TØI report 463/2000
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Oslo 1999, 46 pages Norwegian language

Summary:

Road pricing in Oslo: effects for the travellers

The AFFORD project

The AFFORD project for the European Commission aims to investigate the economic efficiency and equity effect of urban marginal cost pricing in transport, as well as its public, political and corporate acceptability. To this purpose, strategic and tactical transport model simulations have been run for the cities of Edinburgh, Helsinki, and Oslo. In this report, we focus on the Oslo case study.

To enhance the acceptability of marginal cost pricing systems, it may be necessary to envisage schemes by which the revenue collected from private motorists is somehow redistributed to the public, in a way perceived as fair and equitable in relation to the income distribution.

In this report, special emphasis is therefore put on equity effects, as described by changes in the *Lorenz curve* or in the *Gini coefficient*, both of which are defined in terms of *household income per consumption unit* before and after revenue redistribution.

The economic efficiency of marginal cost pricing is assessed by means of *cost-benefit analysis*, in combination with simulations made by the *RETRO tactical model* for the greater Oslo area.

The RETRO model for the greater Oslo area

The RETRO model is operated by the Institute of Transport Economics (TOI) in Norway. The model covers the city of Oslo and the municipalities of the surrounding county of Akershus, exhibiting 49 zones of residence and employment. The RETRO model predicts aggregate car ownership, trip frequency, destination choice, and mode choice within each zone, separately for two time periods (peak and off-peak).

Calculations in the RETRO model are based on the *prototypical sample technique*. In essence, this means that *for each zone* in the network, a set of weights is defined, in such a way that when these weights are applied to the disaggregate units (respondents) of a travel survey, the sample becomes «representative» of the zonal population in the sense of reproducing, at least approximately, the true zonal income distribution, as recorded in official statistics. A total of eight income brackets are defined and used in the calculations.

Network assignment (route choice) is done by means of an EMME/2 application run in an iterative loop with the car ownership/travel demand submodel of RETRO.

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The EMME/2 network includes a total of 438 zones. Simulations are referred to a benchmark situation as calculated for 1995, and assume that cordon toll charges – if any – are collected at the same toll plazas that are currently in use.

First and second best marginal cost pricing

The AFFORD study distinguishes between «first best» and «second best» road pricing policy packages. By definition, the first best pricing policy is the unconstrained welfare optimum, in which one imagines that each traveller is charged the true marginal social cost of road use, as given by the level of congestion, environmental and accident costs – and of any other external or internal cost, such as vehicle operating costs and time costs – generated by the marginal road user exactly *there* and *then*.

By equating the marginal social cost to the marginal private cost, the first best pricing policy induces all individual decision makers to make the socially most profitable choice, whenever they maximise their own utility or profit. This first best pricing solution, however, presupposes a very sophisticated, real-time revenue collection and information system, in which road user charges vary instantaneously in space and time, i e between all road links and for every single minute, depending on the current level of congestion etc. This ideal road pricing scheme is, unfortunately, only a theoretical construct, infeasible in practice (at least with the present state of technology and legislation).

It can, however, be mimicked in a network simulation model, so that one may derive the theoretically optimal level of road user charges and their hypothetical effect on traveller behaviour. To do this, we simply run a network assignment task in which, *rather than the average private cost, we use the marginal social cost function as our volume-delay relationship*. The equilibrium solution thus generated will be interpretable as the *system optimum under marginal cost road pricing*, i e as the solution after the imposition of an optimal road charge.

Thus, although it is hard to imagine schemes by which true marginal cost pricing could be imposed on the road users in practice, it is – in principle – perfectly possible to describe such a situation with the help of a network assignment model.

We use this theoretical first best solution as an interesting benchmark case, against which the various feasible, *second best* solutions – based on real-world policy instruments – can be judged. How far in the direction of the ideal, first best solution are we able to move, when constrained by the pricing instruments actually available to planners and politicians?

In general, by a second best policy package we shall understand the *optimal («best practice») combination of policy instruments under the constraints represented by technology, geography, legislation, and institutional barriers*.

These constraints may, of course, be defined in various ways, depending on the temporal and spatial horizon. As a first ordering of second best scenarios, we shall distinguish between

- *Second best under current institutions*, and
- *Second best after institutional reform.*

In the Oslo case study, the following instruments are assumed available *under current institutions*:

- time differentiated cordon toll rates, and
- time differentiated parking charges.

After institutional reform, a third policy instrument is assumed to become available:

- local fuel tax.

Thus, in this report we present two sets of «best practice second best solutions». One makes use of cordon toll rates and parking charges only. The second set optimises with respect to the levels of cordon toll, parking charges *and* fuel tax.

The marginal cost of public funds

Each «set» consists of one scenario calculated under the assumption of a zero shadow price of public funds, and another solution based on a 0.25 shadow price of funds.

The interpretation of the latter assumption is that *alternative sources of public funds generate an efficiency loss throughout the economy amounting to 0.25 Euros per Euro public revenue raised*.

It is, in other words, assumed that the road pricing revenue is used to step down distortionary taxation somewhere else in the economy, or to extend the supply of a public good for which the willingness-to-pay exceeds the marginal cost of production. In such a case, a «double dividend» accrues: not only do we reduce the costs of congestion, we also improve the overall efficiency of the economy.

Under certain circumstances, the latter effect may be well the more important. In the Oslo case, e g, a major part of the overall efficiency gain from second best road pricing turns out to be due to the extra value attached to public funds. A bit simplified, one might say that road pricing appears, more than anything else, as a favourable form of taxation. As seen in this perspective, the double role of road pricing (discouraging congestion and raising public revenue) becomes an asset rather than a liability.

Under the assumption that the marginal cost of public funds is positive (and of some non-negligible size), the efficiency gain from substituting marginal cost pricing for some distortionary tax could be among the more important benefits obtained. When, on the other hand, the shadow price of funds is zero, the overall benefit derived from marginal cost pricing is weakened. Indeed, for the second best policy after institutional reform in Oslo, it is cut by 90 per cent.

When it comes to revenue redistribution, the value attached to public funds becomes a rather decisive factor. If the redistribution is done in such a way that distortionary taxation is not reduced, there is no rationale for including the shadow value of public funds in the efficiency measure. In this case, we are faced with a clear-cut trade-off between efficiency and equity: the equity can be improved through redistribution, but only at the expense of certain parts of the efficiency gain.

If, on the other hand, the redistribution does contribute to reduce the incidence of distortionary taxation, at a rate equal to the assumed, average shadow price of public funds, the efficiency measure has been correctly assessed and will not be altered through the redistribution. In this case, the redistribution of income will improve efficiency in other markets, the total efficiency gain throughout the economy being given – precisely – by the shadow value of the public funds being redistributed.

To the extent that the marginal tax on labour is distortionary, a redistribution scheme which lowers the marginal tax rate by a given number of percentage points would seem to qualify as a scheme which does not reduce overall efficiency. Such a tax relief would reduce the tax wedge at all levels of income and hence reduce distortions in the labour market. But this redistribution scheme does nothing to correct the income inequality between households.

The «poll transfer» («flat») redistribution scheme, on the other hand, would give equal amounts to all adult persons, irrespective of initial income, rather than reducing the marginal tax rate. In this case, the efficiency benefit due to additional public funds is most probably lost through redistribution. Since the toll revenue is handed back out to the consumers, without affecting – *on its way* – the marginal tax wedge, there is simply no net public revenue left which can to be used to finance corrections to whatever distortionary taxation schemes may exist.

Economic efficiency

The overall economic benefit accruing from marginal cost road pricing in Oslo depends crucially on the marginal opportunity cost of public funds.

Under the assumption that the shadow price of public funds is zero, meaning that (alternative) public revenue can be (and – indeed – *is*) raised without loss of efficiency throughout the economy, the welfare gain obtainable from an ideal, first best marginal cost road pricing scheme in Oslo has been calculated at *75 Euros per capita per annum* over a 30-year period.

Under the alternative assumption of a 0.25 shadow price of public funds, the overall benefit more than doubles, reaching 199 Euros per capita per annum.

The second best solution under current institutions invokes the use of (i) cordon toll rates (peak and off-peak) and (ii) parking charges. It turns out that, if one assumes away the cost of funds, these instruments are rather inefficient compared to the ideal first best policy. The overall welfare improvement amounts to a mere *12 Euros per capita per annum*, or 16 per cent of the theoretically optimal («first best») gain under a zero shadow price of public funds.

This rather discouraging result must, however, be interpreted with caution. We cannot rule out certain methodological explanations, such as the fact that our model specifies only two, rather crude travel time periods («peak» and «off-peak») and does not allow for substitution between them. Nor can we exclude the possibility that these results are strongly tainted by the particular traffic conditions in Oslo, notably by the location of the cordon toll ring, which is such as to maximise revenue rather than to restrain the traffic, and by the fact the toll revenue has

already facilitated massive improvement in the road network, to a point where congestion is kept at a fairly moderate level.

Also, it should be noted that the benefits accruing to freight carriers and to their clients are not accounted for in the analysis, the RETRO model being a *travel demand* model not incorporating commodity transportation.

When a 0.25 shadow price of public funds is assumed, the second best policy under current institutions achieves a 56 Euro per capita annual benefit, or 28 per cent of the first best solution.

Turning to the «second best after institutional reform» scenario, in which the fuel tax is allowed as a third policy instrument, welfare gains increase noticeably, at least under non-zero cost of funds, when a per capita annual benefit of 110 Euros, or 55 per cent of the first best optimum, is calculated. This estimate relates to the «medium term», in which it is assumed that some households will choose to own fewer cars, in response to the increasing costs of operation. Thus, part of the fuel tax is «evaded» through a reduction in the tax base.

Almost all scenarios are characterised by a negative travellers' surplus before revenue recycling. Assuming, however, that the net public revenue flow (tax, toll, parking, and public transport operators' surplus) is somehow (and costlessly) redistributed to the private consumers, even the second best solution would imply a certain welfare improvement for the travellers.

Equity effects

Road pricing schemes have the double consequence (i) of discouraging road use at least at certain times on certain parts of the network, and (ii) of transferring cash from private persons to public funds.

The fact that road pricing – at least in the first place – involves a transfer of cash from private travellers to public institutions, is likely to be a major impediment to its public acceptability. The implementation of efficient road pricing policies typically affects equity in a way that policy makers and/or the general population are likely to disapprove of.

Therefore, to render marginal cost pricing schemes politically and publicly acceptable, it is probably necessary to recycle the revenue generated in such a way as to keep most population subgroups at least equally well off. Such redistribution schemes appear by no means infeasible, but in the process of redistribution large parts of the initial efficiency gain may in important cases (i e, if there is a non-zero shadow price of public funds) be lost. Thus, marginal cost pricing accentuates the traditional conflict between the goals of economic efficiency and equity.

It may be argued that road pricing schemes are unfair to the less affluent, who may not have the means to pay their way out of the situation and therefore incur a disproportionately large loss in the form of reduced accessibility. Or, if they do find it worthwhile to pay the road price, they do so at a higher rate, in terms of utility, than the more affluent, because their marginal utility of income is higher than the average. They have to spend a larger share of their income in order to maintain the level of accessibility.

Even if one does not take account of differences in the marginal utility of money, but measures in terms of nominal willingness-to-pay (as most cost-benefit analyses do), road pricing schemes may be expected to worsen the (generalised) income distribution, unless one can make the higher income groups pay a higher price.

Studies made by means of the RETRO model for Oslo indicate that, before redistribution, the *Gini* coefficient, which summarises the degree of income inequality within the population, increases (i e, worsens) when road pricing is implemented.

If the revenue is redistributed proportionately by personal income, i e as a given percentage point relief in the income tax rate, the *Gini* coefficient is – by definition – unaltered from the level attained as a result of road pricing. Such a redistribution scheme does nothing to correct the initial, adverse equity effect as between people within different income brackets. But it does reverse the potentially unpopular transfer of funds from private consumers to the public treasury.

If, on the other hand, the redistribution is done in a more progressive manner, e g by recycling the same, absolute amount of money to each adult individual (a «poll transfer» or «flat redistribution»), the *Gini* coefficient not only improves considerably, but even ends up at a much more favourable level than before the road pricing measures were implemented.

It is, in other words, in principle possible to conceive of a road pricing scheme with revenue redistribution, which enhances economic efficiency as well as equity (as measured by the *Gini* coefficient). It will usually be sufficient to redistribute a certain part of the revenue generated in a progressive manner, in order to keep the less affluent households at least equally well off.

Interestingly, our RETRO model results show no indication that (second best) marginal cost pricing affects the accessibility of low income groups to a larger extent than people in the higher income brackets. The percentage change in travel by car is similar between all income brackets. Since the upper income groups have a much higher car travel frequency to start with, the impact on accessibility is actually higher in these groups, as measured in absolute terms.

Thus, according to the Oslo model simulations, the unfavourable income distribution effect of road pricing is due, in its entirety, to the fact that the out-of-pocket expenditure on road charges represents a higher share of the household income in the low income groups than among the more affluent.

Conclusions

Marginal cost road pricing has the double effect of *discouraging congestion* and *raising public revenue*. To the extent that public funds are a scarce resource, the latter effect may be well the more important as seen in an economic efficiency perspective. This is at least the case in a less heavily congested city like Oslo.

This would, however, depend on how the road pricing revenue is used. If it is used to step down distortionary taxation somewhere else in the economy, or to extend the supply of a public good for which the willingness-to-pay exceeds the marginal cost of production, then a «double dividend» accrues. If, on the other, the revenue is

redistributed to the private sector in a way that does not improve the incentive structure faced by economic agents, there is no extra dividend to be accounted for.

The use of a non-zero cost of public funds implicitly assumes that a double dividend somehow does arise.

A bit simplified, one might say that in Oslo, second best marginal cost pricing is socially profitable first and foremost because it is – we assume – an attractive form of taxation. If, on the other hand, the marginal opportunity cost of public funds is *not* larger than zero, the benefit of marginal cost pricing is very substantially reduced.

The income distribution impact of marginal cost road pricing is generally unfavourable, not so much because lower income groups have their accessibility reduced, but because they end up paying a larger share of their income in road charges than do families in the upper income brackets.

This unfavourable income distribution effect may, in prinicple, be neutralised if the revenue is redistributed to the consumers in the form of a poll transfer. But in this case a major part of the economic benefit, due to the provision of additional public funds, will most probably be wasted.