tool for this, for its flexibility of use, is of course the car; and lifestyle observation shows that all over Europe, leisure-based and less-than 25 kilometers travels are responsible for most of the continuous increase of mobility mileage and time allocation.

3. On this basis, let us stress the subtle importance of such factors as optimisation, reliability, improved fluidity and safety, intermodal coordination, aided-planning, facilitated transactions, tracing and tracking assistance, etc. They have a rather indirect effect as no one would move more on the basis of one of these features only, but taken in their systemic flow, each facilitation plays its part and enhances overall effectiveness.

How to measure ICT influence in this multiple evolution[13]? We shall see suggestions for this in the modelling issues briefly discussed further. For the moment, let us stress that in 1993 already and based only on the use of phone as measuring feature, direct induction of new traffic was estimated by Claisse and Row (1993) at 20 %. This means that according to these authors, each 20 out of 100 phone calls generated a specific travelling activity. Of course, including in this figure, we are not talking only about pure induction, but a combined everyday life whose tasks, in most commercial and utility activities, are carried out with the omnipresent assistance of ICTs and therefore fit both our direct and indirect influence claim. In this "rich" perspective, it would not surprising to see that the above-mentioned figure is now considerably higher.

5. The longer-term horizon stakes

These mapping and documenting of cross-fertilising features and stakes should also lead to understand better the future of this issue, not only from the environmental point of view, which is often the claim for leveraging the hope that ICTs will diminish mobility (and therefore to restore a more realistic picture on this battlefront) but also economic (mobility is a resource and asks for organisational creativity) and societal points of view (let us consider here, in particular, the notion of pervasive or ubiquitous information technology horizon).

6. Methodologies

6.1. Modelling potential and limitations

[13] See for that in particular Peaucelle (1997).

Basically, two types of approaches are possible in the ICT-physical transport trade-off or combination analysis.

- One, more global, deals with the hope to model entire mobility configurations and trends. This is for instance what Mokhtarian and Meenakshisundaram (1998) have done in their broad study of tele-substitution schemes. The advantage here is linked to the overview that it provides, probably fitting policy-making and technological tool development. The disadvantage is that it requires that reality be simplified. We saw how complex it is and any simplification has its cost: one looses some level of understanding or some meaningful dimensions along the way.

- Another one, more specific and tied to particular functionalities, aims at examining the effectiveness and boundaries of a target ICT/transport configuration. This is for instance what Peaucelle has done in the domain of on-line collaborative work (1998). The result is excellent, but its scope is difficult to appraise as the observation bears on a very limited reality.

6.2 Other perspectives

Actor strategies are interesting to identify, understand and help monitoring. This is what we have done with enterprises having to choose or combine physical and virtual mobility choices (Buser, Rossel and Bosset 2000) or with SMEs in the freight sector (Buser, Poschet and Rossel 2002). We had followed as similar path in our studies on home automation and telematics, in terms of domestic strategies (Rossel and Glassey 1998). The idea if to discuss and understand the in-depth implications of reasoning, choices, decisions, practises and strategies of specific categories of mobile actors in order to conceptualise better changing behaviour patterns in relation with technological innovation.

7. Conclusion: The learning path

Quite clearly, we are in the beginning of a learning process and to a great extent, ICT implementations, telematics developments and acceptancy channel design should be considered as knowledge management issues. This perspective could suggest a common and open approach to several actors who for the moment have the habit of dealing with problems and solutions in separate and unbundled manner, far from the intricacies we have proposed to take into account. Any blueprint on the relationship between ICT and transport must have this dynamic hidden agenda, in order to cope with medium-term learning steps and learning potential of actors in the diversity of tasks and activities they support.

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