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EVALUATING THE ENVIRONMENTAL COMPONENT OF AUTOMOBILE PRICING SCHEMES

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Abstract

This paper assesses the economic literature on urban automotive pricing to determine whether pricing schemes designed to promote efficient road use would also be good for the environment. No empirical evidence is found to justify the claim that reducing traffic congestion will automatically improve the environment.

TAKING A LOOK AT THE PROMISES MADE FOR ROAD PRICING

Throughout the world, governments face the challenge of adapting transportation policies to mitigate the environmental and social costs of automobile use in cities (Bates and Watson 1988; Lowe 1991). This task is complicated by the fact that the automobile's environmental impact appears relatively benign outside urban centres, and by the widespread popularity of the auto as a mode of transportation. As the costs of car use in cities become unmistakable, made obvious by increasing levels of congestion, governments have turned to the idea of road pricing as a means to increase urban transportation efficiency (Hau 1992; Lewis 1993; London Planning Advisory Committee 1991). Efficiency is equated with relieving congestion, which is treated as a proxy for negative environmental externalities.

Surely, putting an end to traffic jams in which cars burn fuel while going nowhere fast could only work to improve the environment. This very premise, that reduced congestion will produce environmental benefits, lies at the heart of policy proposals calling for new ways of pricing auto use. The 'Pigouvian' marginal cost pricing instruments such as special area licensing fees, road user charges, and parking taxes, are claimed to be superior to regulatory instruments that restrict car use because pricing could recoup negative externalities more efficiently, that is, without penalizing car use where and when its net social benefits turn out to be positive (Hensher 1993). But before policy makers undertake the difficult political task of transforming the ways in which people pay for car use, evidence that pricing instruments would actually improve the environment needs to be presented in more detail.

This paper reviews the economic literature on the most analyzed variant of marginal cost automotive pricing, urban road charges, to determine whether pricing car use to reduce congestion offers a simple and straightforward formula to enhance sustainable urban mobility. We find no empirical evidence to justify the claim that reducing auto congestion will automatically improve the environment. At the theoretical level, where congestion pricing instruments have been developed in some detail in recent years, we introduce a counter-argument that challenges the premise that reduced congestion yields environmental benefits. We go on to suggest how an environmentally beneficial application of automotive pricing would differ from formulas that target traffic congestion. To us, it appears clear that more environmental data will be needed to establish sustainability criteria that can calibrate market mechanisms. Furthermore, environmentally sustainable automotive pricing requires recognizing that externalities arise from effects that span auto production, ownership, and use. We believe that reconciling the automobile with the environment can occur only when externality pricing mechanisms are introduced in each of these three domains.

THE ECONOMIC CHALLENGE OF EVALUATING THE CAR'S ENVIRONMENTAL COSTS

The economic literature on automobile use has been seeking to measure environmental externalities for close to two decades. Studies in the mid 1970s laid the groundwork for putting a price on the environmental impact of the car (Ingram et al. 1975; Small 1977). They also set the terms by which such impacts would be assessed. A key analytical parameter was the expression of pollution costs in relation to vehicle miles travelled, yielding a cost per mile value of environmental impact. When expressed in this way, the cost of environmental externalities appeared modest.

Using 1974 emissions data, Small calculated that the automobile's pollution costs ranged from 0.5 to 1.0 cent per vehicle mile depending on vehicle age and location. Buses and trucks had pollution costs ranging from 0.53 to 2.8 cents per vehicle mile. Viton (1980) then used Small's findings to model a pricing policy for the Oakland–San Francisco Bay Bridge. He found that the car's environmental costs were insignificant compared to congestion costs. During peak periods, the bridge toll would have to be between 15.4 cents and 33.1 cents per vehicle mile to reflect congestion externalities, but only somewhere between .69 cents and 2.2 cents to recover environmental costs.

The Ingram et al. study compared the effects of 1970 Clean Air Act Amendments in the United States with a hypothetical economic instrument, special license fees, on auto emissions in the Los Angeles basin. The regulatory approach in the Clean Air Act was estimated to reduce carbon dioxide output by 54% at a cost of US $197 million while the pricing instrument would have cut carbon dioxide emissions by 44% at a cost of $83 million. Pricing policy was shown to reduce the car's externalities more efficiently than regulatory controls.

Eighteen years after making an initial estimate, Small returned to the question of putting a price on the environmental impact of the auto (Small and Kazimi 1995). This effort revised Small's 1977 estimate of air pollution costs for passenger cars operating in the Los Angeles basin upward to 3 cents per mile, but remain sceptical that such a relatively modest charge would alter motorists' behaviour if pollution pricing were to be attempted. It must be noted that their assessment is based on the assumption of constant average pollution costs without considering either spatial or temporal variation in marginal costs across the study area. The gap between the real costs of urban air pollution and the ineffectiveness of pollution charges calculated through indiscriminate aggregation and subsequent averaging-out underscores the need to use marginal cost pricing for a meaningful solution to automotive air pollution created in urban areas. If any pollution charges can be effective in making urban auto use sustainable, they must be based on the marginal cost pricing principle.

Guensler and Sperling suggest that the reluctance to deal with automotive air pollution on a disaggregate level stems from a lack of technical capacity. Although congestion pricing analysis has gone far toward disaggregating the marginal value of time that would be saved by various pricing schemes, little work has been done on assessing the environmental impact of reduced congestion. In reviewing current practices in auto emissions modelling, Guensler and Sperling (1993: 2) note, "The results of the impact assessment indicate that the ability to estimate emission impacts of congestion pricing are questionable at best."

Given the explosion of economic research measuring pollution costs during the 1980s, reviewed by Tietenberg (1990), we find it problematic that such methodology has found so little application to the automobile. Although Small and Kazimi (1995) recognize a substantial increase in pollution impacts arising from car use, their aggregation and averaging out of auto pollution costs across the entire Los Angeles region yields such a low per-mile value that its internalization through pollution pricing would be unlikely to affect the typical driver's travel behaviour. But when Small and other transport economists turn to automotive congestion, their evaluation has been quick to embrace marginal cost pricing. Based on the effectiveness of marginal cost pricing, transport economists have favoured using this instrument as a means to eliminate gridlock. At least part of the explanation for the economist's divergence toward pricing auto use in average terms for pollution costs and marginal terms for congestion costs can be found in the politics of transportation policy, where environmental concerns appeared to be unsuccessful in building support for pricing initiatives.

Despite the evidence that pricing could offer greater economic efficiency than traditional environmental regulation, governments met with no success in implementing marginal cost pricing instruments. Such efforts in England, Hong Kong, the Netherlands, and Sweden had to be abandoned or drastically scaled back in the face of public opposition. Pricing instruments never even made it off the drawing board in the United States or Canada. The political pitfall turned out to be public perceptions. Citizens proved unwilling to tolerate paying for auto use directly, when such a charge appeared tangible and immediate (ie money spent at the toll booth) while the corresponding benefits seemed abstract and long range (ie cleaner air leading to improved public health). The auto's environmental damage turned out to be a weak guide for policy makers because costs were not perceived as such by the travelling (and voting) public.

Empirical studies in the late 1970s and early 1980s revealed a low willingness to pay for environmental quality among the U.S. public. Freeman (1982) estimated the benefit perceived from pollution control policies by measuring changes in property values accompanying increased pollution levels. The results showed little change in property values as pollution increased, leading to the conclusion that the public put a low value on the benefits of pollution control. Given Freeman's findings, it is less surprising that researchers found few incentives to refine economic models of the environmental costs of the car. The gulf between abstract economic theory and the political resistance to direct payments for car use led Borins (1988) to predict that marginal cost automotive pricing is "an idea whose time may never come."

POLITICAL INCENTIVES TO EQUATE CONGESTION WITH ENVIRONMENTAL COSTS

Carrying on with the formative research on car use and environmental costs turned out to be a demanding and under-rewarded activity, even for those who undertook such studies. Further development of the pollution cost estimates produced by Ingram et al., Small, and Viton has awaited the extensive, and expensive, collection of new data on vehicle emissions and their health effects. Facing a limited demand for such costly empirical exercises, transport researchers turned to models of automotive costs that could be developed with less expensive data. Measurements of congestion were far easier to grasp than estimates of environmental damage. Furthermore, transportation agencies also collected the data needed to evaluate auto congestion, and calibrate pricing instruments, at public expense.

Cost-benefit analysis is very much "anthropocentric" in that things have costs or benefits only to the extent that they are identified or are perceived to reduce or increase welfare. Added to the problem of identifying a complete list of costs and benefits is the challenge of taking account of their changing magnitude over time. This fluid nature of cost-benefit analysis is a more serious problem in the case of pollution than in the case of congestion. Unlike environmental damage, congestion forms a dependent variable that can be measured easily and cheaply. All that is needed to calculate congestion costs with great precision is a value for the extra time that drivers spend in heavy traffic.

The public's growing exposure to urban traffic jams added another incentive to focus economic research on congestion rather than pollution. By the 1990s, traffic congestion was a fact of everyday life in many cities. With congestion so widespread, the cost of "free" road use became more apparent to drivers. As gridlock mounted, a consensus emerged that the costs of maintaining a status quo urban transport policy were beginning to rival the potential costs of marginal cost pricing. Public officials grew motivated to consider alternative transport strategies.

Both the general public and policy makers thus began to exhibit a marked increase in their appreciation of Downs's so-called "fundamental law of traffic congestion" (Downs 1992). Downs's law teaches that it is impossible to reduce city traffic jams and other automotive externalities by investing in road and transit infrastructure. For without a system of demand management, new infrastructure simply stimulates more use, resulting in continued congestion. Fiscal and physical constraints have thus added pricing to supply side expansion on the list of urban transport policy options.

Congestion, rather than pollution, has proven itself to be an issue that can translate economic theory into policy innovation. When motorists in Norway's major cities were presented with a new road use policy that linked congestion pricing with infrastructure expansion, the opposition that had greeted environmentally focused pricing schemes failed to materialize. Urban automotive congestion is now recognized as an effective vehicle by which to return marginal cost automotive pricing to the transport policy agenda (Evans 1992).

The key question now facing transport researchers and policy makers ready to translate congestion costs into new auto pricing mechanisms is whether these costs can form the sole basis for setting road prices. We have found no analysis, other than a subtle subtext of political pragmatism, that suggests congestion pricing will reduce any other automotive cost beyond congestion itself. Several authors advocate redistributing the revenues from new pricing instruments, either to generate public support for these measures, or to pay for various environmental enhancements that would not otherwise occur.

Goodwin (1990) suggests that the revenues generated by marginal cost pricing be used to "buy" political support by reducing property taxation, funding an employee commuting allowance, and improving the quality of public transit service. Small (1992) has presented a distributive formula for revenues generated by new pricing instruments. He claims that incorporating such a formula into transport policy making can mobilize a political coalition that will support these new pricing instruments.

Although Jones (1991) has offered evidence of environmental benefits attracting public support for marginal cost pricing in opinion surveys and focus groups, setting these charges to combat congestion remains the operative analytical premise. At best, environmental concerns appear to be addressed through a strategic calculus of how to sell pricing schemes by bribing the public with newly collected revenues. It is not surprising to see a pro-road pricing alliance developing between transportation policy makers, economists, and environmentalists. Since the first proposals to implement road pricing in Britain during the 1960, public officials, policy specialists, and academic analysts have lost numerous campaigns to introduce such schemes. Yet with growing environmental concerns over transportation externalities, road pricing advocates have sought to develop a "green" coalition with ecological activists in order to overcome opposition to road pricing. Recent campaigns to initiate road pricing, such as the "Rekening Rijden" in the Netherlands and Norwegian schemes in Trondheim, Bergen, and Oslo, were designed to pursue multiple objectives in order to satisfy environmentalists, road builders, and economists (Jones and Hervik 1992). However, as we will show later, the "green" coalition for road pricing is a tenuous one.

While redistributing revenues from congestion pricing may make these schemes more politically palatable, we question the implicit claim that such policies will actually approach sustainable mobility. Based on evidence from supply side policies that have previously sought to reduce congestion, we believe that even when some revenues from marginal cost pricing are targeted to environmental objectives, the net environmental consequence of such pricing schemes is likely to be negative.

HOW LESS CONGESTION CAN YIELD MORE AUTO POLLUTION

Economists are virtually unanimous in claiming that marginal cost automotive pricing mechanisms will manage urban transportation more effectively than supply side regulation of infrastructure (Small et al. 1989; Downs 1992). Where economists disagree, and part company with a number of transportation planners, is in the relationship between reducing congestion and cutting down on automotive pollution.

Downs (1992: 136) states, "Long average commuting trips in general, and traffic congestion in particular, both increase the emissions discharged into the atmosphere". Thus, once a pricing mechanism designed to reduce congestion is implemented, a drop in traffic jams will lead directly to reductions in energy consumption and air pollution. But extrapolating from the expanding supply of new infrastructure, Newman and Kenworthy have claimed just the opposite, that freely flowing traffic induces more vehicle-kilometres of travel, leading to more fuel consumption, and more auto emissions.

They demonstrate that road expansion and development will reduce congestion and promote "fuel-efficient traffic." But new urban road infrastructure is also likely to increase total traffic volumes, the average distance of auto trips, total fuel consumption, and total auto emissions. They conclude that there is a fundamental trade-off between fuel efficient traffic and "fuel-efficient cities" (Newman and Kenworthy 1988). These findings suggest that a variable cost road pricing scheme designed to reduce traffic congestion will also fall short in addressing the negative environmental impact of the auto upon cities. There are at least three reasons for such a hypothesis.

First, road prices that are set high enough to prevent congestion on tolled routes in peak periods will not reduce traffic volumes below the optimal capacity of such infrastructure. If the marginal social costs of free flowing traffic volumes remain higher than the prices charged, their social and environmental externalities will continue. Second, variable cost pricing has proven to be an effective instrument for stimulating the use of other networks ranging from electric power to telecommunications to air travel. Price discounts would stimulate off-peak travel on tolled roads, while untolled infrastructure would continue to attract users who preferred to "pay" for more congested travel with their time. Finally, using congestion pricing revenues to finance further road investment, as the majority of such schemes envision, would entail the same supply-side problems found by Newman and Kenworthy.

Empirical evidence on the effects of road pricing remains sketchy and unreliable, due to the extremely limited application of the policy. What evidence we have found supports the claim that variable cost road pricing will not in itself discourage increasing levels of auto ownership and use. For example, Smith (1992) has found that Singapore's congestion pricing policy has failed to stop the growth of either vehicle ownership or total traffic volume.

DOES TARGETING CONGESTION LEAD ROAD PRICING TO AN ECOLOGICAL DEAD END?

Some economists would argue that the problems we have raised with existing pricing models applied to congestion management can be overcome through improved measurement and better implementation. While we agree with Barthold (1994) that marginal cost pricing needs to be better adapted to serve environmental objectives, we believe that the core problem runs deeper than simply adjusting economic means.

For in its computation of costs and benefits, marginal cost pricing ultimately produces a price at which drivers who are willing to pay can buy the right to damage the environment. Even when both congestion and pollution costs are adequately incorporated into marginal cost pricing, the economic costs of urban auto use continue to be judged in a relative manner. The socially optimum level of pollution will vary according to the magnitude of costs in relation to benefits. And as the experience of both Hong Kong and Singapore suggests, the perceived benefits of greater automobile use can offset high congestion and pollution charges.

Figure 1 illustrates the point that rising incomes and economic growth will inflate the pollution levels that marginal cost models identify as being socially optimal. Initially, under circumstances where individuals value auto use along the lower Marginal Benefit curve, MB1, self-interested consumers will choose point "a" as their optimum level of private consumption, although point "b" is the socially optimum (and lower) level of such auto use. The Pigouvian tax, set to cover the difference between private and social marginal cost curves, I, will induce auto users to shift to the socially optimum equilibrium at point "b".

But in societies like Hong Kong or Singapore, and in many of the world's largest cities, economic growth is rapidly pushing the marginal benefit curve upward, denoted by MB2. Under the new economic reality of the MB2 curve, the private equilibrium for auto use occurs at point "c" while the social optimum now moves to point "d". A newly calibrated Pigouvian tax would recapture externalities and move auto use to point "d". However, we note that the resulting social optimum of car use and pollution would still be greater than the previous social optimum at point "b". Marginal cost pricing fails to prevent the social optimum level of pollution from rising, and in fact provides economic justification for such a rise. Marginal cost pricing is thus fully compatible with a growing level of car use and air pollution, as long as the "value" of the marginal benefit increases.

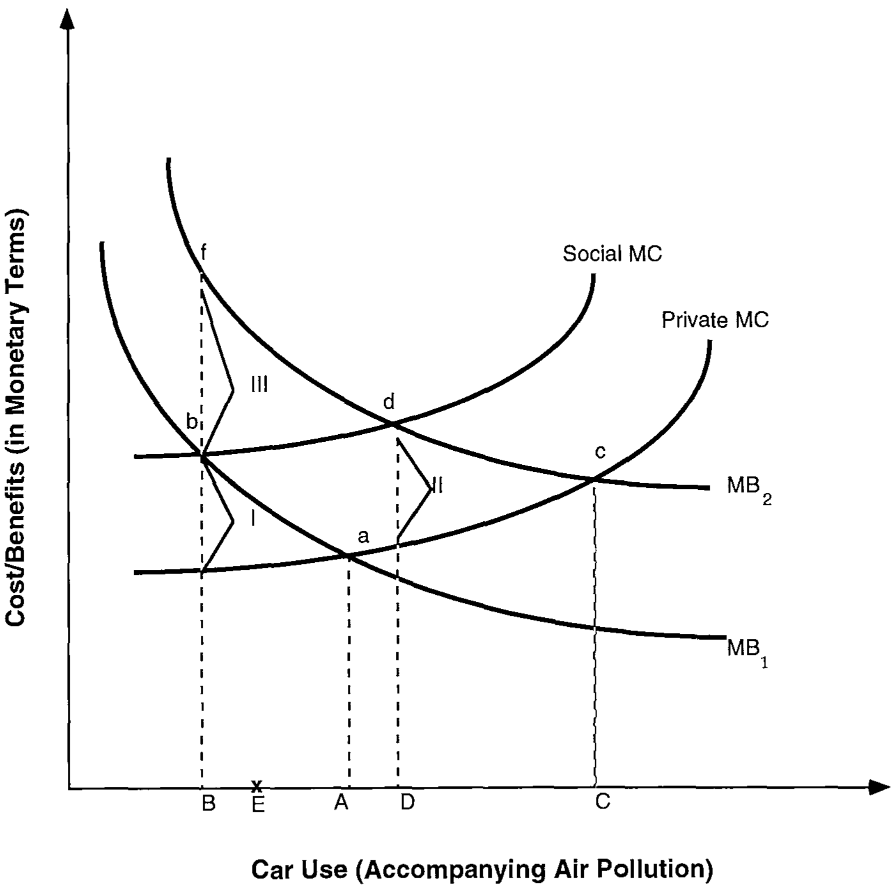

Figure 1 **Externalities and marginal pricing of car use**

Given the rapid economic growth found in many developing nations, marginal cost pricing offers little hope for achieving sustainable mobility in some of the world's largest and fastest growing cities. Developed nations are not immune to the inflated benefit curves that would also push up optimal levels of auto pollution under marginal cost pricing schemes. For instance, when urban core areas are redeveloped, rising land values will attract higher income residents and workers, who will place a higher value on the marginal benefits of automobility. Thus even when national incomes remain relatively stable, efforts to revitalize city centres would have the perverse consequence of increasing traffic volumes and air pollution, by raising urban dwellers' marginal benefits of mobility.

In the scenario discussed above, where the marginal benefit curve perceived by consumers shifts upward and to the right, the Pigouvian internalization principle turns out to inhibit achieving a truly sustainable level of vehicle use and pollution, for instance "B". The fundamental reason is that "B" deviates from a social optimum from the viewpoint of welfare economics. The surcharge that yields traffic volume "B" turns out to equal the sum of charges II and III. Charge II represents the Pigouvian tax *per se* used to internalize social costs, and charge III denotes the additional charge needed to offset the influence of rightward shifting marginal benefit curves. With these charges (II + III) added to the private marginal cost, the resulting equilibrium will be at point "f" where the total marginal cost faced by individual auto users is equal to the marginal benefit that they attach to auto use. The targeted level "B" is thus achieved. However, from the point of view of the Pigouvian principle, the above target "B" is clearly suboptimal in that marginal benefit exceeds the social marginal cost by III. Advocates of marginal cost pricing who do not accept an independent limit on the social or environmental carrying capacity of a given area for auto use will argue that the charges embodied in III are too high and the traffic volume of point "f" is too small.

A number of problems could arise in implementing an ecologically sustainable auto pricing scheme. At the present technical level of environmental economics, the computation of either the Pigouvian tax to achieve a social optimum (II) or the social optimum of car use and pollution (D) is neither easy nor certain (Cropper and Oates 1992). However, if policy makers opt for sustainable traffic volume and thus specify, say, point B in Figure 1, it may not be necessary to calibrate the charge (II + III) which achieves the target. For instance, through trial and error or survey data which reveal the threshold level as deterrents, policy makers may set toll charges in a certain area which effectively hold traffic volumes to a specified target. Over time they may raise the charges as the actual volume surpasses this target.

To achieve sustainable levels of auto-mobility over time, car ownership and use will have to be priced simultaneously. This means that a graph similar to Figure 1, except with the x axis denoting car ownership, would have to guide auto registration or licensing prices. The same problems of income effects and a rising willingness to pay for the right to damage the environment would apply, requiring a similar effort to set targets for the maximum auto population that could be sustained by an urban environment.

Singapore's approach to auctioning auto entitlement certificates illustrates how policy makers can let market mechanisms allocate the quota of sustainable auto ownership. The resultant auction prices are in fact the revealed effective charges. This drastic yet effective system emerged following the limited success of the previous marginal cost pricing scheme to stem the growth of auto ownership amidst strong economic growth.

Auctioning a quota of urban auto ownership can be viewed as an adaptation of the tradeable emission permit system which is in place in the U.S. Since car ownership confers the right to pollute, the value of that right is determined by the market forces which take account of effects of changing income and other factors on auto demand. Thus, when income levels rise or demographic changes lead to an increasing demand for cars, the market value of the limited amount of emission rights automatically increases to keep car ownership at the target level.

The challenge facing policymakers is thus to formulate the environmental objectives that can guide economic analysis more effectively than an unaided Pigouvian approach to automotive pricing. Putting environmental objectives first will also yield greater political advantages than seeking to justify marginal cost pricing purely on grounds of economic efficiency. Jones and Hervik (1992: 143) note "the main impetus to date behind any successful introduction of traffic restraint—whether price based or otherwise—has come from environmental quarters". If congestion management becomes the principal objective of road pricing schemes, and environmental enhancement is reduced to a strategic symbol used only to sell such policies, a valuable transport policy opportunity will have been lost.

INTEGRATING CONGESTION AND POLLUTION CHARGES IN SUSTAINABLE AUTOMOTIVE PRICING

The renewed attention to pricing options for the automobile presents a valuable, but by no means certain, opportunity to build environmental objectives into the heart of an efficient policy instrument. Policy analysts must resist the temptation to focus new pricing instruments on congestion solely because its costs can be easily measured and readily acknowledged by the general public.

Whether working within government, or outside it, advocates of sustainable mobility should not be seduced by the revenues generated from congestion pricing proposals. The claim that environmentally friendly supply side spending (eg pedestrian amenities, bicycle paths, and public transport subsidies) funded by some or even all the revenues generated from a marginal cost pricing scheme will result in real environmental improvements without the use of pollution and traffic volume targets remains to be proved. We believe that there are four dimensions along which pricing mechanisms that achieve sustainability (pollution pricing) will differ from those aimed at maximizing total net social benefits (congestion pricing).

First, congestion pricing schemes are concerned with smoothing out traffic flow, by redistributing trips away from peak periods. At times when traffic flows smoothly (eg night time and weekends) congestion pricing will charge drivers little or nothing. Pollution pricing, on the other hand, will charge drivers at all times when their motoring does environmental damage, with surcharges aimed at congestion added on top of a base pollution charge. As experience in Singapore has demonstrated, pricing mechanisms that offer any form of "free ride" during offpeak hours act to stimulate car use during those periods, thereby reducing urban air quality. Fee exemptions for any class of vehicle (eg taxis, trucks, buses) add further economic distortions.

Second, congestion pricing tariffs use cross-subsidy to reward high volume users. Pollution pricing mechanisms will use cross-subsidy to reward low volume users. Instead of providing discounts for regular users (eg monthly or weekly rates for unlimited travel) and charging the highest rate for an occasional user, pollution pricing would charge regular users extra, and discount the price to occasional users. Commuter rates would thus charge those who drive every day of the month more than those who use their car only on certain days of the week. If drivers were offered multi-trip discounts that were valid only on three or four days per week, then they would gain an incentive to walk, bicycle, or use public transport regularly.

Third, congestion pricing isolates its charge from the total cost of travel, while pollution pricing seeks to integrate charges with total costs. Pollution pricing would discriminate among uses, offering reductions for alternatively fuelled vehicles, those that form part of the public transport fleet, or even private cars en route to or from a park-and-ride interchange with public transport. Charging extra for low occupancy vehicles would be another aspect of pricing that reduces both pollution and congestion. Pollution pricing would build appropriate disincentives into the demand side of urban transport which complement the supply side stimuli given to public transport, bicycles, and walking, making these subsidies more effective and efficient. Such substitutes for urban auto travel must meet minimum thresholds of attractiveness to convince urban residents that practical alternatives to the auto do exist.

Fourth, sustainable pricing schemes will link the production, ownership, and use of the auto under a compatible pricing regime that applies the most efficient balance of externality reducing charges to each domain. Policy makers must recognize that auto externalities are a function of their design, ownership levels, and rates of use. An adaptation of the tradeable emissions permit scheme appears a promising means of incorporating incentives to reduce externalities in the design and production of autos. Compared to the current practice of setting emissions standards for various categories of cars and trucks, this system offers the additional advantage of giving the auto manufacturers an incentive for emissions reduction innovation. An auction of auto ownership quotas would extend the logic of sustainability to car purchases in cities.

CONCLUSION

In conclusion, we believe that those responsible for urban transportation must ask themselves whether the price is right when considering new forms of urban automotive pricing. If a congestion oriented variable pricing logic predominates in new schemes, then the environmental costs of the auto will continue to be under-recovered. Only when auto ownership and use reflects these full social costs will it become possible for new pricing mechanisms to do as much good for urban areas as they do for those who drive through them.

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