Voluntary road pricing

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Abstract
In voluntary programs that encourage socially responsible ("safe", "green", or whatever) driving, it is possible to implement pricing schemes that more closely reflect the variation of the social marginal cost of driving than can be made with regular (more uniform) taxes and charges. This paper discusses motives for such programs and presents three examples: pay-as-you-drive car insurance, "economic" intelligent speed adaptation, and urban city driving guidance with automatic booking and payment of parking and/or road use charges.

Introduction

"Traffic becomes each day more difficult in the streets of the capital", observed Louis Figuier, the author of *Merveilles de la Science*, describing Paris in the 1880´s, adding " the traffic of vehicles at the intersection of boulevard Montmartre and rue Montmartre, vulgarly called the Crossroad of run-over-pedestrians […] reaches more than 100 000 per day".[1] The streets of Paris were overcrowed already in the beginning of the 19th century, but as the number of horses fivefolded from 1819 to 1891 problems went out of hand.[2] But it could become even worse. After the first automobile show in Paris in 1898, motor vehicles began to try to make their way through the narrow streets of the city. The result was an incredible congestion, a lot of dust making it hard to breathe, and even more accidents, raising the annual number of fatalities in the city from around 80 in the 1880´s to a peak at 300 in the 1930´s (Barles and Guillerme, 2003).

The main solutions to problems such as these, as they spread with urbanisation and industrial development all over the world, have relied on engineering. Huge infrastructural investments have been made to expand the capacity of the traffic networks. Vehicles have become much more safe and clean. Advanced technical systems for traffic control have been developed. However, this has also promoted further traffic growth. Decoupling of traffic related problems and GDP growth has not yet happened (Kågeson 1997, Ch. 18). Congestion remains a major issue. In the beginning of the 21st century, the average speed of traffic in the central business districts of some large European cities is not higher than in the end of the 19th century. Macadam and asphalt once reduced dusting, but urban populations still suffer from exposure to unhealthy particle matters from diesel engines, tires, etc. Noise, nitrification, terresterial ozone, carbon dioxide and several other things hurt local

[1] Figuier cited from Barles and Guillerme (2003).
[2] From 16 000 in 1819 to 78 851 in 1891 (Martin 1894, cited in Barles and Guillerme (2003).

and global environments. The death toll of traffic remains intolerably high.

To economists, this is a case of “tragedy of the open access” due to insufficient rationing, and the profession has since long argued that the most efficient instrument to influence the decisions of numerous car drivers would be price. By road user charges internalising the negative externalities of driving, motorists can be given incentives to adapt behaviour in accordance to the social good. Since the seminal contributions by Pigou (1920), Knight (1924), Walters (1961), and Vickrey (1963) economists have tried to convey this “obvious” insight to policy makers and the general public.

Few have listened, though. So far, only Singapore, London (February, 2003), and now Stockholm (full-scale trial June 2005 – July 2006) have decided to levy charges on cars with the main purpose of alleviating urban congestion. Road and bridge tolls are sometimes used for funding purposes, but charges mainly aimed at affecting driving behaviour have mostly failed to receive public support. Traffic control has therefore remained in the engineering realm.

The reasons for the resistance to the use of economic incentives in this field are plentifold. First, congestion charges can be regressive as the poor are priced off the road (Richardson 1974, Glazer and Niskanen 2000).[3] Therefore, the median voter may find herself a prospective looser from a suggested road-pricing scheme, at least if redistribution of the toll revenues is ignored. Also, citizens appear to find willingness-to-pay to be the least fair of many allocation mechanisms, including queuing (Oberholzer-Gee and Weck-Hannemann 2002). Second, many drivers oppose the loss of a kind of usufructuary right, i.e., the right to move their vehicle in the streets for free (Jakobsson et al. 2000). Third, various institutional obstacles, such as the need for horizontal and vertical cooperation of

[3] However, in cities with a well-developed mass transit, like many European cities, this is reversed (Armelius, 2004), or more precisely, the middle class is losing, while individuals at both tails of the income distribution will find themselves better off.

local and central government, can make it difficult to design credible and effective compensation schemes for redistribution of the social gains. The specific institutional circumstances of Singapore, which is both a city and a country, made such issues more simple to resolve than in other places.

However, these difficulties are much related to the coercive nature of the suggested road pricing schemes. These are framed as tolls; i.e. payments required for entering a zone, etc. In this paper, we will discuss voluntary schemes that are embedded within a broader set of services offered to motorists, allowing drivers to choose charges or premiums that depend on driving behaviour.

Road pricing and subsidies

Internalisation of the external cost of transport is at the top of the European transport policy agenda. For road transport, the European Commission has given support to a broad policy of km-taxes on heavy haulage, congestion charges, and extended differentiation of traffic insurance rates. Hitherto, the internalisation debate has focused on (rough) internalisation by driven distance. To handle the externality in speed choice, most countries instead rely on a combination of regulations (speed limits), enforcements (fines) and insurance schemes (deductions and bonus/malus). A common problem for all these instruments is the limited possibility to observe actual behaviour.

In many instances, economic incentives in the form of sticks (charges/fines) are preferred to carrots (subsidies). The Polluter Pays Principle gives an ethical foundation for that. In the transport context motorists are polluters, in contrast to victims such as residents or walkers suffering from pollution, noise, accidents, etc. However, transport related externalities are to a large extent reciprocal, making it difficult to sort sinners from saints at heaven´s gate (through which presumably walking only is allowed).

A more substantial motive for choosing charges instead of subsidies is that a program based on charges can be expected to be more effective and efficient than a compensation program (Baumol and

Oates, 1988, Ch. 14). Whilst a charge and a subsidy may be equivalent as means of promoting technical substitution of a firm toward cleaner technologies there is a significant difference when it comes to the effects on substitution of consumption. Charges induce further reduction of pollution by reducing consumption of "dirty goods", while subsidies may give rise to substitution in the opposite direction. In the road pricing context, as observed by Hau (1994), even if a usage-based compensation scheme would affect motorists´ driving behaviour in a desired direction, it would also induce them to drive more. This argument in favour of charges is further strengthened by the observation that subsidies have to be financed, and therefore are burdened by the marginal cost of public funds, while public revenues from road-user charges, on the contrary, can be used to reduce other taxes.

However, we submit that compensation to drivers that voluntary accept charges that are more differentiated than regular taxes or charges on traffic may be a very useful means for influencing car driving behaviour. In voluntary programs that encourage social responsible ("safe", "green", or whatever) driving, it is possible to implement pricing schemes that more closely reflect the variation of the social marginal cost of different ways of driving than can be made with regular (more uniform) taxes and charges. The case against subsidies is less clear for subsidies that are used for awarding enrolment to such more differentiated charging schemes.

First, while road pricing more or less by assumption is Kaldor-Hicks efficient, it seldom fulfils the Pareto criterion. The task of compensating losers is overwhelming, given that such individuals can be motorist who pay the road toll (if their individual assessment of the value of time saved, and the value of the reduction of the variation in travel time, is lower than the toll), previous motorists that change mode or reduce their travel, and passengers by public transportation modes if their comfort is lowered when some motorists switch mode.

Compensation schemes therefore as a rule target broad categories, such as commuters in mass transit, not the single individual. In both London and Stockholm, enhanced bus services are provided as a part of the road pricing bundle. That will be enough compensation for some, but probably not for everyone. Also, many may suspect that the compensation given is temporary, while the road toll will last, or that other public spending will be cut.

Charges based on participation in voluntary programs can be expected to have less of a problem in this respect. Compensation is given on an individual basis and anyone who wants can stay out of the program. Of course, third parties can still be harmed and subsidies have to be funded in some way, so some distributional issues may remain. Also, issues concerning legality and integrity are less likely to arise in implementation of non-coercive programs.

Second, in some applications, the countervailing effects of a subsidy on pollution/congestion/safety from increased consumption may be desirable. This can be the case, for instance, if substitution from car to public transit evoked by a congestion charge would increase congestion in the public mode.

In particular, Glazer and Niskanen (2000) observe that a policy involving a toll on car travel only will unambiguously hurt the users of the public transportation system, when both modes are subject to congestion and there is no redistribution of toll revenues. They conclude that this can make it difficult to get political support for congestion charges in cities with well-developed mass-transit systems, at least in absence of a credible compensatory scheme, as both users of cars and of public transportation will oppose it; car drivers because they are charged, users of public transportation because the will suffer from increased congestion.

However, motorists who want to avoid a road toll can change mode or time of departure.
In a recent survey in Stockholm (Bång et al. 2003), 37 percent of car commuters respond that they will leave home earlier or later if a road toll is levied between 7.00 am and 9.30 am. Assuming that there is no congestion at off-peak time, such adaptation will not increase congestion on the slow mode. As shown by Armelius (forthcoming), it is possible to design road-pricing schemes that enhance substitution from peak to off-peak car travel and thus

reduce or completely avoid effects on public transportation. That, however, requires that a toll on peak travel is combined with a subsidy to off-peak car travel. This can be done in an integrated road and parking pricing scheme, as described below, by reduced parking charges to motorists arriving during off-peak.

Third, car driving is subject to multiple taxes and charges. These include petrol taxes, vehicle taxes, and insurance premiums. Therefore, the net effect on car use of a subsidy hinges on whether it is combined by changes of taxes or charges that also affect car use. A voluntary program that seen in isolation implies a net subsidy, can in a broader context be a usage-based differentiation of a tax or charge that allows lower payments for drivers who behaves in a certain manner. Whether “dirty” consumption is promoted or deterred depends on the broader context.

For instance, a mandatory traffic liability insurance can be combined with a “voluntary” program that awards good driving behaviour by reducing the insurance premium. Although a subsidy is given to anyone who complies to the program, the insurance as a whole is not subsidizing car use.

Another example would be a city with a cordon-based road toll that offers motorists an option to be charged in a more differentiated way according to the actual position of the car and/or the time of the driving. Such an option would only attract car users that benefit from it, so it has to involve a differential “subsidy” to the regular toll. However, in evaluating the net effect of the program on car use one would have to consider whether the net subsidy was funded by an increase of the level of the cordon toll.

Another possibility is to integrate congestion and parking charges. The road tolling system in Stockholm will be based on automatic vehicle identification with road-side micro-wave transmitters and on-board transponders. Similar systems are already in use for parking control in garages and public parking areas. It is therefore possible to design an integrated system for automatic payment of both road toll and parking duties (Ny Teknik 2003). With such a system, the car users can be separated into for instance peak and off-peak arrivals, which makes it possible to differentiate both the road toll and the parking charges.

Fourth, intelligent transport system (ITS) devices for improving the functioning of the traffic system often involves electronic equipment for mobile communication and data processing that is installed in the cars. Such on board units may provide more efficient means for monitoring and charging driving than traditional methods (such as police surveillance, Eurovignettes, etc.). However, the consent and cooperation of the driver will be needed, as they easily can be obstructed. A voluntary system based on a combination of subsidies and charges is likely to be more easy to implement than a system based on charges only, combined with mandatory use of on-board units (like the German km tax system).

Finally, as is well known in the organization literature, real humans´ responses to carrots and sticks may differ from the reactions of the *economic man*. Recent research in experimental economics has shown that many individuals choose strategies in social interaction that are based on "similar responses", i.e. by rewarding friendly acts and punishing hostile behaviour (Rabin 1993). Therefore, it could be conjectured that car drivers that were awarded for "good driving" would feel a stronger responsibility for compliance to the rules of the program than car drivers that were imposed fines punishing "bad driving".

The scope for offering bundles of services and charges that depend on individual choices and behaviour is now rapidly widening due to the progress of information and communication technologies. We will now briefly review some insurance policies that already are offered to car owners; experimental research on how economic incentives can be used to increase car drivers compliance to speed limits; and ideas on how congestion charges can be embedded within an information system for motorists, giving real-time route navigation advices and making reservations and payments for parking and public transit.

Pay-as-you-drive car insurance

Car insurance premiums depend on features of the car and driver, such as type of car driven and security, job, marital status and even habits like smoking. The inclusion of driver characteristics suggests that insurance companies indeed consider driver behaviour to be an important determinant of accident risk. However, car usage is normally taken into account only as crude differentiation according to mileage, often within broad intervals. Hence, the insurance cost of a marginal kilometre will often be zero. Nor are insurance payments affected by where, when, or how fast a car is driven. Car insurance premiums therefore do a poor job in internalizing the marginal external costs of traffic accidents due to driving and driving behaviour.

Lack of differentiation of insurance schemes gives rise to moral hazard and adverse selection. The former is mitigated by excess and no claims bonuses, i.e., by reductions of the effective loss coverage. Adverse selection is reduced by legal obligations for insurance of liability to other persons, but probably curbs demand for insurance above that. Young drivers, motor cyclists, and drivers that have been previously involved in an accident are some categories that may be especially hurt by the inability of current insurance policies to take into account the real individual variation in risk. Their payments are based on the high average risk of their category, although individuals with a safe driving behaviour may have a considerably lower risk.

The effect of a move towards a differentiation of insurance payments that better reflects the variation in risk would therefore be twofold. One is to reduce adverse selection and thereby increase the demand for extended insurance coverage by low-risk drivers. Another is to reduce moral hazard and therefore the probability that accidents will occur as well as the cost of the inflicted damages.

A few insurance companies have launched insurance policies that use on-board units to monitor driving, though. In the United States, the insurance corporation Progressive has developed a “policy called “Autograph”. Customers choosing this policy get special tracking equipment installed in their vehicles. It uses global positioning satellites to constantly record the car's location, direction and speed. At the end of the month the device calls in and tells the company's computer where it has been, and the customer is charged accordingly.

Based on an exclusive agreement with the Progressive corporation, the insurance group Norwich Union, in cooperation with IBM and Orange, offers a similar “pay-as-you-drive” policy in the United Kingdom. The scheme uses a combination of GPS tracking and wireless communication to track where, when, and how often a vehicle is used. Detailed journey data are used to calculate insurance premiums based on vehicle use. The system also allows drivers to send and receive messages about insurance, routes and traffic problems via their mobile phones.

According to the website of Norwich, customers choosing this insurance “will benefit from individual premiums based on how often, when and where they actually used their cars. Motorists would receive a fairer deal as this initiative provides them with the opportunity to really be in the driving seat when it comes to controlling their premiums.” The “pay-as-you-drive” policy is provided as an option, along traditional schemes. It is thus a voluntary scheme.

So far, these insurance schemes are still being offered on a limited scale and just by these two companies. At present insurance is charged by the mile, but the on-board monitoring uses GPS and maps so the insurances group also know about among others overspeeding.

Intelligent Speed Adaptation

The possibility of enhancing safety through a subsidy to safe drivers was mentioned by Boyer and Dionne (1983) but never explored because ‘it is usually either very difficult or extremely costly to observe self-protecting activities of a particular individual’. This has now changed. Intelligent speed adaptation (ISA) represents a range of technologies used to help keep drivers from exceeding speed limits. Some systems are based on short-distance microwave conveyance from roadside beacons, others are based on GPS positioning.

A large scale field trial funded by the Swedish National Road Administration between 1999-2002, involving around 10 000 drivers in several urban areas and using different technologies, indicated that significant reductions of speed violations could be brought about with an ISA device (Vägverket 2002). A display in the vehicle shows the going speed limit and an annoying acoustic signal alerts if the driver goes faster than that. By comparing speed during months when the device was switched on to speed during the first months when it was dark and silent, it was found to reduce averge speed by 7 km/h. According to the National Road Administration's (Vägverket 2002) evaluation, the accident risk of drivers with this equipment was thereby reduced by 20 percent. However, surveys to test drivers revealed that few would like to have it installed in their cars. Only one third of the drivers would buy this equipment at any (positive) price and the average willingness to pay was below 40 Euro, as a one-time payment.

Two recent experimental studies (Hultkrantz and Lindberg 2003, Nilsson and Thomas 2004) have investigated the effects of real economic incentives on the use of ISA. Such incentives could be provided by reductions in insurance premiums, or by differentiated vehicle taxes, such as an km tax. In the first study, 114 private car owners that still had the equipment installed were invited to participate in an economic experiment for two months (September and October 2002). They were informed that they would receive a monthly initial bonus with a reduction for each minute they drove faster than the speed limit. They were randomly assigned to a high or low initial bonus group (250 SEK/month or 500 SEK/month). Each group was further divided into thre sub-samples; with no, low, or high charges for speeding. The three-tier charge in the low charges group were 0.1, 0.25, and 1.00 SEK/minute for speed offences at 0-10%, 11-20%, and above 20%of the speed limits. The charges were doubled in the high charges group.The experiment was designed so everyone would at least have a payment of 75 SEK each month. The result showed that participants that were charged (low or high charge) reduced their severe violations (i.e., more than 10 percent above speed limit) significantly more than the two reference groups of car drivers that were offered just the lump-sum bonus, i.e. with no charge; the formers had an average reduction of 64 percent while the latters only had a reduction of 15 percent.

These results were obtained within a strongly selected group of mainly middle-aged male drivers.The recruitment to the first vehicle trial had among others failed to attract young drivers. Nilsson and Thomas (2003) therefore performed a recruitment experiment targeting a randomly selected sample of 636 young drivers (under 29) in the same town. All drivers were offered a free installation of ISA equipment, but one sub-sample was promised a fixed annual remuneration at approximately Euro 200, irrespective of speeding behaviour, while a control group was given nothing. The results confirmed that young drivers are reluctant to install such an equipment, but that money helps a lot, raising yes-responses from two to ten percent (as percent of letters sent out).

A similar study (Forslund 2004) has explored the willingness of young motor cycle drivers to accept a similar device. Insurance premiums to young motor bikers are very high. Annual premiums in Sweden for a 23 years old driver with a four years old driver´s licence range between a third and a half of the price of a new Yamaha R1. In a stated preference survey to intercepted young drivers, Forslund found that close to 50 percent would consider installing an ISA equipment if this were combined with a significant reduction of the insurance payments.

The driver´s little helper

Road pricing has so far built on the notion of the driver as a rational consumer, reacting on price information conveyed directly to her. However, driving is to a large extent driven by habits, changing only slowly over time. Also, the driver must not be disturbed while driving by cognitive demanding information, such as complex road price information, as that can inflict upon safety. Therefore, road pricing schemes are as a rule simple cordon or zonal tolls, with possibly a a two-tier structure to affect peak/off-peak driving. They are also fixed for some time, at least a few months, and are communicated to drivers by announcements in newspapers, etc.

This limits the scope for using road pricing as an instrument for short-term traffic control. The so called HOT ("high occupancy/toll") lanes at some freeways in southern Californa and in the Houston area in the U.S. provide an exception. For these lanes, prices are adjusted frequently ("dynamic pricing") to ensure a minimum speed in the lane for which a charge is required. The toll is announced on a message sign prior to the point where the driver has to choose which lane to enter.

Congestion is indeed very dynamic. There is often a large regular variation over time in the demand for road space, especially by commuters, and more or less stochastic fluctuations occur due to accidents, road work, etc. Furthermore, even very small disturbances can be magnified and cause considerable traffic perturbations through complex interactions among motorists. By a simple fixed road-pricing scheme one can hope to reduced overall traffic demand, which will reduce traffic in non-congested areas as well, and will not eliminate severe traffic disturbances that are due to short-term variation or unpredicted events.

Road-pricing based on cordon tolls therefore has a service-quality problem: You may not get what you pay for. Toll payers may find themselves at one time in the middle of a jam, another time driving in streets with traffic that is far below the free-speed capacity limit. Similar problems are pervasive, for similar reasons, in parking. Parking fees are not adjusted to clear the market in the short-term. As a consequence, car drivers often have to cruise for a long time to find an empty parking lot, even though there is a price-rationing system. When cruising for parking congests both parkers and through traffic, the benefits from pricing are substantially reduced (Anderson and de Palma 2004).

New information and communication technologies seem to be ready to offer a way out of such dilemmas, though. On-board units with GPS positioning and mobile communication, similar to the ones used for "pay-as-you-drive" insurance and for ISA, can be used to give guidance to the driver, based on complex real-time information and customized to the individual preferences. Information sources that can provide data have been developed by traffic authorities in many metropolitan areas in recent years. They use sophisticated systems for monitoring traffic flows, increasingly combing static sensors with GPS-based floating-car information, and make short-term forecasts. This is used for direct traffic control by traffic lights, etc. and to give warnings and recommendations to drivers over the radio, road-side displays or the Internet.

A "smart" on-board micro-processor unit that receive such information by mobile communication can utilize it in more precise ways. As the position of the individual car is known to the system, it can filter out infomation that is of relevance only to drivers at a specific place and time. Also, the on-board unit can be adapted to the specific preferences of the individual driver by menue-choice based pre-programming. Furthermore, the driver can be reached, wherever she is, over the mobile phone. Therefore suggestions and recommmendations on time of departure, route choice, etc. can be given at a convenient time, for instance before leaving home or work, and not just en route.

As shown by the insurance and ISA applications, such devices can also be used as instruments for road pricing. In fact, similar devices are used in the German km-tax system and in road-pricing trials in some European cities within the EU-funded PROGRESS project. The focus of interest in these cases, as well as in the pay-as-you-drive insurance, is on the possibility to charge according to the distance driven.

However, the current technology can achieve much more than that. A "smart" on-board unit does not have the informational processing constraints of the human mind. It can be loaded with much more, and more detailed, information about the traffic system than the driver. Based on real-time information and on pre-selected choices (such as "I want to get home as quick as possible" or "I want to park as cheap as possible, within a ten minutes walk to my office", etc.), the device can give advice ("wait another quarter of an hour", "choose the northern route", "park at garage B", etc.). Such recommendations and suggestions can be given in ways that are simple to understand and adapt to, minimizing the risk of distracting the driver`s attention. An on-board unit and the driver can communicate within the car by different means (a display, voice control etc.) or outside the car over the mobile handset of the driver. Given the driver's acceptance of a proposed action, the unit could book and pay road tolls, parking charges, and tickets for public transportation.

The detailed information processed by a "smart" unit could contain not just "ordinary" traffic information on disturbances, average projected speed in various parts of the road network, etc. but also current price information. As an on-board unit lacks the cognitive restraints of a human driver, this would allow complex and frequently adjusted prices for the use of both roads and parking space. It would therefore make possible "dynamic pricing" schemes like the ones used for the "HOT lanes" (or for air and rail tickets bought over the Internet) for increasing the utilization of capacity of the road and/or parking infrastructure.

There is currently no such system in operation. However, a study by the Swedish National Road and Transport Research Institute (Hultkrantz, Lindberg and Nilsson 2003) on a possible implementation in Stockholm ("Smartic") shows that most components needed in an information and payment system of this sort already are in place. Real-time information on current speeds by different routes, parking vacancies, delays in public transit etc. is available over the Internet (www.trafiken.nu). Individual profiles can be choosen for selected information. Also, parking can often be paid with the mobile, and prototypes have been developed for systems for reservation in advance of parking space, much as flight seats or hotel rooms.

However, all these systems are not yet integrated. Nor are they readily accessible in vehicles. The information systems are maintained by national and local public authorities, parking by public and private parking lot operators, on-board technology is sold by car dealers and telecom operators, and so on. To build a complete, fully integrated system, it is necessary to get cooperation among several public and private actors.

Also, congestion and speeding are public bads that will be excessively provided even if drivers have complete information about the current traffic. Hence, charges are needed, but as is evidenced in the ISA applications, few motorists will deliberately buy devices that make that possible without subsidies. As the "smart" unit is an impure public good that provides both public and private services, the willingness to accept such a device will depend on both the monetary remuneration offered, on the quality of the private services that are provided (such as reservation in advance of parking space), and on how closely they are bundled to the provision of the public services.

Conclusion

The problems encountered in Paris already in the 19th century remain basically unsolved. Transport appears worldwide to be the sector of the economy where particularly strong policies will be needed in order to reach sustainable growth. The problem is that technical fixes are not enough, so behaviour has to change. However, as can be seen for example from the resistance to gas taxes in the United States and to road pricing almost everywhere, the reforms of taxes and charges needed to induce such changes in behaviour are often blocked by political opposition.

In this paper we have paid attention to the scope for using emerging technologies, in particular mobile communication and GPS positioning, to charge traffic in ways that reflect the substantial variation of the social marginal cost of car driving under different circumstances. By combining such charges to subsidies, or to valuable informational services, it may be possible to enrol a substantial share of motorists to voluntarily accept such differentiated incentives.

In the words of Mancur Olson (1965, p. 51), the large group of motorists is a "latent" group that has a latent power or capacity for collective action that can be realized or “mobilized” only with the aid of “selective incentives”. These “selective incentives” can be either negative or positive, in that they can either coerce by punishing those who fail to bear an allocated share of the cost of the group action, or they can be positive inducements offered to those who act in the group interest. The new information and communication technologies have thus advanced new possibilities to assemble a mix of positive and negative selective incentives for reconciling the decisions by numerous individual motorists to the common interest of themselves and society as a whole.

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