Report for Workshop 5:
ROAD PRICING AND PRIVATE FINANCING

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The workshop focused on private car as a means of passenger transportation. The main topic was the different ways to deal with highway congestion, and to eliminate the induced social waste (misallocation of resources). Various questions related to optimal pricing and investment policies on congested roads were discussed. Special attention was also given to the issues of road financing, and private provision of roads.

The following five papers were presented at the workshop:
1. Evans, Andrew W., "Some Objections to Road Pricing"
3. Hills, Peter J. and P.T. Blythe, "Technological Developments in Road-pricing"
4. Larsen, Odd, "Road Investment with Road Pricing — Investment Criteria And the Revenue/Cost Issue"
5. Roth, Gabriel, "Pricing, Financing and Ownership of Roads in a Free Society"

The papers #3, 4 and 5 appear in this volume. The paper #1 has been published in the September 1992 issue of the Journal of Transport Economics and Policy, under the revised title "Road Congestion Pricing: When Is It a Good Policy?" The paper #2 will be published in the Policy Research Working Paper Series at the World Bank.

The purpose of this report is to briefly review the main issues addressed at the workshop. The report consists of five parts: introduction; road pricing; road investment and financing; privatization/decentralization of road provision; conclusion.

1. INTRODUCTION

Two major concerns in the area of highway transportation are the social waste that is associated with congested urban roads, and the insufficiency of general tax revenues to cover the provision and maintenance costs of roads, urban and rural.

It is generally agreed among transportation economists (and engineers, I think) that marginal cost pricing of congestion externalities would effectively help to solve the first problem. To solve the second problem, it is suggested that earmarked road tolls, increased fuel taxes, and other taxes on vehicles, should be collected. Also, as another application of marginal cost pricing, it is suggested that different types of vehicles should be charged user fees equal to the damage they cause to the road surface.

Besides different pricing policies, alleviation of the congestion and financing problems is also suggested by means of appropriate investment policies. Obviously the most effective policy would be to synchronize pricing and investment decisions, to use an optimal combination of them. This approach is strongly favored e.g. by Winston (1991).

A third group of policies that are suggested are organizational rearrangements; decentralization of the relevant pricing and investment decisions to independent governmental road agencies, or ultimately even privatization of these decisions. First, government organizations in themselves are claimed to be inefficient and wasteful. Second, it is claimed that one reason for excessive congestion is the failure of governments and politicians to make efficient allocational decisions. Special interest lobbying is perhaps thought to be the main reason for this: Politicians are believed to act too often on behalf of various interest groups, and against the interests of consumers in general.

2. ROAD PRICING

2.1. Marginal cost pricing

Standard textbook analysis defines marginal cost (private or social) as the cost of increasing output by one unit. Short-run marginal cost refers to a situation where certain factors of production are kept fixed at a predetermined level, and long-run marginal cost to a situation where all factors of production are determined optimally. In the case of roads, short-run marginal cost assumes that road capacity is kept fixed; long-run marginal cost then applies to a situation where also road capacity is optimally chosen.

By definition, at every point of a long-run marginal cost curve (as a function of output, trips here), the capacity is at its optimal level. The long-run marginal cost curve is an envelope curve to the corresponding short-run marginal cost curves, quite similarly as the long-run average cost curve is an envelope to the short-run average

* I thank Amihai Glazer, Timothy Hau and Odd Larsen for their comments.
cost curves. The envelope property means that if a road is optimally built and priced, the short-run and long-run marginal cost of a trip on it are equal.

These general principles of marginal cost pricing, as applied to the standard traffic flow model, with uniform demand, are of course well-established in the literature. Moreover, it is understood that the principles equally well apply to congestion externalities and the damaging externalities on the road surface. It is well-known that these general principles also extend to situations where demand fluctuates diurnally.

2.2. Practical considerations

There are certain practical questions that need to be solved when adopting marginal cost pricing in practice. Such questions are faced when we want to determine the numerical values for the optimal tolls, and when implementing these tolls in actual situations.

The determination of the “theoretically correct” marginal cost price, to be charged on an actual road, and given the demand conditions for the road, may not be always an easy task. Road links in real life can be very heterogeneous, and, due to intersections and other interferences between individual road links, traveling conditions on individual road links can be affected by traffic volumes on other links. Therefore, the question whether the analyst has available sufficient data in each single case is highly critical. What data can be considered as “sufficient” in each case of course also depends on the costs of collecting information. However, it may be fair to say that the importance of these kind of problems should not be exaggerated. Road tolls can in many cases be beneficial even if they are not exactly the “correct” ones. This fact is verified by a number of empirical studies.

Another practical question is the actual method of collecting the tolls. It is a general conception that technological problems are no more any serious obstacle to implementing flexible marginal cost pricing in practice. The situation has radically changed during the last few years, owing to many innovative technological breakthroughs in the area of automatic vehicle identification (AVI) and electronic charging methods. Peter Hills (the workshop paper # 3) described some recent technological developments in this area. Another important recent work on these questions is Hau (1992).

2.3. The politics of road pricing

Road pricing always has some redistributive effects: While road pricing necessarily benefits some groups (at least those non-travellers whose taxes are decreased if a larger portion of roads is financed from the road toll revenues), it almost inevitably harms some others. On the basis of these effects, we can in principle consider the normative question whether road pricing is at all morally acceptable. But we can also use the analysis of these effects as a way to increase our understanding of the puzzle why road pricing has thus far attained so little support among politicians and the general public.

Anthony Evans (the workshop paper # 1) addressed the normative question. He first shows that the redistributive effects can be very large relative to the efficiency gains. On the basis of this he then argues, since weighting between the redistributive effects and the efficiency gain (measured by the sum of the consumers’ surplus and the collected toll revenues) is ultimately “a matter of judgement”, that no definite answer concerning the desirability of road pricing can be given. Naturally the extent of redistributive effects hinges on how the toll revenues are used.

Two basic results concerning the effects of road tolls on road users’ welfare, when the toll revenues are not returned to users, are the following: (i) when road users have identical valuations of time, none of them can gain but they all lose; (ii) when road users are heterogeneous in their time valuations, and when their valuations of time and travel is positively correlated, then those with the highest valuations of time and travel will gain.

These results hold for a single road in isolation. But these kind of considerations can be extended to allow for situations where road users have available two or more alternative roads (or modes), as the case usually is in real life. Glazer and Niskanen (1992) assume that road users have available a fast mode and a slow mode, and show that road pricing is more likely to be implemented on the fast than on the slow mode. This fits with the facts: we often see tolls being charged on faster expressways, while slower alternative roads are free of charge.

3. ROAD INVESTMENT AND FINANCING

The short-run optimum refers to a situation where road pricing is optimized given a predetermined road capacity. The long-run optimum, or the full optimum, requires that both pricing and capacity are optimized. This means undertaking investment in infrastructure whenever the additional benefits exceed the cost to society of doing so.
It is a standard result in the transportation literature that when the provision of capacity exhibits constant returns to scale, and when travel cost depends on the volume-capacity ratio (is homogeneous of degree zero), then the revenues from optimal prices exactly cover the capacity cost. Moreover, the revenues from optimal prices fall short of capacity cost under increasing returns, and yield a surplus under decreasing returns.

The basic version of this fundamental self-financing result assumes uniform demand and an infinitely durable road. However, these assumptions are not critical. It is known, since Kraus, Mohring and Pinfold (1976) and Keeler and Small (1977), that the result holds in a model with systematic (diurnal) peak-load demand. Another extension, by Newbery (1989) and others, assumes use-dependent maintenance costs. In this case, the analysis determines the optimal durability of a road, and solves for the optimal marginal cost prices equal to the damage that each type of vehicle causes to the road surface. The self-financing question is also discussed in club theory literature.

4. PRIVATIZATION/DECENTRALIZATION OF ROAD PROVISION

4.1. Motivations for privatization and decentralization

One reason for why the questions of decentralized and private provision of roads have attained so much interest recently are the technological innovations in road pricing, which allow more sophisticated and flexible toll collection methods. But of course, the technology alone is not a sufficient reason to favor decentralization and privatization in this area. As well we could in principle let the central governments do the job. The general view however is that this would not work well, because of poor performance of government organizations, and governments' failure (due to rent seeking etc.) to make efficient allocational decisions. For instance, it is doubted that if road pricing is completely left to government, it would give politicians incentives to use road tolls as a "cash cow", thus possibly increasing inefficiency rather than eliminating it. It is even claimed that congestion pricing might in some cases give government a financial incentive to promote congestion.

No one may have argued that all road provision should be privatized. But it is claimed that, even if privatization is carried out only in smaller scale, the presence of privately provided roads would have the wider benefit of providing a yardstick with which the service levels of publicly provided roads could be compared. It is conjectured that this would indirectly compel also public authorities to act more efficiently. The general consensus seems to be that a mixed system, where some roads are provided by private firms, and others by more or less independent government organizations, may be the best. Gabriel Roth (the workshop paper # 5), and many other workshop participants, shared this view.

Below is presented a few thoughts that arise when considering the decentralization and privatization of road pricing and investment. The main focus is on the resource allocation effects. Regarding these effects, the critical question is not what the institutional form of ownership should be, but rather whether independent and self-financing road agencies, private or public, when applying genuinely economic criteria in their pricing and investment decisions, can guarantee socially optimal outcomes.

It should however be stressed at this point that no attention is paid to neither the network aspects of roads, nor to the dynamics of congestion and road provision. These aspects were especially stressed by Odd Larsen (the workshop paper # 4). A single road is just considered here in a static model, or at best there is assumed two (or more) parallel roads connecting an origin-destination pair.

Also, it should be remembered that when speaking of privatization and decentralization in the roads market, it is generally agreed that certain administrative and policing tasks should be left to the central government anyway. The most important of such tasks is the enforcement of various measures to improve safety.

4.2. Profit-maximizing pricing for road use

There are two general conditions that must be satisfied for independent road agencies, public or private, to make efficient pricing decisions: They cannot take advantage of their monopoly position, and all externalities must be internalized.

The latter condition is satisfied as far as congestion externalities and use-induced road impairment are concerned. Government intervention is however needed as far as environmental damage is caused. (This may not after all be a serious problem when considering road pricing.) The former (no-monopoly) condition is unlikely to be satisfied in practice in large scale. Because roads are spatially fixed, as also are their users' trips, at least in the short run (between home and work, etc.), it is clear that there cannot be much competition within the roads market. A natural definition of a market here is to let it be formed by a single road link, or, whenever relevant, by two or more parallel road links. But a road owner, having a local monopoly position, cannot normally be compelled to behave efficiently by the presence of potential competitors, either, both because the threat of
entry is not credible (the possibilities for opening a new road are far from free), and because of large sunk costs and indivisibilities.

Ultimately these of course are empirical questions, and the conditions can greatly vary from case to case in practice. Anyway, the general conclusion seems to be that governmental intervention is needed in most cases to prevent monopoly pricing. Otherwise, when left to his own, there is no guarantee that a profit-maximizing road owner would choose the socially optimal price.

There is however one famous case, in which it is claimed that profit-maximizing pricing leads to the social optimum. This is the two-roads case, with a congested, privately owned road, and an uncongested parallel (alternative) road, which is publicly provided and freely accessible. In this case, as originally claimed by Knight (1924), the owner of the congested road, in maximizing his profit, chooses the socially optimal price.

Given that the two parallel roads are considered as a single market, one can conclude that it is competition within the market (between roads) that will lead to the social optimum. However, note that the road owner is not a price taker, in the sense a firm is in the standard competitive model. Instead, he faces a downward sloping demand curve (as a function of his price). The road owner can instead be viewed as a 'utility taker': He takes as given consumers' reservation price for use of his road. This reservation price can be stated as the 'generalized price', the sum of the money cost and time cost, that each user of his road will pay.

There is however one important implicit assumption behind the afore-mentioned Knight's result that may reduce its value as far as practical applications are concerned. Edelson (1971) and Mills (1981) have showed that the result requires the (implicit) assumption that road users' valuations of travel time (or, more generally, of congestion) are identical. If road users are heterogeneous in regard to these valuations, then, depending on circumstances, the profit-maximizing road owner charges too low or too high a toll, and correspondingly allows too much or too little congestion.

4.3. Profit maximization and investment

Clearly it is hard to imagine that a profit-maximizing road owner would choose the capacity of his road optimally without choosing the price optimally at the same time. The conclusion above was that a profit-maximizing road owner chooses the socially optimal price, if there exists an uncongested alternative road, and if road users' time valuations are identical. The question now arises: Can this result be extended to conclude that the road owner will also choose the socially optimal capacity? That is, can the existence of an uncongested alternative road guarantee that the owner of a congested road chooses socially optimal capacity when investing so as to maximize his profit? The answer is 'yes'.

To show this, let the capacity of the uncongested road to be arbitrary, for this is not critical for the argument. Then suppose that the owner of the congested road has chosen the profit-maximizing capacity and price, given the travel conditions on the uncongested road. We know that the profit-maximizing price is optimal, for the chosen capacity. (It is assumed here that both roads are used in equilibrium, no toll is charged on the uncongested road, and road users have identical time valuations.) But is this profit-maximizing capacity also socially optimal?

To see this, consider a slightly smaller capacity for the congested road. (The same argument applies for a slightly greater capacity.) Then, the other road being uncongested, some initial users of the congested road have switched there, without incurring any additional personal cost, until those users who stay on the congested road are equally well-off as initially. But this is not the complete story, since some toll revenues, collected from the profit-maximizing prices on the congested road, are now lost.

Given that the toll revenues are considered as an item of the social welfare function, as usual, the loss of toll revenues must be contrasted with the saving in road construction cost, in order to tell whether social welfare has increased or not. But the owner of the congested road, when maximizing his profit, has already done this. This is so because the induced changes in the profit-maximizing toll revenues exactly represent changes in social welfare, which, of course, is equivalent to stating the above-mentioned result that the profit-maximizing price equals the socially optimal price.

Another case (besides the two-roads model) that has attained special attention in the economics literature is to consider an uncongested road in isolation, and as an excludable pure public good. As reported by Oakland (1987), a profit-maximizing monopolist, when constrained to charge a single uniform price to each of its customers, provides the good too little. That is, a profit-maximizing road owner underprovides road capacity. Of course, as a corollary, he also underprovides trips.

A perfectly discriminating monopolist instead would provide the optimal road capacity, obviously because under perfect discrimination the firm obtains all consumer surplus, so that maximizing profits is the same as maximizing social welfare. He also provides the optimal use of this road capacity, i.e., the optimal number of...
trips by each consumer. Those consumers who “consume” less of the road than its capacity, are charged no price. And those consumers who “consume” all road capacity are charged a price equal to their willingness to pay for this capacity.

4.4. “Quasi-market” criteria for investment

The conclusion above was that if an uncongested alternative road is available, and if road users’ time valuations are identical, then the owner of a congested road chooses, when maximizing his profit, both the price and the capacity of the road socially optimally. Otherwise it is hard to see how profit-maximization on the part of an independent road agency could guarantee socially optimal pricing and investment decisions. This suggests that delegation of pricing and investment decisions to profit-maximizing road agencies, private or public, may not be wise policy in general.

In particular, regarding self-financing public road agencies, this raises the question: Is it possible to derive some other equally simple (as profit-maximization) rule, which the road agency should adopt?

One sufficiently simple rule would be to require that the agency adopts marginal cost pricing, and continues investing in additional capacity as long as profits are positive (curtails capacity when profits are negative). Timothy Hau (the workshop paper # 2) argues that exactly this rule can be optimal.

Hau’s argument is based on the self-financing result (cf. section 3), which says that if the provision and maintenance of a road exhibits constant returns to scale, and if congestion depends on the volume-capacity ratio (the congestion function if homogeneous of degree zero), then the revenues from optimal marginal cost prices exactly cover the road provision cost in optimum.

Now, because the road capacity is at its optimal level (given marginal cost pricing and constant returns) exactly when profits are zero, the road agency should continue investing in additional capacity whenever profits are positive (and correspondingly curtail capacity when profits are negative). Hau calls this rule “quasi-market” criteria.

The quasi-market criteria as an operational investment rule thus requires constant returns to scale in the provision of roads. Of course it is an empirical question whether this condition is satisfied in reality. If returns to scale are either increasing or decreasing, then naturally the criteria does not apply. Now, at the level where capacity is optimized (still assuming marginal cost pricing), profits are respectively negative or positive. Under these circumstances there is no simple investment rule that a road agency could adopt. Therefore, a full-scale cost-benefit study is needed.

5. CONCLUSION

This paper has shortly reviewed a few central questions that arise when considering private car as a means of passenger transportation. The topics included ranged from road pricing, and road investment and financing, to the decentralization and privatization of road pricing and investment decisions. Most of the discussions were based on the standard static model of highway traffic.

The focus has been on the issues raised by the speakers and other participants of Workshop 5. Most of the ideas and results that were reviewed here also are the conclusions made at the workshop, even though not necessarily in all cases unanimously agreed. But the paper has also gone further by bringing forward a few ideas that were not presented at the workshop.

On the other hand, many important questions that were discussed at the workshop were omitted here. Such questions are, in particular, those relating to the network aspects of roads, and to the dynamic aspects of congestion, road provision and privatization. Also, no attention was paid to the relationship between car transport and other forms of passenger transportation. These questions are of course most important when considering practical applications.

All these questions are reviewed in an excellent way in a recent book by Small (1992). Small addresses both the theory and practice. Another practically oriented discussion of the issues of road funding and privatization is provided by the Organization for Economic Co-operation and Development (1987). Beesley and Hensher (1990) also discuss various questions that arise when considering privatization of roads.

REFERENCES:


