Chapter 2
Which Policy Tools to Move Towards Low Carbon Mobility?

Hakim Hammadou and Claire Papaix

Abstract Most of the challenges associated to the transition towards low carbon mobility being concentrated in cities, this chapter focuses on the implementation of policy tools at the urban scale. After a conceptual overview of the economics of low carbon mobility in Sect. 2.1, we present the toolbox of the policymaker for reducing CO_2 from urban mobility in Sect. 2.2, by subsequently appraising the efficiency, equity and acceptability of a sample of policy tools.

Keywords Transport policy · Low carbon mobility

2.1 Introduction

The uncertainty which weigh on the spatial damages from climate change (the locations of the impacts are not necessarily the same as from where CO_2 emissions are generated), on the time horizon (the next generation might be more affected than the present one) and on the magnitude of the events, makes the CO_2 externality rather difficult to evaluate. Currently, CO_2 emissions account for the relatively lowest external cost from road transportation. For instance, in French transport investments analyses, the CO_2 cost in dense urban areas is estimated at 0.45 c€/passenger km whereas congestion accounts for 16.6 c€/passenger km [13].

However, transport activities represent more than a third of overall CO_2 emissions in the EU-27 in 2009, with an increasing trend since 1990 [27]. Therefore,

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Europe has established far-reaching ambitions for reducing the risk for climate change and has identified a potential CO_2 abatement field of 60 % within transport activities [24]. The road mobility accounts for less than 80 % of the total CO_2 emissions from transport in 2009 [25]. Furthermore, because most of the distances travelled are made "locally", and this is a growing issue in line with global demographic and urbanisation trends along with climate change effects [17], urban road mobility constitutes the biggest chunk for cutting CO_2 emissions in transport. Indeed, even if kilometres travelled grow more over long-distance trips, just as CO_2 emissions related levels, the bulk of the trips is made in cities and presents the special feature to create other external costs (local air pollution, congestion, safety, noise, etc.) for the society. At the global scale, urban transport accounts for 10–30 % of the CO_2 emissions of cities depending on the level of travel demand, transport supply, technologies, urban form, economic structure, industrial output, and other characteristics of each city [65]. In developing cities, characterized with high transport demand and an overreliance on inefficient transport systems, this share can be as high as 50 % (as e.g. in Mexico City; whereas in Beijing and Shanghai, carbon emissions from transport represent less that 10 % and other pollutants are more predominant). In developed cities, with saturating travel demand and more performant transport systems, the share can still be around 20 % (e.g. in London and New York City).

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2.2 Background on the Economic Principles of Low Carbon Mobility

2.2.1 Transport Investments and Financing Issues

In the past, road investments have been dominating, leading to a non-sustainable development of transportation systems. The resulting induced demand has then further encouraged such a non-sustainable pathway of investment decisions in transport.

Road infrastructures account in 2008 for the highest share of annual transport expenditures (see in Fig. 2.1), even if this has decreased over the last decade (from 62 % in 1995 to 58 % in 2008; [26]).

The main source of financing for transport infrastructures investments has traditionally been the State. However, with the current scarcity of public funds, resorting to private actors has become a necessity. In Sweden for instance, 67 % of the road infrastructures financing comes from the private sector [39]. In general, Public-Private Partnerships (PPPs) take the form of a public service delegation

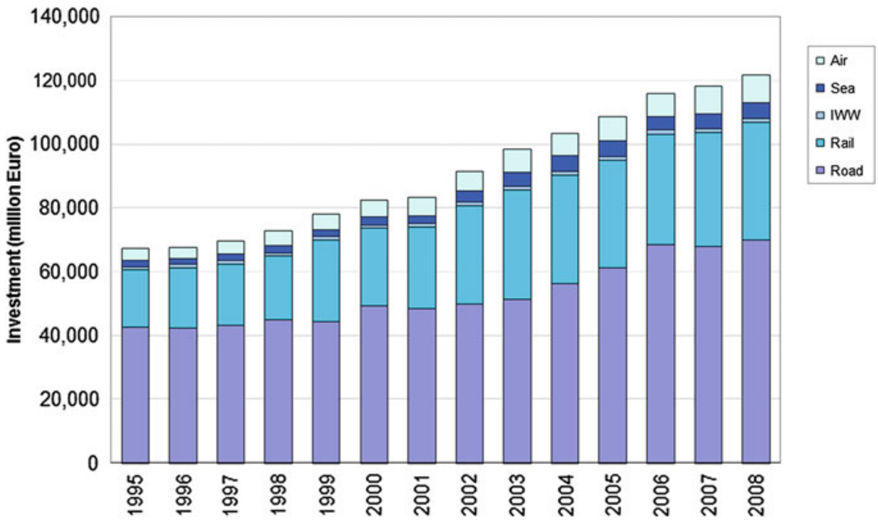

Fig. 2.1 Investments in transport infrastructure (millions of Euros) in EEA member countries. *Source* EEA [26]

contract over a long period, as will be further discussed in section "Public and Private Actors". On the presentation of the public and private stakeholders of the low carbon mobility system.

2.2.2 The Relation Between Economic Growth, Transport Activity and Carbon Emissions

Low-carbon mobility refers to a lesser carbon intensive mobility [33]. This can be achieved by the use of three means (with the different effects shown in Fig. 2.2):

- Changing the social norms to move towards a lower level of mobility (the most difficult pathway).

The key to this pathway is a fundamental shift in societal values that would result in alternative forms of production and consumption, and perhaps also in different forms of car ownership (shared rather than individually owned). This change would lead to a decline of the consumerism and to a global reconfiguration of the production chains. As the 'lifestyle' structurally changes under this scenario, there is no need any more for decoupling the mobility from economic growth (that now follows a different pattern) or from carbon missions (already disconnected from economic growth). Such changes in societal norms give in particular a larger priority to "slower travel", and trigger new forms of economic activity: "slower is better" and "close is better".

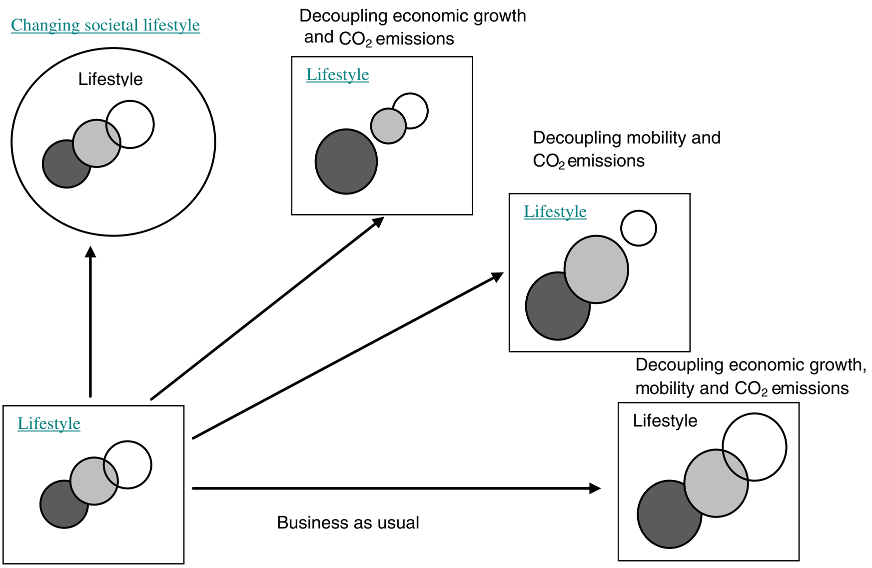

Fig. 2.2 The three spheres of economic growth, mobility and CO_2 emissions. *Source* Givoni and Banister [33]

- Following an economic growth path that is less dependent on transport activity.

Economic growth and transport activity are closely related. This means that a higher volume of transport accelerates economic growth; and respectively, that a rise in transport activity stems from economic growth. However, there is a need for keeping or increasing the economic growth rate without increasing mobility levels to the same extent. To do so, it is possible to preserve the "current lifestyle" but in a way that assumes small changes in daily life not to unnecessarily increase transportation needs. Moving from the standard "globalization" model to a "globalization" model (local/regional autonomy of production; where the distribution and consumption of goods and services relies on shorter trip distances) could provide an answer to this challenge. The key of this trajectory is the shortening of the trip distances. Therefore, home-based work, teleworking, or video-conferences could be strongly recommended.

- Transforming the transportation system to produce less carbon emissions.

To attain low carbon mobility is to decarbonize transport via technological developments, by example the Zero Emission Vehicles. This pathway is attractive as it can be an important driver for increase economic activity, through investments in green mobility technology. The low carbon mobility challenge assumes that environmental and economic objectives do not necessarily contradict each other, and can be attain in the same time. This pathway does not require systematic change but much more research and development (R&D) efforts in surface transport, and car in particular, are focused on efficiency and not on speed, carrying capacity (size) and energy-consumption. The public sector also has an important role to play in supporting and incentivizing (through pricing, subsidies and other economic tools) the private sector and by adopting policies, like widespread adoption of Low Emission Zones (LEZs).

2.3 Efficiency, Equity and Acceptability Criterion of a Sample of Policy Tools

2.3.1 Different Ways of Classifying and Selecting Instruments

2.3.1.1 Depending on the Decision-Makers Involved, Policy Targets and Structural Designs of the Instruments

Public and Private Actors

Low carbon policymaking can emanate from both from public and private actors. If we essentially focus in this chapter on the public policy tools, it is worth mentioning the role and strategies of the private actors too.

Public Private Partnerships (PPPs) illustrate the case of a structured financing source that allows to alleviate the public budget by transferring the risk towards private partners. PPPs have increasingly developed in the past few decades in some European countries, particularly in the UK and Portugal (forerunners of PPPs; [63]), Italy (with the introduction of tolls on major roads leading to central cities already in the early 1920s) and France (where over 70 % of the urban public transport networks in 2011 are operated using a public service delegation).

Open competitive tendering processes can also constitute a public-private solution for rolling out low carbon mobility. In Stockholm County, the use of biofuels in regional buses is supported by legal contracts between the bus operator and the tendering agency. Because the proposed bids are evaluated in the light of their ‘environmental properties’, bus providers are incentivized to invest in low carbon fuels in order to benefit afterwards from advantageous conditions for operating their fleet [7, 30].

Private actors can also unilaterally develop low carbon strategies. As an illustration, Paris has developed a car-sharing service named ‘Autolib’. Autolib is also the name of the mixed syndicate who signed with Bolloré Group a public service delegation that aims at offering an “ecofriendly” transport service, proposing an alternative transport solution, decreasing the use of the private cars and making this service accessible for everybody (see [50]).

Another range of strategies often developed by private companies are the Corporate Mobility Plans (PDE), offering a great potential to deter employees from driving alone and thus to reduce the related CO_2 emissions.

Supply-Side or Demand-Side Targeting

Policy levers can then play either on the demand-side and/or on the supply-side of the low-carbon mobility system's stakeholders. As further detailed in the report of Meurisse and Papaix [50], instruments can be classified according to their targeted groups:

1. Tools such as speed limit measures, Low Emissions Zones (LEZs), High Occupancy Vehicles lanes (HOV), parking access management, pricing schemes related to vehicle purchase, ownership or use, fuel pricing, road user charging, parking fees, energy consumption and CO_2 emissions labeling for new passenger cars, etc. apply to road users—regarding the demand-side;
2. Tools such as CO_2 emissions standards, obligation of a minimum content of biofuels in fuels, car tyre labeling, etc. apply to industrial actors; and instruments e.g. the binding information to report on CO_2 emissions from transport services, eco-driving training, etc. apply to transport professionals—regarding the supply-side.
3. A third category of policy levers could be the one applying to local transport authorities (see e.g. the norms on publicly accessible charging infrastructures for electric vehicles).

'Hard' Versus 'Soft' Measures

Pricing signals may, at least in the short term, have a limited effect on travel behaviors especially on the choice of route, destination, modes and trip frequency regarding the use of congestion tolls; and vehicle ownership and departure time in the case of parking charges [64]. Therefore in some cases, the so-called 'soft measures' such as information, education, marketing and communication policies can be used for redirecting user practices more efficiently than when using 'hard measures' (e.g. subsidies for technological innovation, transport infrastructure investments, etc. see [5]). Besides, the study of Xenias and Whitmarsh [66] on the preferences of political experts and civil society regarding the use of instruments for low carbon mobility reveals that qualitative and demand-side management tools were better accepted than technical-and-economic levers.

The individualized marketing operation set up by the Region Picardie in 2012 [68] confirms this argument and adds the 'trial' phase to the policy recommendations. Following from the experimentation carried out in September 2012 and according to the two-waves survey before (from July 2012) and after (from October 2012) the operation, 60 % of the total surveyed participants continued to use the train after the end of the pilot experimentation, 40 % shifted from car use to other modes, 37 persons over 150 purchased a commuting/leisure subscription and 18 over 150 bought single tickets (because they didn't find appropriate subscription cards).

First-Best and Second-Best Features

'First-best' and 'second-best' adjectives can alternatively denote the economically optimal *a*—conditions for policy implementation and target definition; or *b*—the policy-tool design itself.

On the first sense, establishing a policy "*given that all other parts of the economic system are working perfectly and distributional matters are not a contentious issue*" [10] can be a good definition of what is a first-best ("academic ideal") environment. Where and when major legal or social imperfections come into play (generally following the introduction of the scheme in practice), one can prefer second-best arguments for policy recommendations. Second-best policies generally aim at correcting such full short term and long term effects, as markets' multiple overlaps (e.g. between transport, urbanism and labor supply), external effects interactions (e.g. between CO_2, local pollutants and road safety, etc.), etc. De facto, their underlying instruments do not pursue one objective only (e.g. reduce CO_2) but interfere with several at once (reduce or increase environmental externalities, accessibility, territorial attractiveness, etc.). Since at the scale of urban mobility, suboptimal equilibrium conditions are frequent, we choose to focus on *second-best* policies (i.e. on instruments that can play positively or negatively on several goals at once) instead of *first-best* ones (one tool per policy target).

On the latter sense, policies can be qualified of second-best not because distortions exist elsewhere in the spatial economy but by the 'design' of their schemes. Besides, note that their net welfare effect can actually be better than the one of first-best schemes—this is the example of flat cordon pricing schemes in mono-centric cities over distance, route or time differentiated tolls [62].

2.3.1.2 Efficiency, Equity and Acceptability Properties of the Tools

Conditions for Their Economic Efficiency

When looking at the different sequences of the overall travel demand choices' formation process, (alluding to the traditional *Four-stage model* of Ortuzar and Willumsen [52]), 'trip origin choices', 'trip destination choices' (the two latter affecting 'vehicle ownership choices' but also 'land uses' on the longer run), 'travel mode choices' and 'route choices' (also potentially changing e.g. 'departure time choices' on the shorter term) are differently impacted by the policy-levers. The travel mode choice step appears to have the largest room for policy-action, i.e. to be the easiest way to convey price signals judging from the number of suitable policy-tools [56, 64].

In addition, if we refer this time to Schipper et al. [58], shift from car use to low-emitting modes is the term of the Activity–Structure–Intensity–Fuel (*ASIF*) equation for CO_2 emissions mitigation in transportation that occurs the earliest in the time-horizon (Structure), compared to vehicle efficiency improvements (Intensity), switch to biofuels (Fuel) or lesser travel activity (Activity), and that brings into play the lowest degree of industrial actors and strategies and thus of market conditions requirements.

If all the different steps are constantly in dynamic interactions, we focus in this chapter on the mode choice step as a central policy target in order to appraise the efficiency of policy tools. However, one can note that other means can participate as effectively to the reduction of CO_2 emissions such as car-sharing, by increasing of the loading factor within a same mode [31, 46].

Echoing to what has been said before on the multi-leveled externalities from urban mobility, the economic efficiency of a tool can either reinforce the global performance of policymaking or run against the implementation of another instrument. On the former case, May et al. [49] identify four ways in which policies (parking charging, congestion pricing and additional measures) can positively interact with each other:

- Complementarity: the use of two instruments has greater impacts than the use of either alone;
- Additivity: the benefit from the use of two or more instruments is equal to the sum of the benefits of using each in isolation;
- Synergy: the simultaneous use of two or more instruments yields higher benefits than the sum of the benefits of using either one of them alone (Additivity and synergy can be considered as two special cases of complementarity [49]);
- Substitutability: the use of one instrument completely eliminates any benefits from using another instrument.

The aforementioned interacting effects between the instruments worth being considered in the appraisal of the tools. In this respect, the accompanying of ‘pull’ measures (disincentives) by ‘push’ tools (incentives) is known for reinforcing the success of policy implementation [40].

Equity Effects of the Policy Levers

No consensus has been found in the literature for defining the equity concept in the transport sector [4]. The equity goal itself is often vague and this is usually due to the difficulty of implementing it or measuring it in practice [48]. In France, social and territorial equity are specified in reference texts (for example in [14]). One of the proposed indicators for appraising it is the ratio between the total surplus created by a transport project in the zone (e.g. time gains, pollutions cost savings, etc.) and the total income of users in this particular zone of impact. To deal with fairness, a special attention is recommended to be paid to the initial rent situation of individuals, for instance when the transport network is structurally servicing more certain categories of individuals than others. Then, redistributive effects from pricing policies in particular are also worth being considered since transport costs can already be significant in households’ budgets (especially for the less well-off). Transport fuel expenditures represent for instance 12.7 % of the most vulnerable households’ annual income in France in 2006 [37]. Hence, the preservation of individuals' capacity for lifestyle adaptation and reliance to available transport alternatives following the introduction of an economic tool constitutes a good focal point for assessing the equity of the scheme at focus. Regulators should be careful to avoid adding a damaging "carbon bill" on these low-income households, who are most of the time and by a majority structurally price-inelastic and highly car-dependent [12].

Following the approach of Martens [47], three questions can be used for appraising equity effects from policy implementation: (1) Which goods and bads or benefits and costs should be at the focus of the equity analysis?; (2) How should 'members of society' be conceptualized, i.e. which population groups should be distinguished?; and (3) What constitutes a 'morally proper distribution', i.e. which yardstick or distributive principle should be used to determine whether a particular distribution is fair?.

Acceptability Challenges When Implementing the Tools

The attitude construct of *acceptability* designs "support, agreement, feasibility, to vote for, favorable reaction" to a particular scheme and "describes the prospective judgment of measures to be introduced in the future". By comparison, public *acceptance* refers to the "behavioral reactions [of respondents] after the introduction of a measure". Moreover, the adjective *public* can involve, depending on the studies, "motorists, voters in general, consumers, citizens or inhabitants" [57].

Looking at the literature on the theory of planned behavior [2], the key findings are that socio-economic characteristics of individuals and transport network related variables explain only a little part of the acceptability of congestion pricing [57]. Attitudes factors remain the largest predictors for policy acceptability. Specifically, the gap between pro-environmental attitudes and acts, i.e. a positive reaction towards policy levers aiming at reducing e.g. environmental externalities, can be explained by five main variables:

1. The absolute importance of the issue. This depends on 'personal norms' (i.e. the general pro-environmental orientations of individuals as measured by e.g. the New Ecological Paradigm scale; see [23, 59]), especially for the push measures; followed by the 'social pressure' effect (the fact that most people strive for social integration, conformity and consonance; see [29] making them more willing to accept the unavoidable), and by other wider preferences, towards risk and uncertainty (see [6]) for example.
2. Environmental outcome desires [from the policy]. Specific policy beliefs depend on (i) the knowledge about options of the scheme (user awareness is loosely related to user acceptance; see [57]); (ii) the perceived effectiveness and efficiency of the proposed measures (respectively potentially influenced by experience/familiarity; the labeling and defined objectives of the scheme [41]; the use of the tax-revenues [56], or territory coverage); (iii) and its perceived

fairness.[1] Tax resistance (iv) can also explain singular attitudes regarding to the previous beliefs (see e.g. [57]).

3. Self-efficacy in solving environmental problems. This depicts the self-reported role of the individual according to his subjective representation of the responsibility sharing to protect the environment [57].

Generally speaking, public acceptability for *pull* measures (policy-instruments aiming at reinforcing the attractiveness of alternative travel options) tends to be higher than for *push* measures (continued opposition to coercive tools aiming at deterring car use; see [23]).

The different ways of classifying policy levers having been presented, along with the criterion for choosing among them, we test this framework in what follows on a sample of instruments. Low Emissions Zones, congestion tolling, parking charging and public transit faring schemes are selected and their economic, equity and acceptability evaluation is, whenever possible, supported by evidences from real experiments.

2.3.2 Sample of Instruments

2.3.2.1 Low-Emissions Zones

Economic Efficiency

A tremendous variety exists among the two hundreds Low Emission Zones (LEZ) operating in Europe [15, 16] in terms of perimeter size, nature of the restriction (total restriction or access fee), polluting vehicles targeted (usually depending on the Euro class, weight or age of the vehicle), and temporality (all day or business/peak hours only). LEZ specifically target local air pollutions e.g. particle matters and nitrogen oxide emissions (also noise from 2002 in the case of Stockholm; [22]) but can have indirect impact on CO_2 as well, by modal shift effect. Referring to the classification of instruments above, the LEZ pertain to the command-and-control levers playing on the demand-side.

If we focus on the London and Stockholm case—both combining an interdiction of polluting trucks over the greater metropolitan area (with increasing standards over time) and a urban congestion charge—the following air quality impacts, socioeconomic costs and car fleet changes can be highlighted.

In Stockholm, the restricted areas apply nationally to all trucks of more than 6 years-old (except those between 6 and 8 years-old if they belong at least to the Euro 3 class) and to buses of more than 3.5 tons since 1996 [1]. Four years later,

[1] Equity perception is obviously differently perceived depending on the ‘evaluator’. It will for example vary if it comes from frequent car users by themselves and for themselves or by themselves and for low income groups or citizens in sparsely populated areas.

PM10 emissions were reduced by 40 % (their concentration by 3 %), and the emissions of NO_2 by 10 % (their concentration by 1.3 %). Looking at the vehicle fleet composition, an energy substitution has occurred in Stockholm following from the measure, with an observed drop in gasoline fuels to the favor of more diesel and LPG fuelled trucks and a drop in gasoline and diesel to the favor of ethanol and LPG buses. The phenomenon has been accelerated since trucks have increased while buses have decreased over the observation period.

Results were more nuanced in London (implementation of the scheme in 2008), where the LEZ only reduced by more than 30 % (according to modeled results) the area of London that was exceeding the annual threshold of PM10 regulatory concentration. The reduction was lower for NO_2, even though the concentration is more problematic than PM10 in London, and didn't improve the local air quality in general. Conclusions were more positive when a more stringent policy was simulated (inclusion of taxis and buses in the measure). The fleet turnover for affected vehicle classes in London increased substantially when the zone was first introduced before returning to the national average in subsequent years [22]. Despite an overall growth in freight vehicles operating in London, the number of pre-Euro III vehicles has dropped and this has been coupled with a switch from rigid vehicles to light commercial vehicles and articulated vehicles.

Regarding financial issues, implementation costs in Stockholm were twice cheaper than expected (the return on investment ratio being the highest when the share of trucks is large), and 80 % of the operating costs were compensated by the environmental gains. In London, costs were about five times higher than in Stockholm (in absolute terms, without relating it to the size of the area to regulate). Infraction fines (and charge revenues in the case of London) are not, in neither of the case, subjected to specific public expenditures outlay [1].

Equity Effects

City-wide restriction schemes tend to cause less spatial unfairness than traffic exclusion from city centres only [51], by setting all the polluting vehicles on an equal regulation and avoiding giving more adaptation capacity to some actors than to some others.

Acceptability Challenges

Again, territorial and social equity largely drive the acceptability of the scheme [19]. But before considering the trip-maker's perspective, the strength of the ongoing health-based air quality standard requirement in the country principally motivates the interest of the policy-makers in implementing the LEZ (tightening of the policy context recognition in Europe (see [51])). Then, the seriousness of the air pollution evidences in cities, transparency, understanding of the measure and exemplarity favor the public acceptability of LEZ, when it is not too much hampered by commercial trucks lobby pressure (high costs on the businesses). In this regards, since freight haulers in London were the principal target of the charging scheme, they expressed their disapproval.

2.3.2.2 Congestion Tolling

Economic Efficiency

Urban road charging is a sound instrument usually recommended by economists raise revenue, reduce traffic congestion, ration road space, improve the local environment, mitigate climate change, and enhance social inclusion and equity through the pricing of the social marginal cost of a trip. Tolling vehicle drivers who enter a specified geographical zone for the cost of the congestion they impose on other drivers is indeed a useful instrument to deter from car use and encourage low-carbon emitting modes. Estimates from the Stockholm charging trial introduced in January 2006 show for example [21] that close to one-fourth of the work trips by car passing the cordon disappeared (between September 2004 and March 2006), of which the big majority moved to public transit and the rest adapted to the scheme by changing frequencies, combining trip purposes and increasing trip chaining.

Adding more to this conclusion, the literature review from Li and Hensher [45] on the impact of congestion pricing on travel behaviors essentially shows that changes in departure times was the major effect from the scheme (when it is time-differentiated, for example in Stockholm), followed by reduced car use, modal shift and relocation of work and/or residential activity. Besides, the use of congestion tolling also avoids having to resort to road capacity investments (to address congestion) that usually induce road traffic (the 'Downs-Thomson paradox', see [20]) and therefore other negative externalities (namely environmental impact, unsafety or infrastructure use).

Referring to the conditions of Gunn [34] for a perfect implementation of a policy measure, Ison and Rye [40] highlight the following success factors relating to congestion charging after reviewing real experiments across Europe:

External circumstances—e.g. the quality of the public transport system, revenue perception and use, technological conditions and the severity of congestion—strongly play on the level of public acceptability. As an illustration of the technological factor, the technology used in the electronic road pricing scheme (ERP) in Hong Kong raised public opposition due to the fact that it was a western European (British) patented technology [40], thus undermining the trust of the population with regard to the overall introduction of the scheme. On the latter condition, the low level of congestion in Cambridge for instance partly explains the failure in implementing the scheme in 1993. To the contrary, the excessive congestion level in Bergen (relatively to the size of the city) was key in the approval of the scheme. Nevertheless, some authors tend to nuance this idea: Eliasson [21] claims that there was no statistical evidence in the case of Stockholm of a relation between the level of congestion and the degree of accepting the toll.

The availability of financial resources (operating expenditures, administration and enforcement costs—in particular for congestion metering on beforehand of the implementation of the scheme and public transit system strengthening afterwards) along with a **good traffic predictability** (limited by the intrinsic uncertainties due to the dynamic pattern of trip-makers adaptation strategies) generally secure the core functioning of the scheme.

A consistent theory of the cause (need for an analysis of the nature of the problem—what drives demand for private transport and traffic congestion), **and of the effect of the policy** (more visible if the implementing groups—i.e. county, city, district councils, etc.—are cooperating on the measurement of the results and have an interest in metering the outcomes) should be communicated to the individuals.

Objectives of the scheme and use of the revenues should be clearly stated. New elections or political instability to a larger extent (e.g. opinion divergences between the electorate and the politician, opportunism of the decision maker and associated moral hazard and adverse selection problems; see [18]) can affect the goals—and even the existence—of the scheme. Edinburgh, Birmingham, Manchester or New York's attempt cases illustrate such failure. However, changes over time in the definition of the scheme's objectives may happen, in line with the new political agenda, without being detrimental. For instance in Norway, the Oslo, Bergen and Trondheim cordon tolls schemes' objectives have moved from road investments and public transport improvement funding to gridlocks reduction, as a result of growing congestion problems and were still well accepted by the population. Secondly, political uncertainty with respect to the use of revenues can increase the probability that voters will be against the introduction of the toll. To be noted in this regards that public transport subsidization is preferred over toll-revenues redistribution to all voters [18].

Dealing with the enforcement of urban toll and the planning of its objectives, the specification and **correct ordering of the corresponding tasks** is an additional challenge in the case of congestion charging since experiences abroad are relatively poor [even if practices have largely increased over the last years since Singapore (1975), Bergen (1986), Oslo (1990) and Trondheim (1991) with: London (2003), Stockholm (2006), Durham (2002), Milano (2008), Rome (2001) and Valletta (2007); The Netherlands, Copenhagen, Budapest, Gothenburg, Djakarta and San Francisco (to be planned)] and thus offer little possibility of comparison.

Equity Effects

Dealing with equity, urban tolling seems to offer more flexibility for the trip-makers than other schemes applying to all car trips on a same basis (e.g. carbon fuel tax), since individuals that have a lower value of time have the possibility to change their itinerary, their mode or to differ their trips during the day, rather than traveling during the time/over the road/with the mode that is charged. However, travel time savings valuations should be treated with a special care (should be differentiated by 'Social Price of time' groups, as advocated by Galvez and Jara-Diaz [32]) when one wants to implement the congestion charge and to appraise equity effects from user benefits redistribution.

Acceptability Challenges

The acceptability of the congestion tax can be low, particularly in France [55], equity issues being essentially at the core of the refusal. In addition, if toll revenues can be hypothecated to public transport improvements (as for parking fees), **political acceptability** of urban tolling is usually lower than for parking charging [67], especially due to its wider charging coverage (e.g. targeting the commuting staff only in the case of parking measures in the frame of a corporate travel plan for example; see [40] vs. a whole region in the toll case).

De Borger and Proost [18] show that voting patterns in the case of an hypothetical referendum crucially depend on the modal choices of voters—leading to specific expectations with regards to tax-revenues recycling dispositions.

Other authors (e.g. [3, 40, 44], referring to the Trondheim and Bergen cases) raise the issue of public transport provision—and satisfaction—as being all important. Moreover, if it cannot be proved that higher income groups better support pricing strategies, one can observe that the latter groups are more likely to expect advantages from the strategies, whereas lower income groups tend to expect disadvantages [57].

2.3.2.3 Parking Charging

Economic Efficiency

Automobiles tend to be parked for 95 % of the time, either using on-street public parking (charge-free but of limited resource) or private off-street parking [64]. In addition, residential off-street facilities are usually provided in excess by building owners, in line with the high requirements from local housing regulators and their belief that a tight link exist between dwelling choice and level of parking services. As a result, and this is particularly true in areas with low vehicle ownership [60] like city-centers, land use can be inefficiently occupied by barely used parking slots. Thus, parking policies deserve a special attention and can be perceived as a low-hanging fruit for mode shift and CO_2 mitigation—and in particular residential parking.

To add more on the suitability of parking charging, Bonsall and Young [8] emphasize in their literature review that urban parking policies contribute to six goals at the time: "*healthy economic climate*; *efficient use of transport and land resources*; *ease of mobility/accessibility; equity of resource distribution*; *improvement of environmental quality*; *and enhanced amenity/cultural attractiveness*".

Dealing with road use and congestion challenges (and with *concentrated* congestion in particular, i.e. when much of the traffic is terminating in a same area), because it has less distributional consequences, lower costs of operation and is easier to regulate than urban road pricing [10], parking charging "*may appear preferable as a second best device for containing congestion and other externalities* [*than urban toll*]". Furthermore, since 'parking problems and costs' appear to be the number one reason to switch from private car to public transport, followed by the personal car availability and public transport faring and frequency policies [36], increasing travelling costs of automobiles through parking charging is usually recommended by economists [42] to trigger mode shift to mass-transit.

However, such policy goals (e.g. environmental objectives, accessibility, public transit system's performance, or regional attractiveness) can be conflicting. In its political economic analysis, Button [10] highlights the difficulty to sort out the different policy-objectives of parking activity regulation (since the public or private governance can change of policy goals, particularly in dense areas where ever higher space constraints must be combined with accessibility extension for disabled persons or goods delivery issues) and to understand the nature of the other markets involved (i.e. road traffic flows but also local businesses, land use patterns, etc.). Moreover, applying the Gresham's Law to parking management, the author explains the inefficient allocation of road space as a consequence of regulators tendency to distribute parking slots according to the willingness of individuals to spend *time* for parking purposes (the "bad currency", notably due to queuing effect and resulting congestion) rather than (driving out) spending *price* (the "good currency", better reflecting the marginal opportunity cost of the resources involved and clearing the car parks market).

The lack of homogeneity between municipalities' decisions and the regional scale policymaking adds more to the governance challenges. For instance, street parking regulation is generally part of the road system management but it can also belong to the wider transport network regulation or land-use policy of a community. At least, real time information on the availability of spaces and/or on pricing rules can be missing and lead to asymmetrical information problems between off-street parking providers (who possess the information) and parking spaces "consumers".

Beyond governance and institutional challenges, some other factors need to be considered upfront for a successful implementation of parking pricing schemes [8]. Among them:

- *The spatial adverse effects*. A first illustration is the fact that parking activity can be diverted from the charged area onto un-priced nearby streets, where negative external effects from car use can be stronger (air pollution, congestion, noise, phenomenon of "urban heat island", etc.). Second, bad geographical coverage of motorists, e.g. as an effect of subsidized parking spaces at workplaces which puts a significant target of car users out of the pricing control, can hamper the efficiency of the scheme. At least, because the charging regime is not, by definition, distance-differentiated, parking pricing can play over the long run on housing decision (the additional fixed fee rendering longer trips relatively less costly than shorter ones), thus leading to urban sprawl, and potentially re-increasing overall emissions.

- *The hysteresis phenomenon.* Indeed, people's behaviors are difficult to move to optimal ones due to stranded cost and uncertainties. This feature is characteristic of any new policy implementation's success conditions, and in particular for parking charging [10].

Equity Effects

Because parking fees take the form of a fixed amount added to the generalized cost of a trip by car and impact proportionally less individuals making longer trips, equity and acceptability issues can be raised if one assumes that high income groups are commuting longer distances (particularly in American cities; see [8]).

Another unwanted consequence deals with the worsening-off of local economic activity (e.g. the suppression of shopping trips and adverse impact on retail turn-over; see [8]).

Acceptability Challenges

Increasing parking fees, especially at workplaces—as part of a corporate travel plan for instance—is known for leading to high staff opposition, particularly in the public sector [40]. Nevertheless, empirical studies (e.g. the on-worksite car parking charging experiment in the Netherlands; [40]), show that opposition to such measures usually vanishes right after their introduction—as long as they are carefully designed (e.g. income-based charges) and that revenue hypothecation directly or indirectly benefits to the commuting staff (e.g. transit improvements for the journeys to work, etc.).

2.3.2.4 Public Transit Faring Policy

Economic Efficiency

When first best tools to combat congestion are not available (i.e. congestion charges), reforming public transit prices can be recommended to act as a second-best measure [53]. Effects of the measure on public transit patronage are relatively rapid, Bresson et al. [9] showing for example for France and the UK that 99 % of the adjustment is realized within 6 years, especially when transit fares were high.

Additionally, lowering transportation fares through subsidization encourage more economic activity [53]. The resulting decrease in the average price of goods and services compensates the distortionary effects and efficiency losses observed on the labor market from the subsidies, the former effect implying an increase of the real wage and to a higher gratification of the work effort. Consequently, less congested roads lead to higher commercial speeds and a barrier-free public transport more broadly enables fleet operations savings, in terms of e.g. controlling costs, boarding time, etc. [11].

However, there is no unanimity in the literature on whether higher or lower transport prices are better for the social welfare [43]. Indeed, if low prices divert car trips during peak period and allow scale economies (seat occupancy in existing busses) during off peak period, Proost and Van Dender [54] argue that the marginal cost of public funds for subsidizing public transit lead to the largest deficit. Additionally, controlling for (i) changes in supply (needed extension of the public transport network, addition of priority lanes and increase of service frequency), and assuming (ii) that cross-elasticity dominates the direct elasticity (i.e. to bring about an equivalent impact as following from a car deterring measure, a larger public transport fare reduction would be required to increase public transport patronage) and that (iii) elasticity of public transport demand with respect to level of service variables is systematically higher than fare elasticities, Cats et al. [11] nuance the efficiency of the scheme. Using the case of Tallinn, the authors notably found that the measure itself has accounted for only 1.2 % of the public transit ridership increase.

At least, three shortcomings of the scheme can be mentioned:

- A differential fare scheme could have better attracted demand to underutilized segments of the public transport service and avoid supply increase problem in the peak hour where the marginal operational cost is the highest;
- Short-distance trips public transport may become a substitute for walking and cycling rather than car trips;
- A fare-free system can also encourage the population to fraud and to register in the inner city to benefit from the scheme leading to higher operational costs on the long run.

Equity Effects

Farber et al. [28] show for the case of Utah that shifting from the existing flat fare scheme of the PT pricing to an hypothetical distance-based fare structure disproportionately and unevenly penalize population subgroups (in particular, young, immigrants, high-income and residents living on the urban fringe).

Then, regarding the implementation of free-fare PT schemes, such systems can be also coupled of a higher access to other cultural activities (through a pass, as it is the case in Tallinn), adding social integration to the equity properties of the scheme. Indeed, transport equity can be favorably influenced by a *correct* distribution of accessibility over households (unequal accessibility is inevitable since space *by its very nature* is divided into center and periphery; see [47]), which can be obtained through the FFPT scheme. Changes in accessibility levels are often accompanied by changes in travel patterns and, in the longer run, by changes in land use (e.g.

dwelling price increase following from more affordable public transit services), with substantial feed-back impacts on accessibility levels (expulsing the most vulnerable to the outskirt of the city; see [35]) that need to be controlled. At least, one can also add that FFPT introduces a non-discriminatory benefit to all public transport users, regardless of their income level [11].

Acceptability Challenges

Experiencing free (or largely reduced) public transit fares can be framed as a trial period in order to secure public acceptability and break deadlock situations [38]. Thøgersen [61] shows for the case of Copenhagen that a public transport's monthly subscription card given for free to car drivers led to successful results, with a higher modal share of public transport even after the withdrawal of the scheme.

2.4 Conclusion

In this chapter, we shown that implementing pure regulatory tools or modifying the generalized cost of car trips through congestion tolling, parking charging or public transit faring all influence modal split on a different manner—by the fixed or variable (time, area-dependent, etc.) feature of the scheme considered, the volume of trip-makers involved, and over a different time-period.

In addition, the presented tools have dissimilar distributive effects on the social welfare, some being known for being more regressive than other.

At least, when acceptability issues are considered, psychological factors dominate self-interest variables. This makes the framing of the tool and the ordaining of the branded arguments the major factor for accepting a policy measure and thus for its successfully implementation.

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