

3. Curb cuts must be no closer than 40 ft to a street intersection for berths serving 30-ft vehicles and no closer than 55 ft for larger vehicles.

4. Joint loading berths serving two or more buildings are permitted.

5. The Board of Zoning Adjustment is authorized to reduce or eliminate the number of loading berths required and to approve the use of off-site loading facilities, including joint loading berths for buildings that front on a major pedestrian-emphasis street.

To ensure that goods delivery does not impede pedestrian and traffic movement within the downtown public right-of-way, the city DOT is considering putting time restrictions on certain activities and on certain streets where this is deemed appropriate. Goods movement and delivery criteria will be established for each street classification.

CONCLUSIONS AND SUMMARY

The District of Columbia DOT has developed a TSM program designed to maximize the use of public space in the downtown for the mutual benefit of all travel modes. This management plan is part of a new Master Plan for Downtown Washington, which includes a street classification system, a parking management program, public transit enhancements, carpool and vanpool incentives, improved pavement markings and signs, regulations governing the movement of goods, and improved safety and security for bicycle users.

This coordinated TSM planning effort is a result of the city DOT's analysis of the potential effects on the transportation system that could result from anticipated land development by the year 2000. Travel demand, mode choice, intersection and arterial capacity, transit needs, parking supply and demand, and goods movement were all examined. The findings of the analysis concluded that a balanced approach to transportation service delivery in the downtown was necessary if the livability and diversity goals set for the downtown were to be realized.

As the level of activity in the downtown increases, the TSM plan should provide for fewer conflicts among travel modes while affording a high level of service for all movements. A pedestrian network, for example, will be designed to provide safe and enjoyable pedestrian access to all portions of the downtown. Sidewalk clutter will be removed and vehicle intrusion minimized, which will result in improved pedestrian mobility. Streetscape guidelines will provide a high level of sidewalk treatment complemented by uniform signing and lighting. Automobile level of service will be maintained through the encouragement of the transit and ride-sharing modes, restrictions on goods delivery, and a limitation on curb cuts on major through-traffic routes. The existing downtown signal system is being replaced, which will greatly improve reliability. Metro buses will be given priority and will run more efficiently on bus-oriented streets.

The development community will be a major participant in the TSM program. Revised parking standards for new buildings will require carpool and vanpool spaces and encourage, through incentives, the establishment of transit incentive programs for tenants of new buildings. Thus, central-city employees will be encouraged, at the workplace, to rideshare or take transit.

These initiatives should improve the overall use of public space in the downtown and, over time, provide transportation services that will complement the objectives of the Master Plan for Downtown Washington.

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Making Progress with Traffic Restraint: The Role of Research

A.D. MAY

The range of measures proposed for restraining peak-period car traffic in urban areas is reviewed, and it is demonstrated that very few of them have been successfully implemented. Based on reported decisions and discussions with decisionmakers, the reasons for rejection of these proposals are identified and the strength of the criticisms made is assessed. Although the need for restraint is still not clearly demonstrated, it is concluded that traffic restraints can probably be justified as a means of improving efficiency and the environment and that fiscal measures are the most appropriate for further development. A number of issues are identified on which further research could usefully concentrate to ensure that future proposals can be more adequately formulated, and several new research developments in the United Kingdom that will contribute to this are mentioned.

The year 1983 marks the 20th anniversary of the publication in the United Kingdom of *Traffic in Towns* (1), a report whose influences are still felt

in much of current policy on urban road provision, traffic control, and environmental management. Although many of its recommendations have found their way into practice, not just in the United Kingdom but around the world, one is particularly noticeable for its absence. Lord Crowther, in his preface to the report, said, "Distasteful though we find the whole idea, we think that some deliberate limitation of the volume of motor traffic in our cities is quite unavoidable." In practice, however, with one or two notable exceptions, politicians in the United Kingdom and elsewhere have avoided such limitations for the past two decades and show no signs of implementing a policy of traffic restraint in the near future. Why is this? Were Crowther and Buchanan and his team wrong in their analysis? Have the

problems that necessitated restraint failed to materialize? Or are there adverse consequences of restraint that make otherwise worthwhile measures unacceptable? In the light of these answers, have traffic restraint a future role as an element of urban transportation policy? If so, what research is needed to promote that role?

This paper proposes to answer these questions by reviewing past attempts to implement traffic restraint, identifying where possible the reasons for their rejection, and assessing their importance. In particular, the need for restraint is reassessed and the limited evidence supporting restraints is demonstrated. Despite this, it is argued that restraint can still play an important role as part of a comprehensive urban transportation policy, and several avenues of research are suggested both to improve its technical feasibility and to understand its effects.

POSSIBLE METHODS OF TRAFFIC RESTRAINT

Traffic restraint measures can be defined as those that impose a restriction on vehicle use in order to achieve a significant modification in the mode, time, route, or destination of journeys. In the extreme case, this can result in a reduction in the total number of journeys made. Such a definition excludes most traffic management measures, such as junction controls, bus priority, and one-way streets, which at most impose a minor change in vehicle routing; it also excludes those measures that attempt to encourage a mode change by improving the alternative mode--e.g., fare subsidies, bus priority, and car-sharing schemes. It is less clear whether it should include measures such as traffic cell schemes, which impose significant changes in route without affecting mode or time of travel. Buchanan, however, considers these a separate set of measures, and they certainly have a more successful implementation history. They are therefore excluded from the following discussion.

Traffic restraint measures differ widely in the restrictions they impose. Physical restrictions are used, for instance, in street closures, barriers to through movement, and reductions in parking space. Delay-based restrictions arise when traffic signals are used to hold back traffic and occur naturally in the process of restraint by congestion. Regulatory restrictions limit the use of transportation facilities to certain vehicles--for instance, by imposing weight or length limits, permitting only short-duration parking, or requiring a permit to use a particular road. Fiscal restrictions impose a charge for the use of facilities, whether they be to park, to enter a particular area, or to use the road system generally, as in the concept of road pricing. It is important throughout to differentiate between those measures that impose restrictions on the parked vehicle and those that control the moving one.

The following discussion outlines briefly a number of proposed and implemented schemes, which are described in more detail elsewhere (2). They do not attempt to be comprehensive, particularly because many proposed but abandoned schemes are never publicized. For simplicity, they concentrate on restrictions on peak-period car movements, which were the main focus of Buchanan's recommendations and of later studies.

Parking Controls

Most studies in the United Kingdom in the 1960s proposed parking controls as the most readily available method of traffic restraint. Both motorists and transportation planners had already experienced

the use of on-street parking controls to reduce the congestion and hazard caused by the parked vehicle and, since such controls frequently reduced on-street parking accumulation by two-thirds, it seemed reasonable to assume that the extension of such controls would be an effective means of traffic restraint. However, as a means of imposing restraint, on-street parking controls alone are clearly inadequate. Typically, they only involve between a tenth and a third of all city-center parking stock (3), and other types of parking also require control if trip ends are to be reduced rather than simply transferred to off-street parking spaces.

A range of measures has been proposed for controlling off-street parking space. Physical controls involving restrictions on provision of new space are now a common element of planning control but have no effect on existing space. Several proposals have been made for extending these measures to the closure of existing spaces. London had a program of closing temporary public car parks in the late 1970s, and Santiago has done so more recently. More wide-ranging plans for reduction of private off-street parking have, however, not been implemented. The U.S. Environmental Protection Agency plan for reducing off-street parking in Boston was abandoned, and suggestions in the United Kingdom in 1976 for using standard reduction orders or taxation to do so (4) never became law although they still have their advocates (5).

Regulatory controls have been less frequently advocated. Apart from some attempts to close car parks until after the peak period, most restrictions on the type or manner of parking have been introduced for reasons other than restraining traffic.

Pricing is the most commonly proposed control, but it is inevitably limited to public car parks, and it is difficult to find examples where it has been imposed comprehensively enough to do more than divert users to different facilities. San Francisco introduced a tax surcharge of 25 percent in 1970, but this was primarily for fiscal reasons (6). Singapore increased charges at all central-area car parks by between 30 and 50 percent in conjunction with its 1975 area licensing scheme (7). The Greater London Council has had powers since 1969 to control the way in which privately operated public car parks operate, and it proposed in 1976 to specify minimum charges throughout central London that involved increases for all-day parking of up to 200 percent (8). However, the proposal was abandoned, and the powers are still unused. In 1981, the U.S. Urban Mass Transportation Administration (UMTA) introduced an experiment with increased parking charges in Madison, Wisconsin. Originally planned to involve five car parks, the experiment was later limited to four, which represented 30 percent of public off-street spaces and 6 percent of all spaces; charges for long-term parking were increased by 55 percent.

Even where comprehensive on- and off-street pricing policies can be introduced, they have no influence on private parking spaces, which typically represent between one- and two-thirds of the parking stock (3). It appears from proposals to date that only reductions in supply have been considered for these spaces, and there is no sign of these being implemented. Even were they to be imposed, parking restrictions would have no effect on through traffic, which frequently represents as much as a third of the traffic entering central areas.

Controls on Moving Vehicles

Faced with these two major shortcomings of parking controls, more interest has been expressed in the

Table 1. Public objections to U.S. and London area licensing plans.

Objection	United States	London
Interferes with right to travel	Major objection	Royal Automobile Club campaign issue
Harms business	Major objection	
Discriminates against those with special needs		56 objections
Discriminates against poor	Major objection	30 objections
Hard to enforce	Minor objection	38 objections
Hard to administer		26 objections
Overloads transit	Minor objection	88 objections
Relocates traffic problems	Minor objection	22 objections
Requires legislative clearance	Minor objection	

possibility of restricting the moving vehicle. Physical restrictions have typically been applied only to reroute traffic away from environmentally sensitive areas, and most of these, including the U.S. experiments with automobile-restricted zones (9), cover such restricted areas that the measures do not have much restraining effect. The largest schemes are in the centers of European cities such as Gothenburg (10) and Groningen (11), where the whole center is divided into four or five cells, each accessible only from a ring road. Even these schemes primarily reroute through traffic, although there is some evidence from Groningen that there has been a reduction in the amount of traffic that terminates in the city center (11).

Delay-based restraint has been proposed on several occasions, including in studies for London (12) and Sheffield (13), but has been attempted only once, in the short-lived zones-and-collar experiment in Nottingham in 1975 (14), which involved the use of bus lanes and traffic signals to increase travel time for city-center-bound traffic.

Proposals for regulations to restrict certain types of vehicle are not uncommon but are frequently limited to the larger commercial vehicles. Among the schemes proposed for restricting car use are a 1976 proposal for allocating permits for entry to central London only to those who could demonstrate a special need (15), simple permit-based restrictions in one or two smaller Italian cities, a scheme introduced in Lagos, Nigeria, in 1977 in which odd- and even-numbered vehicles are only permitted entry to Lagos Island between 5:00 a.m. and 6:00 p.m. on alternate days, and regulations introduced in May 1982 that ban cars from central Athens for 8 h/day.

However, fiscal restrictions have been the measure most commonly discussed. The idea of road pricing, in which an in-vehicle meter records the amount of use of congested roads and the vehicle owner is charged the cost of the congestion that he or she imposes on others, was recommended in the United Kingdom in 1964 (16) and in the United States as early as 1956 (17). No one has yet implemented such a scheme or even publicly tested the necessary equipment, although much developmental work took place in the United Kingdom in the late 1960s (18). Few now advocate such complex pricing systems, but there have been many proposals for simpler charging methods.

In 1974 and again in 1979, the Greater London Council brought forward proposals for supplementary licensing, a concept in which cars entering central London would have to purchase special licenses (19, 20). Both proposals were rejected, although the latter has since been reintroduced for discussion (21). Similar suggestions have been made and rejected in Bristol, Stockholm, Kuala Lumpur, and Bangkok. In the United States, UMTA spent some time trying unsuccessfully to find a U.S. city willing to

experiment with such a measure. Only one city, Singapore, has successfully implemented such controls: In 1975, cars entering the Singapore city center with fewer than four occupants between 7:30 and 9:30 a.m. were required to buy a license costing \$1.25/day. Both the period of control and the charge have since been increased (7).

Finally, the use of existing taxes either on car ownership or on fuel has occasionally been advocated as a restraint mechanism. In practice, these are usually too blunt as instruments designed to achieve specific restraint needs, but they may be appropriate in a few predominantly urban states. Hong Kong has recently demonstrated this by doubling the car purchase tax and trebling the car ownership tax while rejecting other methods of reducing traffic (22).

REASONS FOR REJECTION OF PROPOSALS

As the brief review above has indicated, the failure rate in the development of traffic restraint proposals has been very high, and it would clearly be informative, in assessing the future role of restraint, to study the reasons for the rejection or abandonment of so many of these proposals. In practice, such information is hard to come by; few politicians have made public their reasons for rejection, and even where they have the relative importance of the reasons given is rarely stated. Only two published records of reasons for rejection are available: One relates to the first proposal for supplementary licensing in London (23) and the other to attempts by UMTA to find the U.S. city willing to experiment with similar controls (24). What follows is based on these and informal discussions with those involved in decisions elsewhere; it clearly is less than comprehensive. Table 1 summarizes the public's objections to the London scheme and cities' objections to the U.S. proposals.

Issues similar to those in Table 1 have arisen elsewhere. Car park licensing proposals in London encountered objections that it was unnecessary, would be ineffective, would hasten the decline of central London, would overload public transportation, and would be inequitable and unduly expensive. Proposals for reducing or taxing private parking spaces were abandoned on the grounds that they would be difficult to enforce, would encourage fringe parking, and would be inequitable; in particular, they were considered an unfair imposition on businesses, which had been required to provide the spaces in earlier planning legislation. The zones-and-collar experiment in Nottingham was abandoned as ineffective (14), and similar proposals for London were dismissed because they would have been ineffective, inefficient, and unduly disruptive to essential users.

Various reasons have been given for abandonment of the several supplementary licensing proposals, including doubts as to the need for them and their effects and the public acceptability of such an obvious restriction on freedom of vehicle use. It is possible to categorize these reasons under the following broad headings:

1. The restraint would be unworkable (administratively or from the standpoint of enforcement).
2. The restraint would be ineffective (in that the net response to the penalty imposed would be insignificant).
3. The restraint would have adverse effects on transportation (by diverting traffic or overloading public transportation).
4. The restraint would cause economic activity to relocate.

5. The restraint would be unfair to certain groups in society (the poor, essential users, and others).

6. The restraint would involve an unacceptable restriction on freedom of movement.

7. The restraint would be unnecessary.

It is useful to consider each of these reasons in turn to identify the strength of the arguments and the further research that is necessary if the issues involved are to be further clarified.

Restraint Would Be Unworkable

The practicability of individual measures should be relatively easy to demonstrate. Regulation, administration, and enforcement procedures can all be developed and pilot tested before implementation and their costs set against the anticipated benefits of the scheme. Even so, this is a surprisingly frequent objection. In some cases, the objection seems valid: The Nottingham experiment demonstrated the impossibility of imposing more than 2 or 3 min of delay for lack of queue storage space (14), and proposals in London for permits based on need foundered on the problems of defining need and checking the validity of applications (20).

However, doubts about enforcement, particularly, often result in potentially workable schemes being rejected. For example, the 1974 proposal for supplementary licensing in London involved using 400 wardens to carry out random roadside checks and stop apparently violating drivers. Even this relatively labor-intensive method would, with about 90 percent compliance, have consumed only 6 percent of the license revenue (25); yet the proposal was considered unworkable by politicians and public. However, Singapore demonstrated that by checking all vehicles entering, without stopping offenders, 98 percent compliance could be achieved at a cost equivalent to 5 percent of revenue (7).

Such suspicions concerning the feasibility of enforcement are perhaps not surprising, given the poor record of enforcement of existing on-street controls; it is estimated, for example, in central London that there are between 0.25 and 0.5 m offenses/day, only 2 percent of which are detected and only 1 percent of which result in fines (26). However, there has also been a marked reluctance politically to take any of the steps that could improve compliance: increased manpower, less labor-intensive methods, higher penalties, or reductions in the checks necessary to protect the innocent motorist (26). There has also been a failure technically to understand the nature of the relation between chance of detection, level of penalty, and compliance, although some work is now being done on this (27).

Restraint Would Be Ineffective

The second criticism is harder to refute, since it requires a demonstration that a penalty can be imposed on a large enough proportion of journeys and that those affected will respond to a significant extent. The types of penalties outlined above are removal of parking or road space for all or selected users, additional time through delay or longer routing, and price. Removal of supply will have the most direct effect: Provided that supply is reduced to below demand or some users are specifically denied access, there will be an inevitable reduction in use. However, such restrictions are notoriously difficult to make effective.

Parking supply is sufficiently flexible for existing sites to absorb more cars if others are closed; street closures with access exemptions at-

tract violations. Experience has shown that sizable delays are difficult to impose; Nottingham could only impose 2-3 min of delay because of lack of queue storage space and signal violations (14), studies in London produced similar findings (12), and even diversion around a city-center traffic cell scheme to reach a cell on the far side would only add at most 5 min to journey times. Given the total cost of journeys to work, such small penalties are unlikely to have a significant effect.

There are no such limits, however, on the extra price that can be imposed on a journey; the uncertainty here concerns the ability of motorists to pass on the costs to others and the size of response of those who cannot. In countries such as Sweden, where commuting costs are tax-deductible, price is clearly less effective; so it may be in countries such as the United Kingdom, where the costs of a large proportion of car users are met by their employers. There are some hypothetical indications that employers who subsidize their employees' journey to work would refuse to pay large increases in the costs of car use (28), but the extent to which such costs can be passed on is generally little understood.

So, too, is the overall scale of response to price. Studies of response to petrol price increases suggest short-run arc elasticities of -0.1 to -0.3 (29); for all-day parking charges, values range from -0.3 to -1.2 (30), but these are increased by the availability of alternative facilities. A study of responsiveness to peak-period tolls on an isolated bridge crossing found values of between -0.2 and -0.5 (31). None of these ranges of values can reliably be used to estimate the effects of supplementary licensing, which would involve a much higher cost increase and a different form of charge. However, experience in Singapore, where a charge of \$1.25 produced a 44 percent reduction in traffic entering the city center, indicates that the response to such penalties can be considerable (7).

The proportion of users not subject to control is clearly also a crucial determinant of effectiveness. Experience in London has demonstrated this weakness with parking controls: While on-street and public off-street parking fell by a third over a 12-year period, private parking and through traffic both doubled, which resulted in a one-third increase in traffic entering the city center (32). In a similar case, experience in Lagos suggests that exempting half the vehicles on any day enables them to increase their use of the road to the detriment of the control's effectiveness. Clearly, if exemptions are to be provided, a very careful balance is required between fairness and effectiveness.

Restraint Would Have Adverse Transportation Effects

Those restrained from traveling will almost always make alternative journeys by different routes or modes, at different times, or to different destinations. Restraint may provide the spare capacity for some of these new demands; for example, reduction in radial traffic may permit more orbital traffic, or faster buses may provide more capacity. However, most new demands will impose some new costs. In the case of parking controls, traffic that parks on the fringes of the control area may well impose substantial environmental or traffic disruption; with moving-vehicle controls, diverted through traffic may cause an increase in congestion on the orbital route around the control area. Both types of measures may well encourage new peaks immediately before and after the control period, stimulate growth in car sharing, and require additional capacity on public transportation that, if used only in the peak pe-

riod, will worsen the economics of public transportation operations. Some of these effects--particularly the changes in parking location, time of travel, and car occupancy--will be difficult to predict, and it may be difficult for politicians to conceive of already overburdened ring roads or bus services accommodating more traffic.

The true size of these effects is probably only adequately determined by experiment, but the question will still arise as to whether the resulting costs outweigh the benefits of restraint. In the one adequately documented experiment, in Singapore, the area license scheme resulted, after some adjustments, in a 20 percent reduction in ring road speeds and a 10 percent increase in flow after the control period (7). Singapore's politicians considered both of these acceptable in view of the direct benefits resulting from the 44 percent reduction in central-area traffic.

Restraint Would Cause Economic Activity to Relocate

The short-term effects on travel considered above can to some extent be predicted and can be relatively easily measured by experiment. The longer-term effects on economic activity are much more difficult to predict and, because they are less reversible, are more serious causes of concern. The suggestion is made that increased travel costs will encourage employees and customers to take their labor and business elsewhere and that firms will necessarily leave the control area as a result, thus exacerbating trends that are already apparent, and relocating activities in areas where control of travel demand is far more difficult. Conversely, it can be argued that reduced congestion and an improved environment would make the area a more attractive one in which to work or shop and reduce the costs of doing business, thus strengthening the area's economic base. It is notoriously difficult to isolate such processes (11) and, although studies have demonstrated that firms may exaggerate such effects in the short term (33), few models have attempted to predict the longer-term responses of employees and firms to transportation changes. One prediction for Leeds suggests that a high city-center parking charge would cause 20 percent of city-center jobs to relocate to the suburbs, where, of course, traffic restraint would be more difficult to impose (34). However, even this model excludes many of the benefits of restraint to employers and employees.

Restraint Would Be Unfair to Certain Groups in Society

Perhaps the most fully analyzed criticism of restraint policies is that restraint would be unfair to certain segments of society, although much of the debate centers on the nature of fiscal controls (i.e., their regressiveness, etc.) (35). In practice, much depends on the relative numbers of the wealthy and poor who currently use cars in the area to be controlled, their relative sensitivity to charges, and the extent to which improved conditions for poorer bus users can be considered to outweigh the adverse effects on poorer car users. One analysis suggested that the poorest third of London residents made only 12 percent of the car journeys to central London, which represents only 2 percent of all journeys there, but they were three times more likely to use a bus and hence to benefit from traffic restraints (36). It is interesting that the study in Singapore found no difference between wealthy and poor car drivers in responsiveness to price (7). It is also interesting to note that such

equity issues are frequently raised with charges of car use but seldom with charges for parking.

Contrasts between rich and poor are not the only distributional implications of restraint that are of interest. One criticism of supplementary licensing in London was that it would impose undue hardship on those who had no choice but to use cars. In practice, analysis suggested that those who made frequent use of their vehicles would more than recoup the license fee in journey time saved (25). This clearly was not the case with the Nottingham zones-and-collar experiment, in which all drivers incurred penalties that could not be outweighed by savings elsewhere if the principle of restraint by delay was to be successful. Similarly, bans on parking at certain times or for certain durations and restrictions on certain vehicles on certain days have a considerable element of rough justice that will adversely affect essential users. Generally, the analysis of such distributional effects is difficult because it requires the individual groups of concern to be separately identified and the implications of penalties and exemptions on each group to be separately estimated.

Restraint Would Involve Unacceptable Restriction of Freedom of Movement

No analysis can refute the argument that traffic restraints would restrict the freedom of movement of car drivers. The issue is clearly a matter for political debate. However, unless such freedom is considered sacrosanct, restraint measures that in other terms produce net benefits will presumably justify some infringement of drivers' freedom. The strength of this argument, therefore, needs to be judged in the context of the arguments above about the adverse effects of restraint and those below about the need for restraint.

Restraint Would Be Unnecessary

Clearly, if the argument that restraints are unnecessary is upheld, the issues raised above under the other arguments are irrelevant. Particularly because traffic restraint imposes restrictions on some members of the community, it is essential that it be presented as a means to clearly defined ends and that it can be demonstrated that other, more acceptable measures are not available. The evidence on these issues has been reviewed elsewhere (3) for the United Kingdom, and it is clear that little information is available on the scale of the problems to be overcome (37). The lack of references in the international literature suggests that such information may also be lacking elsewhere.

The arguments presented against each of the potential objectives of restraint can be briefly summarized as follows.

Efficiency

Reducing the congestion costs imposed by each vehicle on others has always been one of the objectives of restraint (38), and various attempts to cost such congestion have produced estimates in the range of \$1 billion to \$2 billion/year for the United Kingdom. However, there are few data on trends in congestion, particularly urban-area speeds, and what there is suggests that conditions are, if anything, improving (39). This information for provincial U.K. cities has been used to argue that the true costs and achievable improvements in congestion have been grossly exaggerated (40). Somewhat against the trend, however, recent central London figures suggest a 15 percent reduction in peak-period speeds

and a 10 percent reduction in the off-peak between 1974 and 1980 (41). In developed cities, trends in congestion may worsen or improve depending on the ability to manage transportation systems better and on rates of growth or decline in city-center activities. However, in the developing world it is clear that congestion is not only already more severe but is rapidly getting worse (42). Generally, it appears that the ability to reduce congestion significantly in the short term by means other than restraints is severely limited (43).

Resource Conservation

Traffic restraint has been proposed as a means of saving not only the resources required in road construction but also the fuel consumed in private vehicle use. However, the contribution to national energy saving of city-center traffic restraint is so small that local authorities seem unlikely to accept such restrictions in the interests of fuel economy. For example, one U.K. study estimated that a 50 percent reduction in car use for all urban journeys to work would only reduce national energy consumption by 2 percent (44).

Environmental Improvement

Many traffic restraint measures have been proposed on environmental grounds, and there are clear indications that many environmental improvements can only be achieved in the short term by restraint. However, the seriousness of environmental problems is less clear. There has been only one national survey of attitudes to the environment in the United Kingdom, in 1972 (45) and, although that showed that two-thirds of the population were concerned about danger as pedestrians and half about noise and fumes in the street and noise at home, it says nothing about trends in attitudes since then or the extent to which such concern justifies restrictions on car use. Indeed, some measures that have both restricted accessibility and improved the environment in residential areas have been rejected by residents who considered the environmental improvements not worth the resulting loss in accessibility (46).

Land Use Planning Goals

It has often been argued that congestion is encouraging firms to decentralize, that the adverse environment is encouraging residents, shoppers, and employees to leave city centers, and that by tackling these problems traffic restraint can help revitalize the center (9,10). There is some evidence that pedestrian streets, at least, have this effect (47). However, not only is restraint only one means of achieving these ends, but, as noted above, it may well have the reverse effect.

FUTURE ROLE OF RESTRAINT

Many of the arguments in favor of traffic restraint have in the past rested on largely unsubstantiated claims of severe transportation problems to be overcome or appeals to the apparent logic of restricting private users in favor of public transportation and the pedestrian. Given the distributional effects of restraint and its possible adverse consequences, such arguments are hardly acceptable. As the above analysis has shown (3), there does not appear to be a defensible case for traffic restraint as a necessary means of achieving energy conservation, financial, land use planning, or equity objectives. However, analysis of both the efficiency and environmental objectives suggests that, if there is a

clearly demonstrated need for significant improvements, restraint is the only method available in the short term to achieve them. There is little evidence available to confirm that significant improvements are required, but it seems likely that there will at least be some cities where they are. In such situations, the implementation of traffic restraint measures as part of a comprehensive policy of public transportation improvement, limited upgrading of bypass routes, and environmental treatment seems most likely to be able to achieve the desired results with the minimum adverse side effects.

As to the types of measures that are most appropriate, evidence to date indicates clearly that delay-based measures are likely to be counterproductive, physical or regulatory bans unduly harsh on essential users, and parking controls on their own insufficiently comprehensive. On the other hand, simple fiscal controls such as supplementary licensing have been shown to be effective and sufficiently flexible (particularly if combined with a system of exemptions) that most of their disadvantages can be overcome. It seems sensible to concentrate further work on such measures, although there may also be a role for comprehensive parking controls if they can be combined with effective restrictions on through traffic.

FURTHER RESEARCH NEEDS

However, it is clear that more work will be required before policymakers are prepared to adopt such measures. The above analysis suggests that this research should fall into three areas: (a) the need for restraint, (b) the effects of restraint, and (c) the practical requirements of restraint. Some suggestions under each of these headings are made below.

Restraint Needs

If traffic restraint is to be justified solely on efficiency and environmental grounds, then the severity of these problems needs to be demonstrated. There is currently little evidence on trends in travel time in urban areas and even less on travel time variability. This appears to be largely because sufficiently low cost and statistically reliable survey methods have yet to be provided. Work on the development of such techniques and the understanding of patterns of travel time variability has recently started (48), but more work is needed, particularly for public transportation users.

More information is also required on the extent of environmental problems. Here the difficulty is not one of measuring levels of noise pollution or visual intrusion but of understanding their implications and particularly the extent to which increased costs to travelers can be justified to achieve given levels of environmental improvement. This is a particularly difficult area, as attempts to cost the effects of traffic noise have shown, but it clearly merits further work.

Restraint Effects

Several issues arise concerning the effects of traffic restraints. First is the question of response to controls. As others have noted (49), there is a need to develop greater understanding of elasticity with respect to car use charges, perhaps by analyzing parking charges, tolls, and fuel prices as elements of generalized cost and calculating elasticities in these terms. Motorists' ability to pass on the costs of car use and the implications of this for such elasticities also require further study, although some preliminary work has already been done

(50). As a separate issue, response to supply constraints and costs paid by those who do not respond need to be more fully understood if they are to be used as a restraint mechanism. Some work has been done in studying response to bridge closures (51-53), but this may not adequately represent reaction to permanent, as opposed to emergency, closures. Finally, in this group of issues is the question of response by those on whom penalties are not imposed. The response of through traffic is of particular concern, since growth in through traffic and excessive diversion can both seriously undermine the benefits of restraint (54).

The second issue is that of the resulting transportation effects. In addition to the rerouting effects mentioned above, for which more detailed assignment-simulation models are now available (55, 56), there is a need to be able to predict response by peak spreading and car sharing, both of which Singapore showed to be attractive alternatives to solo car use (7). Behavioral car-sharing models now exist (57) but have yet to be integrated into analytic packages; such models have yet to be developed for peak spreading. Similarly, locational response to parking controls requires further study, and some work has recently started on this (58).

The third issue is the longer-term relocation response of economic activity. As indicated above, there have been recent developments in models that incorporate longer-term movements of households and jobs (34). However, they do not as yet include responses of firms themselves, particularly to issues such as environmental improvements and operating cost reductions, which may be important benefits of traffic restraint.

The final issue is the distributional effects of restraint, which, as noted earlier, require predictions of response of and impact of exemptions on different groups of users. Some of these, such as residents and business travelers, can be readily identified from existing models, but others will require more detailed analytic tools.

These research issues are not necessarily best answered by the development of further predictive models; in many cases, more faith can be placed in studies of people's reactions to actual changes. In some cases, opportunities arise to measure reactions to the changes introduced by specific restraint measures; the studies in Nottingham and Singapore are good examples. However, it is one of the basic dilemmas of research on traffic restraint that, although some experience of such measures is needed in order to understand and predict their effects, one is unlikely to find many authorities willing to experiment with restraint measures and hence provide the necessary experience, in the absence of adequate predictions.

One partial solution to this problem is to take more advantage of unplanned increases in the cost of using the transportation system as was the case with the bridge closure studies mentioned above (51-53). Such opportunities are themselves (fortunately) rare, and careful planning is required if advantage is to be taken of them.

Practical Requirements

It appears that the main need here is to develop improved enforcement methodologies and equipment. Indeed, there is a general need in the field of traffic management for a better understanding of the effects of different levels of compliance on effectiveness (59) and of the relation between compliance, chance of detection, and level of penalty (27). Separately, concern over the manpower implications of enforcement suggests the need for further

study of more automated detection techniques, such as automatic vehicle identification (60).

Such a long list of research requirements seems rather daunting and may only be justifiable if the political will is there at least to consider restraint further. However, many of the research needs identified will have wider benefits in the field of transportation policy assessment. It is to be hoped that some at least will be pursued and will enable future restraint proposals to be considered with less scepticism and greater understanding.

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