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Cars, Congestion, Public Transport, and Pricing: A Reality Check

By

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ABSTRACT: For some little while now, the flavour of the month in transport policy seems to have been to set goals for massive relative increases in public transport ridership, reduction of car use, all resulting in a hoped-for reduction in road congestion. As a result of this policy focus, we have seen various government entities at the metropolitan, state, and national levels set goals for such activities as increased ride sharing, increased use of public transport, implementation of high occupancy vehicle lanes, and, at least in Australia and the U.K., thinking about congestion pricing of some form.

Through political rhetoric, it seems that use of the private car, congestion, and declining shares of the market for public transport are all labeled as negatives that should be set right by some type of policy intervention. Since the first introduction of ideas of demand management in the late 1970s, the idea of trying to change behaviour of car users has been an increasingly significant focus of transport policy. This paper seeks to check the reality of these policy directions and questions whether these are desirable, let alone achievable end states. It is noted that major changes in transport market share have never been achieved in the past, and as such, it seems unlikely that such policies will be successful in the long term. Even if such policies can be achieved, it is questionable whether the end results will have desirable consequences or not.

KEY WORDS: Vehicular emissions, Congestion, Externalities, Transport policy, Public transport

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1. Introduction

For some little while now, the flavour of the month in transport policy seems to have been to set goals for massive relative increases in public transport ridership, reduction of car use, all resulting in a hoped-for reduction in road congestion (Bonsall, 2000). As a result of this policy focus, we have seen various government entities at the metropolitan, state, and national levels set goals for such activities as increased ride sharing, increased use of public transport, implementation of high occupancy vehicle lanes, and, at least in Australia and the U.K., thinking about or preparing to implement (in the U.K.) congestion pricing of some form (Livingston, 2001). Starting with concerns with vehicle emissions as far back as the mid-1980s, and moving now into more of a focus on greenhouse gases and congestion, these policies are aimed at reducing two perceived externalities of increasing car use – vehicular emissions and congestion.

This paper seeks to check the reality of these policy directions and question whether these are desirable, let alone achievable end states. Through political rhetoric, it seems that use of the private car, congestion, and declining shares of the market for public transport are all labelled as negatives that should be set right by some type of policy intervention. Since the first introduction of ideas of demand management in the late 1970s, the idea of trying to change behaviour of car users has been an increasingly significant focus of transport policy. In Los Angeles, in the mid-1980s, a regulation was introduced by the Southern California Air Quality Management District (SCAQMD), known as Regulation XV, which was aimed at changing market shares of public transport, drive alone, and shared ride to a point that there would be significant reductions in traffic congestion and the consequent emissions of petrol-driven vehicles. Indeed, with average car occupancy in the peak period in Los Angeles averaging around 1.1 persons per vehicle, Regulation XV sought to achieve a level as high as 1.75 in the CBD, 1.5 in the urban areas, and 1.25 in the remotest suburban areas. However, after nearly ten years of fairly draconian measures implemented through employers in the region, the regulation was seen as a failure, and attempts to continue to enforce it were abandoned in 1995, when the California Legislature ordered the SCAQMD to stop requiring companies to offer carpooling and other ridesharing incentives, thereby terminating the implementation of Regulation XV.

More recently, the government of Victoria (Australia) has put forward a policy known as 20/2020, or 20 percent public transport ridership by 2020 in the urbanised area of Melbourne. Current public transport ridership levels in Melbourne are around 9 percent, so this policy calls for the market share of public transport to be increased by a factor of more than 2 in the next 18 years. Such major changes in transport market shares have never been achieved in the past, and one must wonder if such a policy has any chance of being achieved. More importantly, one must ask whether it should be achieved, and whether the end result will have desirable consequences or not.

2. Congestion

Perhaps the first place to start is a consideration of congestion. At least three questions need to be addressed with respect to congestion. Most fundamentally, we need to determine what traffic congestion is. Second, we need to determine if congestion, *per* *se*, is a bad thing. It seems to be taken as axiomatic that it is, but the question has perhaps not been examined very carefully, although there is a notion of optimal congestion in economics that is linked to efficient congestion charges. Third, we need to understand what negative consequences stem from congestion, and whether there are ways to overcome them. In general, congestion is specific to individual roadway segments, and is not a systemwide phenomenon. However, particularly in some developing countries, congestion may be systemwide and of very extensive duration (e.g., in such cities as Bangkok and Mexico City). The focus of this paper is on those regions and cities where congestion is not ubiquitous in time or space, but occurs at specific times of the day and in specific locations.

2.1 An Analysis of Congestion

2.1.1 Definition of Congestion

The dictionary defines congestion as an abnormal accumulation, or excessive accumulation (of traffic, for example). Traffic engineers define congestion as the phenomenon that arises when the input volume approaches the output capacity or attempts to exceed the output capacity of a facility. At least one implication of congestion is that it represents maximum or excessive use of a facility. The relationship between traffic volume and speed is shown in Figure 1 (Garber and Hoel, 1996).

In Figure 1, in the input volume range from A to B, the traffic volume is low, input volume equals output volume, and there is little interference in the movement of any vehicles from the presence of other vehicles on the road. We generally term this regime one of free flow. From B to C, there are more vehicles present, and each vehicle tends to adjust speed downwards a little from the free flow speed, as a result of the other vehicles around. However, speeds are only slightly lower than the maximum speeds and input and output volumes are still equal. From C to D, input volumes are increasing and the interference from other traffic now causes each vehicle to decrease speed by perhaps as much as 5 to 10 percent below the free flow speed. From D to E, input volume is approaching the output capacity. Speeds start to fall much more sharply, because the interference in the movement of each vehicle by the vehicles surrounding it is considerable. From E to F, we have a regime in which the input volume is attempting to exceed output volume, resulting in rapidly decreasing speeds, instability of traffic flows, and, eventually, a jammed condition in which the speed of traffic drops to zero. The line is dashed because the instabilities in the traffic flow result in substantial variation in speeds and output volume in this area, such that a clear relationship cannot be readily established.

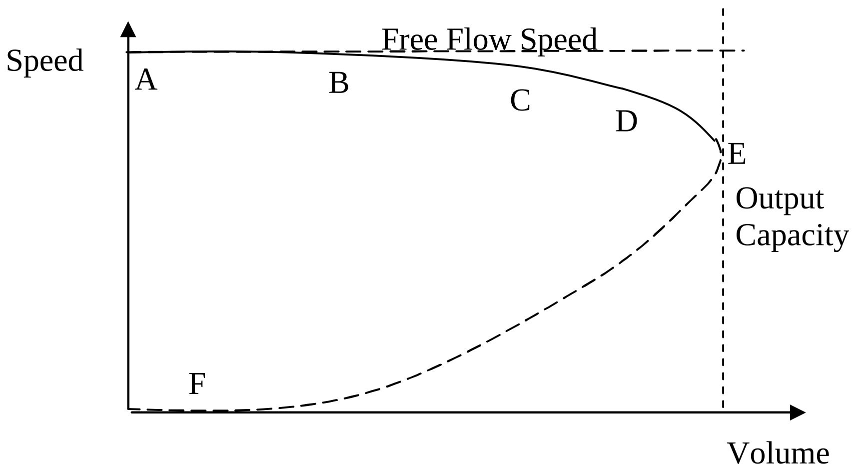

Figure 1: Relationship of Speed and Traffic Volume

In a scientific sense, traffic, unlike most fluids, is compressible. Therefore, as the input volume increases, so does the density of traffic increase (where density is defined as the number of vehicles per lane per kilometre). Thus, the reaction of traffic to increasing input volume is for vehicles to become closer to one another, and hence speeds drop as the density increases. However, there is a limit to how much the density can increase. Once vehicles are literally bumper to bumper, there is no safe speed, and speed drops essentially to zero, thereby defining jam density and maximum congestion. This occurs when the input volume attempts to exceed the output capacity. Clearly, arriving at jam density is not efficient. However, it could be argued that operating the transport system at point E represents maximum utilisation of the capacity of the infrastructure, in that the input volume is equal to the output capacity, and flow has not yet broken down into the unstable regime. However, as noted below, maximum use may not represent optimal use.

There are two types of congestion – recurring and non-recurring. The former is the type of congestion that occurs at the same place and the same time day after day, especially on weekdays. The latter is the type of congestion that arises from temporary conditions, such as a vehicle breakdown, accident, or temporary road works. The interest in this paper is with the former – recurrent congestion. The latter, which can largely be regarded as a random event, can be dealt with through various mechanisms, but is not the principal focus of policies that are aimed at congestion reduction. Recurrent congestion arises for two reasons. First, it arises because of peaking in demand. Figure 2 shows the typical diurnal distribution of demand for travel, with peaks in the morning and the evening, and very low volumes of use in the two or three hours after midnight.

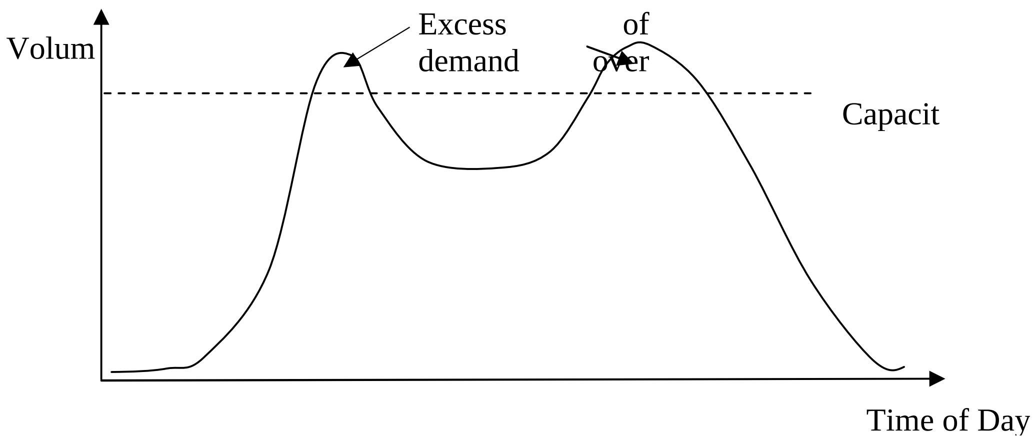

Figure 2: Typical Diurnal Distribution of Demand for Travel

In Figure 2, the facility capacity is shown by the dashed line. Usually, this line is below the maximum levels of demand, both because it would be inefficient to provide sufficient capacity to meet all demand, when the maximum demand occurs for such a short period of time. The line is also below the maximum levels of demand because, as is discussed later in this paper, there is always likely to be some level of suppressed demand, such that raising the capacity line would likely result in the peaks rising yet higher, and continuing to exceed the capacity provided. This distribution shows two important things: first, congestion, which will occur when the demand for travel exceeds the available capacity, will last for a relatively short time, and second that there is spare capacity for much of the day, as shown by those sections of the above drawing where demand is below the available capacity.

The second reason for recurrent congestion (and also the reason for non-recurrent congestion) is the existence of a bottleneck. A bottleneck may be defined as a location where the capacity of a facility is suddenly reduced. In recurrent congestion, this reduction is usually the result of a design feature, such as where a roadway is reduced from six lanes to four, or where two roadways, say of four lanes each, merge and form a six-lane roadway. In non-recurrent congestion, the bottleneck is usually caused by a loss of capacity resulting from a disabled vehicle, temporary road works, or other similar phenomena. Permanent bottlenecks require very careful study to determine whether or not they should be eliminated. Many bottlenecks perform a metering function, by reducing the flow at one point to a level that can be sustained in downstream sections of roadway. In such cases, removal of the bottleneck in one location may simply result in transferring the bottleneck to another point further downstream on the facility. In many cases, the newly-formed downstream bottleneck may result in worse traffic conditions than maintaining the original bottleneck. In other words, bottlenecks may often paly a useful and important function in regulating flows and controlling the level of congestion that occurs on a facility.

2.1.2 Problems Arising from Congestion

The first problem with congested traffic conditions is that these conditions are inherently unstable. That is, vehicles may flow quite well at speeds that are only modestly reduced from free-flow speeds, but flow may also easily break down, with the formation of queues, stop-and-go driving conditions, and average speeds that are very low. This instability produces one of the negatives of congestion – unreliability of service by the highway system. If one travels in congested conditions, one can never be sure of how long the travel will take, and the variability is very large, typically, under these conditions. A second negative of congestion, resulting from this instability, is an increase in emissions from petrol and diesel engines, mostly as a result of frequent acceleration episodes, and the tendency for engines operating at low speeds to emit more of certain pollutants – particularly volatile organic compounds and carbon monoxide. Along with the emissions problem of congestion is the increase in fuel consumption that accompanies the slow speed and stop-and-go driving conditions usually associated with congestion.

The third negative consequence of congestion is that extra time is required under these conditions, time that may be considered to be non-productive time. For those who are caught in congested conditions who are driving outside of normal working hours, it is questionable as to whether the time losses from congested conditions have an economic impact. One can argue that time outside working hours does not contribute to gross domestic product and, therefore, its use has no impact on the national economy. Perhaps, to the extent that driving in congested conditions increases stress, travelling to work in the morning in congestion may impact productive time, by making a person less productive once they arrive at work. However, outside that effect, there appears to be relatively little evidence to suggest that driving in congested conditions, for those who are not driving during working hours, can have any significant negative economic impacts. For those who are driving freight vehicles, buses, etc. in congested conditions as part of their work, there is definitely an economic impact of the time "wasted" in congested conditions. Nevertheless, we see a continuing shift of freight movements to road-based vehicles, suggesting that, whatever the magnitude of the economic impacts of congestion, it is outweighed by the overall more efficient movement that is offered by the road system.

On the other hand, one could also argue that reducing congestion leads to further suburbanisation and sprawl. Increased highway capacity, provided as a response to growing congestion, often adds to pressures to move homes and businesses further out, to where land is cheaper and more plentiful. Improving travel times, as congestion is reduced, allows people to travel further in the same amount of time, and is certainly one of the contributors to urban sprawl. Thus, one could consider that appropriate management of congestion is an important tool in shaping the urban area, and that responses to congestion should take into account the wider system effects, rather than a narrow view of relieving congestion in a specific location.

A recent article (Nasser, 2002) shows that many commuters do not perceive congestion as necessarily an evil of their daily commute. The article notes that in these modern times, many people can find complete privacy in only two places – the car or the toilet. For many, there is actually "…peace and relaxation commuting alone. For many, it's the only time they have to read (by listening to books on tape), enjoy music *they* like, catch up on the news, smoke without being chastised or make personal phone calls in total privacy" (Nasser, 2002). Such attitudes do not bode well for carpooling, which is often seen as one of the alternatives to reduce congestion. The article also reports that a survey of commuters undertaken by Redmond and Mokhtarian (2001) produced the surprising results that seven percent of respondents would like their commute to be longer, and only about half said their commutes were too long (Nasser, 2002). It is also important to note that urban planners continue to find that the distance or time of the commute trip is only one of many factors that people take into account in deciding on where to live, and that it appears to rank as somewhere around 15th or lower among a significant list of attributes that are considered in home location decisions. Although not documented, one presumes that there are thresholds on the acceptability of certain levels of accessibility from potential home locations.

Perhaps a question to ask at this point is whether congestion is a phenomenon of this modern day. This question is relevant in determining if it is likely that congestion could ever be eliminated. In fact, evidence suggests that congestion is a phenomenon that has existed for as long as mankind has dwelt in conurbations. There is clear evidence that ancient Rome experienced serious traffic congestion on its streets. Photographs of cities like London, New York, and Chicago in the 19th century show that, long before the internal combustion engine was invented, cities were very congested (perhaps even more than they are today). One of the conclusions that one must draw from the long-term existence of congestion in urban areas is that congestion may not be curable. In fact, it seems worthwhile to consider in more depth the reasons that congestion arises and to look at ways in which congestion management is a useful policy instrument. Before doing so, however, one additional issue needs to be examined. Transport policy may focus on improving mobility or improving accessibility. These two concepts are not the same although they are closely related (Levine and Garb, 2002).

2.1.3 Accessibility and Mobility

Accessibility can be defined as the ease of reaching destinations (Levine and Garb, 2002), whereas mobility may be defined as the ease of movement. While these two concepts are clearly related, they are not the same thing. If a person lives in an area where there are many possible destinations close by, accessibility may be very high, even though mobility might be constrained, as in a CBD. On the other hand, if a person lives in a relatively remote area, accessibility may be poor because considerable travel time and cost is required to reach any destination, although mobility may be high. In 1960, world inhabitants travelled an average of 1,820 km by car, bus, railway or aircraft. Three decades later, the annual distance travelled had increased to 4,390 km. In light of a seventy five percent world population growth, absolute motorised mobility rose by a factor greater than 4 (Schafer, 1998).

As Levine and Garb (2002) point out, improvements in mobility and accessibility are measured in different ways. An increase in *mobility* implies that the generalised cost of travel (time plus money) per *kilometre* is reduced; an increase in *accessibility* implies that there is a reduction in the generalised cost of travel per *destination*. Generally, mobility is closely related to the level of service provided on the transport system. Higher levels of service represent lower costs per kilometre of travel. Thus, increases in capacity of the system will almost always lead to an increase in mobility. Accessibility, however, is related to destinations, and therefore requires attention both to land use patterns and to the quality of destinations. Miller (1999) has commented that the most theoretically consistent measure of accessibility is obtained from random utility theory, where accessibility is the expected utility of a given destination from a specific location, taking into account the number, desirability, and costs of reaching all destinations considered. This suggests that increases in capacity of the transport system will not necessarily lead to increases in accessibility. However, changes in land use patterns, and changes in the quality of specific destinations may result in improved accessibility even when no change is made to the transport system. Not only that, but if the longer term consequences of improvements in the transport system are movement of potential destinations to locations that are further away, through urban sprawl and lower development densities, then these transport system improvements can lead to a loss of accessibility.

It is therefore very important that policy is clear on transport goals: is it desirable to increase mobility or to increase accessibility? Increases in one can clearly lead to losses in the other. Furthermore, congestion seems likely to produces losses in both mobility and accessibility. Longer travel times and increased monetary costs of travel in congestion obviously increase the travel cost per kilometre. At the same time, these travel times may also reduce accessibility by making potential destinations more expensive to reach. However, different methods for tackling congestion will be likely to have quite different effects on each of mobility and accessibility, as is discussed subsequently in this paper.

2.2 The Source of Congestion

Most transport analysts subscribe to the application of economic theory to travel. From this theory, it is generally held that travel is a derived demand, i.e., that people do not generally travel for the sake of travelling, but rather in order to reach some location where they can pursue an activity (Stopher and Meyburg, 1976, *inter alia*). The notion that travel is a derived demand also means that it is not possible to understand or map the demand function for travel, without some knowledge of the demand function for the activities that travel enables. Transport analysts have handled this, traditionally, by dividing travel into different purpose groups, and assuming that the purpose group is a surrogate for information on the activity. From this, one than can still postulate that there is a downward sloping demand curve for travel, and an upward sloping price-volume curve[1], describing how price changes as a result of different volumes of use, as shown in Figure 3 (Wohl and Martin, 1967). In this figure, price should be interpreted as generalised price, including time, money, and other attributes of value to the traveller. The price-volume curve is also an average cost curve, indicating that this is, on average, the cost incurred by each person using the system as a function of the number of other users on the system.

Whether or not one believes that economic equilibrium actually occurs, it is a useful construct to use in examining the sources of congestion. The microeconomic theory

[1] There is considerable controversy over the shape of the supply curve as opposed to the average cost curve, and over whether volume should be measured in units of flow or trips. We do not deal with these arguments here. Readers are referred to recent papers by Hills and Gray (2000) and Hensher and Truong (2002).

approach would suggest that the intersection of the demand and price-volume curves would represent static equilibrium, and would define the volume and price that would be experienced. Although Figure 3 really represents some sort of average of demand and price-volume curves over the population and the highway system, so that such an equilibrium does not exist, we will consider that V_0 and P_0 represent the price of travel that is experienced and the volume that occurs.

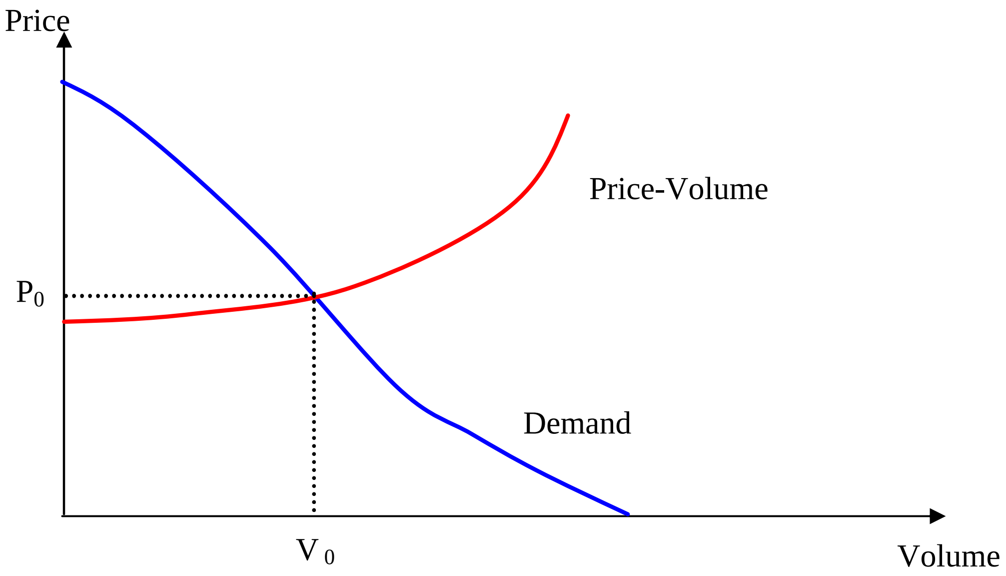

Figure 3: Demand and Price-Volume Curves for Travel

The goal of most national governments is to increase economic growth of the nation, therefore increasing GDP, and most would also seek to increase GDP per capita, leading to the notion that people become wealthier over time. Increases in wealth result in the demand curve shifting upwards and to the right (assuming that travel is a positive good, which Redmond and Mokhtarian (2001) appear to demonstrate is so). People also tend to increase the distances they travel roughly in proportion to increases in their incomes, particularly as they start to access faster modes. That pattern has been remarkably constant in all areas of the world over the past 50 years, ranging from regions with an average annual gross domestic product (GDP) as low as $500 per capita to regions with a GDP as high as $20,000 per capita (World Business Council for Sustainable Development, 2001). Further, without even succeeding at this, people have mobility and accessibility expectations. As time goes by, it seems that our expectations for mobility and accessibility increase, and possibly with this, so does our willingness to pay for those increased levels of mobility and accessibility. This will also have the effect of moving the demand curve upwards and to the right. Figure 4 shows the results of this. If nothing else changes, then the volume of traffic increases to V_1 and the price of travel increases to P_1. Depending on the state of the roadway system, this is likely to lead towards increasing congestion. Note, however, that there is unsatisfied demand, represented by the continuation of the demand curve below the equilibrium point, while those using the increasingly congested system are paying no more than they are willing to pay for the mobility they desire to have. In other words, for those using the system, they are willing to accept the level of prevailing congestion.

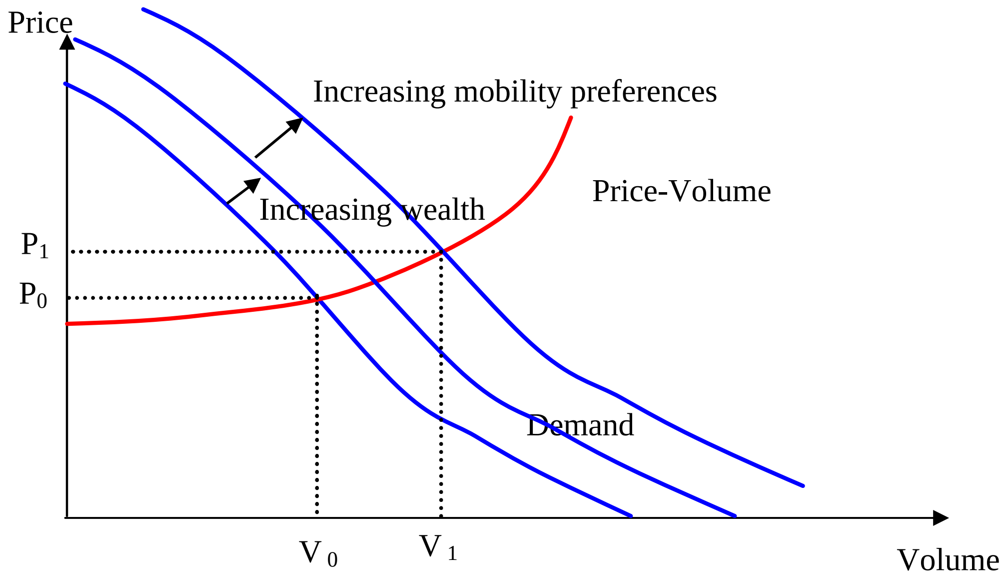

Figure 4: Effects of Increasing Wealth and Mobility Preferences

There are some important implications of this concept. First, over time, if wealth increases and people's preferences for mobility increase, then acceptable levels of congestion will progressively rise. For anyone who has lived through the past thirty years or so, it would appear that this is exactly what has taken place, with levels of congestion increasing. Second, as has only been clearly recognised in relatively recent times by transport planners, increases in capacity, which have the effect of lowering the price-volume curve, will give rise to increasing volumes of traffic, with the facility eventually returning to the same level of congestion as before, because this level was already an acceptable level to a large portion of the population. In July 2001, six months before the opening of the M5 East in Sydney (toll free extension of the M5), the average number of cars using the road each day was 62,081. A year later, this number had increased to 86,208 vehicles per day. Large increases in traffic volume also occurred on the nearby Eastern Distributor toll road over the same period (Kerr, 2002).

Thus, while capacity increases may result in reduced congestion for a time, eventually it can be expected that congestion will rise again, so that there will be more people travelling at the same level of congestion as before the capacity increase. Does this mean that the capacity increase failed? That depends on what the goal was. If the goal was to reduce congestion, then it has failed. If, however, the goal is to increase mobility, then this has clearly succeeded. Between 1950 and 1997, the total number of kilometres traveled each year by each person then on earth went up more than threefold. The total transport system, accommodating both that per capita increase and population increase, provided over eightfold more passenger-kilometres in 1997 than in 1950 (World Business Council for Sustainable Development, 2001). If the goal is to increase accessibility, then more needs to be known as to whether or not accessibility has been improved. As noted earlier, if the capacity increase leads to further suburbanisation, and lower densities of development, then it is likely that the capacity increase will lead to a loss of accessibility.

A third important point here is that these curves represent some sort of average per person. If the region's population is increasing as well, then even if capacity remains unchanged, there will be additional people desiring to travel, leading to a consequent continued increase in congestion levels. In other words, Figures 1 and 2 hold only for a static population. With increasing population, the volume of travel will necessarily increase also, leading to rising costs of travel, and increasing congestion. When all of these effects are brought together – increasing wealth, increasing expectations of mobility and willingness to pay for travel, and increasing population – then volumes of travel will grow much faster than population growth alone. This is the phenomenon that has been experienced through much of the world during the 1980s and 1990s, and appears to be continuing into the 21st century, albeit at a currently somewhat slower rate. This also gives rise to two other situations – a spread of congestion from major thoroughfares into what may have been more lightly-travelled roads, and a spread of the length of time for which the system is congested. After all, congestion occurs when the volume of travel approaches the capacity of the facility. Unless capacity increases are undertaken, then the continuing increase in the input volume must be accommodated in other ways. Peak spreading flattens the camel (Figure 2) by infilling the periods between the peaks with higher levels of utilisation of the transport system capacity..

2.3 Congestion, Emissions, and the Marketplace

From the discussion above, it seems that the primary negative impact of congestion is that of increased emissions and fuel use, with the possible reduction in accessibility and mobility. Over the past three decades, the automotive manufacturing industry has made enormous strides in reducing emissions from motor vehicles. Given this track record and human ingenuity in general, it seems reasonable to suppose that within the next decade or so, the emissions from motor vehicles will be reduced substantially further, assuming that society puts a high enough value on doing this. In large measure, the technology exists today to produce much lower polluting vehicles, as is evidenced by some of the dual fuel vehicles already available on the market (e.g., the Toyota Prius and the Honda Insight) (NRMA, 2002a) and tests of fuel cell vehicles (e.g., the Honda FCX) (NRMA, 2002b). Breakthroughs in research on other forms of motive power, and improvements to the overall technology of vehicles seem likely to continue to occur. Therefore, in perhaps little more time than it would take to plan and construct a major new transport facility, we may have vehicles available that already reduce substantially the emissions problems of current road vehicles. A wholesale change in vehicle fleet characteristics will take somewhat longer, but the emissions problems of motor vehicles do not seem to be insurmountable, and do appear susceptible to technological solution. The same technological advances that seem most likely to reduce vehicle emissions significantly would also potentially replace the present dependence on fossil fuel and may result in the adoption of fuels that are readily replaceable. Included in this would be fuel cells, and vehicles powered by solar or other energy sources.

An interesting policy dilemma exists here. Many governments around the world have instituted extensive excise taxes on petrol and other fossil fuels. With the exception of the United States, these taxes are generally not hypothecated and represent a substantial source of government income. Given this, governments may well consider policies that would reduce petrol consumption to be against their interests. At best, they may be reluctant to pursue aggressive policies that would result in significant reductions in the amount of taxes collected from fuel. For example, the hybrid vehicles have been shown to average as low as 2-3 litres per 100 kilometres, compared to average consumption by conventional cars of around 10-13 litres per 100 kilometres. A general shift to such fuel efficient vehicles would have the implication of decreasing fuel excise tax revenues to one fifth of their present levels. Fuel cell vehicles may achieve even greater economies, by reducing fuel consumption to as low as 1 litre per 100 kilometres or less – a reduction in fuel excise tax revenues of about 90 percent. This point must be addressed in looking at the future of such technological developments as vehicle engines that are less polluting and that consume less fuel, or that consume non-fossil fuels.

One would also argue here that, if the public desires to reduce pollution sufficiently and move away from fossil fuels, then market forces will ensure that a technological solution for emissions from the automobile will occur and new energy sources will be adopted for the car. In the same manner, one must look at the present situation with respect to the dominance of the car in Western civilisation and the desire of less developed nations to emulate Western countries in car ownership and use. It should be clear that market forces are alive and well here, and that the preferred method of travel is a vehicle that can be driven alone, or in which one can carry family members or a few friends, to travel from place to place at a time and by a route that is open to choice by the traveller. In other words, there is a continuing and growing market for cars, representing a means for relatively fast, efficient, and individualised transport. In contrast, there is little evidence of a major untapped market for public transport travel in urban areas, in particular. In most countries of the developed world, the role of public transport is diminishing even though absolute levels of use continue to rise slowly. For instance, in the European Union, public transport use has grown by forty percent since 1970, although the population it serves grew by only ten percent. Western Europeans therefore use more public transport today than in 1970, with buses leading the way, followed by rail, then urban rail. Private vehicle use has grown even more markedly, however, and consequently, public transport’s share of total trips has fallen from twenty two percent to fourteen percent. In the United States, public transport has also grown (albeit very slightly) since 1970, following a dramatic two-thirds reduction in ridership between the end of World War II and 1970. However, with automobile traffic growing by almost ninety percent over this period, public transport's market share has declined substantially (World Business Council for Sustainable Development, 2001). This suggests that public transport does not have a large, untapped market, just waiting for the right combination of investment and regulatory or pricing strategies to release it.

Policies that fly in the face of the expressed preferences and intentions of the public are likely to be particularly difficult to bring to fruition and may not be possible to implement effectively. Possibly this is the situation in which we find ourselves in the early 21st century with respect to cars versus public transport as means of travel within the urban area.

3. Increasing Public Transport Use

Public transport has an important role to play within most urban areas. There still remain significant groups of the population who either cannot afford to own and operate a car, or who make a conscious choice to avoid the ownership and operation of a car. There are also specific movements within the urban area to which public transport is better suited than the car, under virtually any circumstances. This is particularly the case for work trips going to the central business districts of many cities. It is also an important means of travel for the elderly who can no longer drive or no longer wish to, and for young people who are not yet old enough to hold a drivers license, or who cannot yet afford a car.

As noted at the beginning of this paper, many transport policies today call for efforts to increase significantly the market share of public transport within urban areas. Europe and Australia emerged from World War II with substantial public transport networks still in place, and relatively low levels of private car use, in contrast to the U.S., where public transport was already declining, or had even been removed from some cities, and car use was already burgeoning. Through the 1950s and 1960s, the U.S. largely followed policies aimed at providing for the private car, and treating public transport as a largely undesirable form of transport required only to maintain mobility for those who could not afford to own and operate a car (Keefer, 1966). Most of Europe, on the other hand, continued to maintain investment in public transport at very high levels of subsidy, while reluctantly accommodating the increasing use and ownership of private cars. Public transport is essentially a mode of service delivery for niche markets[2], such as the market for commuters to the downtown of a major city. That is to say, public transport has a continuing and important role in the urban fabric, but probably not an extensive one outside these specific markets, to which public transport is better suited than the car.

Beginning in the 1970s, the U.S. began to invest more heavily in public transport, particularly urban rail projects, with a view to reversing the growing dependence on the automobile, and the erosion of the public transport share of the market. Despite investing billions of dollars in public transport improvement projects, the public transport share of the travel market in the U.S. has continued to decline. At the same time, public transport market shares in Europe (Bonsall, 2000), Australia (Hensher, 2002), and elsewhere also began to fall. In some instances, this came about at the same time that investments in public transport were also slowing, and maintenance was becoming a problem. However, there is little question that public transport market shares are tending to fall throughout the world, even in less developed nations, where dependence on public transport yet remains at rather high levels.

In modern history, and perhaps in all of transport history, there has never been success in shifting people into public transport at the rate that is called for in many contemporaneous policy statements. A possible exception to this is the case of Singapore, where policies have been implemented that probably would not be acceptable in most other democratic countries around the world.

This alone, however, does not mean to say that such shifts into public transport are not possible. It may just be that no one has come up with the appropriate policy mix (carrots and sticks) to produce these sorts of market shifts. It is also possible that there has not existed previously the political courage to implement what must be done if such large shifts in public transport markets are to occur. It is, however, important to look at the magnitude of what is required.

[2] The notion of public transport as serving niche markets is a concept first expounded by Hensher (2002).

4. Shifting the Public Transport Market

It may be instructive here to look at some numbers, in order to get a feel for what is actually being envisaged in creating market shifts of the type that are often seen in current policy statements. To start, let us assume that we are dealing with a metropolitan region[3] with a population of about 4 million people, living in approximately 1.6 million households. We know from a wealth of household travel surveys around the world that the average urban household in a western country makes about 10 trips per weekday. That means that this hypothetical region will see about 16 million trips being made on an average weekday. Let us assume that the current market share for each of rail and bus is about 4 percent of trips on each mode, meaning that bus and train each carry about 640,000 trips per weekday. We will also assume that about 15 percent of trips are made by walk and bicycle, leaving approximately 12 million trips being made on the roads each day by car drive alone and car passenger. We will assume that average occupancy for all car trips is 1.5, which means that the 12 million trips are being performed in 8 million cars. This is summarised in Table 1.

Table 1: Hypothetical Metropolitan Region Statistics

Statistic	**Value**
Population	4,000,000
Daily weekday trips	16,000,000
Car Driver trips	8,000,000
Car Passenger trips	4,000,000
Bus trips	640,000
Train trips	640,000
Walk and Bicycle trips	2,400,000

We will also assume that this region is growing in population at about 2 percent per annum, compounded. This means that population of the region and trip making will grow as shown in Table 2, with population over five years growing to a little more than 4.4 million and total trips for the region growing to over 17.6 million. The first point to note here is that the growth in daily travel is over 1.6 million trips, where public transport carries a total of just under 1.3 million trips in the initial year. If the public transport share of the market remains unchanged, then the public transport weekday trips will grow from 1.28 million in the base year to 1.41 million, or an increase of 130,000 daily trips. Assuming that the average bus trip is 10 kilometres in length, and that buses are capable of achieving maximum loads of about 3.5 passengers per revenue kilometre, this increase of 1.3 million passenger kilometres will require an additional 370,000 revenue kilometres of bus operation per day. If the average bus route is 20 kilometres long, then this would require approximately 18,500 additional bus trips per day to accommodate the increased patronage.

[3] The numbers used in this hypothetical example are based on figures for Sydney. They are therefore plausible figures.

Table 2: Forecast Regional Population and Weekday Trips

Year	Population	Weekday Trips
0	4,000,000	16,000,000
+1	4,080,000	16,320,000
+2	4,161,600	16,646,400
+3	4,244,800	16,979,300
+4	4,329,700	17,318,900
+5	4,416,300	17,665,300
+10	4,876,000	19,504,000
+20	5,944,000	23,776,000
+25	6,562,000	26,248,000

Now, let us assume that there is a policy in place that says that the market share for public transport is to be increased to double the present share within twenty years, meaning that public transport must carry 16 percent of the market instead of 8 percent. If public transport maintained the 8 percent share, the number of trips carried by public transport in 20 years would be 1.9 million, or an increase over the base year of over 600,000 daily trips. To increase public transport's share of the market to 16 percent would entail carrying 3.8 million trips per day, or an increase of 2.5 million over the base year. In other words, public transport would have to carry three times the ridership that it does at present. This presents some real problems.

Table 3 shows the situation that should exist in 20 years time, and also in 25 years time, assuming that public transport maintains its new market share.

Table 3: Forecast Statistics for 20 and 25 Years from the Present

Statistic	Base Year	At +20 Years	At +25 Years
Population	4,000,000	5,944,000	6,562,000
Daily weekday trips	16,000,000	23,776,000	26,248,000
Car Driver trips	8,000,000	10,937,100	12,074,100
Car Passenger trips	4,000,000	5,468,500	6,037,100
Bus trips	640,000	1,902,000	2,099,800
Train trips	640,000	1,902,000	2,099,800
Walk and Bicycle trips	2,400,000	3,566,400	3,937,200

First, for train to be able to carry this number of passengers, it would probably be necessary both to lengthen existing trains (and therefore, most station platforms), and also to increase the frequency of trains to at least double their present frequency. Furthermore, it is probably unlikely that train could triple its market along existing lines only, so achieving this level of increase probably requires new rail lines to be built into suburbs that can produce ridership at a similar level to the existing lines. Unfortunately, the population growth shown in Table 2 is more likely to occur in the suburban fringes, more than in the inner urban areas despite the recent increase in high density dwellings in many central city areas. Train generally serves movements from suburbs to the central city more effectively than any other market and existing rail lines tend to be focused on the city centre. Unless employment in the city centre grows very substantially, it is unlikely that the market share for rail can be achieved with existing rail lines, with their CBD focus.

Second, for bus to carry the number of passengers it is now required to carry will probably mean tripling (at least) the frequency on almost every route. This means several things. First, every street carrying buses will now carry at least three times as many buses as before. Unfortunately, even if this market share is achieved, cars on the road have increased from around 8 million to almost 11 million, which means that there is even more competition for road space than now, with three times as many buses and 3 million more cars on the roads each day. Second, there are probably buses already operating at quite close headways – 10 to 15 minutes or less. Tripling service on these routes will generate instabilities in service frequencies that will present major challenges for both gaining and retaining new riders. Of course, we are ignoring the possibilities of new technologies, installation of busways and major networks of bus lanes, all of which could help this problem. (It should be noted that busways represent probably a much more efficient way for buses to serve their optimum markets – suburb to downtown movements of workers, principally.)

Again, however, unless major new policies are put in place and enforced with respect to location of residences and businesses, buses may also have a difficult time to serve the enlarged markets, if residences are growing primarily in what is now the urban fringe, and employment continues to decentralise. Buses, albeit to a lesser extent than rail, are more efficient in carrying people to concentrated employment centres than to low density and dispersed employment. If employment is widely dispersed, then buses are unlikely to be able to run at as high load factors as they do into the CBD and other urban centres, so that the requirement for buses to meet the increased ridership levels may be closer to four to five times the present number of buses. Alternatively, the public transport share must grow much larger along existing corridors, with people moving to the traditional urban centres, while the new population areas have relatively less service.

Assuming that all of this is possible, what has been achieved? First, bus and train ridership has tripled. (Maintenance of the market share would have meant that bus and rail together would be carrying about 1.9 million trips, as opposed to the 3.8 million that they are targeted to achieve.) Assuming that the additional 1.9 million public transport riders are drawn proportionately from car driver and car passenger (in other words, assuming that car occupancy does not change), then this 1.9 million additional public transport trips represents a reduction of a little less than 1.3 million cars on the road. (In reality, public transport is more likely to draw from car passenger than car driver, so the reduction in car trips is probably less than this analysis suggests.) In the next five years, if public transport maintains this new market share of 16 percent of trips, continuing growth of the region will add a further 1.2 million car trips on the road, according to Table 3. This means that the doubling of the public transport market share accounts for just five years' of growth of car traffic. Although this might be seen as valuable, it does raise the question as to whether there are other strategies that produce a better deal for society as a whole.

Accommodating the tripling of ridership on public transport would take enormous investment, and it is unclear how people would be persuaded in such numbers to ride public transport. Yet this enormous investment would be equivalent to buying the relief of about 5 years of congestion. This is not all. This discussion has really ignored the demand and price-volume relationship that was discussed in the opening of the paper. In the above tables, we have assumed that trip making increases directly as a function of the population increase. It is certainly possible that growing congestion would result in a decreasing rate of increase in travel. In other words, assuming that all other things remain the same, total levels of travel may not grow as much as shown in the tables. (However, it must be noted that increasing congestion during the latter half of the 20th century appears to have had little impact on the growth of travel, as shown by the unprecedented growth in travel compared to population growth that has occurred in the 1980s and 1990s in most of the westernised world.) More importantly, as improvements to public transport are introduced and trips are diverted from car to public transport, there will be an easing of congestion from cars, and a concomitant improvement in travel times on roadways that are so affected. This, in turn, will give rise to induced demand for more highway travel. Therefore, the reduction in congestion that one might hope to see from the shift of travel into public transport is unlikely to materialise, but will, instead, be significantly less, as more total travel occurs in the region.

One of the strategies that appears to be moving most into favour currently, as a means to bring about shifts into public transport and walking, and also prevent some of the rebound effect of increasing overall travel in response to improved levels of service on highways, is that of congestion pricing. This needs to be examined in light of what has been said thus far, to see if this might have the potential to change the outcome in some significant way.

5. Congestion Pricing

Congestion pricing is a mechanism that is intended to increase the price of travel when travel is most likely to be congested. It is a special case of the more general notion of road user charges that are intended to charge motorists some portion of the externality costs that they impose through the use of their private cars (Jakobsson et al., 2000; Levine and Garb, 2002). There are a number of different mechanisms through which pricing can be done, such as an areawide scheme where motorists pay as they cross a cordon around the area (or pay to locate within the area), through imposition of tolls on specific roads or lanes, or through distance-based charges (Levine and Garb, 2002; Hyman and Mahew, 2002). However, the specific way in which this is imposed is not important for the discussions in this paper, which are focused on whether or not such pricing could relieve congestion, and contribute to significantly increased ridership for public transport.

In effect, congestion pricing moves the price-volume curve upwards and to the left, as shown in Figure 5. In the short run, the price increase to P_2 results in a reduction in volume to V_2. However, the same effects of increasing wealth and preferences for mobility are likely to mean that, in the longer run, the volume will again increase over time, and the levels of congestion experienced before the pricing will return and probably be surpassed, as shown by the dashed demand curve in Figure 5 and the price P_3 and volume V_3. In this case, did congestion pricing reduce congestion? In the short run, it appears that it did so. However, over the longer run, it would appear that congestion pricing has not reduced levels of congestion, simply it has delayed the time at which certain levels of congestion occur. If we were able to look in more detail into what congestion pricing has done, we would no doubt find a different mix of car users on the road, with those who were unwilling to pay the increased cost being replaced by those who were willing to pay higher costs (Burris and Pendyala, 2002). On the other hand, what it did succeed in doing, almost without question, is to raise revenues which may be a good thing, if the money is spent appropriately.

Of course, it could be argued that effective congestion pricing would entail a much larger price increase than shown in Figure 5. However, the principle remains the same. How the three prices and three volumes in Figure 5 will relate to one another will be determined by the actual magnitude of the price increase caused by congestion pricing.

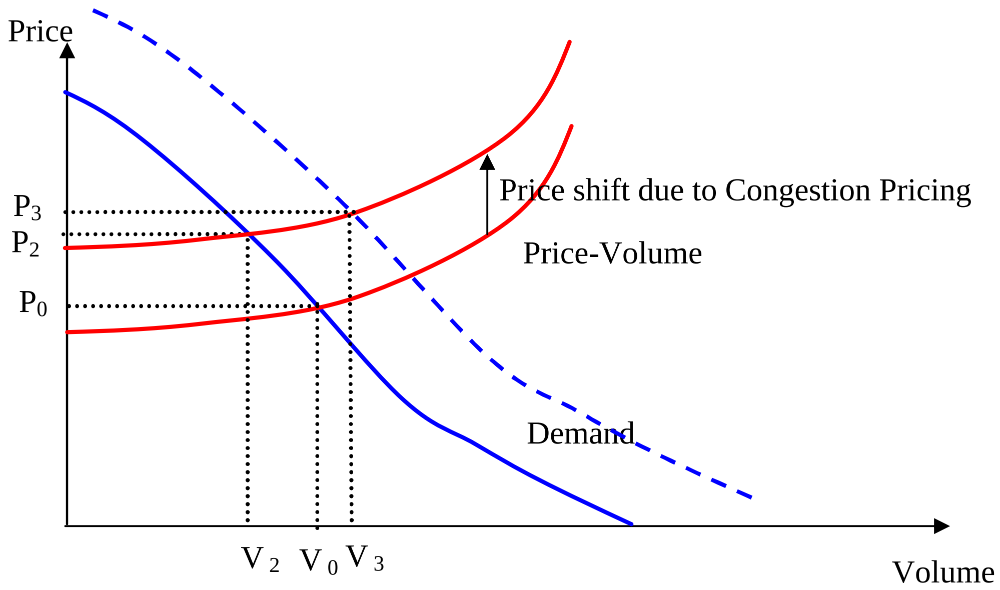

Figure 5: Effects of Congestion Pricing

While on this topic, two other points are important to consider. First, evidence from fuel price changes over the past two decades suggests that the demand elasticity for car travel with respect to fuel price is about -0.1 in the short term, rising to -0.3 in the long term. If this can be transferred to the situation of congestion pricing, then it suggests that even quite large congestion tolls will lead to only modest reductions in car travel. For those examining congestion pricing where petrol prices are still relatively modest, this is further borne out by looking at how little difference there appears to be in growth of car traffic in those countries where petrol prices are already substantially higher. For example, in Australia, petrol is about US$0.50 per litre. In the U.K., the price is about US$1.50 per litre. However, the differences between the U.K. and Australia in terms of growth of car traffic, are small. One can also see the same thing with parking prices, where even high downtown parking prices do not seem to act as much of a deterrent to car use.

Second, congestion pricing presumably is (or should be) applied only during those periods of time when the road system is congested – in most areas this would be in the morning and evening peak periods. However, users of the system always have the option of changing the time of travel to avoid these costs, as indeed is also true for avoidance of congestion without pricing. This leads to the phenomenon known as peak spreading – the peaks cannot generally grow any higher, if capacity remains fixed, so the logical thing to happen is that the peak period becomes longer. People shift the time of travel to obtain a more acceptable price of travel and indeed we start to see better use of infrastructure over longer periods (even public transport operators promote the ideals of a camel without humps for patronage profiles). In many cases, this is one of the least disruptive shifts that people can make in their daily schedules, and is likely to occur increasingly as a response to congestion, for those for whom the costs incurred in congestion are not acceptable.

In relation to the policies to shift travel into public transport, congestion pricing will provide some gains. It will change the relative prices of car and public transport, and will have an effect of shifting some of the demand that the congestion pricing suppresses into public transport demand. At the same time, we will see again the other effect that, to the extent that congestion is reduced by congestion pricing, other users will perceive a reduction in the cost of driving and additional car travel is likely to result. I would propose to add a fourth group to the three identified by Levine and Garb (2002). They identify three groups: Those "…who previously travelled on an untolled facility and remain after it became tolled…", those who previously travelled on the untolled facility and avoid it after tolls are imposed, and those who previously travelled on alternative routes and are now impacted by those who have switched from the tolled facility. The fourth group is those who previously did not travel on the facility when it was untolled, because the congestion level was too high, and now elect to travel on it, because of reduced congestion. This group is largely ignored in most writing on the topic of congestion pricing, yet it is likely to be a real group.

As yet, it is not known how much of an effect congestion pricing can have. In most urban areas, somewhere between 40 and 60 percent of daily travel occurs in the peak periods (about 5 hours). For this paper, we will assume 50 percent. Congestion pricing is more likely to be implemented in a CBD area (as in Singapore and the proposed London scheme), and that is what we will suppose in this paper. Suppose that CBD employment accounts for about ten percent of total regional employment, and that 50 percent of peak period travel is travel to and from work. The CBD already has the highest market share of public transport trips, and in our hypothetical city, may be around 40 percent of trips. Assume that average occupancy is 1.5 persons per car. This means that car trips that might be affected by congestion pricing, under these assumptions, are about one percent of total daily trips. In our hypothetical city, this is 160,000 trips. We will assume that the average trip to the CBD is about 20 kms. Using the full costs of car as a base (say, about 53 cents per kilometre in Australia), the average two-way cost of driving into the CBD might be around $20. If we add to that the cost of CBD parking at about $12 per day, there is a total cost of $32 per day. Assuming a congestion price toll of $10 per entry would represent about a 30 percent increase in the price. If the point elasticities from fuel costs can be applied, we might expect this to lead to a short run reduction of about 3 percent of car trips and a long run reduction of nearly 10 percent. Optimistically, then, it appears that we might move 16,000 cars off the road, requiring about 24,000 commuters to find other means of travel.

Compared to the numbers implied by the earlier discussion on public transport, this is a rather small number. Increases in overall market share of public transport on the order of 5 to 8 percent require that the number of trips on public transport in our hypothetical city increases by more than a million daily trips. If congestion pricing in the downtown area can only produce an extra 48,000 public transport trips per day, we have to find a way to generate more than 20 times this number.

The experience in Sydney of the recent increase in the tolls on the Harbour Bridge and Tunnel provide further evidence that the analysis offered in this paper is potentially quite accurate. The toll increase, which amounted to about a 37 percent increase in the toll (from $2.20 to $3.00) had virtually no noticeable effect on volumes across the bridge in the peak periods. If there was an effect, it lasted no more than a month or two. At the same time, there have not been any reports of a significant increase in public transport patronage for routes that cross the Harbour from the northern beaches suburbs to downtown. In fact, it appears further that the long term elasticity has probably not increased, so that there is no evidence of declining volumes now, when the toll has been in place for over 10 months.

6. Future Transport Policy Directions

If the analyses in this paper are correct and well founded, what then is the direction in which future transport policies for urban areas should move? First, it would seem that policies should recognise that the car is not a negative entity. Western civilisations should, perhaps, recognise that the unparalleled mobility that has been afforded to the average person in these countries is generally a good thing, and has probably helped to bring us to the level of economic development that we currently enjoy. Perhaps, those in less developed countries that aspire to similar levels of mobility that we currently enjoy are not deluded, but have rather put their collective fingers on the main root of economic well-being.

Whether this is true or not, policies should recognise that the car, or some form of personalised transport that is affordable and can take people almost anywhere they wish to go, when they choose to travel, are here to stay. As a corollary to that, policies should recognise the futility of trying to move people in large numbers out of cars and into public transport. Historically, public transport had its heyday before the invention and widespread availability of the car. It worked extremely well in smaller cities than exist today (and were made possible largely by the car), when most jobs were in the central core of the city, and when development patterns of residences were comparatively dense, and clustered around major thoroughfares. Short of redeveloping cities into the forms that were common in the late 19th century, and teaching people to no longer desire the levels of mobility that western civilisation has provided in the beginning of the 21st century, it is unlikely that public transport can ever again carry a majority of travel within an urban area. Probably, it is not too severe a statement to say that policies should largely shift away from trying to increase public transport's market share in general, although there may be niche markets where real increases can be achieved.

Recognising these facts, therefore, the following may be plausible and sensible policy directions for transport in the early 21st century:

Assuming that pollution from automobiles is considered to be a serious issue, then policies should be directed towards encouraging the invention and widespread implementation of non-polluting and sustainable engines for automobiles.
Understanding that congestion is never likely to be eliminated, and that tolerated levels of congestion are likely to get progressively higher, policies should be aimed at

managing congestion, rather than trying to eliminate it. Managing congestion includes understanding the differences between recurrent and non-recurrent congestion and implementing policies to minimise the latter. Second, managing congestion also means seeking out ways to reduce the occurrence of avoidable congestion through better traffic control systems, improved intersection designs, and prohibition of certain types of transport and movement during periods of heaviest use. In addition, improved methods to permit tidal flow, that uses the available road space more effectively, is also a potential useful policy direction.

The niche markets that are best served by public transport should be identified clearly, and policies pursued that would enhance the attractiveness of public transport in these markets. Too little attention is paid to the specific markets that public transport can serve well, and too much time, effort, and money is wasted on trying to make systemwide improvements in public transport, or in trying to raise systemwide ridership, rather than concentrating on the appropriate markets where public transport is a good alternative to the car. This is likely to include the provision of busways and bus-only traffic lanes in certain locations, and also investing in other types of bus priority procedures.

Policies that would improve the potential for people to work from home, or to have flexible working hours should be explored more extensively. Shortened working weeks with longer hours per day may also be options worth investigating. In general, policies that would lead to peak spreading, and a possible shift of travel out of peak periods altogether may be beneficial.

Better coordination is needed between land use policies and transport infrastructure provision. Too often, these are disconnected in the political process, often leading to exacerbation of avoidable congestion problems.

Insofar as road pricing and congestion charging are pursued, these should be seen as methods to raise revenues, rather than as methods to reduce congestion or increase public transport ridership. At the same time, the revenues raised from such charges should be dedicated to transport investments, in addition to public funds already earmarked for that purpose.

As has already become increasingly widely recognised, additions to capacity for roadways should be considered very carefully, with increased recognition that such capacity increases will generally lead to improvements in mobility, but not in reduction of congestion.

7. Congestion Pricing Revisited

It seems appropriate to return to the discussion of congestion pricing in light of these proposed directions, and particularly bearing in mind the policy and revenue conflict discussed earlier relating to fuel efficiency. Hyman and Mayhew (2002) argue for a distance-based charging policy as being the more effective under a variety of different conditions. Opiola (2002) has also argued that a distance-based policy has many merits over other policies, and advocates the use of a distance based charge as a replacement for all or most of the fuel excise charge. This policy direction offers a number of potential benefits that seem worthy of further consideration.

First, replacing the fuel excise tax with a distance-based road-user charge that is revenue neutral would remove the dilemma faced by government that encouragement of more fuel-efficient vehicles will reduce government revenues. At the same time, by making this shift a revenue neutral shift, there should be greater public acceptance of the change. Furthermore, hypothecation of the revenues raised by a kilometrage fee would provide a much greater potential public acceptance, as has been found with the proposed area scheme in London (Livingstone, 2001). By shifting away from the fuel-based charge to a distance-based charge, revenue becomes separated from fuel efficiency, which seems to be a desirable direction to pursue.

Second, having established this change, government may now become much more aggressively involved in promoting alternative-fuel vehicles and influencing the market. For example, establishing different kilometrage charges based on fuel efficiency would permit penalties to be placed on those vehicles that are heavy consumers of fossil fuels, while providing a significant cost savings to those vehicles that are powered by fuel-efficient hybrid or fuel cell engines. In addition, part of the revenue raised from the kilometrage charge could be used to fund further research into fuel-efficient and cleaner vehicles, or could be used to provide a reduction in other fixed charges applied to private motor vehicles, such as registration and licensing costs, and sales taxes, thereby providing further financial incentives to individuals to purchase such vehicles. Increased sales of such vehicles should, in turn, reduce the retail price, and also induce manufacturers to pursue further improvements in the technology.

While beyond the scope of this paper to explore, the imposition of kilometrage charges would also seem to be likely to move in the direction of fostering accessibility improvements and not creating mobility improvements. In fact, a kilometrage charge would, by definition, increase the cost of each kilometre travelled and would, therefore, reduce mobility. At the same time, the kilometrage charge may deter urban sprawl and the dispersion of potential destinations, thereby moving in the direction of improving accessibility, although there is also the possibility that there may still be decentralisation to edge cities. Coupled with judicious capacity expansions, these kilometrage charges might move in the direction of managing congestion better, spreading benefits more equitably, and refocusing policy on achievable ends for the transport problems facing most 21st century urban areas. Technologically, with such devices as GPS antennas and associated hardware and software, improved vehicle tracking capabilities, and other technological devices, kilometrage charges can be implemented reasonably easily and can be varied by time of day, vehicle, and location, if appropriate. A much more extensive study is required to determine all of the policy and traffic management implications of such a direction, but this does appear to offer a potentially sound option for tackling issues of congestion and car use.

8. Conclusions

Several conclusions should be drawn from this analysis and discussion.

First, traffic congestion has existed for many centuries. It has never been possible to eliminate it and it seems unlikely that this can be achieved in the modern era. Indeed, it might be expected that congestion levels will continue to worsen and that periods of congestion will tend to extend over more of the day. The aspects of time wastage of congestion may be overstated. There appears to be evidence to suggest that a significant portion of those who encounter congestion are not unhappy with the time that their travel takes. The emissions problems resulting from congestion can potentially be corrected through technological changes, if there is a market to clean up the air through such procedures.

Second, while it is clearly desirable to continue to maintain public transport systems, they do not offer the answer to reducing congestion significantly. There is serious doubt as to whether it is feasible to increase public transport ridership by a significant amount from present levels, given the sheer volume of passengers that would have to be carried, the downward trend in public transport market share, and the increasing dispersion of jobs and residences, producing a pattern of demand that is very difficult for public transport to serve.

Third, congestion pricing is also unlikely to be a useful mechanism either to reduce long term congestion or to increase the public transport share of the market. As with policies that might succeed in increasing public transport use, congestion pricing may buy a delay in reaching certain levels of congestion, allowing for additional growth of the urban area before that level of congestion is reached, but will not, in the long term reduce congestion or result in a major shift into public transport. On the other hand, congestion pricing is likely to be a mechanism for raising revenues. Whether it is a desirable method requires further analysis, and also depends on how the revenues so raised are spent and how the pricing is implemented.

Fourth, car travel is not an evil and policies that fly in the face of the clear and obvious market that exists for this form of travel are probably doomed to fail. Rather than spending substantial amounts of money in the futile pursuit of major public transport market share increases, or other efforts to curb the public appetite to use the car and to continue to demand even greater mobility, it might be better to invest in policies that attempt to manage the inevitable use of the car better, and that accept that congestion will always exist. Indeed, congestion is indicative that the supply of capacity is being fully utilised. Perhaps, investments and policies should be shaped more to spreading peaks, and using the road space more fully for more of the day, than in trying to somehow reduce congestion that the public is apparently willing to accept.

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REFERENCES

Bonsall, P. (2000), "Legislating for Modal Shift: Background to the UK's New Transport Act", *Transport Policy*, Vol. 7, No. 3, pp. 179-184.

Burris, M.W. and R.M. Pendyala (2002), "Discrete Choice Models of Traveler Participation in Differential Time of Day Pricing Programs", *Transport Policy*, Volume 9, No. 3, pp. 241-251.

Garber, N.J. and L.A. Hoel (1996), *Traffic and Highway Engineering*, PWS Publishing Co., Boston, pp. 182-183.

Hensher, D.A. (2002), "Urban Public Transport Delivery in Australia: Issues and Challenges in Retaining and Growing Patronage", unpublished paper, The Institute of Transport Studies, The University of Sydney.

Hills, P.J. and P. Gray (2000), "Characterisation of Congestion on an Urban Road Network Subject to Road-Use Pricing – A Fundamental Review", paper presented to the 9th Triennial Meeting of the International Association for Travel Behaviour Research, Queensland, Australia, July.

Hyman, G. and L. Mayhew (2002), "Optimizing the Benefits of Urban Road User Charging", *Transport Policy*, Volume 9, No. 3, pp. 189-207.

Jakobsson, C., S. Fujii, and T. Gärling, "Determinants of Private Car Users' Acceptance of Road Pricing", *Transport Policy*, Volume 7, No. 2, pp. 153-158.

Keefer, L.E. (1966), "The Illusory Demand for Mass Transit", *Traffic Engineering*, January.

Kerr, J. (2002) 'Private tollway revenues accelerate' *Sydney Morning Herald* [Online], 29 August, Accessed 5/11/02:
http://www.smh.com.au/articles/2002/08/28/1030508072592.html

Levine, J. and Y. Garb (2002), "Congestion Pricing's Conditional Promise: Promotion of Accessibility or Mobility", *Transport Policy*, Volume 9, Number 3, pp. 179-188.

Livingston, K. (2001), "The Mayor's Transport Strategy, Draft for Public Consultation. Annex 4: The Congestion Charging Scheme for Central London", Greater London Authority, London.

Miller, H.J. (1999), "Measuring Space-Time Accessibility Benefits within Transportation Networks: Basic Theory and Computational Procedures", *Geographical Analysis*, Volume 31 (1), pp. 1-26.

Nasser, H. El (2002), "Commuting Offers Coveted Refuge for Some", *USA Today*, Money Section, 30 May. Accessed 31 May 2002 via http://www.usatoday.com/money/covers/2002-05-30-driving-alone.htm

NRMA (2002a), *Understanding Hybrid Vehicles*, Public Policy Unit, National Roads and Motorists' Association Limited, 1 page.

NRMA (2002b), *Understanding Fuel Cells*, Public Policy Unit, National Roads and Motorists' Association Limited, 1 page.

Opiola, J. (2002), Keynote Address to the NRMA Transport Pricing Conference, Parramatta, Sydney, NSW, 12 November, 2002.

Redmond, L.S. and P.L. Mokhtarian, "The Positive Utility of the Commute: Modeling Ideal Commute Time and Relative Desired Commute Amount", *Transportation*, Vol. 28 Number 2, pp. 179-205.

Schafer, A. (1998), "The Global Demand for Motorized Mobility", *Transportation Research A*, Vol. 32, no. 6, pp. 455–477.

Truong, T. and D.A. Hensher (2002), "Congestion Charging and the Optimal Provision of Public Infrastructure: Theory and Evidence", paper presented to the 25th Annual Meeting of the Australasian Transport Research Forum, Canberra, October.

Wohl, M. and B.V. Martin (1965), *Traffic Systems Analysis*, McGraw-Hill, London.

World Business Council for Sustainable Development (2001), Mobility 2001: World Mobility at the End of the Twentieth Century and its Sustainability: Report prepared by MIT and Charles River Associated for the World Business Council for Sustainable Development, 2001 [Online] Accessed 15/11/02: http://www.wbcsdmobility.org/publications/files/mobility2001/english_full_report.pdf