Urban transport pricing

Discussion paper

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1 Introduction: pricing measures in the general framework of sustainability policies.

Sustainable mobility policies include a varied array of measures and actions, among which transport pricing schemes play an increasingly important role.

As illustrated in the Figure 1 overleaf, there are in fact two main policy areas that are directly relevant to sustainable mobility, corresponding in some way to the traditional distinction between supply side and demand side.

- ⇨ Supply includes the provision of infrastructure (roads, metro lines, cycling lanes etc.) and that of non infrastructural goods and services (vehicles, components, services, etc.). Policy decisions in this area determine, or influence, the allocation of resources to investments. According to economic theory, optimal allocation of resources is that which maximises social welfare, and should be based on social cost benefit analyses (SCBA) incorporating both internal (private) and external costs. In terms of implementation, supply side policies often take the form of regulation whereby the most cost-efficient options are incentivated.
- ⇨ Demand side policies can be defined as those trying to influence the behaviour of transport users. In the perspective of sustainable development, and, more generally, of social welfare maximisation, the ultimate objective of demand policies is to steer the users towards patterns of behaviour which will result in the minimisation of costs imposed to society as a whole. Roughly, such policies belong to two main categories, respectively "command-and-control" and "market-based".
  - ➢ Command-and-control measures are typically based on regulation. This can take the form of restrictive interventions, such as traffic bans, or prescriptive, such as obligatory standards for vehicles (e.g. emission levels) and processes (e.g. mandatory share of reuse/recycle).
  - ➢ Market-based measures rely on the effectiveness of market forces to promote behavioural patterns consistent with welfare maximisation objectives. They assume that price levels – if appropriately set – will determine, through elasticities, the desired changes in users' behaviour. In practice, they are based on fiscal and other taxation mechanisms that are expected to produce the necessary price adjustments.

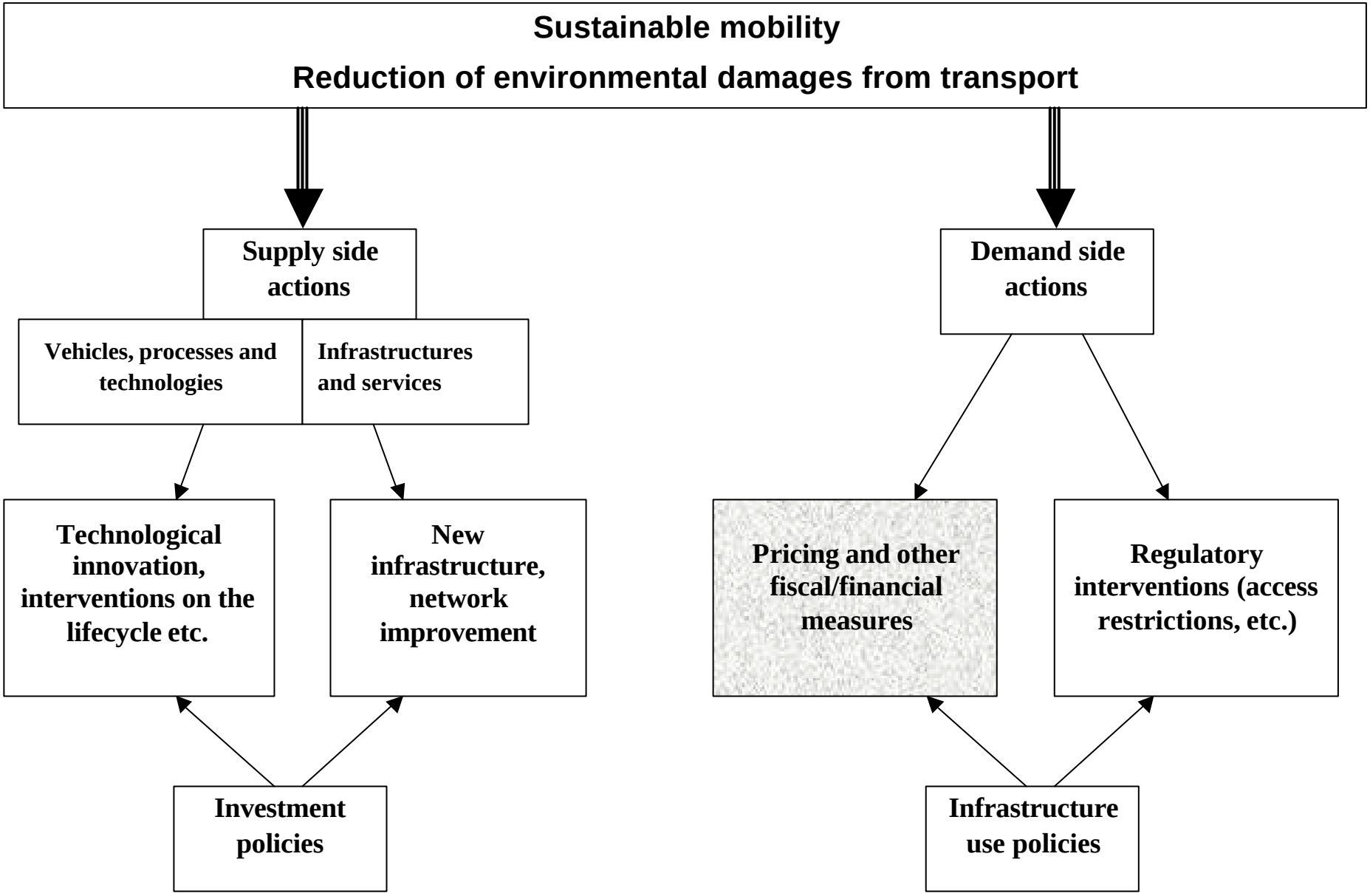
2 What are urban pricing measures trying to achieve?

In the general framework outlined above, urban pricing measures are in fact expected to generate a multiplicity of effects, broadly falling in three main categories:

a) impacts on the transport system itself, assessed in terms of transport service performance (accessibility, speed, reliability, safety, modal split, congestion, efficiency)
b) impacts on environment and health, assessed through the monitoring of air quality, noise levels, greenhouse gas emissions for which transport is responsible
c) impacts on the economy and society as a whole, which can be estimated through the assessment of income distribution effects, equity and, in general, the welfare effects of pricing policies.

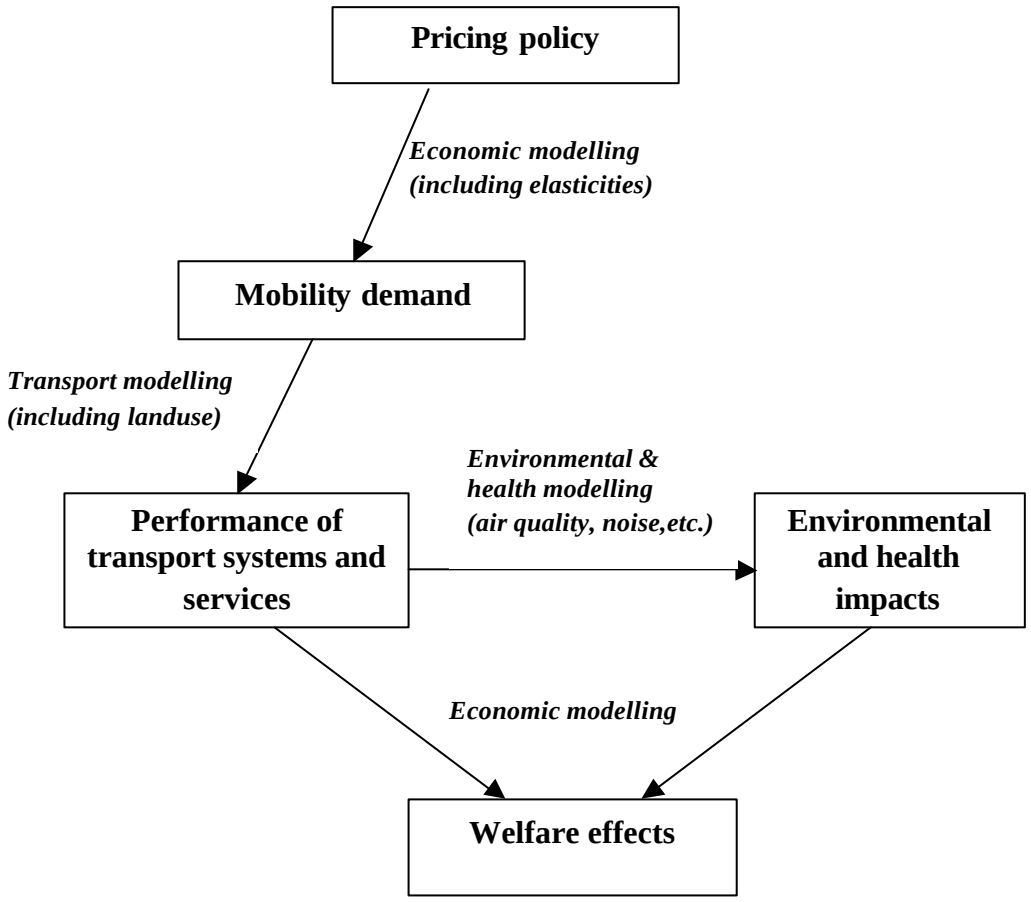
In reality, the design and implementation of urban pricing schemes is geared to a set of priorities, which may change according to the policy context: while environment and health play a major role in the decision process, other objectives are found to be equally important, and at times prevailing. Typically, the reduction of congestion is among those, where congestion is understood as a measure of the transport system performance (rather than one of the phenomena responsbile for additional emissions, and therefore additional environment and health damages).

Figure 1: Sustainable mobility policy framework



Depending on the policy priority, pricing schemes differ in design and implementation mechanisms, and even more as regards the evaluation of their impacts. Ideally, a comprehensive approach to impact evaluation (Figure 2 below) should allow for the concurrent (and consistent) evaluation of the full range of potential impacts.

Figure 2: impact assessment of pricing policies



In reality, past and present practice shows that the focus is, in most cases, on one *or* the other aspect, or even on specific issues within one of the main impact areas (e.g. air quality, modal split, revenue generation, etc.).

3 Why should urban road pricing be more effective than other fiscal and taxation measures?

As all motorists know well, transport (and particularly private mobility) has long been a privileged target of most governments when it comes to levying duties of all sorts. The array of transport related levies currently found in most western countries is abundant and varied, ranging from purchase and registration taxes to ownership taxes, from fuel related duties to taxes on insurance premiums, etc. Most such levies, however, do not differentiate according to the nature and conditions of the trip, with the only significant exceptions of (i) motorway tolls as currently in place in a (limited) number of countries, and (ii) parking charges. Notably, the movement of vehicles within and across cities is not subject to taxation instruments that would be directly and visibly geared to the specific constraints and conditions characterising urban mobility. On the other hand, it is now also well known that the social costs associated to urban mobility are remarkably higher (e.g. per vehicle.km) than those arising from extra-urban traffic: as opposed to rural areas, cities are

characterised by a combination of high intensity of traffic (and therefore of nuisances generated therefrom) and high density of receptors (people, monuments). As an immediate consequence, non differentiated taxes end up by sending the wrong pricing signals to transport users, introducing undesirable market distortions, less than equitable distributional effects and, most importantly, reducing the potential effectiveness of the taxation itself. Conversely, urban transport pricing, if appropriately designed, will efficiently deal with such risks.

In fact, when it comes to applying the "user pays" principle, non differentiated taxation mechanisms turn out to be far off the mark, although this does not amount to recommending the outright suppression of non differentiated taxes, which may still prove effective in specific instances (e.g. in the case of fuel taxes to deal with global environmental impacts such as those arising from greenhouse gas emissions which, owing precisely to their global nature, may be addressed in a context independent manner).

4 How to design an effective urban pricing scheme?

Designing a pricing scheme entails three fundamental choices, related to (i) the organisational concept, (ii) the technological options, and (iii) the price setting.

4.1 Organisation and technology.

There currently seems to be a wide consensus that a distance-based, satellite-controlled charging system would offer the most advantageous solution, combining fairness (the price charged incorporates all the specific features of the trip: vehicle type, distance, time, spatial context etc.) with efficiency, standardisation and interoperability (one system for all), and low operating costs. The development of such a system is in fact already under way in the EU, notably thanks to the GALILEO programme that will provide the communication backbone of such a generalised transport pricing application.

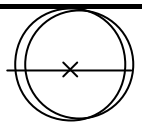
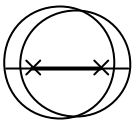
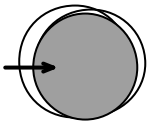
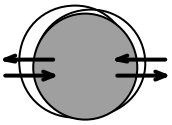
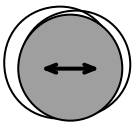
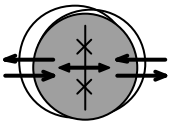
In terms of timing, however, it can be expected that many years will pass before a satellite-based system is actually in place, while urban congestion has already reached unsustainable levels, and European cities cannot afford to wait for the ultimate solution to be available on the market. The options currently practicable are varied, each in fact corresponding to the combination of a basic concept (cordon pricing, area pricing, etc) and of a technological solution to implement the concept in practice and enforce its application.

Figure 3 below summarises the basic concepts and their characteristics.

Each such concept can then be implemented through a variety of technological options, ranging from "traditional", low-tech (or no-tech) schemes (e.g. paper permits with human enforcement) to hi-tech options (based on e.g. the combined use of OCR technology, RF communication between On Board Units and off-street beacons, and IT devices for automatic fine emission). Research has confirmed that there usually is an obvious trade-off between investment costs and transaction costs, whereby capital intensive systems earn their way through low enforcement costs, while the low investment cost associated to low-tech schemes is largely offset by high operating costs and by the comparably low efficiency of the system.

Recent research has concluded with a fairly good level of consensus that, while we wait for satellite-based systems to be available, cordon pricing schemes implemented with DSRC (Dedicated Short Range Communications) offer the most balanced and attractive option. It is in this direction that the (still few) real life implementation efforts can be found, whether in Europe (e.g. Rome) or abroad (recent upgrading of the Singapore scheme, Hong Kong trials etc.). Variants - even significant - around this basic concept are numerous, but not investigated further in this paper, which does not focus on technological options as such.

Figure 3: The basic urban road pricing concepts

Sites for payment			Type of pricing, based on:									
			N	A	S	R	P	V	O	T	C	E
A	**Passing a point (e.g. a bridge)**		♦			♦	♦	♦		♦		
B	**Passing a road section**		♦		♦	♦		♦		♦	♦	
C	**Entrance control (licence area control)**		♦	♦				♦	♦	♦	♦	♦
D	**Entrance/Exit control for a zone**		♦	♦				♦		♦	♦	♦
E	**Zone control**		♦	♦				♦		♦		♦
F	**Combinations**		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
			N	A	S	R	P	V	O	T	C	E

N = National policy, A = Area/Zone, S = Section, R = Road type, P = Point

V = Vehicle type, O = Occupancy, T = Time of day, C = Congestion, E = Environment

Source: *TransPrice* Deliverable 1: Review of Options and Issues

4.2 Price setting

This is certainly an area where empirical work such as is being carried out in a number of European cities will provide precious indications as to the practical applicability of the theoretical economic prescriptions. The general idea is that price structures should allow for an effective application of the "users pay" principle. Accordingly, the first step is to calculate the real, total costs that urban mobility imposes on society, notably incorporating the external components of such costs.

4.2.1 Monetary valuation of social costs

Major advancements have been made in recent years in devising and testing methods for the monetary valuation of external costs; the resulting body of knowledge is commonly deemed sufficient to allow for the systematic incorporation of externalities in transport accounting frameworks, notably for what concerns the main cost categories (i.e. air pollution, noise, and the costs they impose on health, accidents, congestion, and global warming). Bottom-up methodologies,

based on the damage cost approach, are usually preferred to top-down methods that rely on cost control accounting schemes or on other indirect estimates of real costs such as e.g. shadow prices. Nevertheless, the level of uncertainty still affecting many of the external cost values is high, and for specific categories of externalities (e.g. ecosystem damages, community severance, etc.) the current level of knowledge is insufficient. These are limitations applying however to the transport costs in general, while specific issues can be identified that are particularly relevant for urban transport pricing.

Cities are complex systems, where the physical configuration of the landscape affects the pattern of propagation of nuisances (emissions, noise) to such an extent that only highly disaggregated representations of the phenomena associated to e.g. the dispersion of pollutants can provide a reliable account of how air quality is affected. Owing to the complex behaviour of meteorological parameters, combined with the morphological peculiarities of urban landscape, one has for instance to accept that the concentration of a given polluting substance, at a given point in time, can be found to be substantially different in two locations that are only a few centimetres apart. Clearly, this reflects heavily on the monetary valuation of the resulting external costs, considering that the presence – and the density – of receptors can also vary dramatically within small distances.

4.2.2 Applying economic theory to price setting

Recent research decidedly identifies SRMC (short run marginal cost) pricing as the most appropriate reference for setting and modulating charging levels. Several obstacles and constraints however make it hardly straightforward to actually set urban road prices equal to SRMC. In fact, cities that are already in the process of designing, or in some cases implementing UTP schemes (e.g. London) have set charges which have no explicit relationship with SRMC or, for that matter, with any other economic theory.

There are in fact several reasons behind this discrepancy.

- ⇨ Firstly, marginal costs are not easy to estimate for urban trips and, in general, city authorities are not appropriately equipped to carry out reliable calculations.
- ⇨ Second, urban road pricing amounts to introducing payment for a service that was previously free of charge. This is a situation that is known to generate high levels of discontent among the users, all the way to outright rejection, such as e.g. in the case of the Lyon's newly tolled ring road section. Politicians are highly sensitive to such risks, and subsequently tend to set charges based on estimated acceptability rather than on theoretical principles or even accounting evidence. For the same reason, gradual implementation is often a basic feature of UTP schemes. Whether in London, or in Rome, the initial level of planned charging is likely to be adjusted in time according to users reaction and to the level of attainment of original objectives.
- ⇨ And thirdly, it is precisely the specificity of local objectives that drives the setting of the charging levels: in Rome, for instance, road pricing is designed to alleviate congestion in the historical city centre. Simulations carried out prior to the introduction of charging indicate that below a certain threshold (ca. 2.5 Euro), there is little chance to achieve a reduction of congestion, not because of standard elasticity mechanisms, but for a very specific phenomenon associated to the high number of two-wheelers, whose drivers might opt back to their private car as soon as they are permitted (although at a price) to enter the city centre at all: for cordon charges below such threshold, the number of private cars entering the city centre is therefore likely to *increase* with the introduction of road pricing, defeating the very purpose of the exercise. It is therefore understandable, in such cases, if policy makers do not rely on the prescriptions of economic theory to determine optimal pricing levels.

4.2.3 Urban transport pricing as a part of integrated policy packages

It is now largely recognised that pricing alone cannot achieve the ultimate objective of ensuring the sustainability of urban mobility. Pricing schemes should therefore be "packaged" with other measures to enhance their respective effectiveness:

- ⇨ the synergy with parking measures is particularly relevant, especially when considering that, whatever the pricing principle adopted, road pricing (e.g. cordon charge) should be designed so as to avoid the risk of duplicating pre-existing parking charges
- ⇨ research has also shown that, in general, the application of identical (or similar) pricing principles to all modes and all types of trips (i.e. both urban and rural/inter-urban) is likely to generate a surplus from private car pricing in urban areas, while non urban trips might not cover their total social costs. Cross financing (as recently endorsed by the EU) may contribute to correct such undesired effects.
- ⇨ Other possible distortions are associated to the very nature of specific mechanisms, such as e.g. noise costs, as well as, to some extent, accident costs. As repeatedly pointed out, the current body of knowledge suggests that the marginal cost of noise may well follow a decreasing pattern (i.e. the higher the number of vehicles, the lower the incremental noise damage associated to each new vehicle). Clearly, under such circumstances, charging the user for the marginal cost of noise will not contribute to encouraging a reduction in traffic. Regulation is needed in such cases to supplement pricing measures.
- ⇨ Also, urban public transport is often found to be undercharged according to economic theory. Nevertheless, increasing the cost of public transport to the user is likely to counter act all possible strategies aimed at a more sustainable modal split, and should therefore be avoided.

5 What can we learn from past and present experience?

Evidence from real life implementation of urban transport pricing is scarce. With limited exceptions (Norway, Singapore, and precious few others), no experiment has reached a sufficient level of maturity that may lead to drawing conclusive lessons. Nevertheless, recent developments allow for the identification of a set of critical issues deserving particular attention.

5.1 Assessing the impacts

In qualitative terms, UTP trials or/and simulations have confirmed that urban road pricing does have a meaningful potential in reducing traffic (and therefore congestion and the environmental nuisances associated to urban mobility), and, possibly, in modifying the users pattern of behaviour (trip choice, modal choice, etc.).

Table 1 and Figure 4 overleaf, drawn from the CANTIQUE study, illustrate some orders of magnitude of the potential impact of pricing measures in improving urban air quality.

Real life, full scale demonstration projects such as currently under way will undoubtedly allow for much needed advancements in this area, particularly for what concerns the causal relationships between urban transport pricing and users behaviour, where standard economic theory, based on elasticities and utility functions, is not fully adequate to capture the complexity and subjectivity of urban travellers decision processes.

Another fundamental issue is that of generalisation and transferability (of good practice). Clearly, no straightforward extrapolation can be carried out from one city to the other, owing to the substantial diversity of implementation contexts. A full fledged generalisation and transferability framework should therefore be developed, combining statistical techniques (so as to make the best of the input gathered from real life experiments) with economic and transport modelling. Until and unless such a framework is available, results from individual experiments will hardly allow to formulate policy conclusions as to the impact of urban transport pricing *per se*.

Table 1: Pricing Vs other measures: comparative impact assessment

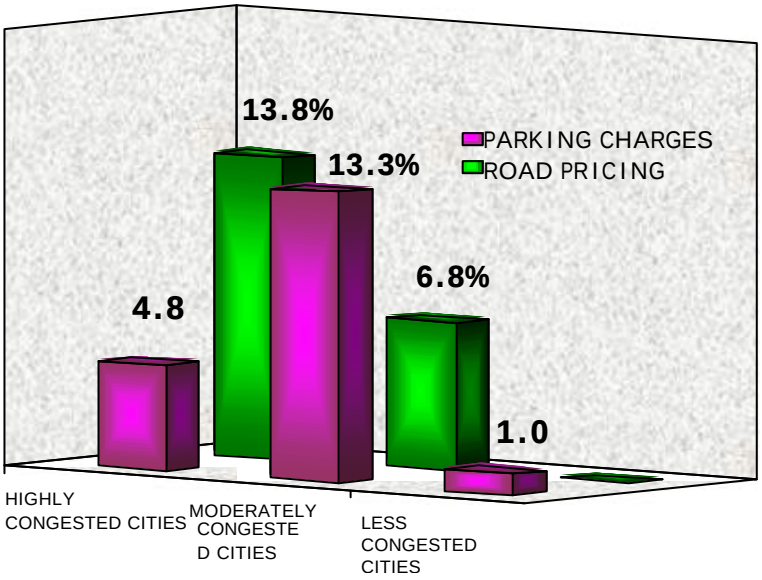
	Measure type	EMISSIONS (*)	VEHICLE * KM	PASS.* KM	AVERAGE SPEED	FUEL CONS.
HIGHLY CONGESTED CITIES	CAR SPEED LIMITS	+	+			
	FUEL PRICING	++	++		++	+
	PARKING CHARGES	+	+			+
	PARKING MANAGEMENT	+	+			
	PT FARE STRUCTURE	+	+			+
	PT INCREASED FREQ.	⇔	⇔			⇔
	PT INVESTMENT	⇔	⇔		⇔	
	ROAD PRICING	+++	++			+++
	UTC MEASURES	⇔			++++	
MODERATELY CONGESTED CITIES	PARKING CHARGES	+++		++++		
	PT BUS PRIORITY	⇔		⇔	⇔	+
	PT FARE STRUCTURE	⇔		⇔	⇔	
	PT INVESTMENT	+	+		⇔	
	ROAD PRIC ING	+		++	⇔	
LESS CONGESTED CITIES	CAR SPEED LIMITS	⇔	⇔			
	FUEL PRICING	++	+++			
	LAND USE POLICIES	⇔	⇔		⇔	
	PARKING CHARGES	⇔	⇔			
	TELEWORKING SCENARIO	⇔	⇔		⇔	

(*) selected mix of pollutants

⇔ (neutral) 0<X< 4%
\+ (acceptable) 4% ≤X≤ 8%
++ (favourable) 8% <X≤12 %
+++ (favourable) 12% <X≤16%
++++ (very favourable)X>16%

Source: CANTIQUE

Figure 4: Potential emissions reduction through pricing



Source: CANTIQUE

5.2 Using revenues to increase the effectiveness of transport pricing

The optimal use of the financial proceeds from urban pricing schemes is a subject of heated controversy. On the one hand, economic theory suggests that welfare is maximised when revenues are not earmarked (and/or reused within the urban transport sector), but rather used to e.g. lower general income taxes, or invested in sectors where the social cost-to-benefit ratio is higher. On the other hand, urban policy makers are convinced that re-injecting the revenues from pricing schemes into the urban transport system, aiming e.g. at the enhancement of public transport services, or at the provision of new infrastructure, is essential to ensure both fairness and users acceptance. The current orientation seems to point at a compromise solution, whereby the basic rule of welfare economics can be bent on two accounts:

- ⇨ firstly, it can be accepted that part of the urban transport pricing proceeds are earmarked for transport system improvements, with the remaining part being used for general fiscal purposes
- ⇨ second, earmarking should in any instance be devised within reasonably flexible rules, e.g. allowing for cross subsidisation of modes.

5.3 Keeping an eye on equity issues

The equity implications of UTP are manifold and potentially dramatic. They range from pure distributive effects to the threat that access restrictions impose on the freedom of movement, but also to the need to ensure the equal treatment of modes and of the various categories of users, whereby transport pricing may affect the quality of service of specific urban transport services more than others.

To a large extent, equity is one of the facets of the broader acceptability issue. On the other hand,

- ⇨ the perception of end-users (transport service users), according to recent surveys, is more balanced than usually expected: it would seem that equity concerns are not overwhelmingly

constraining users expectations and reactions to the introduction of pricing schemes, and that policy makers tend to over-rate the potentially adverse reaction of citizens in this regard

- ⇨ equity measurement poses problems so far unresolved, both theoretical and practical. Decisive progress should be made in this area, based on a balanced mix of: i) analytical tools (for ex-ante modelling and equity impact simulation) and ii) monitoring techniques, based on appropriate equity indicators, to allow for ex-post assessment and policy validation.

5.4 Devising an appropriate institutional framework

The design, implementation and enforcement of urban transport pricing measures require the involvement of institutions and decision makers at several levels (national, sub-national and supra-national). The range of involved institutions and the scope for potential conflicts (or, at least, lack of co-ordination) are very wide: cities are usually constrained in their policy making by legal and institutional rules that are issued at the national level, e.g. in the area of basic taxation (including fuel), but also for what concerns the protection of citizens privacy (an issue that has already been raised in several cases where advanced ICT solutions for UTP enforcement were perceived as a threat to basic privacy rights). Furthermore, within the urban institutional framework itself, conflicts of competence often emerge between e.g. mobility agencies, budget departments, infrastructure departments etc. in relation to scheme design, realisation and exploitation.

5.5 Integrating transport and land use policies

Urban sub-systems evolve over time with different speeds: while transport structures and activities can be modified, even radically, in relatively short periods of time (a few years, sometimes less), other sub-systems, and in particular land-use related patterns and the activities thereto, evolve at a much lower pace.

The sustainability of modern cities is, in fact, both a matter for urgent deliberation and immediate interventions and one that should be analysed in the perspective of long term scenarios. The incorporation of UTP in such long-term scenarios, along with other major long term factors (e.g. ICT diffusion, e-life, etc.) then becomes mandatory.

6 References

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