Digital technology
at the service of sustainable urban mobility

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Abstract:
Urban transit systems have undergone major changes since 2000. Besides the redeployment of public transit, the emergence of “soft” forms of transportation (bicycles, scooters, etc.) and the adoption of measures for restricting automobiles, local authorities now have an additional tool: digital technology for cutting the costs of implementing complex public policies (variable tolls in urban areas, markets for permits to circulate) and better informing users about the external effects of their uses of transportation. Though attractive in theory, this new tool is not yet global enough, since part of the population is excluded from using it.

More than 50% of trips shorter than three kilometers in big cities are made in automobiles (ATEC-ITS 2017). Ride-sharing is an exception occurring during peak periods. This situation’s effects are well known: noise, congestion, lost time, greenhouse gas emissions, wear of infrastructures, etc. To fight against these externalities, local authorities have, for twenty years now, adopted policies for shifting trips in urban areas from automobiles toward urban transit and friendlier modes of transportation.[1]

The new information and communications technology (ICT) is a powerful vector for transforming “mobility” through its actions on the supply and demand of transportation in urban agglomerations. Digital technology widens the range of the modes and services proposed for users’ trips: on the one hand, the new offers from online platforms, which propose a gamut of services for “shared mobility” (ride-sharing, carpools, bicycles, etc.); and on the other, real-time information to users about all modes of transportation. Digital technology also makes it easier for public policies to offer incentives or impose restrictions.

Let us start by debunking a taken-for-granted idea: the information delivered to transportation-users by new ICT tools influences them and orients them toward modes of transit friendlier than the automobile. Several recent studies cast doubt on this assumption. According to Aguilera and Rallet (2016), “*empirical studies show that merely providing information in real time does not suffice to make a truly significant proportion of car-users shift toward public transit […it even] tends to reinforce the market share of automobiles by, for example, helping people adapt their schedules and trips to avoid congestion.*” Transportation habits are very inert (BRISBOIS 2010). Users are taken captive by the modes of transport that they use. They are not ready to change their habits, not even if they receive, via apps, precise information on alternatives to the trips they have planned. Under these conditions, the information delivered to users cannot by itself modify their consumption patterns in the field of transportation.

[1] This article, including any quotations from French sources, has been translated from French by Noal Mellott (Omaha Beach, France). The translation into English has, with the editor’s approval, completed a few bibliographical references. All websites have been consulted in October 2019.

What can strongly affect the demand for transportation are public policy instruments. For instance, if the main objective is to reduce congestion and the use of polluting vehicles in urban areas, digital technology can make it easier to set up a toll system. To reduce the overall volume of car trips, the preferred method is to set up a market of "tradable driving credits (or permits)", which, too, can be facilitated by digital technology. A final point: since the decisions to be made hinge on a policy's acceptability, ICT can easily make information available and follow up on a policy as it is conducted.

The objective herein is not to discuss the comparative advantages of the two previously mentioned economic instruments. For information on urban tolls and a market for permits to circulate, we refer readers to the articles by De Palma *et al*. (2018) and Raux (2007). Instead, we want to focus on how digital technology can help us use such instruments in urban agglomerations.

An optimal price signal: Modulated urban tolls

In writings on the economic theory of urban tollgates (which have nothing to do with the tolls for turnpikes), an optimal pricing of automobile trips involves sending to users a price signal that includes all externalities (nuisances) stemming from using a car. In other words, tolls should be modulated as a function of the place, time of day, real-time traffic conditions, the vehicle's horsepower, its type of fuel, age and occupancy, etc. When used to tax trips in real time, these elements would dissuade people from using the vehicles that emit the most pollution during rush hour. However, passing from theory to implementation is complicated: "*In practice, tolls cannot be freely varied along all these dimensions […] This is unfeasible in contrast with the theoretical ideal*" (DE PALMA & LINDSEY 2009:6-7). Given the impossibility of real-time prices adjustments, the literature has proposed second-rank tolls to be adjusted in increments depending on the time of day.

Owing to advances in digital technology, it is now possible to reduce or even eliminate the technical obstacles to adopting a price signal that would approach the "ideal form" and have a genuine impact on users' choices. Singapore is a noteworthy example. In 1975, local authorities set up a manual urban toll system (ALS: Area License Scheme) to regulate the flow of traffic into the business area. As traffic increased and technology evolved, the city opted for electronic tollgates in 1998 (ERP: Electronic Road Pricing). This real-time digital tool had the objectives of setting tolls at different rates depending on the time of day and of modifying behaviors so as to eventually lower automobile traffic and pollution. This system fine-tuned the toll system (tolls now being set on the basis of time-related criteria) and reduced traffic (by 10-15% compared with the manual system).

Current technology based on geolocating vehicles by satellite could be used to develop a system with tolls that vary in real time as a function of predefined criteria. Prices could be set depending on the time of day and distance of the trip (Pay-as-you-drive) or on the pollution emitted by the vehicles identified in the zone. The cities of Singapore and London want to adapt their toll systems by introducing an optimum of price-discrimination factors in an effort to change behaviors and lower urban traffic and pollution.

Markets for "driving credits"

Given technologist developments and the unpopularity of traditional pricing methods, markets for tradable driving credits seem to be another solution for restricting the use of automobiles in urban areas (BAO *et al*. 2018). Inspired by the market theory of pollution permits, as formalized by Montgomery (1972), the idea underlying such markets is simple. In line with classical hypotheses about competition, economic agents will, if they can sell or buy in a marketplace credits that allow an automobile to circulate, choose the less expensive option in line with the imposed quota on trips. They will choose between the marginal cost of not using a car and the market price of the driving credits (or permit). The general quotas that authorities set on trips will be enforced at the lowest cost to users.

As Raux (2009) has pointed out however, "*none of these proposals has been detailed enough to judge whether this type of measure could eventually be applied in an urban area.*" The major obstacle to setting up such a system is the transaction and administrative costs, especially when the number of users is very large. Raux & Marlot (2000) have reviewed the three major transaction costs discussed in the literature: *a)* the costs of acquiring information about the options offered and of searching for partners to the transaction; *b)* the costs stemming from bargaining and decision-making (consultants, the time spent bargaining, legal aspects, insurance); and *c)* the costs (in principle, borne by public authorities) of enforcing the regulations.

Owing to the evolution of ICT however, these obstacles are less of a hindrance. Online platforms could be the marketplace for buying and selling credits for permits to circulate in the urban area. The price would thus be set in the marketplace and posted on a smartphone application in real time so that automobilists can buy or sell credits depending on the price. As explained by Brands *et al*. (2019), the search and bargaining costs would amount to next to nothing, since the information is easy to access and the same for all users. This system would be transparent and eliminate many of the transaction costs, which were initially an obstacle to using this sort of tool.

Thanks to digital technology, the idea of setting up a market for a tradable driving credits scheme is theoretically possible in cities. However actually doing so naturally means answering questions about the initial allocation of the credits, the urban zones where they will be needed, the operation of the market, etc. Nonetheless. Raux (2009) has proposed driving credits based on vehicle-kilometers, which would be adjusted as a function of the vehicle's category of emissions so as to dissuade people from making trips in the most polluting vehicles. Accordingly, a transit authority would delimit zones (based on density) in the urban area and define peak- and off-hours as well as vehicle emission categories. These parameters would then serve to calculate the credits (usually a number of tokens), a price to be paid by drivers circulating in regulated zones (*cf*. Table 1).

Table 1: Calculation of toll tokens depending on:
a vehicle's category, the time of day and the urban zone

Type of private vehicle	*standard*	*tokens*	*conditions*	*tokens*
with a gasoline (petrol) engine	Euro I	10	Less dense zone	1
	Euro II	5	Dense zone	2
	Euro III	2		
	Euro IV	1		
with a diesel motor	Euro I	10	Off-hours	1
	Euro II	9	Peak hours	2
	Euro III	5		
	Euro IV	3		

On European emission standards for passenger cars, see https://en.wikipedia.org/wiki/European_emission_standards#Emission_standards_for_passenger_cars.

Digital technology for better accepted transportation policies?

As we have seen, digital technology can now assist in implementing efficient public policies for reducing the flows of automobiles in cities.

Since the installation of urban toll systems (Singapore, London, Stockholm, Oslo) and reports on them in the media, the question of how acceptable restrictive transportation policies are has become a topic of interest. Citizens do not like tolls, nor an eventual market of driving credits; and local elected officials are, naturally, still skittish. However, ICT is a medium for news and information.

Thanks to online platforms and mobile apps with real-time information, authorities can provide more granular information to users and gain more approval for policies that are not yet accepted. According to the Association for the Development of Transportation, the Environment and Traffic (ATEC 2017): "*Digital tools alone can make the variety of the supply of mobility visible, even generate it as in the case of shared mobility […] We cannot make the modal shift without a multimodal management of traffic flows; this implies incentives and restrictions, the carrot and the stick.*" As Aguilera and Rallet (2016) have emphasized, digital technology lowers the costs of coordination and serves as an intermediary between the parties concerned.

New forms of technology, in particular the digital applications available for smartphones, can be part of the effort to persuade users by better informing them about the real costs of their trips. An automobilist does not, before getting in his car, calculate the real cost of the trip to be made. Automobilists only take account of out-of-the-pocket expenses (for gasoline, insurance, tolls, etc.). They overlook the social costs paid by themselves or others (being late, making noise, emitting CO_2, wearing down the infrastructure, etc.). Since these externalities are left out of account (MIRABEL & REYMOND 2013), automobilists should at the very least be informed about their responsibility for them.

Finally, ICT can be a vector for conveying information about the general interest of reducing automobile trips. Smartphone applications could pass on messages, warnings and real-time alerts that compare the environmental impact of various forms of mobility. More "*normative pressure*" (BRISBOIS 2010) can be brought to bear by telling people that, for example, the best choice is the one that does not pollute. Behavioral economists working on this question have highlighted the value of messages that enable individuals to "situate" their behavior in relation to what others are doing ("descriptive norms") and that tell them whether the members of the group to which they belong approve or disapprove (injunctive norms). Such messages could be about how using an automobile has harmful effects and worsens global warming for future generations. This would definitely improve the acceptability of the pricing and regulatory measures introduced to reduce "auto-mobility".

In the same vein, games and other "fun tools" could be used to convince people to switch modes of transportation. An original study has designed a mobility management system based on the smartphone and gaming, what has been called "gamification" (NAKASHIMA *et al*. 2017). The app, a pedometer, calculates a score and rank. This study has shown that games and competition can change some participants' behavior patterns.

Conclusion

The first article of the so-called LOTI Act for orienting domestic transportation declares the "*right of users to travel and the freedom to choose the means*" but goes on to state that this right is to be exercised "*by observing the objectives for limiting or reducing risks, accidents, nuisances (especially noise), pollution and greenhouse gas emissions*".[2] Digital technology can be a factor in this right to mobility by making available to users precise, real-time information about alternatives to the automobile and by creating opportunities on platforms and in smartphone applications for innovative forms of shared mobility, multimodality, intermodality…. In parallel, these tools can be used to develop efficient policies for reducing mobility in automobiles, thus helping us observe the second part of the first article of the LOTI Act.

Despite digital technology's very positive aspects, a major drawback still exists: digital illiteracy (or "illectronism") (SÉNAT 2018). According to a survey (CREDOC 2017), 27% of the French do not have a smartphone; and among those who do, 31% do not feel very competent using it. According to a survey carried out for Keolis in 2016, 30% of respondents are offline, *i.e.*, they would not use digital transportation services. This is clearly an impediment both to using the services now available to users via smartphone apps and to developing platforms for tradable driving credits. Ultimately, the statistics describe a digital divide and severely nuances the role of digital technology as a vector for the sustainable transformation of urban mobility.

[2] Act n°2005-102 modified the LOTI Act . The two acts are available respectively at
https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000006068730
&
https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000809647.

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