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Managing congestion – Are we willing to pay the price?

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ABSTRACT: A number of authors have written on the topic of congestion, both pointing out that it is not necessarily wholly undesirable, and also that it may not be susceptible to being reduced, let alone eliminated. Nevertheless, concerns continue to be raised about the costs of congestion, both to freight and passenger movements, and solutions tend to be put forward mainly in terms of capacity increases at particular congestion locations. This paper explores the extent of the problem of congestion and current trends in Australia. It looks at current policy directions and their impacts on congestion. It concludes that the most politically popular strategies are unlikely to make any impression on congestion, and may even exacerbate it. It then considers some possible changes in policy directions and investment and examines the likely impact that these would have on future congestion. The paper concludes that congestion is unlikely to be reduced significantly and that there will be major challenges to maintain congestion at current levels, as opposed to having it get considerably worse. A comprehensive program of strategies is required to even maintain current congestion levels, and the paper also concludes that a central policy that must be considered is that of time-distance-place user charges.

KEY WORDS: ***Congestion management, congestion, transport policy, road user charges***

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1. Introduction

Traffic congestion is becoming an increasing issue in Australia's capital cities, and elsewhere in the country, as evidenced by both newspaper reports and political statements of current issues. Growth in the number of private vehicles has been outpacing population growth for some years. Growth in vehicle kilometres of travel (VKT) has been at an even higher rate than growth in vehicle ownership. At the same time, truck traffic has also been growing faster than population growth. Because trucks have a much greater impact on the traffic flow than the equivalent number of private passenger cars, increases in truck traffic have a disproportionately larger effect on traffic flow and, hence, congestion. Overall statistics for VKT, vehicles, and population are shown in Figure 1 for the period from 1971 to 2005. The figures demonstrate the disparity in growth rates.

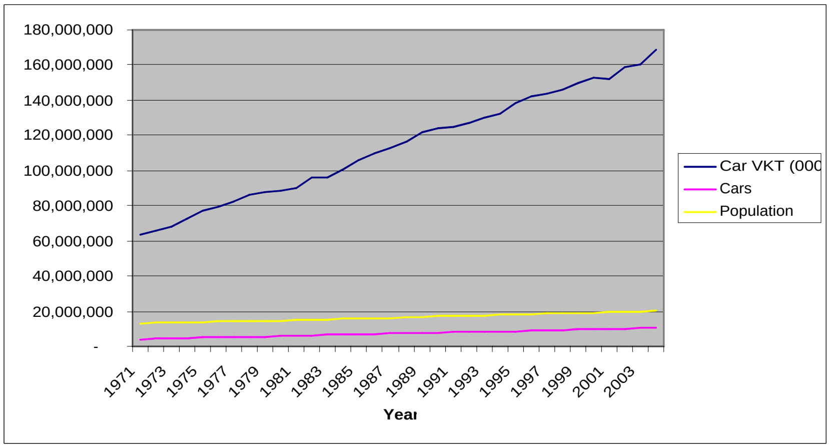

Figure 1: Car VKT, cars, and population in Australia 1971-2004 (Data provided by BTRE)

Because of the scales in the graph, it is worth pointing out that cars per capita have increased from 0.31 in 1971 to 0.53 in 2004. Similarly, VKT per capita has grown from 4,882 to 8,403. This means that we have 71 percent more vehicles per person in 2004 than in 1971. Those vehicles are used for about the same amount of driving on average, so that, as a result, the amount of travel per person has increased by a factor of 72 percent. At the same time, the road system has not expanded at anything close to this rate. Indeed, figures on investment in roads show a growth rate of less than 1.6 percent per annum in investment in the road system by all levels of government in Australia, representing less than a 60 percent increase in road capacity in that same period.

Figure 2 contrasts the rate of growth of population and cars with the rates of growth of the entire road network and the sealed roads. In fact, the graph shows a shallow decline in total road length in kilometres and a slow growth of sealed road. When one then looks at the VKT growth in Figure 1, contrasted to the population and car growth, one can see clearly that the rate of growth of VKT is far outstripping additions to the road network. The result of this contrast in growth rates will be increasing congestion, especially in urban areas.

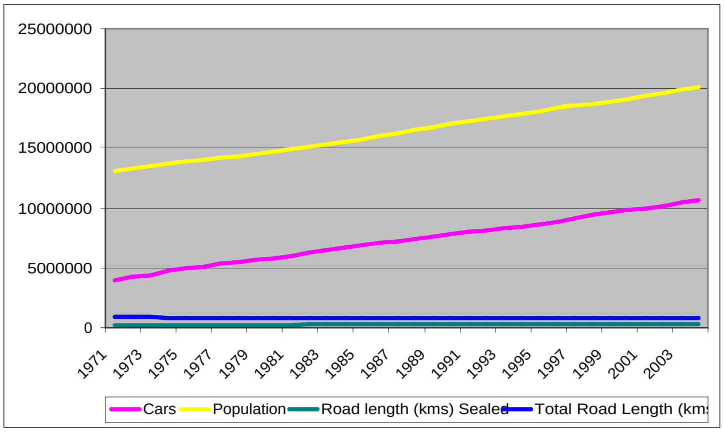

Figure 2: Growth of population, cars, and road length from 1971 to 2004 (Source, BTRE figures)

1.1 History of Congestion

Perhaps, before proceeding further, it is worth examining the question as to whether traffic congestion is a modern-day phenomenon, or if it has existed in prior times. In fact, it is far from a modern phenomenon. It appears that cities in the Ancient Roman Empire experienced traffic congestion, as did medieval cities. Indeed, it seems that traffic congestion has existed for as long as there have been conurbations, with only the nature of congestion having changed over the years. For example, in the 1860s, Walt Whitman described traffic in Manhattan in the following terms:

"...[similar to] military battles, where regiments and platoons clashed in violent disarray. Wagons, lorries, carriages, and omnibuses moved at different speeds, manoeuvred in and out of traffic, and dodged from one side of the street to the other." (quoted in Hood, 1995)

Another commentator described peak period streets in Manhattan in 1860 as "...a solid mass of braying, animal-powered vehicles..." (Hood, 1995). Pictures can be found depicting serious traffic congestion in London from the early nineteenth century to the present day.

Congestion today also occurs in cities throughout the world, both in less developed and more highly developed countries. Cities such as Bangkok, Mexico City, Jakarta, and Bombay are notorious for the levels of traffic congestion, as are cities such as London, Los Angeles, San Francisco, and Atlanta. Entering the phrase "Traffic Congestion" in Google® produces more than 10 million hits. The latest analysis of traffic congestion in the US (TTI, 2005) suggests that traffic congestion is getting worse throughout the US, although the largest cities are experiencing worsening traffic congestion at the greatest rate.

Writers on congestion have also pointed out that congestion in many areas of marketing and economics would actually be a sign of success. For example, if one were to build a sports stadium and it became congested for every game, the owners would be more than delighted. Long queues at a restaurant or at a theatre box office would also be considered to be signs of success. As suggested by Taylor (2002), possibly we need to view traffic congestion differently. Perhaps, it is an indicator of the success of the development of a city, rather than a negative. Nevertheless, it is clear that people complain about traffic congestion, and that politicians, because roads and highways are predominantly provided by the government sector, feel that something needs to be done about traffic congestion.

In the balance of this paper, we take a further look at the dimensions of the problem and common solutions that are put forward as to a way of solving congestion problems. We then examine a number of other options for managing congestion and draw conclusions about what appear to be the most important policy directions for the future in Australia's major urban areas.

2. Sydney as a case study

A few facts are useful to understand more about the problem of growing congestion. To illustrate the issues, we use figures from Sydney, although Sydney does not necessarily have the worst congestion in Australia. In 2004, the population of Sydney was approximately 4.17 million persons. According to estimates from the Transport and Population Data Centre (TPDC), these 4.17 million people made about 15.8 million trips per day (TPDC, 2006), or an average of 3.8 trips per person per day. Of those trips, 70.5 percent were made by private vehicle, consisting of 49 percent by vehicle driver and 21.5 percent by vehicle passenger. The overall private vehicle share of trips is increasing, as is the percentage of vehicle driver trips, although the percentage of vehicle passenger trips is declining. After private vehicle, the next most common means of travel is walking, which accounts for 17.2 percent of trips. Public transport carried a total of 9.9 percent of daily weekday trips in 2004, with 4.6 percent on rail and 5.3 percent on bus. Comparing these figures to 1999, rail has lost 0.3 percent of the market and bus has lost 0.9 percent of the market. On average, from 1999 to 2004, VKT was increasing at about 1.2 percent per annum, while population was growing at 1.0 percent per annum and vehicles per household were growing at about 2.4 percent per annum (TPDC, 2006). It is also stated quite frequently in Sydney that the rail system is running at its current capacity, at least insofar as train operations are concerned. Travelling in Sydney's peak on the train also suggests that the system is operating near capacity in terms of number of passengers carried.

Given these statistics, it would be interesting to examine the result of extrapolating these figures into the future. For this, we assume that population growth continues at 1 percent per annum, and that VKT grows at 1 percent per annum. Weekday trips were reported to be growing by 0.9 percent over the period from 1999 to 2004 and weekend trips by 1.1 percent. We assume that trip making grows by 1.5 percent per annum, which is a balance between the past year or so and about five years ago. The result of this growth over the next 25 years (to 2031) is shown in Figure 3.

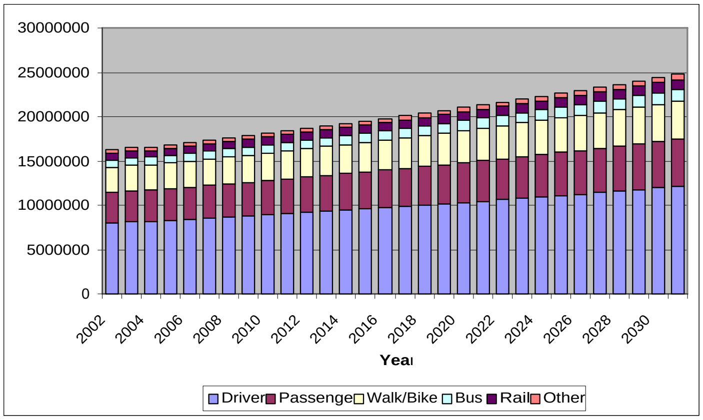

Figure 3: Potential growth in Sydney travel by mode to 2031

In Figure 3, the first three bars are actual figures, and the remainder show the result of applying 1.5 percent per annum growth on the number of trips per day. As can be seen from this, the total number of car driver trips would increase, in this scenario, from over 7.9 million in 2002 to 12,1 million in 2031. This represents an increase in cars on the road of about 53 percent over this time period. Thus, if we consider that the roads in Sydney are congested today, then by 2031, we will be looking at a much more severe situation. Of much more concern, perhaps, is that this also shows that train trips increase from 768,000 in 2004 to almost 1.15 million in 2031, and bus trips also increase from 881,000 in 2004 to 1.32 million in 2031. These increases are also of around 53 percent, because we assumed that the market shares remain unchanged. A worse scenario for congestion occurs if we assume that recent trends in public transport ridership and car use continue. In that case, we might assume that bus stabilises at about 1 million rides per day and rail at about 850,000 trips per day (since we have noted that rail is near capacity now), an increase over today of about 15 percent for bus and over 10 percent for rail, and the rest of the increase shifts to the car. This would add about 650,000 more trips to car. Assuming that two thirds of this goes to car driver, then we would see cars on the road increase to almost 12.6 million trips per day, an increase of nearly 60 percent in Sydney's road traffic. Even if most of this increase occurs outside the central business district, it will result in very major increases in congestion throughout the network.

2.1 Dealing with congestion

Given these scenarios, one would wish to question how to deal with the resulting congestion. There are several questions that one might wish to raise in this context:

- Will increasing fuel prices result in reductions in congestion?
- Can public transport investment reduce or eliminate congestion?
- Can increasing the capacity of the road system reduce or eliminate congestion?

2.1.1 Increasing fuel prices

Anecdotally, most cities in Australia have reported some increase in public transport ridership as a result of recent fuel price spikes. However, while the increases in public transport may have been noticeable in terms of public transport ridership, the overall reduction in highway traffic has been negligible. This can be explained in part by looking at the comparative journey to work mode figures for Australian cities, shown in Figure 4.

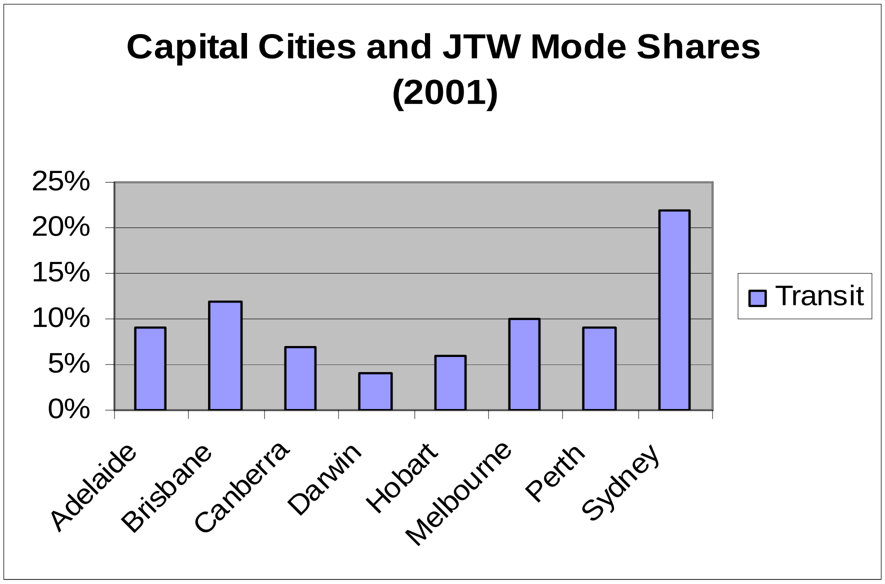

Figure 4: Public transport mode shares in Australian cities, 2001

As can be seen in Figure 4, in 2001, Sydney had the largest public transport share of the market for the journey to work, with about 22 percent of trips by public transport for commuting (which had dropped to 20 percent by 2004). Despite this figure, the overall market share of public transport, as noted earlier, is less than 10 percent. Brisbane with 12 percent and Melbourne with 10 percent for the commute probably indicate shares of the overall market of less than 5 percent for public transport. An increase of several thousand rides on public transport, especially in the peak period, may translate to a significant increase for the public transport operators, but it will be insignificant in reducing highway traffic. For example, suppose in Sydney that there is an increase in bus ridership of 25,000 new rides per day. This will probably represent a reduction in car trips of no more than about 18,000, out of the almost 8 million per day – not a very noticeable reduction. At the same time, the public transport operator feels that there is a substantial increase in ridership taking place, where 25,000 new rides added to a peak ridership of 278,000 represents an almost 10 percent increase in ridership.

Interestingly, a recent poll by the Sydney Morning Herald and ACNielsen revealed that about 74 percent of Sydneysiders currently do most of their travel by car and that 60 percent of all respondents would not travel more on public transport, even if services were improved (Clennell and Baker, 2006). This survey was done during the recent spike in petrol prices. It shows that people are strongly attached to their cars. Even among those who currently use public transport, there is little indication of a willingness to use public transport more. The same survey found that about 13 percent of Sydneysiders currently travel mostly by public transport and 13 percent travel almost equally by public transport and car. Even among these two groups, only 45 percent indicated that they would possibly use public transport more if services were to be improved. These results are reported for what must be considered to be the most public transport oriented capital city in Australia, based on Figure 4. One could assume that residents of the other capital cities would be even less likely to consider switching to public transport, even if services were improved.

To date, there appears to be little evidence that people are driving less, as a result of increased fuel prices. Other anecdotal surveys by newspapers and others have reported that reducing driving is low on the list of actions that people expect to take in response to fuel price increases. Reducing the number of times they eat out, and economising in other family budget areas appear to be the principal response that is given, but cutting back the amount of driving is quite far down the list. In fact, according to Sensis (2005), only about 21 percent of drivers in 2005 indicated that they had cut back on driving as a response to rising petrol costs in Australia. We must conclude that the evidence to date indicates that increased fuel prices will have only a modest effect on the amount of driving and, consequently, on congestion.

2.1.2 Public transport investment

This continues to be one of the most popular political responses to congestion and air quality concerns. However, it is an ineffective policy. To illustrate this, we use the case of Sydney. As noted earlier, public transport in Sydney in 2004 carried a total of about 9.9 percent of the 15.8 million daily trips. Suppose that policies and investments were put in place that doubled this market share (an achievement that has never been attained in any city in the world in the past 50 years). We will round figures up, and assume that this means that public transport will carry 20 percent of the current market. This would mean total public transport ridership of 3.16 million daily trips, compared to the current 1.65 million.

Looking at morning peak trips (because the morning peak is higher than the evening peak, as shown by Figure 5), in 2004 train carried 255,000 trips and bus carried 278,000 trips (TPDC, 2006). If we look at doubling these figures, then bus will need to carry about 560,000 trips and train about 510,000 trips. The morning peak is defined as the period from 6:30 a.m. to 9:30 a.m. Total car driver trips in that period were 1.74 million in 2004. There were also 710,000 car passenger trips, and 448,000 walk only trips, apart from a small number of ferry trips and trips by other modes, such as bicycle. Assuming that the new public transport trips are drawn proportionately from car and walk, then we might expect that this increase in public transport trips would reduce car driver trips by about 315,000 in the morning peak. The remaining trips would be drawn from car passenger, walk, and other modes. In other words, the total of car driver trips would drop from 1.74 million to 1.43 million, approximately.

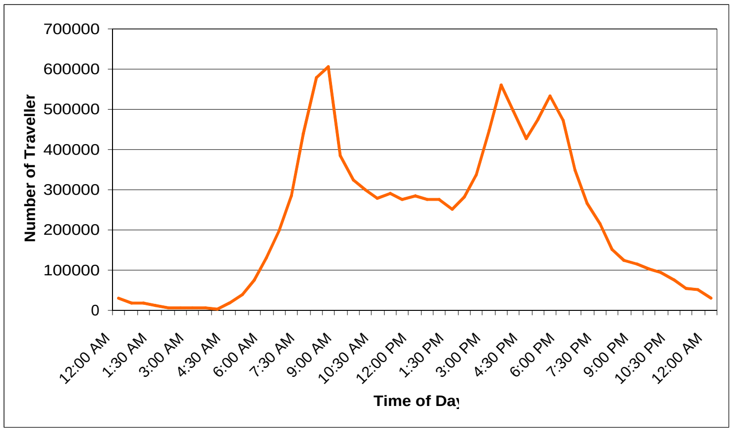

Figure 5: Motorised trips by time of day for Sydney in 2003 and 2004 (Source: TPDC, 2006)

Continuing with this hypothetical situation, we need to consider what this would require in the way of increased bus and train services. We estimate that the current peak bus requirements in Sydney are about 3,200 buses. Assuming the same load factors could be achieved as on current service, doubling bus ridership would double this figure, requiring an additional approximately 3,200 buses (allowing for spares to cover breakdowns and other problems). So far as the trains are concerned, assuming a capacity of about 1,300 persons per train (including standing passengers), the additional passengers in the peak will require an additional 210 train services in the three-hour peak period, assuming that all trains run at capacity. Since actual average loading is closer to 850 passengers per train, train services would probably have to increase by 300. This represents an increase of more than one train every minute on the system, which the system is incapable of handling, without significant expansion. Currently, almost all services pass through Central station, where the peak service frequency is about one train every 2 minutes and is the maximum that the system can carry. Adding a further train every minute is clearly not feasible. In fact, it is questionable if any significant addition to services in the peak period is possible.

Of more concern, in this hypothetical situation, is where the passengers come from. It is probably true that the majority of bus and train routes are currently drawing substantially from along their existing routes, so that the new riders in this hypothetical scenario probably need to be drawn from areas that are currently either not served or have only very minimal service. For bus, this would not be too difficult, because buses can be put on many different streets. However, it does mean that the load factors experienced on current, long-established routes would not be attained for years on new routes. For rail, it is more difficult, and would presumably involve construction of new rail lines. We might assume that such construction efforts would require at least five years to accomplish, although realistically, it is probably more like ten years. Assuming growth in those years equal to the growth between 2003 and 2004, by 2012, which might be the earliest that we can have all this new capacity in place, the total peak period trips should have grown from the present 3.51 million to approximately 4.05 million trips, an increase of over half a million trips. Doubling the ridership of bus and rail actually involved a total of slightly more than half a million trips (535,000 to be precise). Therefore, if it takes five years to put the increased bus and rail capacity in place, and these patronage figures are attained, then the net gain is only about 10,000 trips above the growth that will have occurred over the period in which the capacity additions took place. Again, we can assume that probably no more than 7,000 of those are car trips. We have, therefore, achieved a reduction of 7,000 car trips, but an increase of probably more than 7,800 bus trips (current peak loading averages 36 passengers per trip). Given that a bus is equivalent to anywhere from 1.5 passenger cars on the level to as high as 6.5 passenger cars on a fairly steep grade, and given the hilliness of Sydney, we might take the passenger car equivalent of the buses as about 2.5, then this addition of bus trips represents the equivalent of about 19,500 car trips, or nearly three times the car trips we have reduced with this never-before achieved increase in ridership. To achieve even this requires that almost half of the additional public transport travel is accommodated on the rail system of Sydney, which we have already seen is likely to be extremely difficult.

In other words, what this brief hypothetical example shows is that, given we cannot achieve instantaneous major capacity increases, even a never-before-achieved doubling of public transport ridership in Sydney would realistically do no more than absorb the growth in peak period travel. Applying this same analysis to the rest of the day will lead to similar conclusions – the total growth in public transport patronage that we are seeking, if achieved in about a five-year period, would barely reduce any of current congestion. Unless one were to suppose that investment would then continue at a similar rate in public transport services, the result in the years following this one-time expansion of the public transport system would be a return to continuing growth in car travel, and concomitant congestion in the system. We are forced to the conclusion that public transport can do very little to *decrease* current congestion and is actually not likely, based on past experience, to lead even to keeping the present levels of congestion from worsening.

2.1.3 Increasing road capacity

Increases in road capacity are likely to lead to increases in total car use (Stopher, 2004a), based both on empirical evidence and on the theory of induced traffic, which suggests that increasing capacity of a road, especially a road that is currently congested, represents a decrease in the price of travel. From simple microeconomic arguments, the result will be an increase in the demand for travel. However, we also need to be cautious; this should not lead us to assuming that all road building is necessarily bad. First, if roads are built with the express intention of catering to new demands, as a consequence of population growth, then the arguments of induced traffic are generally irrelevant. As a result of growth in population, there will be an increased demand for road space, whether or not additional capacity is provided. This means that existing facilities, if not expanded, will become more congested over time. Second, where there are genuine bottlenecks in the system, adding capacity to remove these should result in some reduction in congestion, without necessarily inducing significant growth in total traffic (although growth may occur in some circumstances). Conversely, it is clear from the literature that we cannot build our way out of congestion. If new capacity is added to congested roadways, providing more additional capacity than is required to meet traffic growth arising from population growth, then the probability is very high that this new capacity will result in increased traffic growth, over and above that required for the population growth.

In looking at the numbers for Sydney in the preceding sections of this paper, we can see that there is the likelihood that traffic will grow substantially in the future. Suppose now that we acknowledge the unachievable, and set our goal instead as to maintaining the current market share of traffic carried by public transport. This still means that, in absolute terms, over the next five years, bus rides need to increase in the morning peak by almost 14 percent, which would result in about 39,000 new bus passenger trips in the morning peak period. Using the current peak bus loading, this would involve scheduling an additional almost 1,100 bus trips per morning peak period in the peak direction regionwide, or about 360 additional bus trips per hour. This implies an expansion of the present bus fleet by probably about 450 buses over the next five years. At today's prices, this means spending at least $45 million per year for the next five years and beyond on fleet expansion, let alone replacement of existing vehicles as they age. Rail will also increase by about 36,000 rides in the morning peak, or the equivalent of about 45 more trains per peak period – about 15 more trains per hour. At a minimum, this will require that improvements are made to current operations to permit closer headways for trains operating on the existing system, and may require new rail lines, or track expansion to accommodate even this modest increase. It will also probably necessitate purchasing additional rolling stock to accommodate the demand, unless existing trains are speeded up, so that the average turnaround of existing stock is improved significantly. We must also view this scenario against what has happened over the past five years. In that time, rail patronage has declined by 2,000 rides per day in the morning peak period, while bus rides have declined by 23,000 rides per day (TPDC, 2006). These changes have to be arrested and reversed even to maintain the status quo of market share for bus and rail.

At the same time, car driver trips can be expected to increase in the morning peak period to 1.99 million trips from the current 1.74 million, assuming that we are able to reverse the trends in bus and rail patronage and maintain the current market shares. Over the past five years, average vehicle occupancy has remained unchanged in Sydney, so we should probably assume that it continues unchanged into the future. This five-year growth suggests that we need to be able to handle an additional 250,000 car trips in the morning peak, or an average of about 83,000 more car trips per hour. In 2004, the average length of a car trip was about 10.5 kilometres. Therefore, assuming this average distance for the morning peak, this represents an increase of about 870,000 vehicle kilometres of travel per hour in the morning peak in the peak direction. Assuming an average arterial road capacity of about 1,000 vehicles per lane per hour, this increase represents a requirement to add about 870 lane kilometres in each direction to the highway system of Sydney, just to ensure that congestion gets no worse than it is now. For those who know Sydney, this is equivalent to adding 21 M2 motorways over the next five years, or a little more than 4 M2 motorways per year. Another way to think of it is in terms of the Lane Cove Tunnel, that, at the time of writing, has just opened. This is a 3.6 km tunnel of 4 lanes, i.e., about 15 lane kilometres of capacity. Assuming 2,000 vehicles per lane per hour on this facility (the maximum capacity for freeway lanes), the capacity addition required is on the order of 14 Lane Cove Tunnels per year. Not only does this not represent any attempt to build our way out of congestion, but it also only maintains traffic congestion as it is at present. Clearly, this level of highway building has not been achieved in Sydney over recent years, with the result that congestion is increasing.

2.1.4 Popular solutions to congestion

On the basis of this rather brief review of the situation, the popular prescriptions to alleviate congestion are actually infeasible options. We cannot depend on fuel price increases to make a significant reduction in car use, nor can we expect public transport, even with massive investments, to achieve any reduction in congestion. Indeed, we need to accept that substantial investment is required in the public transport system just to maintain its current market share. We must also acknowledge that, while we cannot build our way out of congestion, we must expand the road system significantly if congestion is to get no worse, and that this must be done with care so that it does not result in further reductions in public transport use and inducement to people to use the car more.

These conclusions lead to a question as to whether there are other approaches to the problem. In the remainder of this paper, we examine a number of other strategies and draw conclusions as to the probable optimum strategy to manage congestion. It is important to keep in mind that, based on the foregoing, we assume that it is relatively unlikely that we can do much to *reduce* congestion, and that the role of strategies into the future is to *manage* congestion and attempt to ensure that it does not get significantly worse than at present.

3. Managing congestion

The notion of managing congestion is at once an admission that we do not know how to eliminate or reduce congestion, or that the political and economic costs of making a serious reduction in congestion are not acceptable. It is reasonably clear that there is one way in which congestion could be reduced, although the costs of doing so are unacceptable. Let us first consider that option, so that we are clear about the basis of the rest of this paper.

3.1 Draconian road pricing

Economists have long maintained that traffic congestion on the roads is a good example of the 'tragedy of the commons' (Hardin, 1968). Simply stated, because roads in most places are free at the point at which they are used, there is little or no financial incentive to car drivers not to over-use them. This remains the case up to the point where the traffic becomes completely jammed, and the opportunity costs begin to limit further demand increases. Even where tolls exist, as is the case in many places in urban Australia, the costs incurred by drivers are unrelated to the amount that the roads are used, because these are flat charges, not varying by the amount of existing congestion, nor even, in most cases, by the distance that the driver travels on the facility. Clearly, as was argued in the 1950s by Milton Friedman, and expanded by the Transport and Road Research Laboratory in the UK (Smeed, 1964), if we charge motorists at the point of use, with a charge that varies with the level of existing use, and the charge is made sufficiently large, we will provide a financial incentive not to over-use the road space. However, if there is not sufficient capacity in other modes of travel to accommodate the drivers who will then opt not to use the road space, serious economic repercussions are bound to ensue. At the worst, the traffic that is suppressed would lead to loss of jobs, failures of businesses, and personal bankruptcies.

For example, in a rather simplistic way, we could consider that the reduction in traffic required to move from Level of Service F to D (TRB, 1994) requires a reduction in traffic volumes of about one third. This would mean that the road price would have to be set high enough to deter one third of motorists in the peak period. Using Sydney figures, this means we have to reduce the current morning peak volume of cars by about 600,000. Given the current average vehicle occupancy of 1.41 in the morning peak (TPDC, 2006), this would mean diverting about 846,000 people from car to other modes (recall that doubling public transport ridership entailed a peak increase of only half a million trips – much less than this figure). From the analyses in the preceding section of this paper, such a shift of travellers could not be accommodated by current public transport. In addition, the very sizeable user charge that would have to be implemented to deter this volume of car users would have to be paid by the remaining 1.1 million car drivers, which would represent a severe level of taxation, with probably quite important implications for the local economy. It is difficult to say how much the user charge would have to be to divert this many car users. However, based on the London experience and also on the rather small effects that recent toll rises have had on traffic, it might be as much as $15 to $25 per vehicle. The result of such a charge, if implemented across the whole of Sydney, would be potentially disastrous to the economy of the region. This leads to the question of how to manage congestion. The remainder of this section examines some options.

3.2 Kilometrage changes

As an alternative to the draconian road pricing of the preceding section, some form of road user charging, preferably by means of a kilometre and time of day based charge, is still a feasible method to manage congestion. It still has the merit of charging motorists at the point of use, and should lead to more careful thought about whether a journey has to be made at a particular time. It is interesting to note that 31 percent of the morning peak in Sydney is commuting trips, 20 percent is for education and childcare, and 25 percent are to serve a passenger. It is certainly conceivable that some of these journeys, as well as part or all of the remaining 24 percent do not have to be made in the peak period. Rather than the fixed tolls that are common today in Australia, a charge that varies with the distance driven and the time of day would be likely to have a beneficial effect in moderating peak congestion. It would penalise more heavily those who travel in the peak periods, thereby leading to some flattening of the peaks. It should be coupled with removal of other taxes and tolls, such as excise taxes and GST on fuel, and even possibly such fees as annual registration charges. While many suggest that the aim should be to make the imposition of such road user charges revenue neutral to the public as a whole, we do not agree with this. For road pricing to be effective, it will need to represent an actual increase in the cost of using the road, overall, otherwise it is unlikely to have a significant effect on road use. Revenue should also be hypothecated to transport improvements, with a large share of the revenue going to improvements in public transport, so that alternatives are provided for those who have no flexibility to change the time of their commute. Within this paper, it is not possible to discuss in depth how such charges should be imposed, how the fees should be collected, etc. However, this gives a brief sketch of the essential components of the policy.

3.3 Traffic engineering measures

A range of traffic engineering measures can be used to help manage congestion. These include a number of strategies already used in various cities in Australia, such as tidal flow lanes, improvements to intersections, restrictions on right turns during peak traffic periods, use of areawide traffic control, CCTV, and other technologies to improve incident detection and monitoring of traffic conditions with response from traffic control devices. More extensive traffic engineering solutions can also be considered, such as bus and carpool lanes, although these must be enforced strictly to be effective. More extensive use and enforcement of clearways, truck routes, and even bans of trucks in peak periods can also provide benefits to traffic flow and improve the performance of the system. Many of these measures are already in use in Australian cities, so it is possible that there are only restricted opportunities for further implementation. This being the case, it is possible that only somewhat minor gains can be obtained with further implementation of traffic engineering measures.

3.4 Voluntary travel behaviour change (VTBC) programs

These programs have become popular in Australia as a mechanism both to manage congestion and reduce greenhouse gas emissions from transport (Stopher, 2004b). The extent to which these programs can impact congestion is partly a function of whether or not there is spare capacity in the public transport system. Also, these programs are generally not aimed at commuting traffic, although there may be impacts on the peak period if people realise that some of their present travel does not need to be done at that time. If VTBC programs can be shown to produce sustained results in changing the behaviour of people to use their cars more efficiently and to consider the use of other modes, such as walking, bicycling, and using public transport, then benefits will accrue to the management of congestion.

3.5 Parking restrictions

Within the city core, parking can be restricted to only short term use. Such a policy can only be implemented if there are adequate alternative modes of transport to the car. If a policy to implement restricted parking is put in place without first ensuring that all those who would be displaced by such a policy can still access their workplaces reasonably, then serious economic consequences will arise. Congestion usually occurs where there is limited parking space, such as in city centres. If demand for parking can be reduced, this will usually have the effect of reducing congestion. One mechanism for reducing parking demand is to increase the price for parking. However, so much of the parking in central city areas of Sydney is subsidised by employers that it is unlikely that pricing will have much of a dampening effect on demand. This may be true in most of the large cities in Australia. Therefore, it seems more likely that an outright ban on long-term parking would have to be implemented. Reducing parking demand can also reduce the traffic from drivers looking for parking spaces, which often makes up a significant proportion of the traffic in such areas. Reducing long term parking demand in city centre areas is usually feasible because existing public transport services are focused on the city centre. In addition, workers who travel on a daily basis are more able to find substitute methods of travelling to work, and the parking that is freed for short-term use may have significant benefits to the businesses in the city centres, encouraging greater use of city centre facilities. A number of cities in Europe have implemented such policies, often together with making parts of the city centre into pedestrian only areas, closing roads to vehicular traffic. However, it must be stressed that good alternative transport means must be in place before such policies are implemented, or serious economic disruption and damage can occur.

3.6 Changing school and work times

Changing the times of starting and ending both work and school can be used to spread the peak load. For workers in certain types of employment, staggered work hours, flexible work hours, and compressed work weeks may all hold potential to spread peak loads on the transport networks. Staggered work hours are implemented in some businesses, where it is possible to have only a small fraction of workers reporting at the normal business opening time of 8:30 or 9:00, having most employees starting earlier or later than this. Similarly, ending times are varied to provide the same length of working day. In flexible work hour arrangements, employees are permitted to choose their own times of starting and ending work, subject only to a requirement to work a certain number of hours each day and to being in the office during certain core hours, which may often be as short as from 10:30 a.m. to 2:30 p.m., for example. When a core time of this range is required, and for workers working a total of a 7½-hour span of the day, workers could come to work as early as 7 a.m., leaving at 2:30 p.m., or come as late as 10:30 a.m. and leave at 6 p.m. Compressed work weeks allow employees to work fewer total days per week and longer hours per day. There are two common versions of this, in one of which employees work the same total hours in a week as under present work arrangements, but do so in one less day per week. The second version is where employees work the same hours over nine days that they previously worked over ten. In the first of these two, employees come to work only four days per week, theoretically reducing peak period travel by 20 percent, especially if the employer can roster one fifth of their employees to be off on each day of the week. For the second version, there is a theoretical reduction of 10 percent in the peak travel. Also, because of the longer days worked, the timing of employee travel to and from work changes and may spread the peak further. In some areas of the US, government offices often use only half their work force on a Friday, with employees working the nine-day version of compressed work weeks, so that half the employees work on each Friday, the other half being off on that day.

A second contributor to the peak, shown rather clearly in Figure 5, is the school trip. Because schools usually start between 8 and 9 a.m., and end around 2:30 to 3:30 p.m., the morning trip to school coincides with the work peak, while the afternoon trip home causes a peak an hour before the work peak. Changing school hours so that they no longer coincide with either the morning or evening peak can also help reduce congestion. For example, having schools start earlier, at around 7 a.m., and finishing by 2 p.m. would spread the peaks more effectively. However, there may be social consequences of such an arrangement, especially for after-school care for children whose parents work full time. In some cases, even a 15 or 30 minute shift in school starting times can have a significant effect in flattening the peaks. This may have less severe consequences on working parents.

3.7 Road infrastructure improvements

While we know that we cannot build our way out of congestion, there is a need for continuing improvements to road infrastructure. First, this should involve the removal of bottlenecks caused by lane drops, or merges that result in a net loss of lanes. However, care must be taken to ensure that the bottleneck improvement will not simply shift the bottleneck further downstream. Some bottlenecks act as a capacity restraint, preventing more serious bottlenecks further downstream in the transport network, and bottlenecks of this type may need to be left as they are. Second, additional road infrastructure is needed to cater for the growth in car travel that is a result of population growth. Some population growth may occur as infill development, or occur as a result of increasing the development densities in certain areas. Where such developments will put an undue strain on existing facilities, road widening and the creation of new roads may be justified. Other population growth will usually occur on the fringes of the developed area, and will require not only the creation of new road infrastructure to support the development, but may also require additional capacity on routes to major employment centres.

Thus, road infrastructure improvements should be made first to remove existing bottlenecks, where downstream capacity is sufficient to handle the resulting traffic, and second to provide additional capacity in response to growth in population. Such improvements should not be made solely for the purpose of improving travel speeds in the network, where growth is not occurring, and significant bottlenecks do not exist.

3.8 Public transport investment

Similar to road infrastructure, public transport investment is essential to help manage congestion, but it is important that it also is done with correct motivation. There are other policies that can be implemented to manage congestion that also require that there is adequate capacity and service levels of alternatives to driving the car. Usually, this will be the provision of adequate public transport services. Because individual localities have very diverse needs in this area, it is not possible to provide a generalisation of the type of public transport investments required. However, it is important to be realistic about what public transport does well, and where it can be of most potential benefit. First, public transport generally requires relatively high densities of development for success, and should be concentrated in those areas that have either high residential development densities or high workplace densities. Second, there is a need to be open to other forms of public transport than the standard bus and the standard train. For example, many arguments can be made for the creation of bus rapid transit facilities (Levinson, et al., 2003a; Levinson et al., 2003b; APTA, 2003) in appropriate locations, providing service that is comparable to light rail, but at far less cost, and with much greater flexibility to change as demand patterns change. It is also somewhat surprising that, after Adelaide built the first O-bahn in Australia, there have been no additional O-bahn facilities constructed. Yet the O-bahn has been very successful in Adelaide, and also offers a system that is less costly than any type of rail, while offering a level of service comparable to rail, without the need for transfers to access and leave stations. In other locations, it may be appropriate to consider mini-bus services, moving away from a fixation on the 43-45 seater bus (and larger articulated buses), and providing flexibility and lower volume in niche markets, for example. Various other less common and innovative concepts of public transport are also worth examining.

In addition, investment in improvements to existing public transport facilities to provide more competitive travel times, and higher frequencies of service, as well as other possible improvements to safety and comfort, are also likely to be of value as another element of managing congestion. It is particularly important, in this regard, that decision makers use appropriate figures to determine what constitutes competitiveness. There are recent instances where claims have been made about the low cost of public transport compared to car, especially rail compared to car, in which the car costs are full costs, including depreciation, registration, insurance, etc. Unfortunately, such a cost comparison is only appropriate if every person riding the train (in this case) were to sell their car, if they used the train. Given that many will need to use their cars to access the station, and also will probably retain a car for other than commuting travel, it is inappropriate to compare full costs of the car. Rather, the costs that should be compared are the marginal costs of the operation of the car. In this case, the results would be much less favourable to rail. In this regard, it also may be worthwhile exploring increasing the subsidies to public transport, to make it more cost favourable to car users, as one incentive that may help to bring some additional riders to public transport. Especially if road pricing is part of the set of management tools that is implemented, some of the revenue raised from road pricing can be used to subsidise public transport fares as is done in London.

Investment in public transport is an essential component of managing congestion, especially to ensure that alternatives are provided for current car users who may be inequitably impacted by other possible congestion management strategies. Also, public transport should be enhanced for those niche markets where it is strongly competitive with other alternatives. Blanket investment in public transport, in the hopes of luring thousands of motorists out of their cars, is unrealistic and likely to be doomed to expensive failure.

3.9 Other strategies

Unfortunately, space does not permit exploration of all of the many options for managing traffic congestion. Among other strategies that should be considered are providing more extensive park and ride facilities, to encourage drivers to drive to appropriate transfer points, from where they can use public transport facilities; encouraging bicycling as an alternative to driving; changing urban planning practices to encourage less driving and more use of walk, bicycle, and public transport; and the implementation of additional Intelligent Transport System technologies. What should be clear from this brief overview, however, is that there are many options for managing congestion. However, these options come at a price, which may often represent substantially more in both political costs and monetary costs than have previously been incurred for transport. Nevertheless, if we are to make effective progress in managing congestion, they will be required.

4. Conclusion

Perhaps the most important conclusions that should be drawn from this paper are the following. First, congestion is not likely to be eliminated, without unacceptable economic and political damage. Rather, the goal of transport strategies should be to manage congestion. Second, traditional approaches to relieving congestion, such as major investments in public transport and adding capacity to the road system are also unlikely to reduce congestion, and some of these strategies will result in increasing congestion. Third, the essential approach to managing congestion is to implement a range of balanced options that will support one another and result in the ability to prevent congestion worsening significantly as population growth continues, and which may even result in some modest reduction in present levels of congestion. Thus, limited and focused investment in public transport and road construction, together with some form of distance-based road user charging by time of day, voluntary travel behaviour change programs, parking controls, changes in work and school times, and traffic engineering improvements together are likely to be successful in managing present levels of congestion. However, these must be based on the development of comprehensive plans and through adequate information about the effects that can be expected from the different strategies. It is also imperative to recognise that congestion management is not a cheap undertaking, and that significant and substantial resources are required. These are easily justified when one calculates the current losses of productivity caused by congestion and extrapolates these into the future. Figuring in the environmental costs as well simply makes justification easier.

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