

CHAPTER 25

TRAVEL DEMAND MANAGEMENT OPTIONS FOR PERTH

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INTRODUCTION

An assessment of Perth's road infrastructure and traffic management processes concluded that traffic congestion has become more pronounced over the last ten years, both in public perception and in real terms (Office of the Auditor-General, 2015). Since 2005, congestion on Perth's roads has increased rapidly, with the morning peak period into the city being most congested. Congestion is not limited to the road network. The morning rail public transport services on rail lines often reach capacity prior to arrival at Perth central station. The deterioration in both road and public transport system performance is expected to continue, with demands for more road capacity, new rail lines and rolling stock and expanded bus services.

Congestion and its impacts are likely to worsen in future, especially under business-as-usual conditions where improvements from new road and rail infrastructure construction alone will not keep pace with demand. The *per annum* cost of road congestion in the Perth metropolitan area has been estimated to increase almost nine-fold, from \$1.78 billion in 2011 to \$15.87 billion in 2031 (Infrastructure Australia, 2015).

Travel demand management (TDM) is a valuable option to alleviate the effects of increased congestion in transport networks and maintain an efficient urban transport system. Contemporary understanding of TDM relates to the provision of competitive

transport alternatives or maximising the opportunity available to travellers: 'Managing demand is about providing travellers, regardless of whether they drive alone, with travel choice, such as work location, route, time of travel and mode' (Berman, 2006, p. 10). Meyer (1999, p. 576) also views TDM as policies aimed at providing effective travel options: TDM 'is any action or set of actions aimed at influencing people's travel behaviour in such a way that alternative mobility options are presented and/or congestion is reduced.' Other views of TDM focus on resource efficiency where TDM was seen as '... a general term for strategies and programs that encourage more efficient use of transport resources (road and parking space, vehicle capacity, funding, energy, etc.)' (Litman, 2003, p. 245). A key objective of TDM is to optimise the use of the current transport infrastructure so as to reduce or delay the need for road capacity expansion. As such, despite having other benefits, the principal reason for TDM policies is to abate congestion on existing road networks.

Current planning strategies in WA to reduce traffic congestion include a suite of instruments spanning supply-side approaches (investment in public transport, expanding the road network and optimising road-network efficiency) and demand management (providing active transport networks, land-use planning, limiting single occupancy vehicle (SOV) opportunities, through parking management and road pricing, and voluntary travel behaviour change (VTBC) programs). TDM policy measures will become an integral part of transport policy for Perth in the forthcoming years. The increasing population will put pressure on infrastructure, which means that Perth needs to find transport efficiencies by directing demand to alternate modes, time of departure or destinations.

This chapter summarises a review of academic and policy literature to identify a comprehensive range of TDM instruments in use internationally and nationally. The result of the review was a TDM matrix, developed by the Planning and Transport Research Centre (PATREC) for the purpose of identifying TDM

instruments suited to Perth (Babb & Smith, 2014). The matrix categorises the range of TDM policy instruments available to policy makers in Western Australia according to the key characteristics of the instruments to better enable evaluation, appraisal and selection of TDM policy programs for Perth. In the second part of the chapter, a selection of TDM instruments is discussed in more depth, focussing on their applicableness to Perth, their public and political acceptance and a strategy for implementation.

TRAVEL DEMAND IN THE PERTH CONTEXT

Perth is a physically dispersed city of more than two million people. It is characterised as being car dominant, with some of the highest rates of car ownership and mode share in Australia, and modest public transport use (Mees & Groenhart, 2013). It is also a relatively young city that has limited geographic barriers that contain the urban area, resulting in a sprawled metropolitan region that developed rapidly during the post-war car era. With more inner city living and technology and consumer preferences, there is a growing recognition that the underlying social, economic and physical structure of Perth's activities has been changing for some time.

Perth's transport system is dominated by a hierarchy of roads, which have been planned to focus on the CBD but also across the region as a whole (Curtis & Tiwari, 2008). The system has provided mobility for passenger cars and road freight, with less emphasis on public transport. There has been an increasing recognition of the value of public transport over about twenty years with considerable associated investment and an emerging recognition of other forms of transport, particularly cycling, which has also recently attracted increased policy recognition and funding (Babb et al., 2015).

Perth's monocentric urban structure, with white-collar employment concentrated in the CBD, is accommodated by radial transport routes that have sufficient capacity to facilitate

trips during peak periods. The resulting temporal congestion affects major freight-road corridors, especially when high freight demands coincide with commuter peak flow. In contrast, peak-hour, contraflow link capacity is under-utilised significantly, generating inefficiencies in capital and operating expenditure. According to Infrastructure Australia (2015), a business-as-usual approach to the year 2031 would see Perth featuring in seven of the top ten congested road corridors nationally. While the claim appears brazen, it nevertheless alerts policy makers that congestion in Perth is at a nascent stage and will almost certainly mature.

The strategic spatial plan for Perth and Peel, *Directions 2031 and Beyond* (Western Australian Planning Commission (WAPC), 2010), and the recent draft *Perth and Peel@3.5million* report (WAPC, 2015) have outlined a plan for a 'connected' city, setting targets for 47 per cent of new dwellings to be consolidated within the existing urban area. Since the late 1990s, spatial planning in Perth has directed growth towards activity centres, activity corridors and transit station precincts. These growth directives are underpinned by the goal of managing urban travel demand in order to achieve transport system efficiencies and produce a more sustainable urban form by limiting growth on the urban periphery.

IDENTIFYING TDM INSTRUMENTS TO ALLEVIATE CONGESTION

Selecting and resourcing TDM policies appropriate for Perth requires an understanding of the range of instruments available and how they manage demand for travel. Typologies of TDM instruments have been developed (Austroads, 1995; Broaddus, Litman, Menon & Replogle, 2009; Rose, 2007). The typologies categorise instruments according to significant characteristics to enable policy selection: where transport problems occur; when those transport problems occur; whether instruments provide disincentives for car travel or incentives for alternative modes; what travel outcomes are sought; and performance against multiple

social, economic and environmental criteria. The effectiveness of the TDM measure against these criteria should also be considered. Reduction of vehicle kilometres, mode shift or reduction in air pollution levels may be considered as measurements of the effectiveness of the TDM.

Several key characteristics relevant to policy deliberation were outlined for each of the TDM instruments identified from a search of academic and policy literature. Firstly, TDM instruments were identified as either providing incentives for travel by modes other than SOV or providing direct disincentives for travel by SOV. This distinction is referred to in the TDM matrix as 'push' or 'pull' and has been referred to elsewhere as a 'carrot and sticks' approach or 'command and control' versus 'incentive based policy' approach (Meyer, 1999; Santos, Behrendt & Teytelboym, 2010). Instruments that use a 'push' approach typically involve charging for travel or restricting mobility, either spatially (such as reducing road space) or temporally (at specific times during the day). 'Pull' instruments, on the other hand, provide incentives for alternative modes of travel to the car. Incentives may take the form of reduced direct costs, system efficiency improvements or improved comfort and utility. It is widely agreed that effective TDM strategies employ both 'push' and 'pull' mechanisms, particularly to enhance public acceptance of disincentives.

Secondly, the TDM matrix identified instruments according to their target travel markets. Demand for travel varies according to differing trip purposes and, for effective TDM strategies, an understanding of the type of demand for travel associated with different trips is required. Meyer (1999) identifies these segments of travel demand as travel markets, which have a differing range of factors influencing discrete choice between travel modes.

Thirdly, TDM instruments were identified according to the outcomes or behavioural responses sought. The four intended outcomes of TDM instruments include trip substitution, mode shift, reduced travel distance and shift to travel outside peak periods. Overall policy objectives determine the types of behavioural

outcomes required by policy interventions. For example, policy makers seeking a reduction in the level of congestion in the road system may use instruments to shift travel to outside peak periods; whereas sustainable policy objectives also address reducing travel, social equity and shifting to more energy efficient and less polluting modes of travel. Knowledge of the underlying behavioural outcomes sought by TDM instruments can help policy makers select suitable instruments to achieve specific policy objectives.

Finally, the planning and implementation of TDM instruments can necessitate the participation of a range of actors. For road transport the prominent actors are decision-makers (national, state and local governments), courts and government agencies (regulatory, delivery and operational), companies and industry associations and individuals, both within the above and as direct users of road transport. These actors cover all of the actions for transport to occur, including policy, regulation, strategy, planning, infrastructure, operations and maintenance for all of the core and wider components. They seek differing outcomes from transport policy (often characterised as economic, social or environmental) that can be complementary and/or competing. In general, higher-level actors exercise control over the lower levels and any actor can attempt to influence any other actor at any level in order to achieve their desired outcomes.

Congestion may be alleviated through supply and/or demand strategies. To identify appropriate TDM instruments or policies, delineating supply and demand approaches is necessary. Supply-side instruments include construction of new capacity as well as enhancements to existing transport network operations. Demand instruments aim to change the way people evaluate their travel options using the existing transport network. However, such a strict definition poses some difficulty in framing the possible instruments for managing travel demand. Many policies commonly thought of as being TDM instruments aim to improve the level of supply offered by non-car alternatives. Extensions to bicycle lanes to improve cycling safety or improved connectivity

of public transport are examples of supply instruments aimed at making alternate (non-car travel) modes more attractive. Integrated land-use and transport represent planning decisions, but the implementation of these decisions are necessarily supply initiatives as they guide the built environment and the transport function. While it is impractical to define the scope of a TDM review by whether an instrument affects the supply side or the demand side of the transport function, it is necessary to specify some boundaries. Two broad areas of transport supply policy outside the scope of TDM instruments for Perth are:

- **Road building and improvements to traffic flows:** Road capacity is the most important factor affecting the level of congestion. Governments manage the level of congestion by way of transport investment in lanes (lane kilometres) and removing intersections along freeways and major arterial routes and highways. The second supply instrument available to transport authorities is to improve operational efficiency. Smart intersections, controlled freeway on-ramps and other intelligent transport systems are used to improve the travel time on existing roads. The third supply instrument is the capacity of the network to manage and limit incidents. Intersection design, improved safety engineering, road management for special events and incident response are not considered to be demand management strategies in this chapter.
- **Public transport infrastructure investment:** Construction of urban rail, metro systems and light rail are considered supply-side instruments, which can affect road transport demand. Major investment in public transport rolling stock and additional new bus services are also considered to be supply instruments. However, improvements to localised public transport services delivered through additional staff or a redeployment of assets are regarded as TDM

measures. For the purposes of this chapter such incremental changes are included in the ‘pull’ instruments that improve the quality of service of non-car modes.

TRAVEL DEMAND MANAGEMENT INSTRUMENTS

Drawing on the key characteristics of TDM outlined above, a matrix of TDM instruments was developed, ordered according to degrees of whether the instrument used a push or pull approach. Nine categories were identified, each with a number of sub-categories. The matrix organised TDM instruments according to distinct categories, however, many instruments had characteristics that were suitable for multiple categories. A summary diagram of the matrix is illustrated in Figure 1.

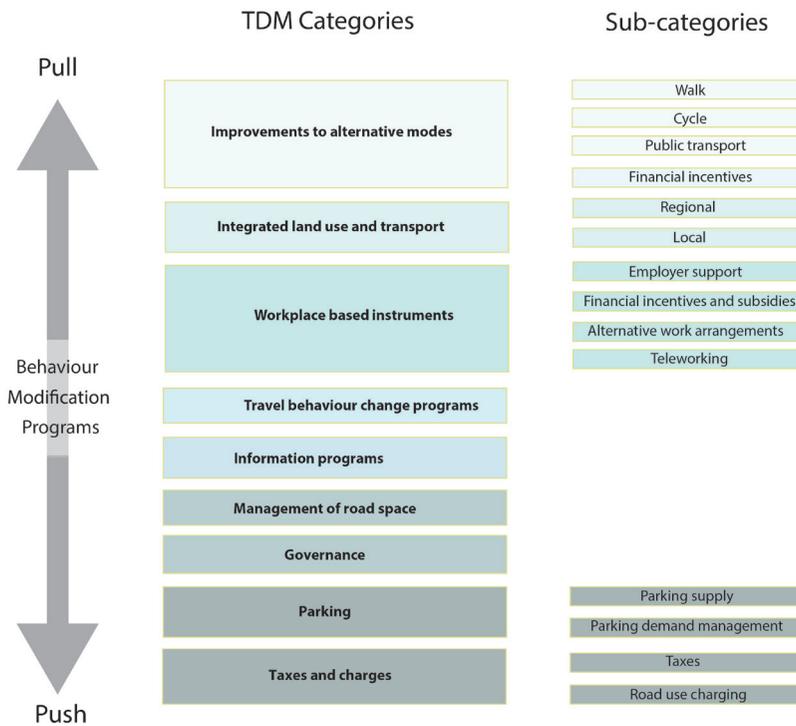


Figure 1: Travel Demand Management (TDM) categories.

Improvements to Alternative Travel Modes

Improving the quality of walking, cycling and public transport trips manages travel demand by increasing the attractiveness and incentivising alternative modes of travel to SOV. Achieving mode shift by making alternative modes attractive delivers a broader range of benefits in addition to reduction of congestion. For pedestrians and cyclists there are benefits for health through more physical and social activity. Increased public transport use can lead to greater transport system efficiencies and incentivise land-use development in accessible locations, as proposed in chapter 21. The improvement of alternative modes of travel to SOV is likely to be of critical importance to the planning and implementation of 'push' style TDM instruments, such as congestion charges.

Two TDM policy instruments provide examples. Street-scale improvements, such as the Woonerf in the Netherlands, have seen numerous cities and towns redesign neighbourhood streets to create areas where cars, cyclists and pedestrians coexist on equal terms. By altering signage, visual cues and the physical infrastructure of streets, and therefore limiting the speed on traffic, there may be an induced demand for walking and cycling with or without a reduction in car travel. Since 2011, Auckland Council in New Zealand has delivered a number of shared-space projects in the Auckland CBD (Auckland Council, 2015). The streetscape design is known as Home Zones in the UK, Shared Zones in Australia and New Zealand and Complete Streets in the USA. Shared-space projects have been attempted in Perth, of which Bay View Terrace in Claremont is an example.

Effectiveness

While there is evidence that higher quality walking environments are associated with higher levels of walking, this increase has little effect on the traffic volumes (Handy, Sciara & Boarnet, 2014). Cavill et al. (2008) undertook a meta-review of reported economic evaluations of active transport infrastructure, concluding that most projects had benefit to cost ratios (BCR) higher than 2:1 (median

BCR for reviewed projects was 5:1). However, it was noted that health benefit was the main factor driving these high ratios, rather than congestion relief. Improvements to the walking environment are felt locally and the (majority) of walk trips are not replacing car trips. The Residential Environment Study (RESIDE) identified that Perth households living in compacted and connected designs (smaller lots, grid street layouts and ample supply of footpaths) and green designs (designated open spaces and parks) were more likely to undertake walking for leisure purposes (Hooper, Knuiman, Bull, Jones & Giles-Corti, 2015). However, to encourage walking as a mode to replace the car, neighbourhoods require a village layout with a 'walkable local neighbourhood or town centres which act as community focal point or hub' (Hooper et al., 2015).

There are a number of interventions available to policy makers who wish to promote cycling. From a safety point of view, dedicated cycleways that separate cyclists from the general traffic is the most effective solution to reduce cycling accidents (Talbot, Reed, Barnes, Thomas & Christie, 2014). However, the solution is not practical or economic for all cycling routes and, for all routes, the cyclist will enter the main road network at some point. It is these intersections that pose a 'high risk of collisions' (Talbot et al., 2014, p. 62). While not being a perfect solution, the provision of dedicated cycleways is the most effective single measure for encouraging cycling (Cavill et al., 2008). Furthermore, the impact on travel is enhanced when the cycling infrastructure forms part of a compressive cycling policy (Pucher, Dill & Handy, 2010).

Perth Context

Transport planning policy in Perth supports increases in walking and cycling in a number of ways (see chapters 12 and 13). Increasing the proportion of trips undertaken by walking or cycling can provide multiple individual and social benefits including more efficient use of transport infrastructure, environmentally sustainable travel, increased health benefits and greater economic productivity for local economies. Improving movement networks

is one way that greater demand can be stimulated for travel by alternative modes. In 1996 the *Perth Bicycle Network (PBN) Plan* set out a network of local bicycle routes, principal shared paths and regional recreational paths. The *Western Australian Bicycle Network (WABN) Plan 2014 to 2031* emphasised extending the cycling network to support increased cycling commuter trips. Other positive programs to raise awareness of cycling and promote commuter cycling through greater information and incentives include the annual Bike Week and Bike to Work Breakfast. Despite some policy successes, principally increases in cycling commuter trips, there are still many opportunities for improving the connectivity of cycling networks and capturing the latent demand for shorter cycling trips within the local areas (Royal Automobile Club of WA (RACWA), 2012). The safety of on-road cycling has received recent critical media attention and more cyclists are dissatisfied with on-road travel than travel on separated, shared paths (RACWA, 2015a). Reallocation of road space for dedicated cycling lanes and complete street approaches would contribute to broadening the mode share of cycling.

Planning for walking has received some support across state and local government and through travel behaviour change programs. Strategies such as *Walk WA: A Strategy for WA 2007–2020* provide guidance for local and community organisations and advocacy groups and set out strategies for increasing mode share by walking. Neighbourhood design at the subdivision scale is important for shaping the built environment to support walking and cycling trips. Liveable Neighbourhoods provides guidance on neighbourhood planning to facilitate walking, cycling and public transport trips. However, implemented Liveable Neighbourhoods have contributed only modest increases in recreational trips and have had minimal effect on increasing utilitarian walking trips when compared to conventional neighbourhood designs (Falconer, Newman & Giles-Corti, 2010; Giles-Corti et al., 2008). There is even less-clear policy guidance on facilitating walking in existing neighbourhoods within the central and middle urban regions,

many built to cater for the car. Adapting existing streets, through reallocation of road space, use of signage and visual cues and traffic management, will be important to increase walking mode share in urban areas that are subject to pressure from increased urban consolidation.

Integrating Transport and Land-use Planning

Improved integration of transport and land-use planning refers to the efficient and synergistic functioning of land-use and transport systems (see chapters 15, 16, 17 and 27). Better integration means greater accessibility, a reduction in the distances people need to travel and the co-location of services that enables the chaining of trips. Integrating transport and land-use planning can occur at a broad strategic policy level, guiding metropolitan development patterns, or at the local scale, through assessment of developments and subdivision.

In the Netherlands, the ABC location policy is an example of integration between the strategic land-use policy and transport accessibility at a regional scale (Schwanen, Dijst & Dieleman, 2004). The policy objective is to match the transport needs of businesses with areas with suitable locational accessibility. Businesses are assigned a mobility profile based on trip attraction potential (employees, customers and freight). This profile is matched with an accessibility profile that classifies locations according to the level of accessibility by car and by public transport. For example, businesses that attract large volumes of customer, employee or freight trips are directed to locations outside high accessibility areas that support greater proportions of trips by public transport, cycling or walking.

At a local scale, demand for travel can be managed through the development assessment process. In the UK, the National Planning Policy Framework requires that significant developments be subject to an impact assessment (UK Government, 2007). Assessments identify developments' likely impacts on transport system efficiency and identify measures to mitigate such impacts.

Transport impact assessments are usually accompanied by a travel plan that sets out strategies for the ongoing management of travel demand produced by the assessed development.

Effectiveness

Cervero (2002) indicated that land-use mix and density have a positive effect on the level of public transport use. This relationship is supported by other empirical cases (Cervero & Kockelman, 2007; Frank & Pivo, 1994). However, it may be that density and land-use mix provide higher levels of accessibility by non-motorised travel, which directly influences travel (Cervero & Duncan, 2006; Ewing & Cervero, 2010). Greater levels of accessibility and higher densities may lead to a greater use of the car; when these densities are supported by provisions for auto-accessibility – such as lane density – they act as a demand inducement (Cervero & Murakami, 2009; Chatman, 2008). Such an outcome led to policy suggestions, such as increasing residential density but reducing road capacity and therefore using reduced travel speeds (i.e. congestion) to encourage people out of their cars (Chatman, 2008). The aim of planning should not only be about reducing car use, but creating a form that supports a diversity of transport options including shorter active trips.

Perth Context

Bannister (2008) outlines that for a city to operate a sustainable transport mix it should be sufficiently populated with a medium density and incorporate land-use diversity that focusses development on public transport routes and interchanges. The challenge for Perth is that it is a low-density city that spans over 150 kilometres of coastline. Despite this, the development of the new Mandurah to Perth railway has had operational success (Olaru, Smith & Taplin, 2011). However, because of its alignment along the centre of the freeway, the development of transit-oriented designed (TOD) communities around stations has been challenged and Park and Ride is a major access mode (Martinovich, 2008). Curtis

(2008) noted that the development of railway stations in Perth had tended to move away from the traditional walk to the station and ride (compact place development) to more car-integrated or transit-interchanged multimodal nodes.

Travel Behaviour Change Programs

Behaviour change programs aim to change the decision-making and behaviour of individuals in the household or workplace, usually through a range of strategies including the provision of information, support and feedback, coaching and incentives for travel by sustainable modes. Travel behaviour change is successful when individuals initiate change towards more sustainable travel behaviour and habits without coercion through 'push' policies (see chapter 24). Travel behaviour change programs for several target groups have been implemented in Perth under the TravelSmart banner and evaluations of these programs demonstrate they are effective in achieving mode shift from SOV (Ker, 2002). The evidence of travel behaviour change programs in Perth is illustrated in more detail later in this chapter.

There are different types of travel behaviour change programs, which often focus on particular target groups such as households in an area, workplaces or activity nodes. Voluntary change and individualised marketing refer to travel behaviour change programs that are specifically designed for individuals. The programs involve targeting individuals with information regarding sustainable travel options and benefits. Travel blending (Ampt, 2003) is a program that has the objective of increasing the number of households consolidating trips for multiple purposes or 'blending' travel modes and activities in order to reduce travel. The program involves households keeping diaries of travel behaviour in conjunction with the provision of information and education about factors such as the rates of emissions and costs.

Evidence of Effectiveness

There is a growing body of literature indicating that the demand

for travel can be managed through behaviour change programs focussing on several different target groups. Household-, local government-, school- and work-based programs provide information and support to encourage a more blended travel pattern. These programs promote mode shift to manage demand by raising awareness of alternatives to driving alone, building positive perceptions of these options and leveraging change in the social and physical context in which people make travel decisions.

In a meta review of the effect of ‘soft measures’ (travel behaviour change programs and related measures), Möser and Bamberg (2008) found that personalised or household travel behaviour modification programs led to an 11 per cent reduction in the share of trips made by car. They exercise some caution over these findings as the before and after studies on voluntary participants omit sampling from a control population. Taniguchi, Suzuki & Fujii, (2007) reported a meta-analysis of the results of programs conducted in Japan. The programs were divided into three categories depending on where they had been conducted: residential areas, workplaces or schools. The meta-analysis was limited, however, to programs conducted in residential areas. It was shown that the number of car trips fell by 7 per cent and that the number of public transport trips rose by 69 per cent. A closer analysis of the programs that used control groups showed a fall in the number of car trips by 12 per cent. The results are comparable to Cairn’s et al. (2008) report of a 7 per cent to 15 per cent reduction in car use in their study of UK local government personalised travel planning initiatives. In Australia, household voluntary behaviour change programs have a reasonably high participation rate, of 30 per cent to 40 per cent (Taylor, 2007).

Perth Context

In the TravelSmart program with local government, WA State Government provides seed funding for local government to undertake travel behaviour modification projects (Department of Transport, 2011). The local government TravelSmart Officers

supported under this program were involved in the implementation of community travel behaviour change initiatives (e.g. conducting cycling and walking activities, working with local schools), helped liaise between local and state government and were change agents within their local government organisation (Murphy, 2012).

In 1997, a pilot TravelSmart household program delivered individualised marketing of travel alternatives to South Perth residents, resulting in a 10 per cent reduction in SOV trips (James, 1998). A full-scale program was rolled out in 2000, which was subsequently replicated in Stirling, Subiaco, Melville, Fremantle and other local areas of Perth (Ashton-Graham, John, Radford & Rampellini, 2005). These projects were initially undertaken without complementary new investment in public transport. The Living Smart program that followed the construction of the Perth to Mandurah line showed a modest increase in public transport shares over and above the initial impact of the railway completion (Kent & Ampt, 2012). This supports the contention by Percy, Clark, Valero, Roon & Young, (2006) that augmenting a public transport investment with travel behaviour programs offers real potential to reduce the level of congestion on major economic routes. The recent household programs in Cockburn (2013–14) and Wanneroo (2015) have evolved into sophisticated travel behaviour change methodologies with extensive government, private and association partnerships (Department of Transport, 2016a).

The TravelSmart Workplace program builds capacity in workplaces to change the travel demand of employees. The program supports workplaces to develop and implement travel plans in order to reduce solo car commuting and enable greater use of travel alternatives (Wake, 2007). Travel plan actions typically include providing practical information on travel options, improving end-of-trip facilities for cycle commuters and offering incentives to use travel alternatives. Participating workplaces are encouraged through collaborations and engagement with senior management to ensure effective program delivery. Similarly, the

state government invests in building capacity in schools to reduce local congestion by supporting staff, students and parents to implement measures that encourage walking, cycling and catching public transport to school. The TravelSmart to School program provides teacher and parent training, classroom activity resources and an online platform for exchanging ideas to aid school communities and replace 9 per cent of car trips with active transport. Stakeholder engagement, flexible strategies and recognition have been used to support effective delivery in schools, workplaces and local governments.

Parking TDM Instruments

Parking policies can be deployed to manage travel demand through effective pricing of the existing parking supply or the control of parking supply in strategic locations (see chapter 26). As cars spend most of their time parked, the availability and cost of parking spaces at origins and destinations plays an important role in shaping the decision to own and use motor vehicles. Parking policies may address the level of on-street and off-street parking provision for residents, the provision of parking for work or parking for retail or other activities. Marsden (2014) suggests that there is a key difference between managing parking and using parking policies as a means of reducing overall travel demand. While managing parking requires timely and effective supervision, resourcing, information and application, parking policies require a proactive macrocosm view in addition to the balancing of transport modes. Simply, the two have to co-exist in order to effectively address and balance the provision of different parking types.

Parking-demand management schemes include parking pricing strategies that reflect the real-time demand for parking spaces – parking demands are higher at peak times and lower at off-peak times, creating an incentive for people to travel outside peak times, although it could be argued that such incentives could also lead to an overall increase in demand for car travel.

Travel demand may also be managed by adjusting the supply of car parking spaces. Parking caps have been used in the Perth central business district since the 1980s and there are now parking caps at Murdoch and Curtin activity centres. The parking caps are determined by modelling of the regional road network at peak conditions and allocated based on bays per hectare of the site area (Department of Transport, 2016b). Parking policies fit within a number of other categories in the TDM matrix, including workplace TDM instruments that include priority parking for high occupancy vehicles (HOVs) and providing cash in lieu for forgoing a parking space at work and land-use planning instruments that separate parking from dwellings, creating separate markets for parking spaces.

Effectiveness

Parking pricing schemes are an efficient approach to encourage car drivers to shift towards public transport as well as promoting economic development through higher parking bay turnover. Studies of twenty-six employer-based TDM programs in the USA indicate that five out of seven schemes, which reduced 12 per cent to 40 per cent of sole driving, contained a parking pricing strategy (Higgins, 1990). Generally, parking elasticity for car travel demand varies from -0.1 to -0.6 with -0.3 as the most frequent exploited value (Vaca & Kuzmyak, 2005). Comparing the trend of travel behaviour before and after the introduction of a parking levy in Melbourne, the number of public transport work trips to levy areas increased by 40 per cent, partly attributed to the parking pricing scheme (Hamer, Currie, & Young, 2009). The scheme also generates \$AU40 million in revenue per annum.

Parking maximums and parking caps have been successfully introduced in cities around the world as a means to manage car trips in specific areas and to encourage commuters shifting to alternate modes. The city of Portland, Oregon, applied the parking maximums policy in the downtown area, whereby developments located near public transport nodes had highly restricted levels of

parking (US Environmental Protection Agency, 2013). Multiple travel demand management measures, which included a parking cap policy, have also been implemented in Zürich to prioritise public transport and reduce automobile use. From 2000 to 2005, modal share of car use there decreased by 6 per cent while public transport modal share increased by 7 per cent.

Perth Context

Parking levies have been internationally and nationally employed to increase the proportion of travel through public transport, cycling or walking (Babb & Smith, 2014). In Perth, the *Perth Parking Management Act* of 1999 was set to outline the development and management of parking facilities through the encouragement and establishment of a balanced transport network as a means of managing congestion and transport operations to, from and within the city centre. An example is the use of licensed parking revenue as a means of funding transport, bicycle and pedestrian access, in addition to improving the Central Area Transit (CAT) bus system. Since the Act was introduced, it has successfully reduced the proportion of car trips to the city centre as well as provided revenue for public transport infrastructure.

Parking supply restriction policy has been introduced in hospitals, universities and high-demand destinations in Perth. The parking payment provides returns on investment to local government and private parking suppliers. Additionally, it has been an effective tool to incentivise mode shifts to public transport. Measures such as a parking cap and high parking fees have significantly decreased drive mode share from 73 per cent to 43 per cent between 2009 and 2012 in QEII Medical Centre (Martin, 2014).

Workplace TDM Instruments

TDM programs in workplaces can use a push or pull approach, with governments providing training or resources for policy implementation. Programs can provide encouragement and inducements for employees to travel to work by cycling, carpooling,

public transport and walking. Typically, local governments work with the larger employers within their community. In Perth, the Western Australian government requires workplace travel plans or regulations from the strategic activity centres, such as universities and public hospitals.

Examples of incentives include priority-parking bays for car-pooling employers or end-of-trip facilities for cyclists. Workplaces also provide the option to travel outside peak hour with flexible working start and end times. Direct financial incentives may be given such as rebates for public transport fares or the opportunity to salary-sacrifice for bicycles. An example is the Cycle Scheme in the UK. As part of a 'green transport plan', the UK government introduced legislation allowing employers to offer bicycles and related safety equipment as tax-free benefits for employees, accessed via a typical salary-sacrificing scheme (UK Department for Transport, 2011).

Effectiveness

Adopting a flexible working schedule alleviates traffic congestion during peak times. Commuters who had access to flexible working times in the Los Angeles and San Francisco regions were 7 per cent more likely to depart after the peak hours (He, 2013). In Berkeley, respondents with flexible working schedules reported their preference to travel during off-peak hours; consequently, they were able to spend seven minutes less per day on commuting, which represented 15 per cent to 25 per cent of a worker's one-way commuting time (Picado, 2000). In Florida, a compressed work week significantly reduced the number of car commuters by 7 per cent to 10 per cent (Center for Urban Transportation Research, 1996) and the compressed working week introduced in the Philippines resulted in lower commuting times (Sundo & Fujii, 2005).

Telecommuting has also demonstrated its effect in reducing travel. During telecommuting days, employees in the USA were

able to reduce their vehicle kilometres travelled (VKT) by 50 per cent to 75 per cent (Salon, Boarnet, Handy, Spears & Tal, 2012).

Other strategies adopted in the workplace refer to the ride-sharing schemes. Results in North America indicate that the averaged observed VKT per year reduced by 27 per cent due to ride sharing (Martin & Shaheen, 2011). Bike share replaces approximately 90,000 kilometres of car use per year in Melbourne; a similar result (24,000 kilometres) is reported in Washington, DC (Fishman, Washington & Haworth, 2014).

Perth Context

Approximately 40 per cent of Australian employees have at least some say in their working times and 25 per cent have flexibility to make a choice from day to day (ABS, 2012). Professions that are likely to be employed in central business districts – managers, professionals and administrative staff – have the greatest flexibility (52 per cent having some say in working hours). With the advent of advanced traveller information systems, flexible work hours allowing for day-to-day decisions could provide congestion relief through peak spreading. Car sharing in Perth was first introduced by The University of Western Australia to solve the challenges of limited student parking space at campus. A survey conducted for Perth indicated that 21 per cent considered the car sharing mode as very or extremely appealing and nearly half of respondents found it to be at least moderately appealing (RACWA, 2015b). To encourage car sharing for WA, City of Fremantle and City of Vincent have proposed policies to cover the provision of car share spaces and management of car share providers (City of Fremantle, 2014).

Information and Communication Services

The provision of information about the performance of transport systems can improve decision-making about travel. Real-time indications of congestion on roads or on public transport can allow travellers to adjust travel schedules or substitute trips. Responsive

and real-time communication about transport system performance is increasingly enabled by information and communication technology, which is becoming increasingly cheaper, more powerful and accessible.

Rose (2007) discusses three types of TDM information communication. The addition of sensory technology to information and communications services enables Advanced Traffic Management Systems (ATMS) to manage traffic flow. These may be used in conjunction with signalling priorities and dedicated HOV or transit lanes to encourage commuters into alternate modes. Advanced Traveller Information Systems (ATIS) provide information about the transport system function to influence departure time, mode or route choices. Advanced User Payment Systems (AUPS) are integrated payment systems that improve the efficiency of transport systems that require charges.

Evidence of Effectiveness

In the early 2000s, the at-stop, real-time, arrival information system reduced London commuters' perceived waiting time (by 30 per cent) and it also increased the reliability of public transport (Schweiger, 2003). Research by Tang and Thakuriah (2012) attributes 1.8% to 2.2% of the route level average weekday bus ridership to the presence of a mobile bus tracker information system on routes in Chicago. The application of a mobile, real-time, arrival information system in the Seattle-area also decreased bus riders' waiting times by nearly 30 per cent (Watkins, Ferris, Borning, Rutherford & Layton, 2011).

Radio Frequency Identification (RFID) Technology used in Italy improved the effectiveness of the transport network through users electronically paying for public transport fares and parking tickets. This technology has also been applied in Paris as an effective approach to manage inter-public-transport transportation (Gnoni, Rollo & Tundo, 2009). The Washington, DC, Metropolitan Area Transit Authority contributed US\$11.58 million to build its transport system, which facilitates the

payment for park-and-ride, train and bus through one smart card (Kovavisaruch & Suntharasaj, 2007).

Perth Context

Transperth facilitates commuters' daily travelling through the provision of timetable information and a journey planner through the website and mobile device app, which provide free and updated travel information. Transperth's information system is highly utilised and valued by passengers with 96 per cent of users rating it as useful (Batini & Barbaro, 2015). In 2007, the Public Transport Authority of Western Australia introduced SmartRider, which is an electronic payment system. It combines the payment of public transport, park-and-ride and access to bike shelters at railway stations into one smart card. Additionally, SmartRider provides the Public Transport Authority with useful information about passengers' travel behaviour, which further assists to estimate travel demand and analyse travel patterns.

Management of Road Space

The management or reallocation of road space can incentivise travel using alternative modes to the car by improving travel time, safety or comfort of travel by walking, cycling or public transport. Dedicated lanes may be provided for buses or HOV vehicles in order to provide these vehicles priority movement along congested roads. Traffic signal prioritisation gives road-based public transport, such as buses and trams, precedence at traffic signals in order to maintain or improve reliability of public transport vehicle flow.

Additionally, restricting mobility of cars through the reduction in road space may lead to disincentives for driving. Car-free areas are used to restrict vehicles from roads in designated areas permanently or at different times of the day or week. Car-free areas are used in many European cities and are usually located in city centres, commercial districts or where there is a high volume of pedestrian activity (Cathcart-Keays, 2015).

Evidence of Effectiveness

HOV lanes have been used in the USA, New Zealand and eastern states of Australia with the purpose of alleviating arterial road congestion and decreasing air pollution. However, pure HOV lanes in the USA provide modest benefits in terms of reducing vehicle trips (Plotz, Konduri & Pendyala, 2010). The performance of California's HOV system did not meet expectations, as HOV lanes are under-utilised and offer small travel time savings (mean savings is 1.7 minutes per 10-mile route and median is 0.7 minutes per 10-mile route; Kwon & Varaiya, 2008).

Truck lanes are considered an important tool to improve freight mobility and enhance road safety for trucks and other vehicles. Studies in Southern California indicate that the success of truck lanes may be limited to the characteristics of truck trips (Fischer, Ahanotu & Waliszewski, 2003). Lane access constraints are important factors in influencing the benefits from separating car and truck lanes (De Palma, Kilani & Lindsey, 2008). Forkenbrock and March (2005) mentioned that truck-only lanes are cost effective only if the traffic volumes are high.

Perth Context

Perth does not have HOV lanes, while selected bus lanes, on a permanent basis or during peak hour, have been completed to provide for the priority of public transport on roads (Public Transport Authority, 2015). Evidence from North America does not clearly certify the effectiveness of HOV lanes in improving road congestion, which may be constrained by the severity of congestion during peak hour as well as city density.

Currently, trucks and other vehicles share lanes on major arterial routes. Due to the intensive existing traffic flow, a freight priority plan is not beneficial as it increases congestion on other vehicle lanes. With the increment of freight volumes, freight priority measures will need to be considered in the future.

Governance and Administration

Demand for travel can be managed through regulatory mechanisms or through administrative support. These mechanisms may provide support for the functioning of transport markets. An example is Singapore's Certificate of Entitlement that provides rights and effectively rations vehicle ownership (Land Transport Authority, 2016). Vehicle quotas may be combined with other mechanisms such as vehicle tradeable driving rights or permit schemes to provide market-based mechanisms to price the 'right to drive' at peak times or in congested areas.

Alternatively, travel demand may be managed by better governance arrangements. Partnerships or management associations of transport organisations involve the collaboration of community and businesses to address travel issues at a precinct or regional scale. The purpose of partnerships may range from providing information and networking opportunities for sustainable mobility programs, through to allocating grants and funds for transport improvement projects.

Taxes and Charges

The use of taxes and charges introduce pricing signals that can create a disincentive to drive at particular times or places. Taxes and charges are 'push' measures. Their use is often justified by the assumption that the incorrect pricing of transport services and infrastructure results in over-consumption at periods of high demand. There is widespread support among transport economists and, increasingly, among transport planners and bureaucrats that some form of pricing of congestion would be the most effective means to manage the demand of use of urban roadways (King, Manville & Shoup, 2007).

Vehicle ownership and usage taxes, such as broad-based fuel taxes and vehicle registration aimed at revenue collection, also provide disincentives for private vehicle travel. On the other hand, income tax measures such as business vehicle claims and salary packaging opportunities create an incentive for a higher use of

the private vehicle. Road-user charges attract the greatest amount of support from transport economists and TDM planners for congestion abatement. Two types of instruments illustrate road use charging as a demand management mechanism.

1. Distance-based charges allocate road use prices according to the overall distance vehicles travel and are often collected once a year, through insurance or vehicle registration transactions. Annual distances travelled have usually been recorded by odometer readings.
2. Cordon charging involves charging drivers when they enter a cordon area, usually a city centre. The cordon charge may make other modes more attractive, shifting demand away from private vehicle to public transport, for example. The cordon charge also works as a disincentive for vehicles moving through the cordon area, as opposed to vehicles travelling to a location within the cordon (Ker, 2003).

Congestion Charging?

A cordon charge for Perth, like the one in place in London, may seem a dramatic step to take in the coming years. However, as the city continues to grow and there is greater pressure placed on limited infrastructure, pricing mechanisms become more attractive. Theoretically at least, it has long been held that an efficient price on congestion results in a net social benefit (Vickrey, 1955). Despite suggesting low cost alternatives – such as varying the rates on existing toll routes into New York, for example – Vickrey's idea was never really adopted until 1975, when Singapore introduced a variation of a congestion pricing scheme. This scheme required vehicle owners to purchase a monthly licence to enter a restricted zone during certain hours. The scheme was later replaced by an electronic pricing system that enabled a per use charge (Goh, 2002). Adopting a similar approach, the London congestion ring charged a flat daily fee for entering the city centre and since that

time a number of other cities have proposed, trialled or successfully implemented congestion levees.

Perth road users currently pay for their road use through fuel taxes and vehicle registrations. While these measures may affect demand, they do not specifically target congestion. The instruments act at a global level and are aimed at funding public investment on roads. Nor should congestion pricing be confused with tolls used to finance new infrastructure. However, for example, the toll ring around three cities in Norway was originally used to fund infrastructure, but has evolved into a demand management tool (Ieromonachou, Potter & Warren, 2006). The reason for pricing congestion is such that the driver bears the external costs they impose on others by delaying traffic. It is a Pigovian tax¹ (after the English Economist A.C. Pigou) such that: an *efficient* price is the difference between the private cost borne by the driver and the impedance cost exerted on other drivers. Yet, for all practical purposes, this is an ideal. Most schemes use flat rates (e.g. London) or vary by time of day (e.g. Singapore), but no city has set a real-time price to vary with the level of congestion.

Effectiveness

The reviews of existing congestion charging schemes and failed attempts to introduce a scheme highlight two issues. Firstly, the cost of collecting fees and enforcing compliance is high. Prud'homme and Bocarejo (2005) calculated that while the social benefits for the London scheme outweighed the implementation and operating costs, there was a net-revenue loss. The monetary loss is challenged by Mackie (2005), but not the sentiment. Mackie computed a revenue to cost ratio just exceeding one, but noted: '[If most of the] ...net revenue surplus which is used ... goes to pay the operator, the win-win scenario becomes elusive' (p. 290). Secondly, the path to implementation rests heavily, in general, on political and public acceptance (Li & Hensher, 2012). However, each case rests on highly specific factors, including the political will of the players (Noordegraaf, Annema & Van Wee, 2014): strong political will and public experience with tolls

were notable factors in the cases of Singapore and Norway. If Perth considers using pricing as a TDM instrument, it should incorporate the lessons from overseas experiences.

Perth Context

At present, Perth has no direct road-charging mechanism (tolls or congestion charges) for private use. If a congestion charge is introduced, it should be in consultation with the public and be accompanied by an awareness campaign explaining the benefits. The electronic pricing scheme in Singapore was accompanied by a comprehensive information campaign explaining how the measure fitted into the overall transport strategy (Foo, 2000). Unsuccessful policies in Hong Kong and Edinburgh were characterised by poor communication (Attard & Ison, 2010; Rye, Gaunt & Ison, 2008). Secondly, any proposal will be severely hampered if the relevant local authorities, including the City of Perth, vehemently oppose the scheme. An alignment of political will is critical. The proposal for a congestion charge did not have support of the national government or the Edinburgh Council and it was ‘surprising that the scheme progressed as far as it did’ (Gaunt, Rye & Ison, 2006, p. 100). Finally, it should be made clear that the levy is a congestion price aimed at improving the level of service, rather than just another tax. Among the most cited factors for the successful implementation of congestion pricing schemes is that any charge is seen as part of a holistic transport policy (Noordegraaf et al., 2014). Livingstone (2004) introduced the London congestion charge ‘alongside improving public transport, as a means of creating a less congested and more sustainable London’ (p. 492).

CONCLUSION

The instruments identified in the TDM matrix illustrate the range of TDM in use worldwide. Selecting the most effective measures for Perth requires consideration of contextual factors that are likely to aid or hinder effective implementation. TDM needs

to be applied where it offers best value for money, is feasible to implement and is acceptable to the community. Doing so takes account of the transport system, land-use patterns, travel demands and consumer preferences, both now and in the future, and ensures the best outcomes are achieved.

Consideration of the latent synergies within packages of TDM policies is also important. Individual parts of the transport systems do not operate in isolation, but are interconnected and interdependent. Therefore, combinations of TDM instruments may create mutually beneficial policy outcomes, which are greater than applying them individually: central Stockholm and London provide excellent case study examples where congestion charges have been implemented successfully in both contexts. Around 20 per cent and 18 per cent congestion reductions have been reported within the Stockholm and London congestion charge cordons, respectively (Hugosson & Eliasson, 2006; Peirson & Vickerman, 2008; Prud'homme & Bocarejo, 2005). These results are tied to the synergistic effects of a package of TDM policy measures, including parking supply and management policy, and investment in alternative modes of access, alongside the charge itself. The literature also shows application of appropriate push and pull policies including road tolls and roadway space allocation to HOV and transit, which have strong potential to reduce SOV trips and congestion along corridors (Victoria Transport Policy Institute, 2009; Spears, Boarnet & Handy, 2010; Inturri & Ignaccolo, 2011).

Returning to the opening point that congestion and its impacts are likely to worsen in the future, this chapter sheds some light on the broad categories of TDM instruments available to Perth to manage the growth in demand. Perhaps the most relevant context is that Perth is a medium-sized city in terms of population but is one that occupies a lot of land. Discussions on TDM tools for Perth need to take into account that travel by private vehicle remains an attractive alternative. To this end, travel behaviour programs that assist residents to make alternative travel arrangements, coupled with serviceable active and

public transport networks, appear to be appropriate for Perth. However, such an approach does not provide an incentive to change land-use patterns to make the most of the alternatives to travel by private vehicle. At some stage Perth – like many other cities – will need to consider congestion pricing to maximise the efficiency of existing infrastructure. The alternative is to continue expansion on the fringes and for Perth to experience the levels of congestion seen currently in cities with populations of 3.5 million or more.

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NOTES

- 1 A Pigovian tax is a levy on any market activity that generates negative externalities. The tax set is equal to the social cost of the negative externalities

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