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Impact of Better Traffic Management

Traffic management can improve the flow of traffic on the roads, reducing emissions per vehicle kilometer traveled and enhancing urban mobility. But if it generates extra traffic, does it necessarily reduce air pollution by vehicles? This note addresses the question of how traffic management policy can be best implemented to achieve <u>*both*</u> *significant mobility and environmental benefits.*

Traffic management comprises both "supply side" measures—traffic system management to improve speeds of existing traffic volumes—and "demand side" measures—traffic demand management to improve speeds by reducing traffic volumes. The aim of this note is to consider the various ways in which traffic management can affect local air pollution, and to suggest how it may be best employed to secure both traffic flow and environmental benefits.

Traffic management may require some physical measures, usually referred to as traffic engineering. However, the engineering involved in traffic management tends to have a short gestation period and low cost. So traffic management has the potential to achieve rapid reductions in air pollution and to be affordable even by poor countries.

Dimensions of Air Pollution from Vehicles

For any given vehicle and fuel combination, aggregate emission levels vary according to the distance traveled and the driving pattern. The emissions of carbon dioxide (CO_2) and oxides of sulfur (SO_x) vary directly with fuel consumption. The tailpipe emissions of carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter and hydrocarbons vary in addition with the engine design, the air-to-fuel ratio, and vehicle operating characteristics, with an optimum speed usually in excess of 60 kilometers (km) per hour and rarely achievable in urban areas. Broadly speaking, NO_x emissions increase, and CO, particulate and hydrocarbon emissions decrease with increasing engine temperature (or increasing vehicle speed). The most important influence on emission levels for a given vehicle is the driving cycle, with both fuel consumption and pollutant emissions many times higher per vehicle km during acceleration and deceleration than during cruise. Moreover, as catalytic converters depend on heat for their effectiveness, they are least effective at cold start, further accentuating the influence of the driving cycle.

The adverse impact of local air pollution is highly location- (and to a lesser extent, time-) specific. It is greatest where most people are exposed and emissions lead to high ambient concentrations (on account of high emission intensity and low dispersion of pollutants). A high level of exposure is thus the product of a series of decisions or circumstances that determine the number of trips made, their distribution over space and time, the choice of routes, the driving characteristics of drivers and where people spend time. From an environmental point of view, the critical features to address by traffic management are the variability of traffic speed and the location of major traffic flows, particularly congested flows.

Reducing Emission Rates

Traffic mix is a dominant determinant of emission levels because of its impact on variability of traffic speed. This is a serious problem where motorized and non-motorized traffic shares road space. Measures to segregate these types of traffic on main thoroughfares is thus as important for environment as it is for safety reasons. In contrast, in residential areas it may be better to use traffic calming measures to harmonize speeds of different traffic categories at a safe level.

Traffic signal control systems are the most common traffic management instruments to secure traffic flow and safety objectives. However, because they achieve their advantages by bringing traffic flows to a stop, some have argued that they are a major cause of air pollution and should be replaced by roundabouts or fly-overs [1]. Other commentators have challenged the validity of this claim, arguing that the pollution impacts of traffic signals are highly situation-specific.

Some conclusions on traffic signals are widely accepted. Linking of uncoordinated signals to create "green waves" can reduce travel times by 10 percent and emissions by a similar proportion in the controlled area, and allowing "nearside turn on red" (left turn where vehicles are driven on the left side of the road) gives another 1.5 percent improvement. Cycle lengths that minimize pollutant emissions are 50 percent longer than those that minimize delays, and in heavy traffic conditions these extended cycle times can reduce emissions by up to 3 percent. The most efficient are Area Traffic Control (ATC) systems, which link signals across whole networks. These systems can be made traffic responsive on a real time basis but are more expensive in terms of capital equipment (partly because of the need for more traffic sensing equipment). However, ATC has a chequered history of contract failure, dispute and procurement difficulties in developing countries. The Phase I ATC system in Bangkok, installed in 1996, still functions imperfectly due to lack of sustained co-operation from the traffic police [2].

Bus priority systems [3] change the relative travel times by bus and car and, particularly if supported by parking restraints, encourage people to use the more space-efficient public transport modes. Congestion levels may thus be reduced. More importantly, they increase the average and reduce the variability of bus speed. A range of priority measures was shown to reduce bus exhaust emissions in London by between 7 and 60 percent (Table 1). The most effective of the measures, the segregated busway, has subsequently been developed as a mass transit system in Curitiba and Bogotá.

Table 1. Bus Priority Measures in London [4]

Measure	*Proportion of buses affected*	*Exhaust emission reduction*
Peak period bus lane	5%	20%
Contra-flow lane, all day	2%	35%
Signal pre-emption	20%	12%
Segregated bus street	2%	60%
Priority turns	5%	7%

Traffic incident detection coupled with prompt appropriate response can reduce congestion significantly. Much congestion in large cities can be attributed to the dislocation effects of what may be relatively trivial accidents. The ability to identify incidents, remove obstructions and redirect traffic can thus be effectively used to improve traffic flow.

Parking policies have impacts both on the effective supply of road space and the demand for it. In many developing countries, both the highways and the walkways are encumbered with parked vehicles that congest traffic and increase air pollution. Strong regulation to limit on-street parking to locations where it has no effect on traffic flow is thus likely to be the appropriate "supply side" response.

This is often accompanied by the imposition of minimum parking provision requirements in all new developments to create enough off-street parking space to cater for all vehicles wishing to access the development. As long as the costs of parking space are recovered through property rents, parking users can be said to be paying directly or indirectly for the space allocated to parking.

Unfortunately road space and parking space are jointly demanded so that the provision of off-street parking space may attract new traffic, offsetting the gains from getting parking off the streets. If road space is provided below cost, then jointly demanded good (namely parking) should be charged more than its full costs in order to avoid excessive vehicle use of roads. For that reason, many industrial country cities use parking pricing and availability as a demand restraint measure. The amount of parking in any area is limited to the maximum level considered necessary to support an "optimal" amount of road use. Pricing and parking supply regulation is used to implement this strategy, which also implies specification of maximum (rather than minimum) parking provisions for new developments.

Restraints on vehicle use have been used in several cities in both industrial and developing countries. The most popular restraint measures are schemes that limit use of vehicles on specific days according to their registration plate number. These have been introduced in many cities including Athens, Bogotá, Lagos, Manila, Mexico City, Santiago, São Paulo and Seoul, for both congestion and environmental reasons. There are obvious risks to the "odds and evens" policy (that is, vehicles with registration numbers ending in odd digits cannot drive on certain days, and those ending in even digits cannot drive on other days) and its variants. They may encourage an increase in the number of vehicles owned, and induce more trips by permitted vehicles than would otherwise have been made. In particular, they may encourage the retention in operation of old, highly polluting vehicles that would otherwise have been scrapped. But they have worked in the short term (Bogotá reports 20 percent increase in average travel speeds). Above all, they have achieved public acceptance as a demonstration of commitment by government to reduce congestion and air pollution, and have proved less difficult to enforce than might have been expected. If well designed to discourage peak use and coupled with public transport improvements, as in Bogotá, they can at the very least give a "breathing space" to develop even more effective policies.

Protecting Sensitive Locations

Ring roads are not traffic management per se, but are often advocated as the basis on which it is possible to introduce environmental traffic management. The basic argument is that by providing adequate capacity to navigate across the town it will be possible to keep through-traffic out of environmentally sensitive areas. In some small or medium cities that have followed policies of restricting vehicle access to central areas, such as Freiburg, Germany, this has worked well. But in many it has not, for two main reasons:

- Improved radial or ring road performance increases the number and length of trips made to the extent that total traffic and total emissions actually increase. Both average speeds and journey times may be increasing simultaneously.
- The supporting traffic management necessary to take advantage of the "breathing space" is not implemented. This has been a particular problem in Chinese cities such as Guangzhou and Shanghai.

Pedestrians are poorly served in many developing countries. They tend to be controlled rather than provided for. Footways are often not provided, and when they are, are left in poor state of repair or taken over by traders and parked vehicles. The consequence is that pedestrians are forced to walk in the highway pavement. This is not only unsafe, but contributes to traffic congestion. Provision of adequate pedestrian facilities increases safety and encourages pollution-free walking as the preferred mode for short trips.

The ultimate protection for pedestrians is total banning of motorized traffic in particular areas. Pedestrianization of city centers began to gain popularity in Europe about 40 years ago, and is now a feature of most city center plans.

Other restraints on vehicle movements are usually targeted at particularly sensitive areas. Spatially the most common restrictions relate to access to central business districts (CBDs). The "cell system," introduced in Gothenberg and replicated in some British towns such as Oxford and Leeds, uses physical restrictions on cross center movements to keep through-traffic of private vehicle, but not buses, out of the CBD. Some schemes also discriminate by vehicle type. The bus franchising system in Santiago, Chile limits the number of buses licensed to operate into the CBD. Some European cities specify particular routes for heavy goods vehicles, or may completely ban their access to central premises during the daytime (as Delhi has done). The difficulty for many developing countries is that important commercial establishments, such as ports and major markets, are located in or close to downtown areas.

Pricing by means of fuel taxes to reduce air pollution is considered in another note [5]. We comment here only on direct pricing of vehicles as a means of reducing congestion. Direct pricing can include charges for entering or traveling within a designated part of the city experiencing congestion (typically the CBD), for use of selected road links, or for parking. Physical restraint measures have hitherto proved more acceptable than direct charges for road use both in industrial and developing countries. Even in industrial countries, however, their effectiveness appears to have been exhausted. Direct charges for traveling in designated areas prone to traffic congestion are now being planned in some European countries. Singapore—which has for many years taxed vehicle ownership very heavily as well as being a pioneer in charging motorists for traveling into the city center—is now placing a greater emphasis on vehicle use rather than restrictions on ownership. In the few cases in OECD (Organization for Economic Co-operation and Development) countries where direct cordon or area congestion prices are charged, part or all of the revenues have been earmarked for public transport improvements. For cities in developing countries, which lack resources to finance urban transport, the introduction of direct charges might thus be expected to have a double attractiveness as a source of finance as well as an instrument of restraint.

One aspect of restraint is particularly important. Both theory and practical experience indicate that combinations of car restraint and public transport improvement will work better than either in isolation, at least in their effect on travel to city centers. A coherent policy is therefore likely to include a combination of measures.

The Limitations of Traffic Management

Traffic generation. It is widely acknowledged that improved traffic management may induce more or longer trips to be made so that congestion is little relieved and total emissions may even increase. Detailed evidence of the traffic generating effects of urban ring roads has been assembled in analysis of the M25 motorway around London. Traffic management in industrial countries has been estimated to reduce emissions by 2-5 percent overall, but by much greater proportions in specific corridors or areas. Because of the worse initial situation, the potential in some developing country cities should be much greater. However, traffic management is likely to realize the potential to reduce air pollution only if supported by measures to restrain new traffic generation.

Technical capabilities. Good traffic management requires effective planning, implementation and enforcement skills which tend to be in short supply in developing countries. Critical to the successful implementation of traffic management measures is the establishment of a traffic management unit at the local government level with the consolidated authority and ability to plan and implement suitable traffic management schemes. Similarly, the role of the police in complementary enforcement activities is crucial.

Continued commitment. Traffic management is not a guaranteed, one-shot cure for traffic congestion. It needs constant adjustment and enforcement to be effective. Where it does not involve any major engineering (as for instance with bus or non-motorized transport priorities), the program can fall away quickly. The commitment of the police to maintain enforcement of measures is particularly critical. The traffic management systems implemented in Mumbai and Manila in the 1980s are now largely out of commission.

Conflicts of interest. The difference between traffic signal settings for delay and for emission minimization was noted earlier. Other conflicts of interest may occur between jurisdictions competing for business, because restraining parking freedom can discourage trade in their area. Some conflicts are perhaps inevitable. But their incidence can be minimized both by better information (for example, evidence that city center pedestrianization actually increases local trade rather than reduce it) and by institutional coordination to prevent "beggar-my-neighbor" policy competition between jurisdictions (that is, hoping that other districts, but not this one, will restrain parking).

Conclusions

Worldwide experience points to some important conclusions about the environmental impact of traffic management policies in developing countries.

- Traffic management measures have been shown to improve traffic conditions and reduce emissions significantly by reducing the number and duration of stops and permitting higher travel speeds.
- Traffic management measures are relatively cheap and quick acting.
- They can, however, induce additional travel that may have to be restrained by introducing traffic demand management measures to ensure the sustainability of the traffic and pollution benefits.
- A combination of traffic engineering measures, demand management measures, and measures giving priority to public transport vehicles has been shown to be the best approach, especially in large cities with high volume travel demand corridors.
- Traffic management strategies need a high and continuing degree of political, institutional and human resource commitment to ensure that their benefits are sustained.
- The establishment of traffic management units with appropriate authority and ability to plan and implement traffic management measures is essential.
- The involvement of police authorities working in concert with traffic management units is critical to successful traffic management.

References

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