Not Optimal, but Effective: the Multi-mode Ticket for Reducing Urban Traffic Congestion in Medium-sized Towns*

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Economists have long been aware of congestion externalities and proposed very sophisticated road pricing schemes to internalize the external costs of driving in urban regions. An optimal solution could be achieved by levying road user fees that exactly equal the additional costs that each car driver imposes on others. Since these costs depend among many other things, on location, time and type of car, an optimal policy requires, in principle, individual, time-dependent and locally differentiated road user charges (see Lindsey and Verhoef 2000 for a recent survey). Apart from Singapore, where such a differentiating scheme has been introduced and some far-reaching plans for Hong Kong that have been shelved yet again, not much further action has been observed.

Pragmatic second-best solutions such as cordon fee systems are more promising. Since London introduced its cordon toll system in the spring of 2003, many local administrations have renewed their interest in such road pricing schemes and are eagerly studying the first results. Nevertheless, such low-cost and easy-to-implement solutions are not very popular among scientists. Engineers promote the most sophisticated technology available, which normally requires huge set-up investments. The German highway toll system is a good example in this respect. Economists often do not dare to propose simple rule-of-thumb policies, which, although they may reap huge welfare gains, fail to meet the professional standard of providing optimal or almost ideal solutions to current economic problems.

This article introduces the idea of the "multi-mode ticket" that is described in more detail in the book *Alleviating Urban Traffic Congestion* (Arnott, Rave and Schöb 2005). The multi-mode ticket may be attractive for small and medium-sized towns that often face severe traffic jam problems and are interested in low-cost solutions. In the late 1980s, it was the Stockholm Urban Traffic Committee that came up with the idea of what we call the multi-mode ticket: each driver entering the inner city by car on workdays between 6.00 a.m. and 6.00 p.m. should provide a valid ticket for the Stockholm public transportation system. This could be a monthly ticket for commuters or a single return ticket for occasional travelers. When paying this "entrance fee", each car driver would receive a vignette that had to be put on the windshield for easy monitoring by traffic wardens in the inner city zone. Expectations were that this would reduce peak-period time traffic by 13 percent and total traffic by 9 percent and that the additional revenues would outweigh the administration costs by a quintuple. Although in the end it was not implemented the idea spread and for some time gained political and public appeal beyond Sweden. In Germany, the Green party suggested this scheme for medium-sized towns above 100,000 inhabitants. Since the implementation in both Sweden and Germany would have required a change in federal law, however, the idea completely disappeared from the political agenda. Apparently, modesty in political consulting became outdated and so did the Stockholm proposal. This was a pity, not only for Stockholm but for many other towns as well. Stockholm could have alleviated traffic congestion substantially for the last 15 years. Instead it is still waiting for more sophisticated road pricing systems.

The economic incentive structure of the multi-mode ticket is very simple and appealing for at least two reasons. First, even though the multi-mode ticket might not increase the marginal costs for a car trip downtown, it would reduce the opportunity costs of traveling downtown by bus or train thus inducing substitution of public transportation for private trans-

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portation. Second, since the policy replaces a ticket paid only by bus passengers with a ticket paid by all those entering the inner city by bus or car, revenues would go up dramatically. This would allow the local authorities to both reduce the deficit and increase the capacity of the public transportation system, which in turn would increase the public support for the scheme.

After a brief review of the external cost of urban traffic congestion, we will analyze the economic incentive structure of the multi-mode ticket in more detail and discuss ways to implement such a low-cost solution in medium-sized towns that suffer from severe traffic congestion.

Road congestion externalities[1]

There are several different externalities of urban traffic congestion. First, there are time-related marginal external congestion costs. Every car driver on a congested urban road imposes a cost on all other drivers by slowing them down. For a given road capacity, up to a certain traffic density speed is unaffected when one additional driver enters the road. But when a critical level is reached, each additional driver reduces the average speed and increases the travel time for all other drivers. Estimates show that the time-related marginal external congestion costs are on average between US$4 and US$6. Apart from time-related externalities, road congestion is responsible for several other externalities.

- Congestion also affects the probability and severity of traffic accidents. External costs arise if the total accident costs rise more than proportionately with respect to the traffic flow. Earlier studies pointed in this direction (Vickrey 1968; Newbery 1988), but some more recent studies have found that average accident costs (not including delay costs) may actually fall with traffic flow indicating a marginal external benefit of congestion (cf. Fridstrøm and Ingebrigsten 1991; Zho and Sisiopiku 1997). Speeding up traffic will reduce the frequency with which accidents occur, but at the same time will increase the severity of accidents. In heavy traffic, people drive more slowly and accidents cause fewer casualties.
- Congestion also leads to extra fuel consumption. The running costs on urban arterials are about 40 percent higher than on highways and rise quickly when congestion reduces speed to below 20 miles per hour on an urban arterial (Small 1992, p. 76). Thus, a car driver imposes not only time costs on other car drivers but also extra fuel costs.
- Closely related to additional fuel consumption is congestion-related pollution. Even though pollution depends in a very complex way on both the number of cars and the average speed on a congested road so that it is very difficult to find a significant statistical relationship (cf. Small and Gómez-Ibáñez 1999), pollution costs (including costs from noise) are normally assumed to increase with traffic flow. Small and Kazimi (1995) estimated that the total costs of pollution add up to 3.3 cents per mile in the Los Angeles metropolitan area.
- Finally, it should be noted that congestion fees can reap an additional second dividend that arises when tax revenues from congestion are used to cut other taxes that cause a deadweight loss. Given the huge inefficiency of the existing tax systems, the prospective welfare gains from using congestion fee revenues to reduce the welfare costs of taxation can be significant. Parry and Bento argue that "there is drastically more at stake in terms of economic welfare in what the government does with the congestion tax revenues than the entire welfare gains from internalizing the congestion externality" (Parry and Bento 2001, p. 662). Their simulations for linear demand and marginal cost curves indicate that the second dividend from reducing other distorting taxes is almost four times as high as the welfare gains from reducing congestion externalities.

By using the time-related marginal external congestion cost of US$4 to US$6 as a lower bound for the total marginal external cost, we can compare the cost of car commuting with the cost of commuting by bus. A survey of operating costs and the deficits of the public transportation authorities of some selected medium-sized towns in Europe and North America shows that all public transportation systems run a deficit that is normally covered by the municipality. Thus, municipalities have a genuine interest in raising additional revenues to cover these costs. The operation costs calculated per round trip are in the range of 100 to 160 percent of the price of a daily round-trip ticket which are in the range of US$2 to US$4 in most medium-sized towns. Since these average operating costs give us an upper bound for the marginal costs of bus commuting, this is also the range for the maximum marginal costs of a round trip not yet borne by the

[1] More detailed surveys can be found in Small (1992, pp. 78-85) and Small and Gómez-Ibáñez (1999).

passenger. Hence, some substitution of bus commuting for car commuting promises to improve welfare.

The theory of the multi-mode ticket

We focus our analysis on work-related traffic congestion. Workers who live in the suburbs and work downtown are free to choose whether to commute on a congested road or to take the bus. The number of trips by car is denoted by a (for automobile), the number of bus trips are denoted by b (for bus). Commuting is time consuming, but the time spent in the car or the bus may be more or less valuable for commuters, i.e. commuters consider the two modes as imperfect substitutes. Commuters can either buy daily tickets or a monthly ticket. The price of a daily bus ticket is given by τ_b. If someone decides to buy a monthly ticket, the price for daily tickets becomes zero.

The worker's decision problem

The marginal time costs of the individual commuter equal the average commuting time costs $APC(a)$ for all commuters. For car drivers, it is $APC(a)$, whereby we define these costs exclusive of any road user charges. Each commuter takes this time as given, but the average commuting time is rising with the total number of commuters. The individual commuting costs exclusive of the bus ticket are defined accordingly as $APC(b)$.

In Figure 1, the horizontal distance between the vertical axes measures the total number of commuting trips. The number of bus trips is measured from left to right and the number of car trips is measured from right to left. Average costs per bus trip are rising since commuters prefer some variety and find it increasingly boring to permanently commute by bus. For car trips, the curve is increasing because congestion increases the average commuting time. Without any regulation, commuters will split transportation modes such that their cost of traveling by car, $APC(a)$, equal their individual cost of commuting by bus, $APC(b) + \tau_b$. Hence, without any road pricing we observe an equilibrium with a_0 bus trips and $1 - a_0$ car trips.

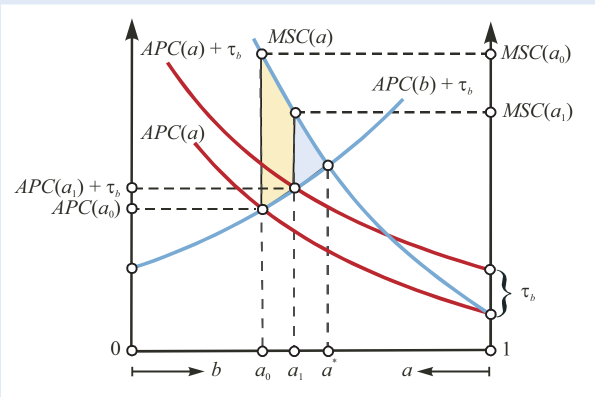
The multi-mode ticket and the day-by-day decision

If every commuter who drives downtown has to buy a daily ticket for the price of τ_b that allows him to travel either by car or by bus, the multi-mode ticket works like a congestion fee: it increases the price of commuting by car relative to the price of going by bus. Starting in the original equilibrium a_0 Figure 1, a commuter who – at the margin – decided to take the car before the multi-mode ticket was introduced, now faces higher car commuting costs and switches from car to bus. An additional $a_1 - a_0$ trip will now be made by bus rather than by car. Without the multi-mode ticket, the bus fare distorts the decision in favor of car commuting. This distortion is now eliminated irrespectively of the price of the multi-mode ticket. The multi-mode ticket thus unambiguously determines the allocation of a given number of commuting trips. Note however, that the introduction of the multi-mode ticket increases commuting cost, which in return may affect the total number of commuting trips.[2]

The marginal social cost of commuting by car is denoted by $MSC(a)$, the difference between $MSC(a)$ and $APC(a)$ indicates the marginal *external* costs of car commuting. In Figure 1, the trapezoid shaded in light gray then indicates the welfare gain from reduced traffic congestion that can be reaped when the multi-mode ticket is introduced. Thereby we consider the reasonable case we discussed in the last section that the marginal external congestion costs exceed the bus ticket price τ_b. The triangle in black indicates the remaining welfare loss with a^* being the optimal allocation. As long as the bus ticket price is low-

Figure 1

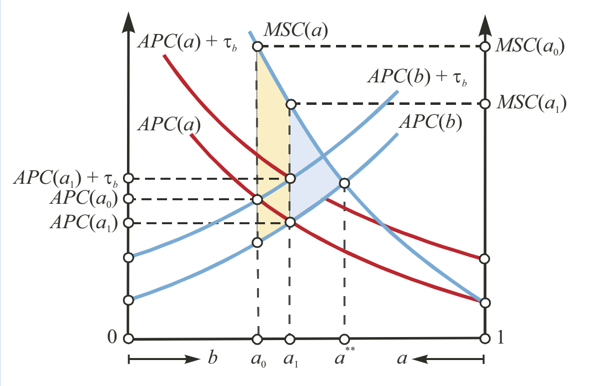
ALLOCATION OF ROAD TRIPS AND BUS TRIPS



[2] This effect is further elaborated in Arnott, Rave and Schöb (2005, chapter 5).

Figure 2

ALLOCATION OF ROAD TRIPS AND BUS TRIPS WHEN THE BUS TICKET IS A PURE MARK-UP



er than the marginal external costs, the multi-mode ticket fails to reach the optimal allocation, but the welfare effect of introducing the multi-mode ticket is unambiguously positive.

So far, we implicitly assumed that the bus fare equals the marginal cost of a bus trip. If the marginal costs of bus commuting were negligible, the bus fare would have to be considered as a pure mark-up. This would not affect the two allocations a_0 and a_1, but would affect the welfare analysis. This is shown in Figure 2.

The welfare gains become more significant when the bus ticket is a pure mark up over marginal cost of bus commuting. In this case, the $APC(b)$ curve represents the marginal social cost of bus commuting. (In Figure 1, by contrast, it is the $APC(b) + \tau_b$ curve which represents the marginal social costs of bus commuting.) In the initial equilibrium a_0, the allocation is the same as before but the welfare gain from introducing the multi-mode ticket increases by $\tau_b(a_1 - a_0)$. The area shaded in light gray in Figure 2 shows the welfare gain. Figure 2 also shows that the optimal allocation requires an even larger shift towards commuting by bus. In this case, the optimal allocation is defined by a**.

The monthly multi-mode ticket

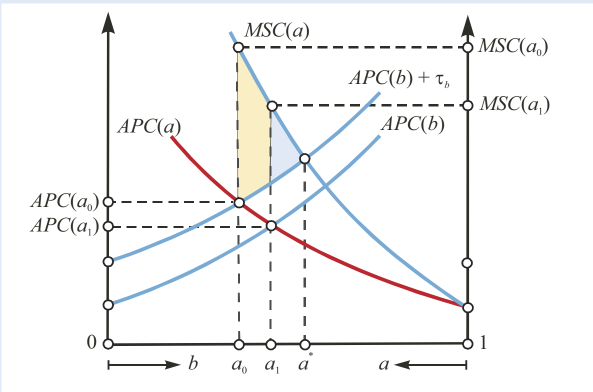
What happens if commuters decide to buy a monthly ticket rather than buying tickets on a daily basis? In contrast to the standard road pricing schemes, the possibility of buying a monthly (or annual) ticket does not affect the main property of the multi-mode ticket, namely the equivalence of the ticket price for commuting by car and bus. The monthly ticket does not affect the price of commuting by car. This remains at $APC(a)$. The costs for an additional trip by bus, however, fall to $APC(b)$ and the new equilibrium is at $APC(a_1) = APC(b)$. We therefore obtain the same condition for the optimal modal choice of the worker as before: for a given number of commuting trips, the equilibrium allocation for the monthly multi-mode ticket is the same as for the daily multi-mode ticket. Figure 3 shows both outcomes.

Compared to the daily ticket, however, commuting costs are now lower by the amount of τ_bThis increases the incentive to commute compared to the case where only daily tickets are available. We may therefore expect an increase in total work-related trips, but workers will also substitute commuting by bus for commuting by car so that it will remain unclear *a priori* whether congestion increases or falls.

The properties of the monthly multi-mode ticket are very different from those of the cordon toll system in London that allows road users to pass the cordon when they have a monthly ticket. For a monthly ticket for passing the London cordon, the marginal costs of a trip by car do not change, but compared to the multi-mode ticket that allows for free bus trips as well, the marginal costs of bus commuting are higher by the bus fare τ_b. In Figure 3, a_0 indicates the cordon fee equilibrium for London for a given number of commuting trips. Compared to such a scheme, the

Figure 3

ALLOCATION OF ROAD TRIPS AND BUS TRIPS WITH A MONTHLY TICKET



monthly multi-mode ticket changes the relative prices for each trip decision. As monthly or annual tickets alleviate the administration significantly, without reducing the efficiency of the instrument, we have identified another advantage: the multi-mode ticket increases the price of car commuting relative to the price of the public transportation ticket irrespective of whether it is paid per trip or introduced as a periodical fee.

Two additional advantages of the multi-mode ticket are worth mentioning. First, in contrast to any cordon price scheme that does not change the price ratio between car trips and bus trips within the cordon, the multi-mode ticket changes the relative prices for trips within the cordon. To see this, we can reinterpret Figure 3 and consider the horizontal distance as the total number of trips within a cordon. The London cordon-fee equilibrium will be at a_0, irrespectively of whether the car driver paid a daily or monthly cordon fee. Although a cordon price scheme reduces trips to the center and through traffic, it does not reduce traffic within the cordon. The multi-mode ticket, by contrast, also creates an incentive to go by bus for another trip when the commuter has already passed the cordon. When car drivers have bought multi-mode tickets, they can use the bus for free in the whole cordon area. When deciding whether to undertake a trip within the cordon, the opportunity costs are therefore $APC(b)$ rather than $APC(b) + \tau_b$. The equilibrium for the inner-cordon mode allocation is at a_1 in Figure 3.

The second advantage is less apparent. Although the multi-mode ticket is not designed as a ticket that allows for price discrimination between peak times and off peak times, price discrimination may be achieved through variations in the public transportation capacity between peak and off peak times. If a bus runs every 10 minutes during peak time and only every 20 minutes during off peak times, the expected waiting time for the bus is 5 minutes lower during peak time. Thus the opportunity costs are lower in peak times than in off peak times. Of course, crowded buses and the risk of not being able to enter a crowded bus may work in the opposite direction. Another channel of price discrimination is offered by the existing price system of many local transportation agencies. They often offer special discounts for daily and monthly tickets if the bus is not used before 9.00 a.m. This price discrimination can be applied to car commuters as well. To guarantee effective monitoring, however, car commuters may not use this ticket before 10.00 a.m., otherwise cheating by those entering the inner city shortly before 9.00 a.m. may be too high.

From theory to policy

We will complement the analysis of the multi-mode ticket by briefly discussing how to implement a multi-mode ticket in practice. The first and most important question is how to determine the boundaries of the inner city. Initially, the cordon defined by the public transportation authority might be used to define the cordon of the multi-mode ticket. While the former is only defined by bus stops, the latter also requires borders for roads. As many towns apply a ring system for its public transportation system, one also has to clarify which rings should be included in the new scheme and which should not. Introducing a multi-mode ticket may lead to a rethinking of the public transportation cordon as it is important to include the most congested areas of the town. In this respect, designing an optimal cordon faces the same problems as designing an optimal cordon for any other road pricing scheme (see, for example, Newbery and Santos 2001).

Of particular interest when designing a cordon is the possibility for commuters to use park-and-ride facilities. The multi-mode ticket would certainly increase the value of park-and-ride systems many towns have installed or plan to build. For remote commuters, the multi-mode ticket makes it more attractive to drive to a park-and-ride facility where they can easily find a parking slot and from where a quick transfer to the center is ensured. These park-and-ride facilities will generate further time savings as they reduce the search for parking. As most park-and-ride schemes are available at no or low cost, they also allow the commuter to save the high parking fees downtown. To the extent that local authorities plan to enlarge existing park-and-ride facilities, they may earmark some of the additional revenues from the multi-mode ticket for this purpose.

The administration of the whole system can be based on the existing structures regarding the sale of bus tickets and the monitoring of parking in the center. In addition, fuel stations outside the cordon should be allowed to sell the multi-mode tickets. Commuters will learn quickly about the multi-mode ticket, but it might be a problem to provide all necessary information about the multi-mode ticket to out-of-towners. Here, a standardized symbol for "town with multi-mode ticket" should be put on guide posts that are closer than, for example, 30 miles. This would give the occasional commuter the opportunity to buy a ticket in time.

Enforcement is easy with respect to commuter traffic. Local traffic wardens who watch for illegal parking can simply check whether all cars have a valid sticker on the windshield. More problematic, of course, is monitoring the through traffic, but occasional controls at lights within the cordon and at the cordon boundary, combined with high penalties for not providing a valid ticket, will reduce the incentives for free through traffic. Acceptability of these measures can be easily achieved with a tolerant policy in the initial phase where only *pro forma* tickets are issued to inform traffic offenders about the consequences non-adherence will have in the future.

Finally, it should be mentioned that marketing is important to gain political support. The Norwegian experience of selling the policy of introducing a price for a good that was free of charge before shows that the public must be informed in time about the intended introduction and its purposes. Information policy apparently must not simply highlight the advantages of reduced traffic congestion, it has to face people's expectation to be charged for things they wish to acquire, not for things they want to avoid (Jones 1998; Odeck and Bråthen 2002). Ison (2000) points out that earmarking revenue for investments in public transportation may be important for the public opinion. Hence, detailed ex ante plans on the improvement of park-and-ride facilities, the increased frequency in peak times and the modernization of the bus fleet may increase public acceptance.

The multi-mode ticket will not fully internalize the external costs of urban road congestion. Nevertheless, it offers towns with severe traffic problems a low-cost, easy-to-implement policy that promises significant welfare gains and is easy to administer and monitor. It may not be the final step towards more efficient urban transportation. A first modification may be to allow for a cheaper "bus-only" ticket alongside the multi-mode ticket. This allows for more price flexibility with respect to congestion pricing without changing the incentive structure. It may also be a promising start for many towns that, based on positive experiences with the multi-mode ticket, are considering whether to implement more sophisticated systems of road pricing.

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