SOCIAL COST PRICING WHEN PUBLIC TRANSPORT IS AN OPTION VALUE

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ABSTRACT *A well known principle of welfare economics states that an efficient resources' allocation can be achieved in a competitive economy when market prices are in line with social marginal costs. When applied to the transport sector, this implies that the price of the various transport modes should be made equal to the sum of marginal production and external costs, like congestion, accidents, pollution, and road maintenance. It is sometimes argued the internalisation of external costs would bring about a change in demand patterns with a shift towards public transport and cleaner modes. But, public transport is already favoured by a discriminatory fiscal treatment. Whereas public services are normally (heavily) subsidised, private transport is taxed in several ways and, in some countries, quite substantially so. The application of the "optimal pricing" principle, therefore, critically depends on how the subsidisation of public services is interpreted.*

This paper addresses the issue of optimal pricing of urban transport, using different hypotheses about the treatment of public services. After reviewing some traditional arguments in favour of public transport subsidisation, a new approach, based on uncertainty and option values, is discussed. The implications of this approach are investigated by means of an applied model, where optimal prices for urban transport services in the city of Bologna are computed under alternative assumptions.

1. Introduction

Pollution, traffic congestion and other negative externalities caused by transportation are major problems in many metropolitan areas around the world. Among the different measures that have been proposed to cope with these problems, two themes recurrently emerge. First, it is argued that prices of the different transport modes should reflect the social marginal costs, including external costs not normally borne by the consumers of transport services. This view, based on the conventional "Pigouvian" approach to externalities, has been advocated by the European Commission, as well as by other public bodies, and suggested as a guiding principle for the formulation of policies in the transport sector. Second, it is also often argued that the use of public transport services, instead of private vehicles, should be encouraged. Promotion measures include: park and ride schemes, preferential lanes for buses, and subsidisation of public transport.

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As it will be shown in this paper, these two arguments may be contradictory. In particular, pricing policies based on social costs need to take into account the effect on prices of current taxes and subsidies. Public transport is, in this respect, already favoured by a discriminatory fiscal treatment. Whereas public services are normally subsidised, private transport is taxed in several ways and, in some countries, quite substantially so. In Italy, for example, about two thirds of the market price of gasoline is made of taxes.

The level of subsidisation of public transport varies greatly among countries. Subsidies are especially large in Italy, normally covering more than 70% of total costs. In the city considered in this paper, Bologna, market revenues cover 37% of production costs, but the situation is much worse in other Italian cities, for example Turin (26%), Rome (17%), Naples and Palermo (7%) (CISPEL (1996)).

Previous research work (e.g., Roson (1998)) has shown that optimal pricing policies may cause changes in prices and demand levels that negatively affect public transportation. This is because subsidies tend to be eliminated in an optimal pricing policy, unless positive externalities are found to be associated with the consumption of public transport services.

This paper addresses the issue of optimal pricing of urban transport services, using different hypotheses about the treatment of public services. It will be shown that changes in price, demand level, and environmental impact of the various transport modes crucially depend on how the subsidisation of public transport is interpreted and justified. However, instead of adopting traditional justifications about the existence of subsidies, we propose an alternative approach based on uncertainty and option values. Under this approach, public services are valued not just for the actual services provided, but also for their potential use. In this case, revealed preferences methodologies may be inappropriate for the estimation of parameters in planning models. The latter point will be illustrated by using a simple optimisation model that computes optimal prices (or tax levels), taking into account external costs, for different transport modes in the city of Bologna.

The plan of the paper is as follows. In the next section, traditional (and more recent) arguments in favour of the subsidisation of public transport services are reviewed. A new approach is then proposed in section 3 and tested in section 4 by means of an applied model. Conclusions are then draw in section 5. Finally, an appendix provides some technical details about the model structure and data used in the simulation exercises.

2. Why should public transport be subsidised? Some popular arguments.

Most people regards public transportation as a quasi-public good, and subsidisation as a natural compensation for the constraints imposed (on the determination of prices, quality and quantity levels of the services) by public authorities to the transport firms. As public transport has been subsidised in many countries for long time, it is not surprising that arguments in favour of the subsidies have a long tradition in transport economics.

In this section, we shall briefly review some of these arguments. Most of these do provide a rationale for the existence of *some* subsidies, but in our opinion none of the traditional arguments succeeds in explaining the fairly large level of subsidisation currently granted to many transport services, especially at the urban level.

a. Internal and external economies of scale

Perhaps the most well known argument relies on the existence of economies of scale, generated in some transport modes by the existence of large fixed costs and relatively low marginal costs. A situation of this kind may emerge whenever the supply of transport services, like in the case of railways, requires the construction of a costly infrastructure. When this happens, a natural monopoly, that is a situation in which only one firm can survive in the market, would be the outcome under free competition.

It is well known that, under these hypotheses, a socially optimal price, set at the marginal cost, would imply a loss for the monopolistic firm, because marginal costs would fall below the average costs. Economic theory then suggests that social welfare could be maximised by forcing the firm to set the price equal to the marginal cost, and by assigning a subsidy that allows the firm to break even. The subsidy would then be equal to the difference between average and marginal costs.

While economies of scale certainly characterise some transport modes, it is however doubtful that such economies can be found in urban transport services or, if some economies exist, that they create large differences between average and marginal costs. For example, econometric studies by Lee and Steedman (1970), Williams (1981), Wabe and Coles (1975) and Koshal (1970) found no evidence of economies of scale in urban bus operations. Other authors (e.g., Button and O'Donnell (1985), Berechman (1983), Williams and Hall (1981)) found limited positive scale effects under a certain range of supply levels.

However, economies of scale could also be generated on the customer side, since the production of transport services typically requires some inputs (time, comfort, etc.) from the users as well. By increasing the frequency of a service, for example, waiting times at the stops can be reduced. This effect is sometimes referred to in the literature as "the Mohring effect" (from Mohring (1972)).

How relevant this effect is? Suppose that some travellers arrive at random at a bus stop, and the arrival rate is uniformously distributed on a given time period, in which bus services are provided at regular intervals. Under these hypotheses, a doubling of the service frequency would reduce waiting times by 50%. The relative impact of this effect would then depend on the share of waiting time costs of the total (generalised) travel cost. This is likely to be small, especially if the trip length is large.

Furthermore, an estimation of time savings carried out as above is probably too optimistic. First, the distribution of arrivals is generally not uniform, so that waiting times may not be reduced in proportion to the increase in frequency. Second, people may react by adjusting activities during the day so as to arrive at the stops at the right time. The "rescheduling" costs may not be proportional to the time difference between "desired" and "actual" availability of the service.

b. Subsidies as a second best policy

Traffic congestion is certainly one of the most important types of externalities associated to transportation, especially in metropolitan areas and during peak periods. Indeed, when an additional vehicle enters a congested road, time costs are increased for all users of the road.

Road pricing, which means charging the external costs (variable in time and space), is the instrument generally advocated by economists to curtail the negative effects of congestion. By pricing the road usage each driver can be forced to consider the external costs imposed on other individuals, so that he or she will continue to choose a congested road only when travel benefits are sufficiently large.

Road pricing can be considered as a first best policy if tolls can be set precisely at the level of marginal external costs, and continuously adjusted according to the different traffic conditions. Despite this, the actual implementation of road pricing schemes in the world is, remarkably, limited to a very few cases. This is because of a number of practical difficulties, technical and political, which will not be discussed here.

When, for whatever reason, it is not possible to charge the right marginal social cost to the road users, a second best policy could be devised to favour the use of vehicles with a lower impact on congestion. Prices of urban public transport services (e.g., buses) could then be reduced through appropriate subsidies, making the use of public services more attractive.

The effectiveness of a second best policy of this kind crucially depends on the cross price elasticities of the demand of travel by car and by bus (or by underground, by local trains, etc.). Unfortunately, almost all studies carried out on this subject agree on fairly low elasticity values. There is likely to be more flexibility of demand between public transport modes than between these and private transport.

Glaister and Lewis (1978) report an elasticity of peak road traffic demand with respect to bus prices of 0.025. This means that, if bus prices would be halved, private cars traffic would be reduced by only 1.25%.

Even if cross price elasticities for other modes and in off-peak periods are likely to be larger, a disproportion between the costs of subsidies and the benefits of congestion cost reductions would certainly remain. Thus, even if public transport subsidisation could be *in principle* be interpreted as a second best policy for traffic congestion, as a matter of fact this policy turns out to be highly inefficient.

c. Transport as a social need

Economic policies are often designed to sustain the standard of living of the poorest groups in the population, as well as to avoid excessive income disparities. This support can take two forms: direct income redistribution, through income transfers, unemployment subsidies, pensions, etc., or indirect income redistribution, obtained by keeping low the prices of some basic goods like food, housing, schooling, and so on. It could be argued, even if this may be controversial, that transport itself should be included in the list of the "social needs". In this case, access to transport services should be granted to everyone in the society, by means of relatively cheap public transport services.

Roson (ibid.) argues that the effectiveness of a policy of this kind crucially depends on the differences in consumption patterns of the population groups. If, for example, the poors only travel by bus and the riches only travel by car, then taxing private transport and subsidising public transport could be interpreted as an implicit income redistribution policy. Numerical experiments carried out with a model very similar to the model described later in this paper show, however, that the current structure of taxes and subsidies can hardly be interpreted in terms of income redistribution policies. This is because the structure of consumption of transport services for the different income groups is not very different. The rich consumes more of all transport services, and relatively more of private transport, but private transport constitutes a non negligible share of consumption for the poor as well. Cross-subsidisation between private and public transport services therefore have limited distributive effects.

Differences in income elasticities may lie behind the similarity of consumption patterns. Income exerts a positive influence over car ownership decisions, whereas public transport has in many situations proved to be an inferior good. Under these conditions, when income increases for all, but relative income levels do not change, the structure of transport consumption for the different income groups becomes more similar, because the share of private transport in total consumption increases more for the poorest groups.

d. Subsidies as a remedy for distortionary taxation

A rather new and interesting point of view on the issue of public transport subsidisation has been offered by Jansson and Lindberg (1997). These authors correctly point out that "(the transport) sector is situated in the borderland between the "formal" market economy, and the "informal" household production sector of the whole economy". Every transport service requires some production factors directly provided by the consumer, but the incidence of these varies with the type of service. Private transport requires the largest amount of participation by the transport user: for example, to drive a car one has to spend some time, and this has an opportunity cost. There is a basic difference between driving a car and hiring a driver to do it: in the first case, the driver is essentially employed by himself, but *no income taxes are paid*, in the latter case, a compensation, which includes taxes and social security contributions, has to be paid to the employed driver. It is possible that external labour has a lower opportunity cost than self-employment, but the fiscal wedge imposed on labour hiring makes more convenient the latter, thereby creating a distortion in the use of (human) resources.

This phenomenon is by no mean confined to the transport sector, but embraces all sectors of the economy. An ideal, non-distortionary taxation system should not alter the relative prices obtained by equating demand and supply in the various markets. This could be obtained, in principle, by taxing labour and capital endowments of the individuals, which means taxing *potential* labour supply rather than the actual labour supply. Income taxation is therefore distortionary, because it reduces supply in the labour market, while favouring household self-production.

This argument has been very popular among environmental economists, where the concept of *double dividend* has been elaborated. A double dividend effect is created when environmental taxation is introduced, internalising external costs, and the tax revenue is used to reduce income taxation. The benefit of this policy would be double because of: (1) the internalisation of external costs, implying a more efficient use of environmental resources and (2) the reduction of distortions in the labour market, which may imply more employment.

These considerations may be important, but how relevant are there to the issue at hand? Jansson and Lindberg (ibid.) admit: “We cannot solve the problem here, but suggest that in an extended analysis the optimal transport pricing problem should be considered as a part of the larger problem of optimal taxation”. Indeed, it would be odd to think that subsidies in the transport sector have been designed to correct the effects of distortionary income taxation, whereas the problem remains basically ignored in all other sectors of the economy.

Apart from this, however, the point which is important to clarify in this context is the relative importance of this effect. We think that a rough calculation can be carried out by considering, as an example, the case of ATC, the bus company operating in Bologna. Labour costs constitute, in this case, 67.8% of total production costs (CISPEL (ibid.)). To put public transport at equal footing with private transport, labour in the bus company should be made tax free, which amounts to assigning subsidies to ATC exactly equal to the income taxes raised. Taxes due by the employer and by the employee, and social contributions, should not be larger than 50% of total labour costs (the determination of the exact share, of course, requires much more detailed data). This means that the level of subsidies needed to correct for distortionary taxation could not exceed 34% of production costs, which is far below the actual level of subsidies (64%).

Furthermore, the level of subsidies assigned to ATC, in proportion to total costs, is the *lowest* among all bus companies operating in the main Italian metropolitan areas.

3. An alternative point of view: option values in transport services

The market for transport services has a dual nature. On one side, we have private transport. Private transport is expensive but it offers an unbeatable level of flexibility and it is tailored on individual needs and tastes. On the other side, we have public transport. Public transport is cheaper but rigid in terms of time and service quality. However, it must be recognised that public transport offers *a guaranteed service which is valued also by those who do not normally use it*. Car lovers, for example, may still value public transport for a variety of reasons: in some cases, the car may not be available because of mechanical problems, or because it is used by other members of the family, friends may not be able to drive, etc. In this context it is important to recognise that public transport is valued on the basis of the *potential* utilisation, rather than on the basis of the actual use, and that there exists both an *ex ante* and an *ex post* valuation of the service.

When the existence of a possibility in the future, or option, gives raise to an higher level of expected utility than without it, the option is said to have a value. This value is irrespective of the fact that the option is exercised or not. Option values are frequently encountered in financial markets, for example when the right to sell or buy in the future at a given price is bargained. The concept is also frequently associated with the valuation of environmental goods which may or may not be enjoyed in the future (e.g., Cameron and Englin (1997)). Option values, however, have been little considered in theoretical analyses of transport markets, despite the various sources of uncertainty affecting both the demand and the supply of transport services. Few examples can be found, and mainly in the context of infrastructure investment (e.g., Emery and McKenzie (1996)).

The existence of an option value may explain the willingness to pay, through public funds, for public transport services which are little used. In this case the decision is not a discrete one about a single option, like in the case of a specific environmental resource or a financial option, but on a continuous range of potential supply levels.

Consider, for example, the case of an individual who would always prefer to drive a car, but with a probability p faces the possibility that that the car is not available. Without a car, he can choose between using a public transport service or not moving. The decision depends on the availability (in time and space) of a suitable public service, and the probability q of this can be an increasing function of public transport supply levels. This is because more public transport means denser networks and increased frequencies. Once public transport is chosen, the individual can consume different amounts of service.

The maximum willingness to pay t for *the existence* of a public transport service supplied in s units, is determined by a relationship like:

$$pq(s)U\big(b(f,y-t),0\big)+(1-p)U\big(0,c(g,y-t)\big)=(1-p)U\big(0,c(g,y)\big) \quad (3.1)$$

Here we consider a reduced-form utility function *U(b,c)* affected only by the consumption of private transport (*c*) and public transport (*b*). When the individual cannot consume transport services, the utility is assumed to be zero. On the right hand, the expected utility in the absence of public transport is considered. With probability *1-p* it is possible to drive a car for a number of Kilometres which depend on the cost g and on the available income y.

On the left side, we have the expected utility when public transport services are offered. Income is in this case diminished by a certain amount t, but an extra utility term is added. This account for the potential use of public transport services, whose consumption level depends on the (reduced) income and on the fare f per unit of distance. The fare can be assumed to be constant or a to be a function of the capacity *s*[1].

By varying the supply level *s*, the condition (3.1) defines a function *t(s)* expressing the maximum contribution an individual is willing to offer for public transport services supplied in *s* units (e.g., bus-km.). The actual level of public transport capacity is determined by matching demand and supply. The latter is implicitly defined when expected market revenues (*pqbf*) and subsidies (*t*) cover production costs *C(s,b)*:

$$p\ \ q(s)\ \ b\ \ f+t=C(s,b) \quad (3.2)$$

It is important to notice that the existence of a public service is a public good, because the virtual consumption of the good "existence" does not exclude the consumption of the same good by other individuals in the society. On the other hand, consumption of public transport services is an ordinary private good. By aggregating the functions *t(s)* over all individuals it is possible to determine how much the set of potential users of public transport is willing to pay for a certain level of supply.

Even if the availability of a guaranteed public service can be regarded as a public good, it should be noted that the "existence option" may not necessarily be provided by the public sector (Atkinson and Stiglitz (1980)). A good example is the case of taxis, where the users bear the full cost of the service, including part of the capital cost. The choice between private and public provision is therefore based on a trade-off between cost efficiency (favouring public transport, due to cost sharing) and service differentiation (favouring the more flexible private transport).

The consumption of "public transport capacity" s and of "public transport service" b can be seen as the consumption of two complementary goods. Two goods are said to be complements if the reduction in price of a good increases the demand for the other one, in addition to its own. Here, if it costs less to expand the capacity of public transport, more lines will be offered, and more consumption of services will follow. This is not because the service is valued more in terms of utility, but simply because more people will be able to find a suitable alternative to transport by private car. On the other hand, if fares are reduced, there will be an increase in consumption of services. The marginal supply cost of services can be considered constant up to the point where the capacity of a vehicle is reached. If this happens in some periods and in some points of the network[2], there will be another effect: people willing to travel with public transport and who have found a suitable service may still not be able to use the service because of (local) capacity limits[3]. In this case, the marginal utility of an increase in total capacity s will be higher, making more convenient to expand the supply of public transport services.

4. A model for the assessment of pricing policies

In this section we present a model which can be fruitfully used to explore, through numerical simulation experiments, some of the issues discussed so far. The model (MT) is a reduced, simplified version of a more general and complex model with a similar structure (TRENEN), developed for the European Commission[4]. The equations of the model and the data used for the simulations are described in the Appendix.

The model is stated as a non-linear optimisation problem, in which prices for a set of transport services are determined through the maximisation of social welfare (consumers' and producers' surplus), net of the external costs of accidents, road maintenance and emissions. When optimal prices exceed the marginal private cost of the services, consumption taxes have to be imposed, and the tax revenue obtained is assumed to be redistributed "lump-sum" to the consumers. Standard economic theory suggests that in this case taxes should equalise marginal external costs, which may be

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[1] It could also be made function of other variables, like total traffic levels. However, since the optimal fare should equalise marginal production costs, these can be seen as dependent only on the supply level s.

[2] Suppose that local excess of demand occurs randomly in time and space.

[3] This effect is not evident in (1).

[4] The TRENEN model has been developed in the context of the research programmes Joule II and Transport of the DG XII, by a consortium which includes the Universities of Leuven (CES), Antwerp (SESO), Kent, Amsterdam (VUA), Athens (NTUA), the Trinity College of Dublin and the research consortium TREC (Italy).

dependent on consumption levels. The model can also be used to assess second-best pricing policies; these can be easily simulated by introducing specific constraints in the optimisation problem.

One ore more representative consumers are considered. Each consumer generates a demand for transport services by maximising utility, subject to a budget constraint. Income is exogenously given, except for the part which accounts for redistributed tax revenue. The process of allocation of revenue to consumption expenditure can be seen as a hierarchical process: first, income is divided between expenditure in transport services and expenditure in other goods; second, transport expenditure is split between expenditure in private transport and public transport services (buses); third, motorised and non-motorised (cycling, walking) private transport is considered and, finally, motorised transport is further distinguished between transport by "big" and "small" private vehicles (fig. 4.1)[5].

At each level of the decision tree, a choice is made between two alternatives on the basis of: an exogenously given elasticity parameter, preference parameters (estimated within the model), and relative prices. Prices may be market prices, possibly including taxes and augmented by the time costs borne by consumers, or price indices, computed as CES cost functions for a lower decision level[6].

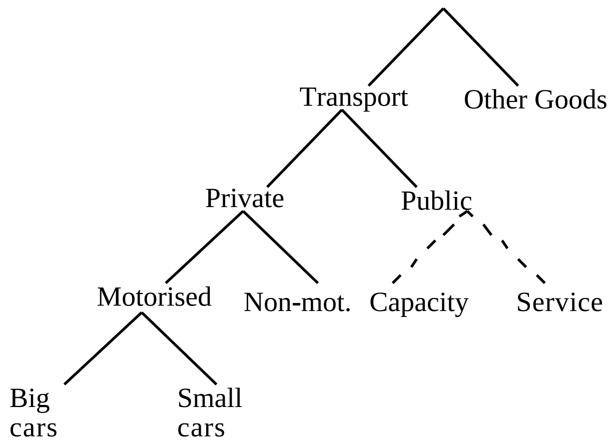

Figure 4.1 - The structure of the consumer utility

Starting from an arbitrary set of prices, the optimisation algorithm begins from the lowest level of the tree. The optimal relative consumption of small and big cars is

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5 The tree structure can be easily extended to account for any choice involved. For example, between departure times, between alternative technologies, or between alternative suppliers.

6 A cost function gives the minimum cost associated with a given utility level. If utility is expressed in monetary terms and the utility function exhibit constant returns to scale, a cost function can be

computed from the initial level of generalised prices, given preferences and the price elasticity. On the basis of the relative expenditure shares an index of the cost of motorised transport is then computed, and confronted against the generalised cost of non-motorised transport. A new price index for private transport is estimated, and so on, until the top of the tree. Here, a price index for total consumption is obtained. The ratio of exogenous nominal income and the consumption index gives an index of real purchasing power and, indirectly, a measure of the consumer utility.

Since real aggregate expenditure is now known, it is possible to follow back the tree from top to bottom and to allocate the expenditure on the basis of the optimal consumption shares already computed. This allows the estimation of consumption levels for all transport services, as well as for the aggregate "other goods". External costs, which are functions of consumption levels, can subsequently be measured. Finally, total welfare, expressed as the difference between a monetary measure of utility (equivalent income) and the sum of external costs, can be computed. The optimisation software then consider what changes in the initial price structure are likely to produce improvements in total welfare, and the whole process is repeated until convergence, that is when further improvements do not seem achievable.

If no constraints are added to the basic optimisation problem, the model provides a first-best solution. This means a situation in which it is possible to price discriminate, perfectly, between the various transport services and consumers groups. Even this may not be possible in reality, the first-best solution is a useful benchmark against which alternative solutions can be compared. In this case, optimal prices are set equal to social marginal costs, including resource costs and externalities.

It is clear that, in a first-best world like this, there is no reason to subsidise public transport services. Public services appear to have positive resource and external costs, but in this setting there are no positive externalities associated with them. Although, for example, pollution costs per passenger-Km. are lower for buses than for private cars, external costs do exist, so that the imposition of a tax on public transport is suggested by the model. Despite the fact that the differential tax treatment favours a shift in the demand towards public transport, the simultaneous elimination of existing subsidies and taxes works in the opposite direction. Given the current, large amount of tax discrimination affecting prices of the various transport modes (especially in Italy), the second effect is the prevailing one.

To obtain subsidies in the model solution, a modification of the basic hypotheses and of the model structure is needed. One possibility is that suggested in the previous section. By interpreting current subsidies as prices collectively paid for the provision of a certain level of public transport capacity, public transport consumption can be considered as a

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interpreted as an ideal price index in which adjustments of demand patterns in response to changes in combined consumption of capacity and service. To this purpose, the model can be easily modified by inserting a new decision level, represented in figure 4.1 with dotted lines. The strong complementarity linking the two types of consumption can also be easily simulated by choosing low values (lower than one) of the elasticity of substitution between transport capacity and service[7].

Estimation of preference parameters for the consumption of public transport can be done by extending the calibration method used for the estimation of other preference parameters. The calibration method amounts to setting parameter values so that the model is made consistent with observed behaviour in a given period, for which data is available. If, for example, substantial use is made of private cars even when the generalised cost of car transportation is relatively large, the model infers an high value for the preference parameter associated with car transport services. The parameter then reflects psychological attitude, perception of service quality, but also other aspects like the extension of the transport networks. Another parameter which influences the calibration stage is the elasticity of substitution: if little substitution is possible, for example, consumption patterns are mainly due to the characteristics of the transport system, rather than to the individual preferences.

In the case of public transport, information on demand levels exists in terms of capacity (e.g. total supplied bus-Km. in a year) and service (e.g., total travelled passenger-Km.). Costs are, however, referred only to public transport as a whole, and a distinction can only be made in terms of costs covered by revenues and costs covered by subsidies. A crucial assumption that is made here (admittedly, a rather strong one) is that costs in the base year are efficiently allocated to the two types of consumption, although the effect of external costs is not initially taken into account. This means that subsidies are assumed to be equal to the marginal costs of expanding supply levels[8], whereas fares are assumed to cover exactly the marginal costs of carrying an extra passenger (ticketing, in-vehicle and administrative additional costs). On the other hand, marginal external costs of public transport are associated only with the level of supplied capacity. This means that external costs are assumed to increase if more vehicles or more Kilometres are offered, but do not increase if more people is carried.

Model results are summarised in Table 4.1. Two cases are considered: the first (MT1) refers to a first best solution in which bus transportation is considered as a single mode

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relative prices are endogenously determined.

[7] Notice also that the distinction between private and public goods is irrelevant in the model version utilised here, because a single representative consumer is considered.

[8] In principle, it would be possible to have a price for the “excess capacity” differentiated between those who use the service and those who do not (Cameron and Englin, ibid.). It is clear, however, that this is not efficient, because it would make the users to pay a price exceeding the marginal cost of the service, for a given capacity level.

in the consumption choice[9], the second (MT2) distinguishes between the consumption of public transport capacity and service. For each transport mode, the table shows the percentage variation, from the initial values, of demand levels and generalised prices, including time costs. The table also shows how total external costs and net tax revenue vary from the base calibration situation.

	MT1	MT2
Public Trans.Service- Demand	-27.8%	-1.9%
Public Trans.Service- G.Price	56.0%	0.0%
Public Trans.Capacity- Demand	-	-3.6%
Public Trans.Capacity- Price	-	6.8%
Non-Motorised Trans.- Demand	2.1%	0.4%
Non-Motorised Trans.- G.Price	0.0%	0.0%
Big Private Cars - Demand	9.0%	7.2%
Big Private Cars -G. Price	-2.2%	-2.2%
Small Private Cars - Demand	-8.5%	-9.5%
Small Private Cars - G.Price	9.3%	9.3%
Total External Costs	-0.7%	-1.5%
Net Tax Revenue	26.1%	1.7%

Table 4.1 - Summary of simulation results

The main difference between the two cases is given by the fact that, in the case MT2, current subsidisation to public buses is justified in terms of potential consumption. This is implied by the calibration procedure in which preference parameters are assumed to be consistent with observed supply levels. Whereas results in MT1 are mainly driven by the elimination of subsidies, causing a drop of 27.8% in the demand for public transport, the MT2 case considers only small increments in the price of public transport supply, due to the internalisation of external costs. The demand drop in the first case is due to the dramatic increase simulated for the price of public transport (which turns out to be about three time higher than in the benchmark). On the contrary, when external costs are taken into account, the total cost of public transport supply does not vary significantly.

Net tax revenue increases in both cases, but significant variations are obtained only when subsidies are eliminated. On average, taxes on private vehicles increase. This explains most of the reduction in external costs for the second scenario (-1.5%). If

[9] To keep the model simple, some modes (like taxis, with a negligible market share) are not considered.

subsidisation is ruled out, as in MT1, externalities from public transport are reduced but the demand shifts towards alternative modes with higher external costs per passenger. This second effect prevails, making the reduction in external costs smaller than in MT2.

When prices are aligned to social marginal costs, which are assumed to be constant here, the demand pattern of private transport also changes, with an increased use of big vehicles. This suggests that current taxes in Italy are in some cases already above the monetary value of externalities, and this is due to the large differences that exist in the fiscal treatment of the various modes.

Despite the equal price level of private transport modes in the two hypotheses, demand levels are affected by the way public transport is priced. In MT2, prices of public services do not vary because they are assumed to be optimally set in calibration, but the demand for bus transportation slightly decreases because of the complementarity with transport capacity. Since more people continues to use public services in MT2, demand levels for all other modes are lower than in the MT1 scenario.

5. Concluding Remarks and Research Agenda

The assessment of pricing policies in the urban transport sector critically depends on how the subsidisation of public services is interpreted.

In this paper, a simulation model has been used to measure the effects of optimal pricing policies under different assumptions about the nature of public transport services. Two extreme cases have been discussed. In the first one, bus transport is treated in a way similar to other transport modes, and this implies that subsidies should not be retained in an optimal pricing policy. In the second scenario, the consumption of public services is set in a probabilistic context in which the potential use of services is taken into account. Parameters for both simulation exercises have been estimated by assuming that a sub-optimal competitive equilibrium occurred in a base year, in which external costs were not internalised.

Although the second approach appears to be superior in terms of realism, it is nonetheless affected by some relevant limitations, making more difficult to draw immediate conclusions from the model results.

First, the probabilistic approach should be extended to other transport modes. For example, private transport by car depends on car ownership, and the decision about buying a car affects future consumption possibilities. In other words, car ownership is also an option value, and this should be taken into account when the actual consumers' behaviour is interpreted. Future research work in this field should therefore pay more attention to the probabilistic nature of the problem.

Second, we assumed in the model that current prices reflect minimum production costs. This is consistent with a perfect competition framework, which can, however, hardly be applied to public transportation. Public services have been provided, in Italy, mainly by public-owned companies acting in a (local) monopolistic regime. It is likely that different kinds of inefficiency lie behind current cost levels, and that optimal prices of services may turn out to be substantially lower than those estimated by the model. Research works, describing the effects of market deregulation in the urban transport, could provide some valuable information on this issue.

Third, in the MT2 case current fares have been assumed to be in line with the marginal costs associated with carrying extra passengers. Although this is consistent with the calibration methodology used for all parameters' estimation, it should be kept in mind that nothing ensures that this relationship is satisfied in the base year. In general, it is difficult to distinguish, among all operating costs, those directly related to the number of carried passengers. Nonetheless, this information could be very important to determine optimal fares.

Fourth, it was assumed that the supply level of public transport services was optimal in the base year, except for the existence of externalities not taken into account. There are several good reasons to be sceptical about this. We have already pointed out that public transport capacity is a public good. However, even if taxes are collectively paid by all members of a community (State, County, etc.), not all individuals can benefit from the existence of some specific services. For example, suppose that people living in a certain area wants to have more bus lines. They would certainly benefit from the actual or potential use of public services, but subsidies for these lines would be paid by a much larger number of individuals. This creates an incentive to "free-ride" and, consequently, to generate an over-supply of public transport services.

Despite all these caveats, however, some important insights may still be gained from the analysis conducted so far. An important point is the need of coupling price reforms, based on marginal cost pricing, with reforms of the market structure, enhancing technical efficiency in the production processes. This is especially important for the public transport sector, which should be opened to competition and contestability. Another important aspect is the identification of services associated with the assignment of public funds. Subsidies should not be granted automatically, but they should be given in exchange for public services that can be measured and expressed in monetary terms, possibly by means of valuation techniques. These points have been recently stressed also by the Italian Antitrust Authority (A.G.C.M. (1998)), which criticises the current system of local public transportation, where "*fares are based on costs of a public service whose borders are not always clear and defined, in which efficiency control is insufficient and market regimes are monopolistic*".

Efficient pricing of transport services requires the internalisation of external costs, and a change in relative prices. Contrary to what is commonly believed, this change may not favour public transportation. However, public services could still play an important role in the market and it may be socially desirable to retain some subsidies. More research is this area is needed to provide instruments and methodologies for the determination of optimal levels of subsidisation.

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Appendix - The MT model: structure and data

MT is a simplified version of a more complex model for the assessment of pricing policies in the transport sector, developed for the European Commission, DG VII (TRENEN). As such, it does not consider some transport modes, like subways, trains and diesel vehicles, and it does not consider neither the introduction of new technologies nor the distinction between peak and off-peak periods. Furthermore, all external marginal costs are assumed to be constant and independent of traffic levels.

The TRENEN model has been implemented for a number of European cities, including Bologna. The interested reader can refer to the final report of the project for further details.

Both models are based on a welfare maximisation problem, defined in MT as follows:

$$\max \quad W = \frac{\bar{y} + \sum_i q_i (p_i - \bar{c}_i)}{p^0} - \sum_i q_i \bar{e}_i \qquad \text{(A.1)}$$

where (variables with bar are constant):

y stands for exogenous disposable income,

q and p are demand and price levels for transport modes indexed by i, produced at a marginal cost $\bar{c}$.

p^0 is a consumption price index,

e refers to total external costs by mode (congestion, emissions, road maintenance).

The difference between price and cost is given by taxation. An increase in taxes is reflected in higher market prices but, since the tax revenue is redistributed, also disposable income increases.

According to the recursive structure of nested CES utility functions, demand for each mode i can be formulated as:

$$q_i = \frac{\bar{y} + \sum_i q_i (p_i - \bar{c}_i)}{p^0} \prod_{n=1}^{N} \alpha_i^n \left(\frac{p_i^{n-1}}{p_i^n} \right)^{\sigma_i^n} \qquad \text{(A.2)}$$

where the index n refers to the nesting level in the choice tree represented in figure 4.1, and index i refers to both the various modes and the aggregate sets to which they belong to at each level (e.g., mode “small car” in the set “motorised” in the set “private” in the set “transport”) . Variables p are either generalised prices (at the bottom levels of the tree) or price indexes, defined as CES cost functions of lower-level prices:

$$p_i^{n-1} = \left(\sum_{j \in i} \alpha_j^n \left(p_j^n\right)^{1-\sigma_i^n} \right)^{\frac{1}{1-\sigma_i^n}} \qquad (A.3)$$

Parameters α are estimated within the model from base year data on prices and demanded quantities. It is requested that the following relationship, between two alternative modes or aggregate quantity indexes[10], holds in the base year:

$$\frac{q_i^n}{q_j^n} = \frac{\alpha_i^n}{\alpha_i^n} \left(\frac{p_i^n}{p_i^n} \right)^{\sigma_i^n} \qquad (A.4)$$

This allows to estimate the marginal utility parameters from given elasticity values and observed price-quantity pairs. For the various alternatives, the following elasticities have been adopted:

Level	Substitution between	Elasticity
1	Transport and Other Goods and Services	0.6
2	Private and Public Transport	1.5
3A	Motorised and Non motorised Transport Modes	0.3
3B	Public Transport Capacity and Services	0.5
4	Big and Small Cars	1.5

Tab. A1 - Exogenous elasticities

The reference year, for which data on price and quantities were available, is 1991. We refer here to an individual living and working in the city centre. Prices include time costs (waiting and in-vehicle) and are expressed in ECU per day. Quantities are expressed in Km. per day. Table A2 shows the data used to calibrate the model[11]

	Bus (1)	Bus C.(2)	Bus S.(2)	Non Mot.	Big Car	Small Car
Reference Prices	0.29833	0.14792	0.24879	0.85134	0.45716	0.26591
Ref. Quantities	1.72157	4.27170	1.72157	1.92772	3.86080	4.25684
Resource Costs	0.36819	0.14792	0.24879	0.85134	0.34842	0.19607
Externalities	0.00998	0.00614	0	0	0.10147	0.10147

[10] Each quantity index is obtained by applying an ordinary CES production function to lower-level quantities.

[11] Note: (a) reference prices for bus MT1 and bus services MT2 are different because of different estimation methods, (b) external costs for big and small cars are equal because available data does not allow to distinguish the car type. Alternative data sources, however, generally show only marginal differences between the two types.

Table A2 - Calibration data