Forum

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The Impacts of Technology on Vehicle Emission and Congestion Reduction

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A few years ago an editorial in *The Economist* (1994) called pollution and traffic congestion the two major bugbears of modern life, after crime. For years the struggle to combat traffic congestion and pollution has been waged by technologists and planners in their different ways. What distinguishes the two approaches and what are their respective prospects of success?

Technologists and planners approach these problems with a fundamentally different perspective. The solutions proposed by planners, be they urban planners or transport planners, assume some form of behavioral modification by city dwellers. In the case of urban planners, this typically involves people accepting to live at higher densities and in more mixed land uses. In the case of transport planners, their solutions are designed to encourage us by means of 'carrots' and 'sticks' to travel by means other than driving alone. By contrast, the technologists' solutions let us continue with our current lifestyle and patterns of travel behaviour. Mechanical engineers try to give us low emission or zero emission vehicles, while traffic engineers try to accommodate more of us on the same quantity of highway space, ideally at higher speeds. The contrast is redolent of two different approaches to weight and cholesterol reduction. The medical profession says we must change our diets, while pharmacologists try to design chemical products that would accomplish the same result with little or no change in our dietary habits. In both cases, we the public would rather have the technological fix than have to modify our behaviour.

Nor is it only on the demand side that there is a similarity of motive in these two fields. On the supply side the financial stakes are high not only for those seeking a technological solution to the dietary problem but also for those seeking technological solutions to vehicle pollution and congestion problems. Consequently concerted efforts are being made in the form of large investments in technological research and development in all these problem areas. By contrast efforts to get us to change our behaviour are slight in the cases of diet and traffic pollution and congestion. Although governments have much to gain from us changing the way we travel they rightly judge that the mood of the travelling public is not likely to welcome serious restrictions on its urban travel choices. Only politicians with a political death wish are likely to have the stomach to tell us to leave our cars at home more often or live at higher density. Having said that, what seem to be the prospects for technological solutions to the vehicle pollution and congestion problems?

The struggle to cut air pollution by replacing the internal combustion engine with electric vehicles is beginning to show signs of success, raising the hope that one of the two bugbears can be eliminated 'in our time.' Some of the best evidence of this success is the announcement last April by Ballard Power Systems of Vancouver and Germany's Daimler-Benz AG of plans, since finalized in August, to spend more than $450 million to develop and eventually produce and market PEM (proton exchange membrane) fuel cell power plants for cars, buses and trucks. Since April there has been a series of press announcements involving further agreements between Ballard and the Ford Motor Company and Ballard and Methanex, the world's leader in methanol production and marketing. Indeed Ballard, the world leader in fuel cell R&D has by now signed agreements with most of the world's major car manufacturers. At its April press conference in Vancouver, Daimler-Benz's Senior Vice-President, Dr. Ferdinand Panik, said there could be a commercial fuel cell car ready by 2005. Market expectations about Ballard's technology reached fever-pitch in October just as this piece was being written with its share value soaring from $55 to $84 in one week, despite the company never having posted a profit! Already experimental buses using Ballard's hydrogen-powered fuel cells are being tested by Chicago's transit authority and are shortly to be tested by Vancouver's. Apparently the problem of increasing the energy density of fuel cells to make them small enough for cars has been substantially solved.

If it proves feasible to reduce mass production costs of fuel cells for cars and to solve problems of on-board fuel storage, we could be on the verge of a transportation revolution that would rival the move from steam power to the ICE a century ago. This time, however, the apparent effect on urban air pollution and global warming would be positive and permanent. Or would it? If motor vehicles, which are the major source of demand for oil in advanced economies, begin to be powered by hydrogen or methanol, the most likely economic consequence is a sharp fall in the price of oil. This in turn will encourage its inefficient use in other sectors of the economy and will increase its consumption by transport in third world countries where old vehicles have a much longer life. Such a scenario calls into question just how dramatic the decline in global CO_2 emissions will be, if fuel cells take over from the ICE in cars, buses and trucks in advanced economies. Perhaps the decline in CO_2 will be small, especially as the demand for cheap motorized two- and four-wheel transport will continue to grow rapidly in large countries like China and India. Instead, the most likely consequence of the fuel cell is a geographical redistribution of urban-based vehicle emissions from the developed to the developing world, with a commensurate improvement in health in the cities of advanced economies and a further deterioration of health in third world cities. The above suggests that at least in the foreseeable future the effect of a seemingly beneficial technological innovation such as the fuel cell might be only slightly better than a zero-sum game. This is not to suggest that R&D on vehicle fuel cells is not in the long run highly worthwhile. It is and will be, particularly once most of the motorized world uses it. Rather we need to remember the effect of a simple law of economics as it applies to oil. The lower the demand, the lower the price will fall, which increases the inefficient use of oil as well as attracting consumers in poorer economies into the market, thus maintaining the demand for an environmentally harmful substance like oil. It is unrealistic to expect the governments of these economies to stem artificially the pent-up demand for motorized vehicles through taxation of motor fuel or vehicles, as happens in Singapore. Unlike Singapore, part of the engine of growth of economies like China and India will be supplying the demand for the most prized of all consumer durables, a motor vehicle.

Beyond such economic caveats, the geopolitical consequences of the fuel cell could be even more harmful than its beneficial effect on local urban air pollution in advanced economies. If the price of oil declines and government oil revenues decline in OPEC, despite price-driven increases in demand from poorer countries, the macroeconomic and even geopolitical consequences could be dramatic. Developing countries that depend heavily on oil revenue to fuel domestic economic growth and social and educational programs may find themselves unable to continue such policies. This will not only cause domestic unrest but in some cases is likely to have adverse political repercussions beyond their frontiers. Indeed the balance of power in certain strategically sensitive areas in the Middle East may be upset. And in several Islamic nations including Libya, Saudi Arabia, Iran, Iraq and Indonesia, the negative effects on national revenue could be politically destabilizing. So the consequences of a dramatic shift in energy demand resulting from the commercialization of the fuel cell may include some unwanted and unintended surprises. As usual progress comes with a hidden price tag.

Returning to the cities where the beneficial effects of the fuel cell would be most welcome, even here we may find some unexpected negative consequences. Over as little as a decade the pollution-related justification for finding ways to reduce traffic volumes in cities would disappear. This could set back attempts to solve traffic congestion problems and to reduce the associated economic and convenience costs, particularly in Southern California where pollution is the primary driving force in the fight against traffic congestion. Of course one might hope that work on traffic congestion reduction would continue simply because it constitutes a growing financial burden on advanced economies that increasingly depend of the rapid movement of freight by road. Also the public clamour for solutions will grow as the problem continues to worsen and commuters spend increasing amounts of time commuting.

As in the case of pollution reduction, so too in the case of congestion reduction technological solutions by traffic engineers may seem to have more prospect of success and public acceptance than the solutions of urban and transport planners that expect us to change our residential and transport choice behaviour. Intelligent Transportation Systems (ITS) is the general term for this suite of technological solutions. Seen from a narrow engineering perspective, they all demonstrate real improvements in travel time for the urban traveller whether travelling by car or transit. However these gains almost always ignore one critical fact. The behavioral responses of travellers to ITS improvements may cancel out much of their benefits. For example an Advanced Traveller Information System (ATIS) which provides real-time on-board information about the relative level of congestion on alternative routes is liable to divert more drivers to the less congested routes than they can handle, if many people respond simultaneously to the same message. The result could be that the optimal routing continues oscillating back and forth between routes as the updated information on traffic delays keeps revising which route is fastest. This sensitivity to behavioral responses is a problem with ITS and traffic engineering solutions that is not shared by mechanical engineering solutions to vehicle pollution problems.

The ITS solution that attracts most attention and would almost certainly be the most costly to implement is the Automated Vehicle Highway System (AVHS). It can control the speed, spacing, steering and braking of vehicles. It is typically envisaged as allowing roadway throughputs to be multiplied five or tenfold, with vehicles moving in closely packed platoons at high speed. Some have uncharitably described AVHS as a high-tech multi-billion dollar rescue program for former defense contractors now that the Cold War is over. Be that as it may, AVHS is certainly an example of a product-oriented mindset, in that its technological advocates focus on the ostensible benefits of a product that it is in their commercial interest to produce, but give little attention to how much it will actually help drivers reduce their total trip time. In particular the technology-driven approach fails to address what happens beyond the immediate confines of the automated highway and whether the behavioral responses of road users to it might reduce its effectiveness. Downs (1996) suggests that if automated highways become as popular as their advocates suggest, there will be massive pile ups of traffic at highway exits because the automated highway will feed traffic onto local streets near exit ramps at a rate well beyond their capacity. The resultant tail-backs on the highway will defeat its purpose and result in a chain reaction of speed reductions along the highway to match the capacity of local streets to absorb exiting vehicles. It is economically and politically unrealistic to imagine that cities, particularly in their core areas, will be willing to sacrifice significant numbers of commercial buildings to make way for a greatly enlarge number of exits and/or enlarged local service streets. It is equally politically unrealistic to believe residents affected by such changes would accept such a sea change in the volume and speed of traffic.

A similar problem is likely to occur in the evening peak period in areas with high concentrations of jobs. Too many vehicles attempting to join the highway will again congest local streets causing delays which will partly cancel out the benefits of higher speeds on the highway. Therefore the optimal volume on many automated highways is likely to be dictated not by the capacity of the highway but of it entry and exit points and adjacent local streets. The most obvious way of setting that limit is through road pricing. It is possible that the exit/entry point constraints could be so low that much, if not most, of the extra capacity generated by the AVHS would be redundant. If so, a much less costly solution to the highway congestion problem would be road pricing alone without an AVHS. Without such a regulating mechanism the door-to-door travel time of many commuters, including the delays to enter and exit the highway, may be reduced by much less than expected. It is after all the reduction in door-to-door travel time that is the purpose of the exercise not simply higher speeds on the line-haul section of the route.

It is also not obvious that automated highways will help reduce emissions. Assume that vehicles will travel much faster on parts of the automated highway than on its predecessor. Assume also that this attracts many more vehicles to it with attendant longer delays entering and exiting than at present. The net effect on fuel efficiency of stop-and-go conditions at entrances and exits combined with high speeds on parts of the highway may in fact be no better than at present where line-haul congestion is the main cause of lower fuel efficiency. Also to the extent that the automated highway is successful in diverting travellers from other more direct arterial routes, the increased mileage travelled may increase fuel consumption. And if the system is so successful that it diverts non-captive transit users to become drivers, fuel consumption and pollution will increase.

Travellers will continue to divert from other routes, travel times and modes to the automated highway until its increased volume causes sufficient congestion for the travel time to be approximately the same as by alternative routes for the marginal user. Only if we can predict these diversions and the associated bivariate frequency distributions of travel speeds and increased travel distances can we estimate the effect on both travel times and vehicle emissions. Unless we have reliable behavioral models of the simultaneous choice of route, mode and time of travel time, combined with adequate sample data on origin-destination pairs, it is a leap of faith with a very large price tag to advocate AVHS as a means of significantly improving travel times or emissions. Furthermore too much, for this writer's comfort, of the seemingly supportive evidence for AVHS comes from the sector that stands to benefit most financially from its development.

None of the above is meant to imply that research on mechanical and traffic engineering solutions to our urban traffic problems are unwarranted. We clearly need all the help technology can provide. But we also need more holistic problem-oriented and less product-oriented approaches to research in this area. We need to explore the direct and indirect effects of attractive innovations whose side effects may be worse than the disease they are intended to cure. In some cases involving massive public infrastructure investments, such as the AVHS, we may be alerted to the imprudence of the venture. In others where largely private-sector initiatives are involved and where, as in the case of the ZEV, there is an overwhelming direct environmental benefit, society may embrace the innovation and hope the negative side-effects can be contained by various means. In all of this one is struck by the inexorable combined power of technology and market forces in shaping not only economic history but also urban form and political history.

References

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