

October 2019



Why it's time for congestion charging

Better ways to manage busy urban roads

Marion Terrill

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Grattan Institute Report No. 2019-10, October 2019

This report was written by Marion Terrill, Greg Moran, and James Ha. Hugh Batrouney and Vivian Duong provided research assistance and made substantial contributions to the report.

We would like to thank Veitch Lister Consulting for generous assistance with transport modelling. We would also like to thank government and industry participants and officials for their input.

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This report may be cited as: Terrill, M., Moran, G., and Ha, J. (2019). *Why it's time for congestion charging*. Grattan Institute.

ISBN: 978-0-9876359-6-9

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Overview

Is New York crazy? It's the latest global city to embrace congestion charging. Vancouver, Beijing, and Jakarta are not far behind. London, Singapore, Stockholm, and Milan have been doing it for years. But in Australian cities, when governments see congestion, the solution they reach for is more roads and more public transport. Decades of more roads and more public transport have given us the levels of congestion we see today. It's time for a new approach. It's time for Australian cities to embrace congestion charging.

Excessive congestion is costly and wasteful. While no one wants to pay more to drive, neither do they want the ordeal of delays and unpredictability when they do travel. Fast and reliable transport of people and goods is essential if we are to reap the economic and social benefits of big vibrant cities.

There's no doubt that congestion is a concern for many motorists in Australia's big cities. Each of us is concerned about all the traffic slowing us down, but there is no trigger for us to be concerned about our contribution to slowing everybody else down.

A cordon charge for people entering the CBDs of Australia's largest cities in the morning peak, and leaving in the afternoon peak, would have a substantial impact. Even a modest charge would mean about 40 per cent fewer cars entering the central area in the morning peak, and speed increases of about 1 per cent across the network. These speed increases are similar to those from building new freeways that cost billions of dollars – whereas congestion charging has no net financial cost to the taxpayer.

And if getting public transport right is a pre-condition, there has never been a better time. Investment in public transport and roads is running at more than \$30 billion in 2018-19 – an all-time high. Significant new public transport is due to come into operation in coming years:

the Sydney Metro City and Southwest in 2024, Melbourne Metro in 2025, and Western Sydney Airport rail in 2026. The technology has improved too, with Automatic Number Plate Recognition now accurate enough to use as the primary detection technology. And one of the many lessons from global cities with congestion charging is that initial public scepticism soon turns to support when people see how effective congestion charging can be.

Critics may argue that congestion charging seems unfair: that it could hurt those who can least afford it, or that they'd feel as though they were being punished for driving when they had no choice, or that they're already paying too much to the government. But these fears are overblown.

People who drive to the city each day for work are more than twice as likely to earn a six-figure salary as other workers; the median income for a Sydney driver to the CBD is nearly \$2,500 a week – about \$1,000 a week more than the median income of a full-time worker across all of Sydney. Nor is it true that people have no choices; the CBD is well-served by public transport, which is how most people get there. The charges would only apply during peak-periods. And commercial traffic can expect to pass the costs through to their customers, because their competitors would be paying the charge too. In the end, if particular roads are in high demand, it's fairer that heavy users pay more than those who rarely or never use them.

This report recommends that Australian state governments introduce congestion charging in the larger capital cities. First, they should introduce a cordon around the CBD. Then, charges should be used to get our most clogged arterial roads and freeways flowing better. Our next report, to be published next week, will explain in detail how it could be done in Sydney and Melbourne.

Table of contents

Overview	3
1 Now is the time to act on congestion	6
2 Existing strategies have made little headway against excessive congestion	15
3 Congestion charging is a better way forward for Australian cities .	26
4 Fears of congestion charging are overblown	33
A Technology options for congestion charging	42

List of Figures

1.1	Governments have promised enormous amounts of transport infrastructure during recent elections	8
1.2	Media interest in congestion is flatlining despite high population growth – perhaps because commutes are actually stable	9
1.3	Spending on transport infrastructure is at record levels	12
1.4	In Stockholm, congestion charging was much more popular after it had been implemented than before	13
2.1	Triple convergence: new drivers emerge from other times, routes, and modes	16
2.2	Cars are a very inefficient form of mass transport	20
2.3	Narrowing lanes may reduce throughput slightly <i>per lane</i> , but could allow space for an extra lane	22
3.1	A CBD congestion charge could have a similar impact on travel speeds as major new roads – at a bargain price	29
3.2	Fuel excise receipts declined mainly because of the rate freeze, but the freeze is over	32
4.1	The most vulnerable drivers have low income, few good alternatives, and need to get to the CBD in peak periods	34
4.2	People commuting to the CBD daily by private vehicle are more than twice as likely to earn six-figure salaries	35
4.3	Higher-income workers tend to drive further	36
4.4	Most households don't use toll roads very often, especially households with lower incomes	38
4.5	It's hard to avoid buying petrol, but lower-income households mostly avoid paying road tolls	39

1 Now is the time to act on congestion

Plenty of people think congestion is a real problem in Australia's largest cities, and they are right.

But a meaningful reduction in congestion requires hard choices. For example, congestion could be cut:

- if many people stopped driving to work alone in their cars;
- if hours of work and education changed so much as to take the 'peak' out of peak hour;
- if people stopped moving to the big cities, and existing residents started leaving;
- if those cities became so dense that it was easier to walk, cycle, or take public transport to the centre than drive; or
- if state governments started charging people who drive on high-demand roads in peak periods.

But governments' main strategies to date have been to build new roads, upgrade existing ones, and add new public transport services. They have mostly shied away from making peak-hour driving less attractive, let alone upending the norms of Australian urban life in the 21st century.

The result is the level of congestion we see today.

This report argues that congestion is a big enough problem to warrant a new approach, and that the most effective strategy available to state governments is to charge drivers a modest fee to drive on the highest-demand roads in peak periods.

This chapter explains why congestion is a problem, and then what we mean by congestion charging. A third section lays out three recent developments that further tilt the balance in favour of congestion

charging: the massive pipeline of public transport improvements now being built; some important technological developments; and a growing body of overseas experience indicating that people's initial hostility fades when they experience congestion charging in practice.

The second chapter of the report explains why building infrastructure and other congestion-management strategies don't seem to work – especially in the long run. The exception is congestion charging, and the third chapter explains why it's so effective and efficient. The fourth chapter takes seriously the issue of fairness. It shows why concerns are overblown that a peak-period CBD cordon charge would be unfair.

1.1 Why congestion is a problem

Congestion is a problem because it is costly and wasteful.

Some of the costs are immediately obvious to people who live in big cities. Trips take longer – sometimes far longer – during peak periods than when the roads are quiet. Traffic can be unpredictable, so people need to allow a buffer to ensure they get to their destination on time.¹ Driving in stop-start traffic uses more fuel and causes more wear and tear on the car – and the driver.

But these obvious personal costs are only part of the problem. Even though it may be less visible, it is costly both to individuals and to the community when someone decides not to take a new job because the commute will take too long, or not to visit a doctor because it's too hard to get there at the time the doctor can see them. Consumers ultimately pay more for goods if trucks and vans carrying freight are delayed. And if emergency vehicles cannot get through congested areas quickly enough, the consequences can be dire.

1. Terrill et al (2017).

Put another way, fast and reliable transport of both people and goods is an essential lubricant for the wheels of the commerce that underpins prosperity.

Each of us is concerned about all the traffic slowing us down, but there is no trigger for us to be concerned about our contribution to slowing everybody else down. This is the fundamental reason there is too much congestion.

1.1.1 The costs to the economy are substantial

In this report we use the term 'congestion' for any situation where a trip takes longer than it would under free-flowing conditions, due to the presence of other drivers. We use the term 'excessive congestion' for any situation where traffic is so slow that the whole community suffers, not just individual drivers. This happens whenever a driver takes a trip at a particular time on a particular route that they wouldn't have taken then and there if they had had to pay not just their own vehicle and time costs, but also for their contribution to slowing everybody else down.²

In practice, congestion is frequent, but excessive congestion occurs only in some parts of the largest cities in peak periods. This report advocates policies to solve excessive congestion. It recognises that there will inevitably be some congestion in big cities, including from unexpected road works and accidents.

In 2015, the Bureau of Infrastructure, Transport and Regional Economics estimated the 'avoidable cost' of congestion in Australia's eight capital cities was \$16.5 billion, including \$6.1 billion in Sydney and \$4.6 billion in Melbourne.³ Infrastructure Australia estimated the

2. A more detailed discussion of congestion charging and its variants can be found at Santos and Verhoef (2011).
3. BITRE (2015). These costs do not imply that society would be \$16.5 billion better off if we eliminated avoidable congestion, because there are costs involved in mitigating congestion.

total costs of congestion in 2016 in Sydney, the Hunter, and Illawarra was \$8 billion, and in Melbourne and Geelong \$5.5 billion.⁴

1.1.2 Congestion annoys drivers

The media brings to life the idea of congestion costs by showcasing extreme cases. Newspapers frequently photograph a miserable commuter who needs to get to the railway station before 6am to get a car park; TV often shows urban freeways in gridlock.

Governments appear to share the perspective that congestion is out of control. 'Congestion-busting' transport infrastructure promises featured heavily in the three most recent elections, in Victoria, NSW, and federally, with record spending commitments in Sydney and Melbourne (Figure 1.1).⁵

Is congestion getting worse? People were concerned about congestion as far back as 1954, when the Melbourne Metropolitan Board of Works created a film about how 'the ever-growing problems of traffic congestion create mounting delays and costs' for this 'vast metropolis of one-and-a-half million people'.⁶ Governments had ripped out most of Sydney's trams tracks by the 1960s, and replaced trams with buses, on the grounds that 'buses are more mobile and get away from the rigid tracks. . . they will certainly speed up vehicular traffic and eliminate bottlenecks'.⁷

If congestion is getting worse, it is not evident from the times and distances that people travel to get to work. Despite very high levels of population growth, commute times and distances in Sydney and Melbourne barely changed in the five years to 2016.⁸ Sydney commute

4. IA (2019a, p. 7).
5. Terrill and Ha (2018); Terrill and Ha (2019); and Moran and Ha (2019).
6. Melbourne Metropolitan Board of Works (1954).
7. Newton (2018).
8. Terrill et al (2018).

times in 2017 were the same as they had been in 2016, and Melbourne commute times were slightly shorter.⁹

Nor is it evident from the level of media reporting that excessive congestion is getting worse. Congestion articles are much less prevalent today than they were in the early 2000s (Figure 1.2 on the following page), notwithstanding rapid population growth rates.

But even though many popular claims about excessive congestion are overblown, and it is hard to assess how much worse it has become, it remains true that people do spend substantial time travelling in conditions of excessive congestion, and that it could be less. Congestion charging is a means to this end.

1.2 Why charge for congestion?

Australian cities are very low-density compared with many cities overseas,¹⁰ jobs are highly dispersed over the city,¹¹ and plenty of people travel across the city on a regular basis. Not only that, but employers want their staff to be at work at the same time as one another; schools and universities require students to gather at set times for class; and people often combine work trips with school drop-offs or shopping. In the morning peak, up to 21 per cent of trips on Sydney roads are for socialising, recreation, or shopping.¹² Most city-dwellers find car travel more appealing and convenient than other means of travel.¹³

9. Grattan analysis of HILDA (2019).

10. Loader (2016a); and Daley et al (2018, p. 55).

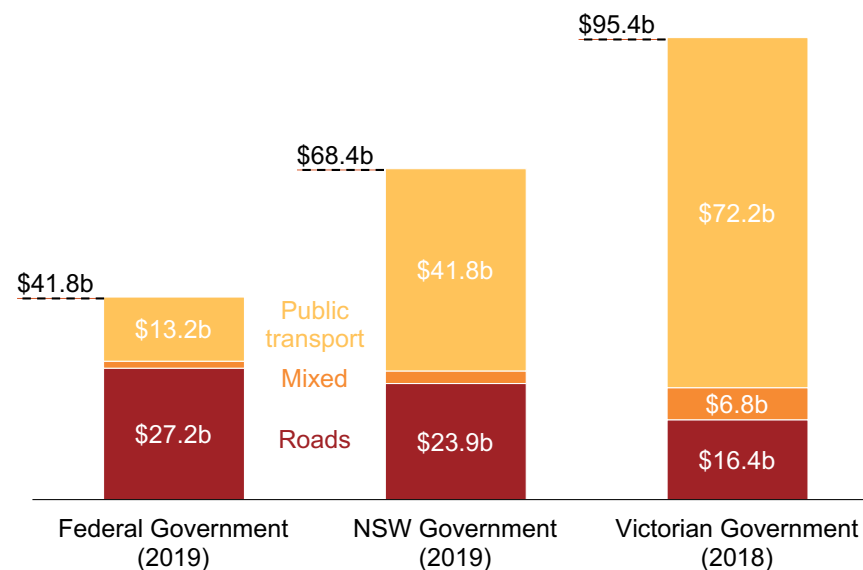
11. Terrill et al (2018).

12. This figure is estimated to be 11 per cent in Melbourne, though the methodology of each data source is slightly different: Grattan analysis of State of New South Wales (2019) and Victorian Department of Transport (2016).

13. Downs (2004, Chapter 2).

Figure 1.1: Governments have promised enormous amounts of transport infrastructure during recent elections

Value of transport infrastructure committed during recent elections by the party forming government



Notes: 'Mixed' projects affect both road and rail. Public transport users may also benefit from 'road' projects, to the extent that buses use those roads. Projects affecting other modes, such as freight or cycling investments, have been excluded, but these are a small fraction of the total promised spend.

Sources: Terrill and Ha (2018), Terrill and Ha (2019) and Moran and Ha (2019).

Given that this is how Australian cities operate, sometimes there is too much demand for particular segments of road space, and drivers end up waiting in line.

What are the options to cope with the disparity between demand for road space and the road space available at busy times of the day?

One could imagine building new road capacity wherever the benefits of doing so exceeded the costs, and hoping that this would eliminate or at least substantially reduce excessive congestion. This could mean double-decker roads, tunnels, major road widening, and paving over a significantly larger fraction of the city than at present. While politicians may speak and behave as if this is a feasible solution, in reality there is nothing to stop the new roads filling up with so much new traffic that there would still be excessive congestion in peak periods.¹⁴

A second option would be to expand public transport so much that frequent, fast, and direct services linked most or all people with a wide range of destinations. Governments are less inclined to propose this solution, and it is likely to be prohibitively costly and yield low or zero net benefits to the residents of Australian cities.

A third option is queuing. That's what we use today – anyone can use any road for free during peak times,¹⁵ but they must wait their turn to get across an intersection or along a clogged section of road.

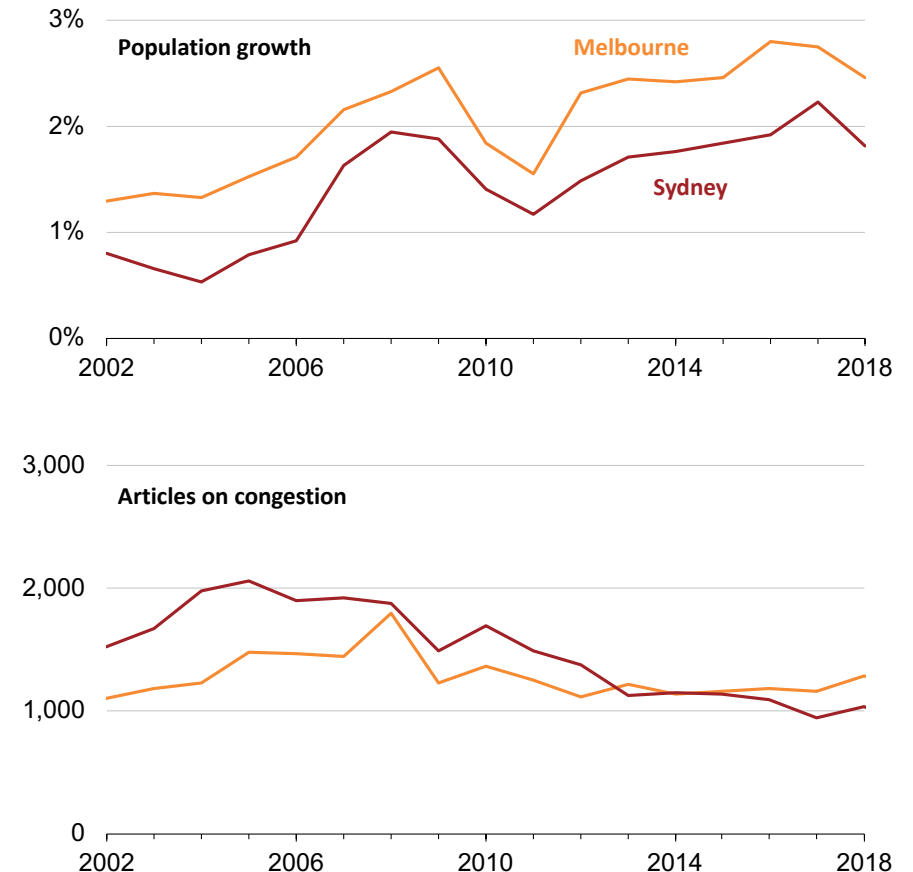
A fourth option is congestion charging, which can be implemented in various ways. Three typical models are:

- Cordon charging, where drivers pay to cross a boundary into (and sometimes out of) a designated zone, such as a CBD.

14. Of course, that is not an argument against building such roads.

15. With the exception of toll roads, a small proportion of the roads in Sydney, Melbourne, and Brisbane.

Figure 1.2: Media interest in congestion is flatlining despite high population growth – perhaps because commutes are actually stable
Population growth (year on year), and articles about congestion in Sydney and Melbourne's major daily newspapers



Notes: Based on articles in *The Sydney Morning Herald*, *Daily Telegraph*, *Herald Sun*, and *The Age* (print editions) that mention 'congest-' or 'traffic', and 'road-' or 'car(s)', but not 'on-road cost(s)' or 'on-roads' or 'drive-away'.

Sources: Grattan analysis of ABS (2019a) and Factiva (2019).

- Corridor charging, where drivers pay to drive along an urban freeway or arterial road.
- Network-wide distance-based charging, where drivers pay to drive within a designated network or area, on a per-kilometre basis.

All of these models charge only or more during peak periods.

We recommend all three models be progressively introduced in Australia's capital cities. Our next report, to be published next week, will lay out in detail a policy design and implementation pathway for Sydney and Melbourne.

This report is about the case for change. We think there has never been a more promising time for congestion charging, for reasons outlined in the rest of this chapter.

1.3 Why now is the time

Even though economists almost universally have long supported the idea of congestion charging,¹⁶ only a handful of cities around the world have implemented congestion charging (Table 1.1). The best-known schemes are in Singapore, London, and Stockholm. Schemes also operate in Malta, Gothenburg, and Milan. Some US cities toll a specific lane on a highway, and drivers can opt to take that lane for a quicker trip.

But congestion charging is becoming more common. In April 2019, New York announced it would introduce a charge for drivers in the most crowded parts of Manhattan.¹⁷ A board has been created to design

16. For example, a recent survey of Australian economists found 96 per cent agreed that congestion charging and using the proceeds to lower other taxes would make citizens on average better off: The Economic Society of Australia National Economic Panel (2018). Similar results were found in the US and Europe: IGM Economic Experts Panel (2012) and European IGM Economic Experts Panel (2016).

17. Cuomo and Mujica (2019).

Table 1.1: Congestion charging is becoming more common

Region	Type	Start date
Singapore	Cordon and corridors	1975
US	Corridors	1995
London	Cordon	2003
Stockholm	Cordon	2007
Malta	Cordon	2007
Milan	Cordon	2012
Gothenburg	Cordon	2013
Jakarta	Corridors	2020
New York	Cordon	2021

Notes: Singapore's initial cordon was gradually extended to include corridors from 1998: Chin (2010, pp. 57–611). The US has highways with tolled express lanes that vary in price throughout the day in response to demand and congestion on the untolled lanes: Sullivan (2000). In London, drivers pay only once per weekday for entering or driving within the cordon: TfL (2004). Milan implemented a pollution charge in 2008 that became a congestion charge in 2012, charging a flat fee for entering the cordon: Croci (2016). In Stockholm and Gothenburg, drivers pay crossing both in and out of the city centre: Eliasson (2014a) and Börjesson and Kristoffersson (2015). In Malta, drivers pay a charge based on how long their car is within the Valletta cordon: Ison and Attard (2013). The New York Central Business District Tolling program was included in the 2019-20 budget, but the 'implementation day will not be before December 31, 2020': Cuomo and Mujica (2019).

the charge, including how it will vary by day and time. Hong Kong is developing a cordon scheme to operate on Hong Kong Island.¹⁸ Vancouver is considering one option in which drivers pay when they pass a congestion point, including bridges, and a second where drivers would pay a network-wide distance-based charge during peak periods.¹⁹ Beijing is contemplating a congestion charge in the face of traffic jams and air pollution, 30 per cent of which is caused by vehicle fumes.²⁰ Jakarta is planning to introduce the first phase of its scheme in 2020, charging vehicles to drive on specified roads, not unlike the Singapore scheme.²¹ Seattle and Washington State are actively considering congestion charging.²²

Three important factors indicate that now is a more conducive time than ever before for congestion charging in Australia's largest cities. The following sections explain.

1.3.1 A particularly large pipeline of public transport is being built or planned

It's often said that congestion charging could not be introduced without a substantial improvement in public transport. Political leaders from across the spectrum subscribe to this view.

In 2015, Sydney Lord Mayor Clover Moore said: 'A congestion charge on traffic through the city makes a lot of sense, but we have to get public transport right first.'²³

In the same year, NSW Transport Minister Andrew Constance left the way open to consider a congestion charge in Sydney's CBD once major

transport projects were completed: 'There is nothing ruling out future governments considering it once the city is settled.'²⁴

And in 2016, then federal shadow minister for infrastructure Anthony Albanese said congestion charging 'works in London [but] the problem is what you need to do is have effective public transport before you can do that'.²⁵

For politicians who believe this, now is an opportune time for congestion charging. Recent election campaigns have been characterised by promises of substantial spending on public transport. The party forming government promised \$72 billion for public transport in the November 2018 Victorian election; \$42 billion in the March 2019 NSW election, and \$13 billion in the May 2019 federal election.²⁶

The biggest public transport projects promised for Melbourne are the Suburban Rail Loop and the Airport Rail Link. For Sydney, they are the Sydney Metro West, Sydney Metro City, and rail to Western Sydney Airport.

Governments are also spending significant sums on roads, to serve both public and private transport. Across all transport infrastructure, the Victorian Government expected to spend \$6 billion in 2018-19; the NSW Government \$13 billion; and the Commonwealth spent \$7 billion.²⁷ These are big commitments by historical standards (see Figure 1.3).

The biggest roads projects planned for Melbourne include the North East Link and an additional 25 level crossing removals. Sydney's are

18. Hong Kong Transport Department (2019).

19. Mobility Pricing Independent Commission (2018).

20. The Economist (2018).

21. The Jakarta Post (2018); and The Jakarta Post (2019).

22. Seattle Department of Transportation (2019, pp. 10–11).

23. Gorman (2015).

24. O'Sullivan (2015).

25. AAP (2016).

26. Terrill and Ha (2018); Terrill and Ha (2019); and Moran and Ha (2019).

27. Victorian and NSW Government spend excludes Commonwealth funding, to avoid double counting: Grattan analysis of Victorian Treasury (2018), NSW Treasury (2018) and Treasury (2019).

the Western Harbour Tunnel and Beaches Link, the F6 Stage 1, and Sydney Gateway.

The Federal Government is also focused on congestion. The biggest election promises from the Coalition were for Melbourne Airport Rail Link, the inner-urban East West Link freeway in Melbourne, Western Sydney Airport Rail, and the Adelaide North-South Corridor.²⁸ It even has an Urban Congestion Fund for smaller projects such as commuter car parks.

People are changing their travel patterns in response to the disruption caused by the construction in the largest cities. Some people who change their method or time of travel in the morning may find the new pattern continues to suit them when the disruption is over. This happened in Stockholm in 2007, after congestion charging had been implemented.²⁹

1.3.2 Technology for congestion charging is getting cheaper and better

Technology is constantly changing and improving. It is many years now since Australians paid their tolls by tossing coins into a basket at a control booth, and even longer since we gave the money to a person staffing the booth.

These days, the main technology for collecting tolls in Australia is Dedicated Short-Range Communication, or DSRC. This system uses equipment mounted on gantries or other roadside structures to scan in-vehicle tags or transponders as vehicles pass by.³⁰

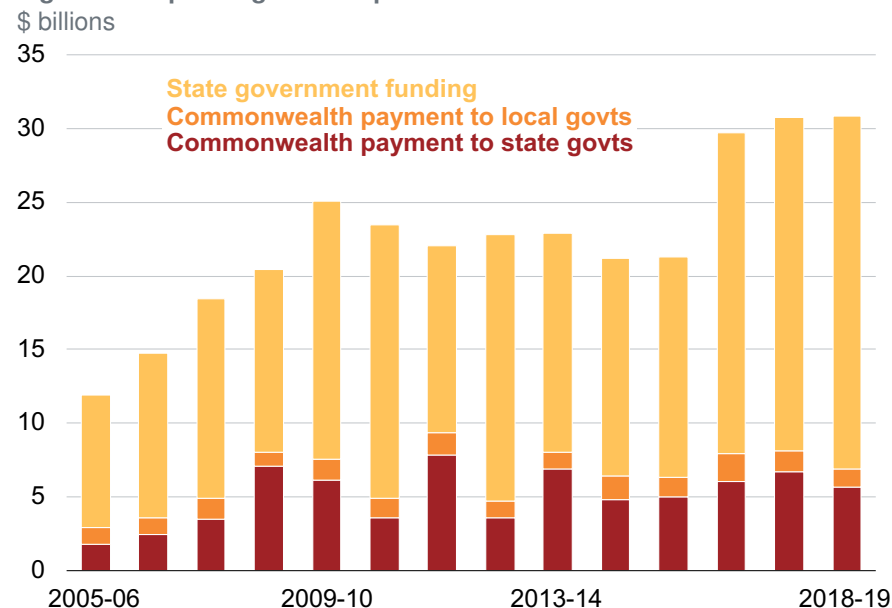
As well as DSRC, Automatic Number Plate Recognition is a common technology on Australian roads. This technology is used for speed

28. Moran and Ha (2019).

29. Eliasson (2014a, p. 27).

30. Palma and Lindsey (2011, p. 1386).

Figure 1.3: Spending on transport infrastructure is at record levels



Notes: Inflation-adjusted to 2019. Estimates used where available from the following year's budget. Otherwise, budgeted amounts used.

Sources: Commonwealth, state, and territory budget papers 2005-06 to 2018-19; Grattan analysis.

and red-light cameras, and can capture the number plates of vehicles travelling on a toll road without an in-vehicle tag. It uses cameras mounted on gantries to illuminate and capture images of vehicles' number plates. Optical character recognition software is then used to convert images to text.

Number plate recognition is used overseas not only as an enforcement technology, but increasingly as a primary technology on charged roads. It has become considerably cheaper and more accurate.³¹ For this reason, most overseas schemes now use number plate recognition as the sole technology for vehicle identification for charging purposes, and it offers the most feasible option for use with a CBD cordon, and potentially for subsequent corridor charging, in Australian cities.

More details on the technology options are in Appendix A.

1.3.3 There is now enough global experience to point to a successful pathway to congestion charging

People tend to be sceptical of change. 'Status quo bias' makes ambitious reform difficult for governments.³²

Congestion charging is a particularly difficult reform because it asks people to pay for something that they think is free. People are keener to keep a benefit such as free roads than to reclaim the benefit once lost;³³ this may explain why so many ministers have been so quick to rule out congestion charging on existing roads,³⁴ at the same time as some of them have introduced tolls on new roads. And the benefits of congestion charging are somewhat intangible in Australia – no Australian city has anything resembling a serious congestion

31. D'Artagnan Consulting (2018, p. 97).

32. Samuelson and Zeckhauser (1988).

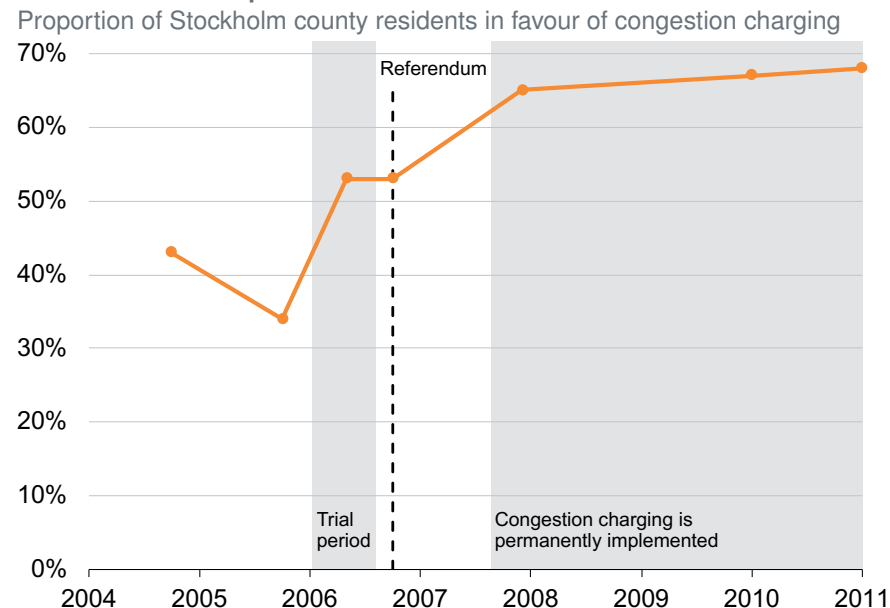
33. Kahneman et al (1991).

34. See, for example, Wiggins and S. Evans (2019), Collie (2018), AAP (2017), Acharya (2016), Wallace (2016) and Sydney Morning Herald (2008).

charge, and so no state government can point across the border to demonstrate its effectiveness.

But there are cities overseas that have implemented congestion charging, and done so successfully. Australian state governments can learn from these experiences.

Figure 1.4: In Stockholm, congestion charging was much more popular after it had been implemented than before



Notes: Share of survey respondents who answered 'yes' to the question: 'How would you vote in a referendum about the Stockholm congestion charges?'. Excludes 'don't know' responses. The 2007 and 2010 surveys covered only the city of Stockholm; in the 2004, 2005, 2006, and 2011 surveys, support was consistently 3 percentage points higher in the city than in the county as a whole.

Source: Adapted from Eliasson (2014b, p. 9).

In Stockholm, congestion charging was least popular in the polls right before it was trialled,³⁵ but once the policy was introduced, support rose (Figure 1.4 on the preceding page). This may have been because the public could see its effectiveness,³⁶ or simply the status quo bias working in favour of congestion charging.³⁷ In fact, many people did not even remember that they once opposed the idea.³⁸

In London, the major party candidates for mayor ruled out congestion charging ahead of the 2000 election.³⁹ And yet, congestion charging was in effect by 2003. It is reminiscent of some other hard reforms that we now take for granted. For instance, after decades of debate on the pros and cons of a consumption tax, the then Opposition leader John Howard in 1995 insisted he would 'never ever' introduce one.⁴⁰ A couple of years later, he persuaded the electorate to support a Goods and Services Tax. And these days, the GST is entirely accepted as a legitimate revenue source.

It seems that as the public gains experience of congestion charging, the policy becomes more popular.⁴¹

35. Eliasson (2014b).

36. Goodwin (2006).

37. Börjesson et al (2016); Eliasson (2014b); and King et al (2007).

38. Surveys showed that far fewer people reported changing their behaviour than could account for the fall in traffic. The authors note that 'around three quarters of the reduction in car trips across the cordon seems to have gone unnoticed by the travellers themselves': Eliasson (2014b).

39. Dobson (2000); and Norris (2000).

40. See, for example, ABC (2015).

41. See, for example, TfL (2004, p. 76), IV (2019) and Transurban (2016).

2 Existing strategies have made little headway against excessive congestion

Drivers make numerous choices that can add to or reduce congestion: what time to take a trip, what route, whether to take the car, whether to own a car at all, how big a car, and how they drive. Road agencies make choices too: how wide a particular road should be, with what slope, surface, speed limit, intersection type, and level of attention to maintenance. And governments decide when and where to invest in new arterial roads, freeways, and rail line extensions.

Because there are so many choices to make, and so many actors making them, it is unrealistic to imagine that there's a single silver bullet policy to alleviate excessive congestion.⁴² But whatever strategies governments employ will have limited impact for as long as in-demand roads at peak periods of the day and week are free.

Congestion charging is a way to make existing strategies more effective. It should be seen as the centrepiece of a mixed strategy of congestion-alleviating policies.

This chapter explains why existing strategies to reduce congestion don't seem to have made much headway. In the first section of the chapter, we explain the key counter-weight to many strategies: that even as they free up the roads, new peak-period drivers emerge. The following three sections explain the limited headway made by the three main approaches to tackling congestion: building more roads; reclaiming road space for more efficient uses; and dampening demand for road space during peak periods.

2.1 Most existing strategies create new demand

Because drivers travelling in peak periods converge on the best and quickest arterial roads and freeways, these become so clogged that

42. Arnott et al (2005).

they are no longer any quicker than small streets and roads. Every trip, people decide when, where, and by what method to travel. When a better option opens up, they take it; when their usual option becomes too slow or unreliable, they find another way.

This is the fundamental reason building new road or public transport capacity doesn't solve congestion: the system never stands still.

If an arterial road or freeway is upgraded with a new lane, or a new road is built, the new space serves not just the existing travellers but also some new ones, who had previously timed their trip to avoid the worst of the peak period or had previously travelled by train, tram, bus, or bike instead. Converging on the new road from other times, other routes, and other modes is known as 'triple convergence' (Figure 2.1 on the next page).⁴³

The new road capacity also encourages residential and commercial development in places that are now better connected to the rest of the city. The term 'induced demand' is used both for the short-term changes of triple convergence, and also for the trips arising from this kind of development, which has been induced by the new road itself.⁴⁴

Does new road capacity just fill back up with traffic? The answer is yes, to a point. Most studies estimate that in the short term, where there is no toll or charge, 20-to-50 per cent of the new capacity is taken up with new trips or trips diverted from other routes.⁴⁵ As time passes, more of the new capacity is taken up, with estimates ranging from 40 per cent

43. Downs (2004, p. 83).

44. Ibid (p. 84).

45. Hansen (1995); Fulton et al (2000); Cervero (2003); Parthasarathi et al (2003); Hymel et al (2010); Small and Verhoef (2007, pp. 173–175); Duranton and Turner (2011); Couture et al (2018); and Turner (2019, p. 12).

to as high as 100 per cent. The extreme case, where all of the new capacity available without a toll or charge is taken up, has been dubbed 'the fundamental law of road congestion'.⁴⁶

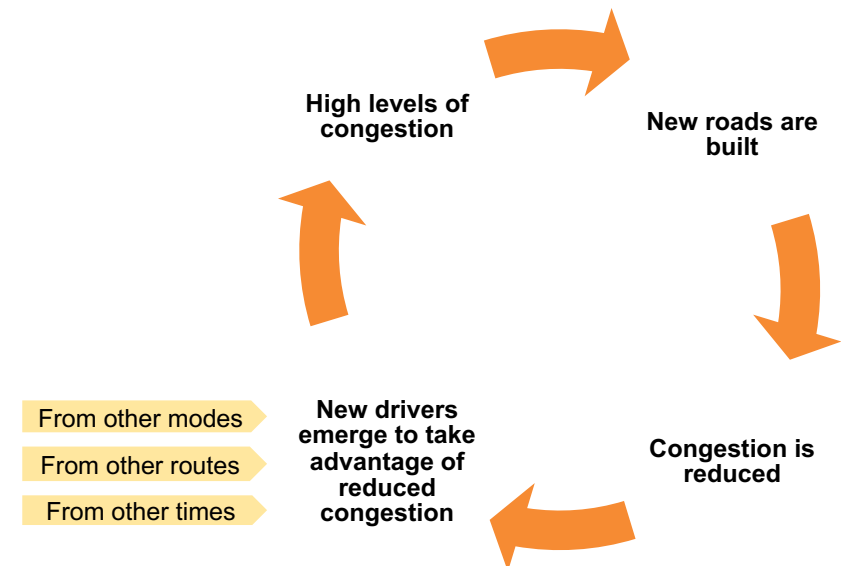
Some people argue that because new roads breed new traffic, there is no point in adding to road capacity. Melbourne's CityLink was conceived to provide a 'triple bypass operation' on the three major arteries leading into the city centre.⁴⁷ But people expecting free-flowing traffic were destined to be disappointed; four years after it opened, CityLink was 'the focus of a new traffic nightmare – worsening peak-hour congestion on the roads that feed into it'.⁴⁸

Public transport investments are subject to the same forces. While they may encourage some drivers to switch mode, the road space that is freed up can encourage other people to take advantage of improved traffic conditions in the comfort of their cars (Figure 2.1). Table 2.1 on page 18 lays out these and other ways to increase the supply of road space and dampen demand for it.

More generally, while new peak-period drivers benefit from the new road space, this constantly emerging new demand explains why we never seem to actually make progress against excessive congestion.

Each proposal for a new or wider road or new public transport capacity should be appraised on its merits. The appraisal should weigh up the costs to the community of building and maintaining the asset,⁴⁹ alongside its benefits, such as the time savings and improved reliability

Figure 2.1: Triple convergence: new drivers emerge from other times, routes, and modes



46. Durant and Turner (2011). This extreme form is likely to be unusual in practice, although it may come 'uncomfortably close to the truth': Small and Verhoef (2007, pp. 173–174).

47. According to a Melbourne CityLink Authority advertisement of May 1995, cited in PTUA (2016).

48. According to The Age of 11 November 2004, cited in PTUA (ibid).

49. And, strictly speaking, the distortionary cost of raising tax to fund the asset, although this is not the usual practice of Australian governments: DFA (2006, p. 38).

it will offer to users, and lower vehicle operating costs. Appraisals are also supposed to quantify the benefit reduction from induced demand.⁵⁰ The WestConnex business case forecast an extra 600,000 vehicle kilometres on the motorway network in 2031 than without the project,⁵¹ with induced demand bringing down the estimated benefits by 25 per cent.⁵²

Overall, we can be confident that new urban road capacity will be used, and also that it will substantially serve vehicles that are not currently on the road in peak periods. And while new public transport capacity is unlikely to increase net demand for roads, some of the road space it frees up will be filled with new traffic. Induced demand is not an argument to never build more capacity, but it does sharpen the question of whether the new capacity brings benefits that are greater than its costs, and to what degree it can reduce congestion.

2.2 New roads have made little headway against excessive congestion

The most visible road capacity increases are new roads. In established capital cities, new road space often means an urban freeway, such as WestConnex or North East Link. It can also include widening of existing roads, such as the Tullamarine Freeway in Melbourne or the M4 in Sydney. These are intended to keep up with population growth, or to help plug an 'infrastructure deficit'.⁵³

But people are often dubious about the effectiveness of major new road construction, for two reasons.

Firstly, people are doubtful about the merits of new roads because of differing views on whether they are needed. Many people worry that big new urban roads encourage car dependency and urban sprawl (Section 2.1), and detract from the city's liveability.

A second reason new roads have their opponents is due to a concern about the use of public money. Road construction consumes a large share of government budgets; Australian governments have in recent years spent about 1 per cent of GDP per year on transport infrastructure, and historically about 80 per cent of what they spend has been for roads.⁵⁴ In 2018-19, NSW completed \$5.0 billion worth of roads, comprising nearly 60 per cent of its transport infrastructure work, while Victoria completed \$1.7 billion, comprising close to 40 per cent of its transport infrastructure work.⁵⁵ This spending comes at the cost of other priorities: other transport priorities or social spending, tax cuts or paying down debt.

As well as being very expensive, the specific projects are not always well-chosen, and thus, in the words of Infrastructure Australia, 'reduce the potential productivity and quality of life improvements of infrastructure investments'.⁵⁶ Decisions to build new freeways or roads are often motivated by political considerations rather than what would best mitigate congestion or provide other community benefits.⁵⁷

Not only are the projects expensive and, at times, poorly chosen, but they often turn out to cost more than initially expected. The bigger and more complex the project, the more likely is a cost overrun. A 10 per cent increase in a project's size (measured by cost estimate when first under construction) is associated with a 6 per cent higher chance of a cost overrun.⁵⁸

50. This does not always happen, although Infrastructure Australia requires it for major urban transport projects: IA (2018a, pp. 93–94).

51. NSW Government (2015, p. 208).

52. IA (2016a).

53. IA (2019b, p. 224).

54. ABS (2019b, Table 11); and ABS (2019c, Table 3).

55. ABS (2019b, Tables 13 and 16).

56. IA (2019b, p. 43).

57. Terrill and Danks (2016, Chapter 2).

58. *Ibid* (pp. 30–31).

Table 2.1: A menu of current and potential measures to reduce congestion

Increase the effective supply of road space for travel	Constrain demand for driving
<p>Add more tarmac</p> <ul style="list-style-type: none"> ● Build new urban freeways ● Widen existing roads ● Build new roads in new or redeveloped suburbs 	<p>Relax zoning and planning restrictions</p> <ul style="list-style-type: none"> ● Permit more residential density around public transport hubs ● Permit more commercial density ● Abolish minimum parking requirements
<p>Reclaim road space for driving</p> <ul style="list-style-type: none"> ● Impose clearways and remove on-street parking ● Upgrade intersections and introduce reversible lanes ● Install ramp metering ● Enable rapid response to accidents ● Install intelligent transport systems 	<p>Dampen local demand for driving</p> <ul style="list-style-type: none"> ● Install traffic calming measures (e.g. speed humps, footpath widening) ● Reduce on-street car parking ● Prohibit driving at certain times (e.g. permit driving only on alternate days)
<p>Give priority to public transport and smaller cars</p> <ul style="list-style-type: none"> ● Upgrade existing public transport ● Build new dedicated bicycle lanes ● Upgrade pedestrian infrastructure ● Provide more bus services in low-density areas ● Dedicate road lanes for very small cars ● Encourage carpooling 	<p>Increase the cost of driving, especially of larger cars</p> <ul style="list-style-type: none"> ● Increase tax via the fuel excise ● Increase the CBD parking levy ● Increase the vehicle registration charge for larger vehicles (Vic) ● Stop subsidising cars relative to other goods and services via Fringe Benefits Tax ● Reduce the size of a standard parking bay ● Introduce congestion charging

New road construction makes new trips possible, and that's a benefit to those people who make the trips, and to the community at large. Sometimes that benefit, however, is not as great as the cost to the community. And for as long as in-demand roads are free to use at peak periods, there will be excessive demand at busy times that could, in the presence of a suitable signal to drivers, be better spread over the course of the day and week.

2.3 The strategy of repurposing road space is not used enough

Whether or not governments build new road capacity, they have a variety of means to get the most out of the road space that already exists.

Strategies to make better use of existing road space for cars and trucks include clearways, roundabouts, converting emergency lanes into general traffic lanes, reversible lanes that switch in the direction of peak traffic, ramp metering on freeway entry ramps, electronic signs to inform drivers, and CCTV linked to traffic operations centres to enable quick action when hazards or accidents happen. Although these strategies can lead to a more efficient use of the road network, they suffer from the same shortcoming as building new road capacity: they make driving more attractive, inducing new demand for road space.

Strategies that reallocate space to other users include the above strategies when coupled with public transport priority measures, such as bus and tram signal priority at traffic lights, and dedicated lanes. They also include reclaiming road space for cyclists and pedestrians, and, for those trips that are by car, providing incentives for people to use smaller vehicles. These approaches are unlikely to solve congestion on their own, for the same reasons as outlined in Section 2.1, but should complement a congestion charge.

2.3.1 Repurposing road space for public transport

Cars are a space-hungry method of transport: a heavy machine that takes up more than nine square metres of road space is most often used to carry a single person. There is hope that connected, automated vehicles will be able to travel closer together and get more out of existing road space.⁵⁹ But there are limits to what they can achieve, if in-demand roads are free at peak times, because their effectiveness will be undermined by the demand they induce.⁶⁰

Public transport is much less space-hungry, and is able to support the greatest throughput of people in a given time (Figure 2.2 on the next page). The larger the vehicle, the greater the number of people it can carry for every tonne of weight and every litre of fuel.⁶¹ For example, a single carriage on one of Sydney's Waratah trains has the capacity of 1.4 Sydney buses or 22 full cars.⁶²

Public transport is most viable where a critical mass of people start and finish their trips close enough to one another in time and space to make frequent services feasible. But people's homes are all over the city, and their destinations mostly are not particularly clustered, beyond the minority who commute to CBDs or other major employment hubs.⁶³ So the challenge for public transport is to compete with car travel, both on comfort and door-to-door trip time.

Nonetheless, Australian governments continue to invest in and give priority to public transport. NSW's infrastructure advisory body has recommended a program to reallocate road space for on-road rapid

59. Stern et al (2018).

60. Fagnant and Kockelman (2015).

61. More formally, the volume (hence the number of people who can be carried in a vehicle) increases with the cube of its linear dimensions: West (2017, pp. 40–41) and O'Flaherty (2005, pp. 86–87).

62. INSW (2018a, p. 132).

63. Terrill et al (2018).

transport links for buses and high-efficiency vehicles on major routes into Sydney's CBD.⁶⁴ Melbourne space reallocation projects include the Hoddle Street bus corridor, SmartBus corridors, and tram routes in the northern suburbs.⁶⁵

Public transport should continue to get priority over cars, not just on the roads but also when it comes to the component of the trip that takes the traveller to their final destination, the 'last mile'. Priority for the last mile can take the form of expanded bus services in lower-density parts of the city, dedicated drop-off and waiting areas for buses and on-demand transport near interchanges; bike storage, e-bike, and bike-share facilities at major interchanges; and better lighting and all-weather protection for pedestrians and cyclists.⁶⁶

The strategies that repurpose space for public transport are important congestion alleviators, improving the alternative transport options available to travellers without inducing significant new demand.

2.3.2 Repurposing road space for cycling and walking

Cycling and walking, known as 'active transport', are less space-hungry than private cars (Figure 2.2). While these methods of transport do not suit all people or all trips, cycling in particular could be more prevalent, as it is in many global cities.⁶⁷

While roads agencies have been developing and expanding the network of separated cycle lanes, there is a further opportunity, often overlooked: general road lanes should be made narrower, and the reclaimed space dedicated to cycling and walking.

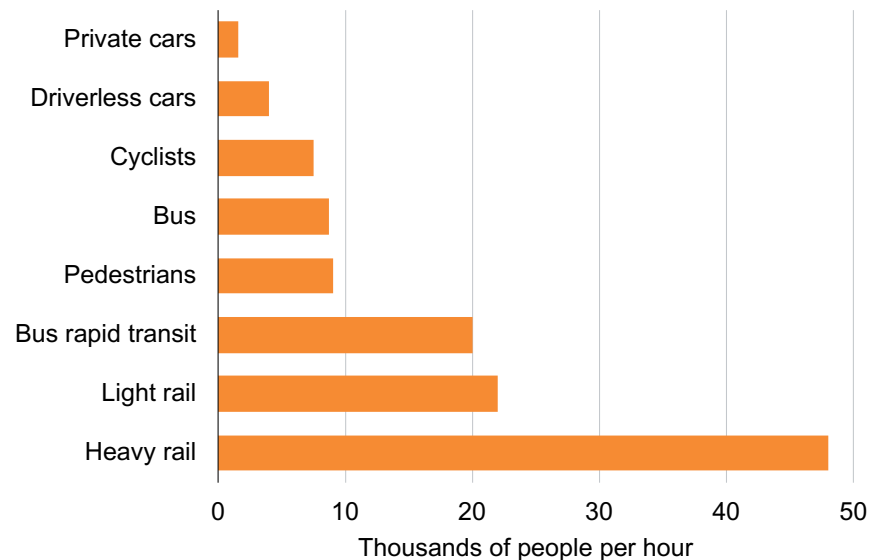
64. INSW (2018a, p. 132).

65. IV (2016a, p. 126).

66. IA (2018b, p. 7).

67. Marqués et al (2018).

Figure 2.2: Cars are a very inefficient form of mass transport
Capacity of a protected 3.5 metre lane



Notes: 'Bus rapid transit' involves traffic signal priority, dedicated lanes, and upgraded boarding facilities: IV (2016a, p. 126). 'Driverless cars' refers to connected and automated vehicles. Theoretical car capacity would be substantially higher if each vehicle were fully-occupied, but this never occurs in practice – unlike on public transport.

Sources: Bus rapid transit and light rail figures from Hickman et al (2011, p. 55). Driverless car figures from Shladover et al (2012). Private car, cyclist, and pedestrian figures from NACTO (2019). Bus and heavy rail figures from Transportation Research Board (2013, pp. 3-8 and 6-21).

Australian engineering guidelines developed by Austroads recommend that traffic lanes on urban arterial roads should be 3.5 metres wide.⁶⁸ If the speed limit is low and there are not many trucks, the guidelines permit narrower lanes, of 3.0-to-3.4 metres.⁶⁹

Over time, the recommended lane width has crept up. In older guidelines, the recommended width of a general traffic lane was 3.3-to-3.5 metres, and for low-speed roads with few trucks, it was 3.0-to-3.3 metres.⁷⁰

Nor is a width of 3.5 metres the norm overseas. For example, in France the range is from 2.5-to-3.5 metres, with the wider lanes for roads where the speed limit is 90, 110, or 130 kilometres per hour,⁷¹ and in Japan the recommended minimum widths are as low as 2.75 metres.⁷² While it is true that the United States tends to have wide lanes, this norm apparently originated in a requirement of the Federal Aid Highway Act of 1956 that interstate highways be built to carry military traffic.⁷³

In Australia, lanes on some busy urban arterial roads are already much narrower than the guidelines recommend.⁷⁴ But many more lanes on many more roads should be made narrower.

If one or more narrow lanes could be created by reducing excessive lane width, there would be greater potential throughput of people,

and of motor vehicles. It may seem intuitive that wider lanes allow greater traffic throughput than narrow ones, but in fact potential vehicle throughput is similar for lanes of width 3.1-to-3.6 metres on urban arterials with intersections. The rate at which lane widths can be reduced is substantially greater than the rate at which throughput diminishes (Figure 2.3 on the following page).⁷⁵ This is because delays result more from junctions than from the speed of traffic under free-flow conditions. In the case of urban expressways, delays result primarily from queueing.⁷⁶

Two narrow lanes will always permit higher vehicle throughput over a given time than a single wide lane. While conventional urban freeways permit faster speeds when traffic volumes are low, this advantage quickly dissipates once traffic volumes increase, because of queueing.⁷⁷

Nor do narrow lanes appear to be any less safe in an urban environment than wide lanes, particularly if a narrow lane is combined with other strategies that reduce accidents, such as removing curb parking and installing central lanes that allow right-hand turns from either direction.⁷⁸

Drivers tend to slow down in narrower lanes.⁷⁹ Narrower lanes are also safer for pedestrians if they reduce the distances to cross a road.⁸⁰ And if there should be a collision between a car and a pedestrian, cyclist, or other car, the impacts are less severe at lower speeds.

68. Austroads (2016, p. 44).

69. *Ibid.* (p. 45).

70. Austroads (2009, p. 35).

71. Héran and Ravelet (2008, p. 51).

72. Road Bureau (2015, p. 59).

73. Murphy (2005, p. 190).

74. The guidelines are not always implemented, due to constraints in the environment. Some Melbourne examples are Alma Road in Caulfield North (3.0 metres); Warrigal Road in Mentone, St Kilda Road in Melbourne, Toorak Road in South Yarra, and Centre Road in Bentleigh East (2.7 or 2.8 metres); and Brunswick Street in Fitzroy (less than 2.7 metres), and Collins Street in the city (2.3 metres in parts): SKM and Bicycle Network (2010).

75. The US guidance has been revised to eliminate any saturation flow adjustments for lane widths between 3.05 and 4.0 metres: United States Transportation Research Board (2016, pp. 19–45). Older adjustment factors are reported in Harwood (1990, p. 12).

76. Small (1992, p. 25).

77. *Ibid.* (p. 25).

78. Potts et al (2007); Schramm and Rakotonirainy (2009); and Karim (2015).

79. Ewing and Dumbaugh (2009, p. 355).

80. Institute of Transportation Engineers (2010, p. 138).

Space currently dedicated to roads could be used for wider footpaths and fully separated bike lanes. And reclaimed space could allow and encourage more of the new micro mobility options gaining popularity in busy cities around the world, from electric skateboards and scooters to self-balancing roller skates and unicycles.⁸¹

2.3.3 Repurposing road space to suit smaller cars

When road space is dedicated or repurposed for public and active transport, one of the benefits is that it enables higher throughput of people, while tending not to induce much new demand for road space.

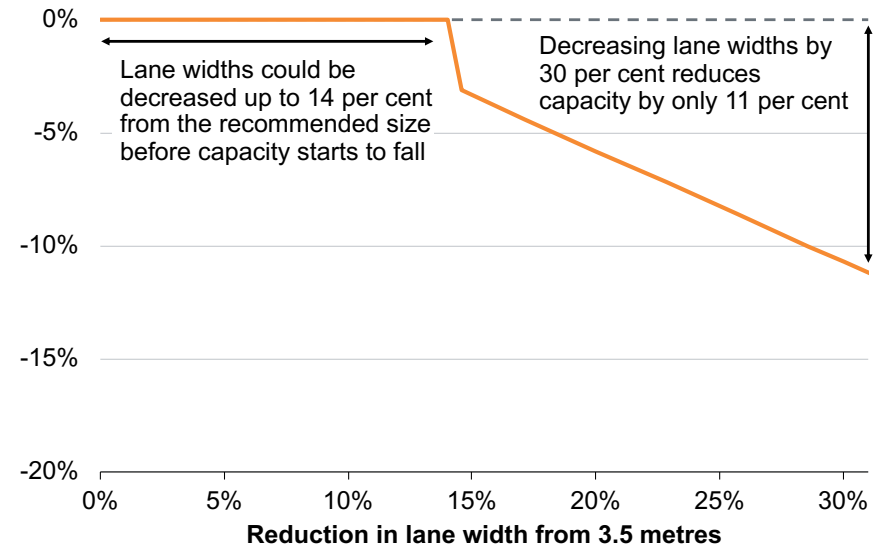
But some trips are not suited to public or active transport. Sometimes people need to carry heavy goods, or drop somebody off, or they may have difficulty walking, or there may not be a feasible public or active transport option at that time. Given how car dependent Australian cities are, it is unrealistic to expect wholesale changes in how people travel, at least in the short and medium term.

However, it is realistic to imagine our car fleet tending towards smaller vehicles than at present.

Larger cars cause more congestion than smaller cars. They not only occupy more space, but also induce other drivers to slow down, partly because they impede the sight lines of those in smaller cars,⁸² and partly because those in smaller vehicles know that they are likely to come off worse in any collision.

Australians have increasingly chosen bigger vehicles,⁸³ as their price has come down and our incomes have gone up. The 'reference' car

Figure 2.3: Narrowing lanes may reduce throughput slightly *per lane*, but could allow space for an extra lane
Change in traffic capacity of a lane



Note: These factors are for signalised intersections.
Source: Austroads (2017, p. 76).

81. Subject to suitable regulations, currently being developed by the National Transport Commission: National Transport Commission (2019a).

82. Austroads (2016, pp. 121–122).

83. Standards Australia and Standards New Zealand (2004, Appendix A).

width used by Austroads, 1.9 metres,⁸⁴ is wide by international standards. It corresponds to a large car, such as a Holden Commodore, or a medium sports utility vehicle, such as a Jeep Cherokee.

By contrast, in Europe and Asia, cars tend to be substantially smaller. Japan has a long-established and highly successful market for light vehicles known as 'kei' cars. They are no wider than 1.48 metres, but can drive on the highway, and account for more than a third of domestic new car sales in Japan.⁸⁵ In China, demand for micro cars is now so high that about 400 Chinese manufacturers are building countless models of tiny electric vehicles, including passenger cars, police cars, and small fire trucks.⁸⁶

Australian cities would get far more value out of their road space if we switched to smaller vehicles. Two strategies to tilt this balance are outlined below. Of course, these strategies alone cannot solve excessive congestion, and their effects would only become apparent as drivers adapted. But they should form part of a mixed strategy to tackle congestion and end the arms race to ever-larger vehicles.

Narrow lanes reserved for micro and light vehicles

Where roads are altered and remodelled, particularly in inner-city areas, there will sometimes be scope to add at least one narrow lane. Skinny lanes could be dedicated to small traffic: micro and light cars and motorbikes.⁸⁷

84. Austroads (2013, p. 6).

85. Hitosugi and Matsui (2015); and Japan Automobile Manufacturers Association (2019).

86. Moss (2018).

87. Murphy (2005). Examples of micro cars are the Kia Ja Picanto, Mitsubishi Mirage, Holden Spark, Fiat 500, Fiat Abarth, Suzuki Celerio, and Fiat Panda. Examples of light cars are the Hyundai Accent, Mazda 200, Toyota Yaris, Suzuki Swift, Honda Jazz, Kia YB Rio, Volkswagen Polo, Holden Barina, Mini Cooper, and Suzuki Baleno: National Transport Commission (2019b).

Drivers who choose a smaller car would have the advantage of a safer, less crowded lane. Over time, more drivers would choose to buy smaller, less-congesting cars.

Smaller parking bays reserved for small vehicles

A standard Australian car parking space is 13.0 or 13.5 metres squared.⁸⁸ A small car parking space in Australia is 11.5 metres squared.⁸⁹

The standard parking bay size has been determined to suit large cars. It was set to suit a vehicle whose length is less than or equal to that of 85 per cent of the passenger and light commercial vehicles on Australian roads in 2000. The car in question at the time was a Ford Falcon sedan, with a 'footprint' of 9.2 metres squared.⁹⁰

Australia's standard car parking space of 13.0 or 13.5 metres squared exceeds the UK and French standards of 11.5 metres squared, and the Hong Kong standard of 12.5 metres squared.⁹¹ Australia shares a design standard with New Zealand, but the small-car standard in New Zealand is 10 per cent smaller than it is in Australia, because the reference vehicle for the small-car standard was smaller in New Zealand than it was in Australia.⁹²

Australia's current approach to setting parking bay sizes does not discourage drivers from buying larger vehicles. An alternative approach would treat parking space as a scarce and costly resource, and so

88. With reference to a 90 degree parking bay; sizes vary slightly for different configurations: Standards Australia and Standards New Zealand (2004, pp. 13–14).

89. Ibid (pp. 13–14).

90. Ibid (Appendix A).

91. The Planning Service (UK) (2015, p. 2); Commission de normalisation (1994, pp. 10); Hong Kong Planning Department (2018, Chapter 8, Table 11). Australia's is less than the US norm of 14.2 metres squared: Dimensions Guide (2019).

92. Standards Australia and Standards New Zealand (2004, Appendix A).

reduce parking bay sizes. This would encourage people to buy smaller, less-congesting cars.

If more parking bays were reserved for small vehicles, more cars could be parked in a given space, and more people would be inclined to buy smaller cars.

2.4 Dampening demand is a very under-used strategy

Most strategies to manage congestion involve adding to the supply of road space. But strategies to dampen demand for road space should also be employed.

2.4.1 On-road strategies to dampen demand often work well at a local level

Traffic calming measures such as speed humps and cushions, footpath widening, chicanes, and roundabouts are inexpensive ways of slowing traffic, enhancing safety, and making an area more attractive to cyclists and pedestrians. And because they slow everyone down, they tend not to induce additional demand.

While this can reduce traffic locally, these measures work by reducing the effective road capacity. This could push more drivers onto already-congested arterial roads, or out of peak period driving altogether. It should be a locally-focused complement to congestion charging.

2.4.2 Relaxing regulations that encourage car-dependence would also help

Planning regulations that mandate or prohibit particular types of development can encourage or discourage driving over other modes of transport.

A key instance is minimum requirements for the number of parking spaces at residential and commercial developments. It remains general

practice for substantial quantities of parking space to be created as part of new developments, although this is changing.⁹³ As some councils reduce or abolish minimum parking requirements, some people can be expected to switch from car travel to other modes.

Similarly, restrictions on residential development in areas with good public transport or within reasonable cycling or walking distance of work locations should be relaxed.

Relaxing restrictions that encourage car-dependence is preferable to regulatory strategies such as 'odds and evens', used in several cities around the world, where people can drive in the city only on alternate days.⁹⁴ This strategy simply encourages new drivers out on the days they are permitted to drive. And some wealthy drivers circumvent the system by buying a second car with an 'alternate' number plate.

Nor is a strategy of encouraging or even requiring segments of the population to leave the city and settle somewhere less crowded likely to be effective.⁹⁵ A century of Australian history shows that government policies to shift people to the regions don't work.⁹⁶ And even if enough people left the cities to make a difference, previously discouraged drivers would emerge to take up the slack.

2.4.3 Weakly-targeted financial charges have limited impact

Even when not specifically designed to dampen demand for road space in peak periods, financial charges still have that effect when they increase the cost of a car trip.

93. Victorian DELWP (2018).

94. For instance, São Paulo, Mexico City, and Beijing allow cars in the city on alternate days only, based on their number plate: Han et al (2010).

95. The Australian Government is implementing this approach: Tudge (2019).

96. Daley and Lancy (2011).

Financial charges are not widely used to address congestion, but two such charges do influence decisions about car trips: fuel excise, and CBD parking levies in Sydney and Melbourne.⁹⁷

Fuel excise is paid at a flat rate, currently 41.8 cents, per litre of petrol or diesel. If the Federal Government increased the rate, people would be likely to travel less – although not necessarily at peak periods.⁹⁸

The Sydney CBD parking levy is \$2,490 for off-street parking in the CBD, North Sydney, and Milsons Point, and \$880 in Bondi Junction, Chatswood, Parramatta, and St Leonards. The similar levy in Melbourne is \$1,440 for the CBD and immediate surrounds, and \$1,020 for suburbs north and the south of the CBD.⁹⁹

These levies dampen demand for driving to the CBD.¹⁰⁰ But their impact is limited by the fact that many inner-city car parks are provided by employers, with employees not necessarily having the option to cash-out the benefit,¹⁰¹ and also that CBD parking levies have no impact on through-traffic, which accounts for about a third of vehicles in Melbourne's Hoddle Grid each morning and up to 40 per cent of vehicles in Sydney's CBD.¹⁰²

A financial charge directly targeting congestion would work better. This is the focus of the next chapter.

-
97. One-off or annual costs, such as car purchase, registration, insurance, and licence fees, have to be paid whether or not a driver takes any particular trip.
98. Typical estimates are that a 10 per cent increase in the cost of fuel would reduce fuel use by 1-to-3 per cent, though estimates vary considerably: Goodwin et al (2004), BITRE (2007, p. 103) and Havranek et al (2012).
99. Details available at Revenue NSW (2019) and State Revenue Office Victoria (2019).
100. Victorian DTF (2010). IV (2018, pp. 72–73) also found that between 2015–2017, there was a 2 per cent reduction in leviable car parking spaces in Melbourne's CBD (the inner zone) and a 9 per cent reduction for the suburbs north and south of the CBD.
101. Loader (2019); and Ison et al (2014, pp. 331–332).
102. City of Melbourne (2019, p. 51) and Grattan analysis of Veitch Lister Consulting modelling.

3 Congestion charging is a better way forward for Australian cities

Congestion charging should be the centrepiece of governments' strategies to manage congestion.¹⁰³

By congestion charging, we mean rationing scarce road space by charging drivers a fee at times and places where there is high demand for that road space. Typical ways to implement it are:

- Cordon charging, where drivers pay at certain times of the day to cross a boundary into (and sometimes out of) a designated zone, such as a CBD.
- Corridor charging, where drivers pay to drive along an urban freeway or arterial road, at certain times in certain directions.
- Network-wide distance-based charging at certain times of the day, where drivers pay to drive within a designated network or area, on a per-kilometre basis.

What we do *not* mean is general road user charging – that is, charging that covers the costs of new road construction, and potentially also the costs of wear and tear on the roads, accidents, and pollution (Box 1 on the next page, footnote d).

This chapter shows that congestion charging is very effective, and explains why it is the least painful way to make a significant difference to excessive congestion. The next chapter shows that fears about congestion charging are overblown.

3.1 Congestion charging is very effective

This section outlines four reasons to believe that congestion charging can be effective in Australia's largest cities. First, congestion charging

manages scarce resources; second, it does not suffer the 'leakage' that undermines many other policies; third, it has worked in cities around the world; and fourth, modelling shows it would work in Sydney and Melbourne.

3.1.1 Prices are our usual way of managing scarce resources

It is common for people to pay for goods and services that are in demand. This applies not only to goods and services produced entirely by the private sector, but to many where the government is or once was involved, such as electricity, mail delivery, and visits to the doctor.

If goods are in demand but free, people will want more of them than are available. As Nobel prizewinner Gary Becker put it:¹⁰⁴

An iron law of economics states that demand always expands beyond supply of free goods to cause congestion and queues. Drivers caught in traffic jams on freeways in and around major cities of the world regularly run afoul of this law.

Even if in-demand goods are not free, but the price is too low, there will be queues or excessive congestion. It is like internet bandwidth: on a Friday night, when people like streaming movies, each household contributes to clogging up the network for others. In the absence of peak-load pricing for broadband, households effectively queue up to get their share, transmission quality degrades, and some people give up on their movie.

Congestion charging would put busy roads during peak periods onto a comparable footing with other in-demand goods and services. People who valued access more highly would pay; others would save their

103. Arnott et al (2005).

104. Cited in Ergas and Greig (2012, p. 8).

money to spend on something else. Rationing by willingness-to-pay often has a strong advantage over other rationing schemes.¹⁰⁵

3.1.2 Congestion charging directly targets excessive congestion, unlike other strategies

Many strategies to reduce congestion are 'leaky'. In other words, as explained in Section 2.1, a new or expanded road attracts new traffic, through triple convergence and induced demand. This means that no feasible amount of road building or new public transport capacity can really remove excessive congestion – even though, of course, new roads and public transport capacity enable new trips and are worth building whenever the benefits exceed the costs.

By contrast, congestion charges reduce the amount of traffic carried on a road link at the time when the charge is in place – even allowing for the fact that some drivers who had avoided the road when it was 'free' but excessively congested may be willing to pay to use it when it is flowing more freely.

3.1.3 Congestion charging has worked in cities around the world

Congestion charging is a proven policy. A number of cities around the world have implemented a variety of schemes.¹⁰⁶

In 1975, Singapore became the first city to introduce a major congestion pricing scheme. It has evolved into a sophisticated scheme combining cordon and corridor charges. It targets congestion by individual detection point, direction of travel, time of day, and vehicle type. Charges are reviewed quarterly to maintain the free flow of traffic.

105. Such as rationing by ordeal – which is what drivers currently experience – or rationing by chance, which happens in cities with license plate lotteries: Bloomberg News (2019).

106. See IV (2016b, pp. 64–70) for a slightly more detailed summary, or Energy Foundation (2014) for a comprehensive review.

Box 1: State governments have contemplated congestion charging

The idea of congestion charging in Australian cities is not new. In 2018, Infrastructure NSW called for a pathway to an integrated system-wide user-pricing regime across roads and public transport, in large part to address congestion.^a Two years earlier, Infrastructure Victoria identified transport network pricing as a transformative way to manage demand and reduce congestion.^b

And as early as 1994, a Victorian Government document noted: 'Traffic modelling suggests that the number of vehicle kilometres travelled on the road network could be reduced by up to 15% by TDM [Travel Demand Management]. A reduction of this size would involve the acceptance of severe measures such as charging for the use of congested roads (road pricing), significantly increasing fuel taxes, and higher parking fees. These measures are unlikely to gain community support in the foreseeable future.'^c

Although congestion management is a state government responsibility, the 2010 Henry Tax Review also recommended congestion charges.^d

a. INSW (2018a, pp. 131–132).

b. IV (2016b).

c. VicRoads (1994, p. 2).

d. Various Commonwealth reports have called for broad road user charging, primarily to fund roads. Examples include the 2016 Australian Infrastructure Plan: IA (2016b, Chapter 5), the Harper Review of Competition Policy: Harper et al (2015, pp. 36–38), and two Productivity Commission reports: the 2014 Inquiry into Public Infrastructure: PC (2014, Chapter 8), and PC (2017, Chapter 4).

In the first year of the Electronic Road Pricing System, traffic was reduced by 15 per cent.¹⁰⁷

Equally well-known is London's Congestion Charge, where drivers pay a daily charge to drive within the cordoned central area. This scheme was very controversial in the lead-up to its introduction in 2003. Modifications since then include the removal of exemptions for commercial vehicles and, in 2019, the establishment of a Low Emission Zone with charging for higher-emitting vehicles. The scheme initially reduced delays in the cordon by 30 per cent, and reduced circulating traffic by 15 per cent, though exemptions granted to private hire vehicles (such as ride-sharing vehicles) have undermined this in recent years.¹⁰⁸

Stockholm's congestion charge is a cordon design, taking advantage of the limited number of bridge crossings into central Stockholm.¹⁰⁹ The scheme was originally implemented as a six-month trial in 2006, with a subsequent referendum entrenching it. It resulted in about a 30 per cent decrease in non-exempt cordon traffic (or around 20 per cent of all cordon traffic) over the first five years.¹¹⁰

Over on Sweden's west coast, by contrast, a similar scheme in Gothenburg has been poorly received by the community. The city was less congested than Stockholm, and the charges were introduced mainly to raise revenue. Nonetheless, they resulted in a decrease in traffic of 12 per cent across the cordon.¹¹¹

Milan's Area C congestion charge started out as an environmental charge, but has evolved to include the objective of reducing congestion. Area C has cut traffic in central Milan by nearly 40 per cent.¹¹²

Some US cities have high occupancy toll (HOT) lanes. Drivers with passengers can use the HOT lane for free; drivers on their own can pay to use the HOT lane and avoid the other, more congested lanes. While not congestion charging schemes in the usual sense, they offer an alternative approach that may be more politically palatable, at least when a new road or lane is built. These schemes operate in Silicon Valley, the Greater Washington Area, and Minneapolis, to name a few. On the 95 Express Lane in Northern Virginia, drivers are guaranteed that traffic will be flowing at 55 mph (88.5 kph) at least 99 per cent of the time.¹¹³

3.1.4 Modelling suggests congestion charging will work in Sydney and Melbourne

A cordon charge around the CBDs of Sydney and Melbourne is likely to substantially reduce congestion in inner areas. Our next report, to be published next week, will detail what such congestion charging schemes could look like. Modelling shows that even a modest cordon charge could result in:¹¹⁴

- About 40 per cent fewer cars entering the CBD in the morning peak.

107. Gopinath Menon and Kian-Keong (2004).

108. Mayor of London (2018, pp. 88–93).

109. International Transport Forum (2018, p. 20).

110. Börjesson et al (2012).

111. Börjesson and Kristoffersson (2015).

112. Croci (2016).

113. Transurban (2019).

114. By 'modest' we mean a charge that is around the level of the fare that most public transport commuters in Sydney and Melbourne pay to travel to the CBD. Our next report will discuss the potential level of charge in more detail.

- An average speed improvement of up to 16 per cent across roads within the CBD,¹¹⁵ and up to 20 per cent faster speeds on sections of major arterial roads leading into the CBD.
- A 1 per cent increase in speeds across each city's road network in the morning peak. While this may sound small, it's worth noting that the North East Link and WestConnex are predicted to increase Melbourne and Sydney's weekday network speeds by 1 per cent and 3 per cent respectively – but with price tags of \$16 billion and \$17 billion (Figure 3.1).

3.2 Congestion charging is the least painful way to manage congestion

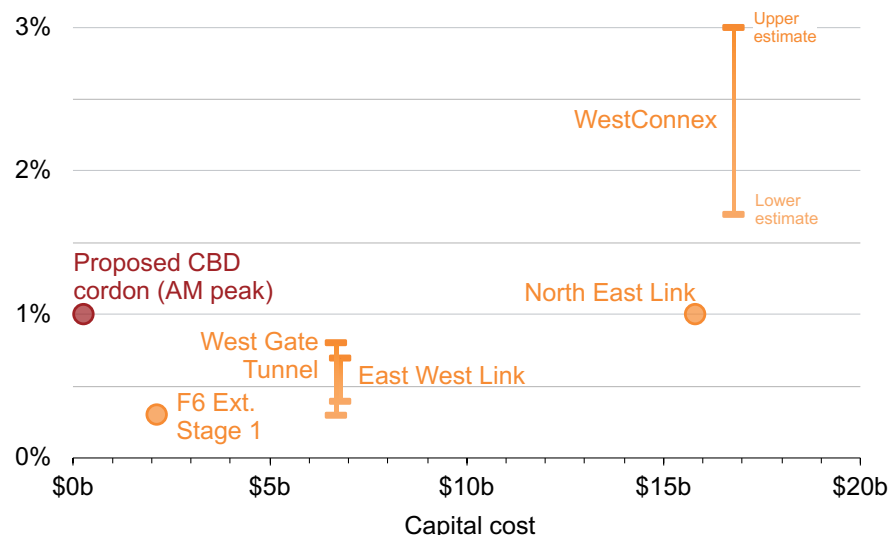
Congestion charging aims to change the behaviour of drivers who are flexible about when, where, and how they travel. An efficient system is one that gets the biggest reduction in excessive congestion for the least cost and hassle to those affected.

It cannot be denied that even a well-designed congestion charging scheme will produce losers as well as winners. Winners would be drivers who value the improvements to their now-faster and more reliable trip more than the charge they must now pay; and bus and tram travellers, who would also benefit from a faster and more reliable trip. Losers would be those who felt the charge had denied them the option of driving; and those who did not value the improvements to their trip as highly as the charge but continued to drive because it was still better than whatever alternative they might have. Of course, governments

115. These speed improvements relate to average speeds, and arise from a combination of slightly faster driving speeds and less stationary time waiting at intersections.

Figure 3.1: A CBD congestion charge could have a similar impact on travel speeds as major new roads – at a bargain price

Estimated increase in network-wide speeds resulting from each project



Notes: There are two competing sources for the WestConnex project. The project's Business Case suggests a 3.0% increase in network speeds across a typical weekday, relative to a 2031 'no project' scenario. But analysis by SGS (2015) suggests only a 1.7% increase in network speeds relative to a 2026 'no project' scenario. The effect of a CBD cordon is indicative only, and based on modelling that will be discussed in the next report. The modelled congestion charges applied in peak periods only, so the impact on network speed across the entire day is less relevant. Changes in network speed are very sensitive to the definition of the 'network'. We have used the Melbourne Greater Capital City Statistical Area and the Sydney Significant Urban Area, as defined by the ABS. Each project may use a different definition of the road network, so speed improvements may not be directly comparable – nonetheless, the effects of a CBD cordon are likely to be similar in magnitude to these other infrastructure investments.

Sources: Grattan analysis of SGS (2015, p. 24), NSW Government (2015, pp. 24, 208), North East Link Authority (2018, Executive Summary, p. 7, Appendix K, p. 31, Appendix Q1, p. 40), State Government of Victoria (2013, p. 19), PwC (2012, pp. 20–21), State Government of Victoria (2019), Victorian DEDJTR (2018, Attachment J, p. 31), RMS (2018, Chapter 8, pp. 86-89) and INSW (2018b, p. 8).

have the option to use some or all of the revenue to compensate people who lose from congestion charging.¹¹⁶

As well as being very effective, congestion charging is the least painful, or most efficient, way to manage congestion, for three reasons. It would lead to a better allocation of road space to those who most need it; it isn't excessively expensive to implement – in fact, it would contribute to government coffers; and in the longer term it would encourage households and employers to make more sensible decisions about where to locate. The following subsections explain each of these reasons in more detail.

3.2.1 Congestion charging leads to a better allocation of scarce space

With a congestion charge, some people would elect not to take a particular trip because the expense was not worth it for them. But even today, some people elect not to take a trip because congestion is too costly in terms of the time spent. Either way, some trips do not happen that would occur if roads flowed freely and cost nothing.

The key change under congestion charging is *which* trips are deterred. If the roads are free to use, but slow, people who are not in a rush won't mind as much as those who are. Congestion in peak periods bothers retirees and shoppers less than commuters and tradespeople.

But if there is a charge for a peak-period trip, a bigger share of the traffic will be tradespeople, delivery drivers, other commercial traffic, and people who need to be at work at a particular time. People such as retirees and shoppers, who may be able to be flexible about when they drive, can save money by travelling off peak.

116. Börjesson and Kristoffersson (2014) found that drivers as a group received net economic benefits from congestion charging in Stockholm even before any of the revenue was spent on them.

Of course, a congestion charge does not prohibit anyone from travel. And if someone needs to go to hospital, or to collect a relative from the airport, or to pick up a sick child from school, they will stand a greater chance of getting there quickly in peak periods if there is a congestion charge. This has been evident in the US, where more than half of drivers have used tolled express lanes on Interstates 495 and 95 in Washington D.C., even though only 5 per cent of drivers use them daily.¹¹⁷

3.2.2 Congestion charging is cheaper than other ways of alleviating congestion – it even raises some money

Most attempts at congestion-busting come with a big price tag, and a consequently higher tax burden. Building new roads in large cities can involve not only normal construction costs but also the costs of compensating the owners of properties acquired to accommodate the road, tunnelling costs, and the costs of major disruption.

But congestion charging can have a similar effect on traffic without the price tag, or the associated higher taxes, or the delays caused by construction work. Speed increases of about 1 cent across the network could be expected from a cordon scheme around the CBD of Sydney or Melbourne. That's about the same as the speed increases expected from the major urban road projects currently under construction or consideration (Figure 3.1 on the preceding page).¹¹⁸

Those major roads cost billions of dollars, whereas a congestion charge, as well as making the road network more efficient, can make a

117. Details from Transurban's 2018 survey report *State of the Lanes* are not publicly available but are cited in Lazo (2018).

118. Of course, a road project improves speeds by creating more road space for road-users, whereas congestion charging improves speeds by changing when and if people use the road. To the extent this is considered a disadvantage of congestion charging, it should be remembered that congestion charging works on a user-pays principle, whereas all taxpayers contribute to road projects.

positive contribution to the budget. This sets a congestion charge apart from most state government revenue sources, which reduce efficiency. For instance, raising an extra dollar from stamp duty is estimated to cause economic harm of around 34 cents, as some people elect not to buy a home or not to sell up and buy a different one; and an extra dollar of payroll tax causes economic harm of around 41 cents, as employers hire fewer staff and employees are deterred from working more.¹¹⁹

Governments can use the revenue from a congestion charge to fund transport alternatives, assist low-income drivers, or reduce taxes.¹²⁰ If they used it to reduce taxes that were less efficient, this would constitute what is sometimes described as a 'double dividend'.

While it is useful that a congestion charge raises net revenue, enthusiasm for this revenue should not swamp the primary purpose of congestion charging – efficient use of the road network (see Box 2 on the next page).

3.2.3 Over the longer term, congestion charging would encourage people to make more sensible decisions about where to live

Without any trigger for people to consider their contribution to congestion, city dwellers have been encouraged to live in more distant, lower-density, and often less expensive suburbs.

If congestion charges were in place, people would factor them into their decisions about where to live and work. This would be most evident for corridor or network-wide distance-based charging; less so for a CBD cordon charge. A corridor charge, for instance, would make it more expensive in financial terms for someone to drive to work from a distant part of town, and so when next they were considering moving home,

they might look at moving closer to work. Alternatively, they might search more actively for work closer to home.

Of course, people would not move home immediately in response to a congestion charge, but they do consider the time and money costs of transport when deciding where to live.¹²¹ Where people live is also highly constrained by residential planning and zoning restrictions.¹²²

With congestion charging in place, as people sought better locations for their own particular lifestyle and budget, this would, over time, discourage urban sprawl and encourage a more compact city. A more compact city would make walking and cycling more feasible for more people, with associated environmental and health benefits.

In the long run, allowing a city's size and shape to adjust in response to both congestion charges and planning reforms has a bigger impact than either reform would have on its own. That's because, while some people would respond to a congestion charge by changing their travel habits, others would do so by changing where they lived.¹²³ Employers also, over time, may change the location of their worksites to attract the staff, suppliers, and customers that they need.

119. KPMG Econtech (2010).

120. Vickrey (1968, p. 111).

121. Eliasson (2014a, p. 27).

122. Terrill et al (2018, pp. 44–46).

123. Langer and Winston (2008); and Arnott et al (2005).

Box 2: The fuel excise furphy

It is often claimed that we need to charge for road use because fuel excise is plummeting and so there will not be enough money to fund new roads.^a But this argument is flimsy, for three reasons.

First, the idea of fuel excise plummeting is a furphy. Fuel excise raised nearly \$13 billion in 2018-19, by taxing every litre of petrol or diesel about 41 cents. As cars become more fuel-efficient, the dollars raised by fuel excise are increasing slightly in real terms and falling only very gradually as a proportion of GDP.

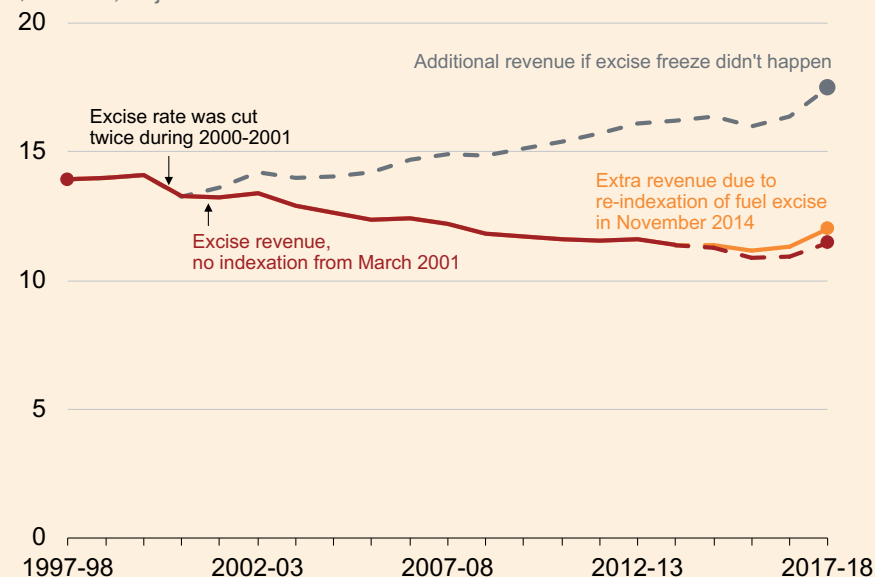
Fuel excise was more obviously on the decline between 2001 and 2013, mainly because of a Howard government decision to freeze the rate at 38 cents per litre. The freeze meant that rising petrol prices did not translate into rising fuel excise revenue; it fell in real terms and as a share of GDP. The Abbott government ended the freeze in the 2014-15 Budget, with the expectation of raising more than \$2 billion of additional revenue over the following four years.^b

Second, even if fuel excise were to plummet, there is no reason to assume this would have any impact on road funding. Excise is a Commonwealth tax and constitutes less than 5 per cent of tax receipts. And the Commonwealth is only a minority funder of roads. In a typical year, the Commonwealth pays 21 per cent of the roads bill, and local government 26 per cent. The state and territory governments pay the remaining 53 per cent.^c And besides, there is no meaningful earmarking of fuel excise revenue for road spending.^d

a. Irvine (2019), Bagshaw (2019), AAA (2016a) and IA (2016b, pp. 84–89).
 b. Treasury (2014, p. 17).
 c. Grattan analysis of BITRE (2018, pp. 39–40).

Figure 3.2: Fuel excise receipts declined mainly because of the rate freeze, but the freeze is over

\$ billions, adjusted for inflation



Note: The grey line scenario assumes that the higher rate of fuel excise would have had no effect on consumption – this makes it an upper-bound estimate.

Sources: Treasury (2018), BITRE (2018), and Fuel Indexation (Road Funding) Special Account Determination (2016-2019).

Third, Australia is not rushing to electric vehicles. Only 0.2 per cent of the current vehicle fleet is electric today. This figure is projected to reach 4 per cent – or 20-to-25 per cent of sales – by 2030.^e

d. The earmarked fuel excise is the amount that is additional because of the reintroduction of indexation: Treasury (2014, p. 17). This was less than \$0.6 billion for the 2017-18 financial year (Figure 3.2).
 e. IA (2019b, p. 284) and Energeia (2018, p. 7).

4 Fears of congestion charging are overblown

Congestion charging is not popular with Australia's federal or state politicians.¹²⁴ They fear that voters won't like the change.¹²⁵

For voters, one concern is that congestion charging isn't *fair*. They feel that a new charge will mostly hurt people who can least afford it, or that they're being punished for driving when they have no choice, or that they're already paying too much to the government.

But these fears are overblown, and this chapter explains why. The first section shows that it is predominantly higher-income drivers who would pay a congestion charge. The second section shows that people are not helpless: they can and do adapt. The third section makes the case that it is fairer for frequent users of peak-period roads to contribute more than those who don't use this scarce resource much or at all. The final section shows how low-income people with few alternatives to driving in peak times in busy areas can be protected from the impacts of congestion charging. These arguments about fairness relate mostly to a CBD cordon because – as will be outlined in our next report – this is the policy that governments should introduce first.

4.1 Congestion charges would mostly affect higher-income drivers

The core concern about congestion charging is that it might stop lower-income people from getting where they need to go. As Figure 4.1 on the next page highlights, the group of greatest concern is those people:

124. Inner-city local governments do not share this scepticism. The City of Melbourne expressed support for congestion charging in its *Draft Transport Strategy 2030*; Sydney's Lord Mayor Clover Moore has expressed tentative support for congestion charging provided public transport solutions such as light rail are delivered first: City of Melbourne (2019) and Gorman (2015).

125. See, for example, VicRoads (1994, p. 2).

- on low income; and
- with few alternatives to driving in peak times and places; and
- who are frequent users of busy roads at peak times.

None of these factors is too serious in isolation. A driver to the CBD with good public transport access can easily switch modes. A low-income person who seldom drives at peak times anyway will mostly avoid the charge. And a wealthy parent who likes to drive the kids to school before work can easily afford to pay for their contribution to congestion.

Though these groups may not *like* the charge, there's nothing particularly unfair about them paying for their use of scarce road space.

More serious problems may arise when someone has a low income *and* they lack good alternatives to driving *and* they rely heavily on driving to the CBD in peak times. But few people are in these circumstances, as we will show.

The following subsections spell out why it is predominantly wealthier drivers who would pay such a charge.

4.1.1 People who drive to the CBD regularly tend to have much higher incomes

Our recommendation in the first instance is a congestion charge in the form of a cordon around the CBDs of Sydney and Melbourne.¹²⁶ This means that only trips to the CBD in the morning peak and out of the CBD in the afternoon peak would be charged.

126. Further details and justification will be provided in the next report, to be published next week.

Only a very small proportion of households would pay such a charge, but the benefits would be felt by a much larger number of city dwellers. For instance, only 3 per cent of Melbourne households have a member who drives to the CBD on a typical weekday morning.¹²⁷

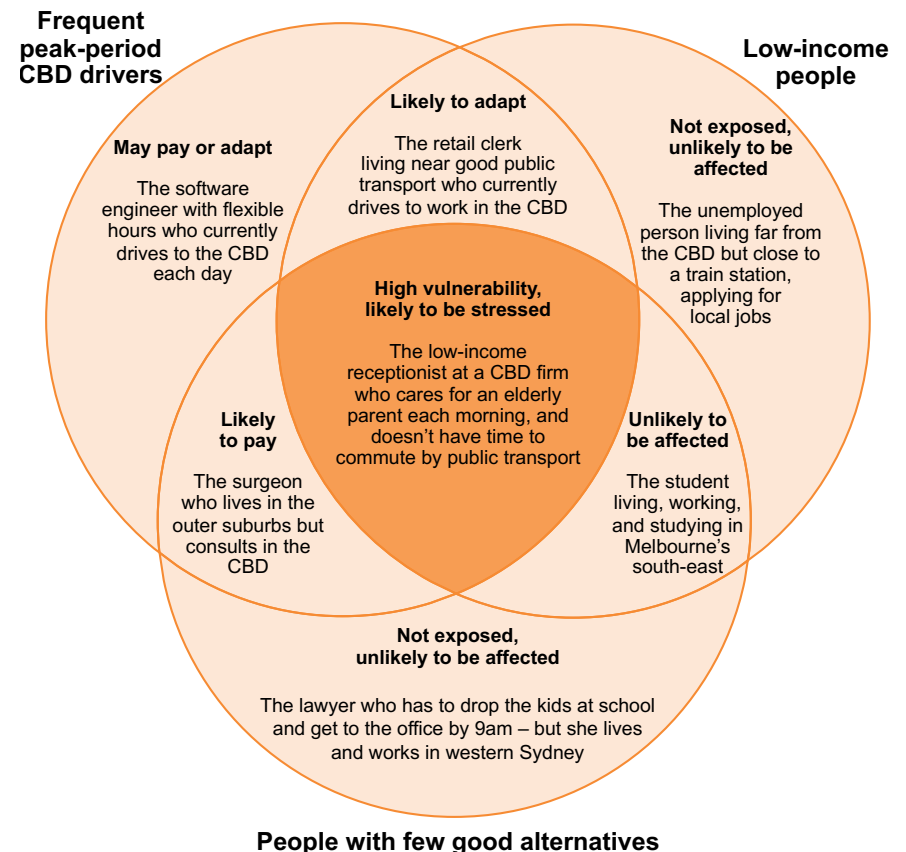
Whether in Melbourne or Sydney, the group most obviously exposed to a CBD cordon charge would be full-time workers who drive to the CBD. On any given day, a full-time worker would be more likely to face a congestion charge than a part-time worker, due to their hours of work. Full-time workers make up about four-fifths of the workforce in Sydney and Melbourne's CBDs.

Among people who drive to work in the CBD, very few are on low incomes. The median income is \$2,450 per week for full-time workers driving to the CBD in Sydney, and \$1,980 in Melbourne. That's \$1,030 and \$650 more than the median income of full-time workers in each city.¹²⁸ In Sydney, more than half of those commuting to the CBD by private vehicle each day earned \$104,000 or more in 2016 – not even one in five Australian workers could lay claim to such a high salary (Figure 4.2 on the following page).¹²⁹

Workers in the CBD are generally well-served by public transport, and most of them take advantage of it. In Melbourne, barely a quarter of full-time CBD workers commute by private vehicle, and those who do tend to earn 17 per cent more income than the public transport commuters. In Sydney, only about 15 per cent commute by private

Figure 4.1: The most vulnerable drivers have low income, few good alternatives, and need to get to the CBD in peak periods

How people in different situations might respond to a CBD cordon congestion charge, and examples of who they might be



Source: This 'tripartite conceptualisation of vulnerability' is presented in Mattioli et al (2017), adapted from Adger (2006).

127. Calculated by determining the proportion of households for which any member visited the Melbourne CBD by car on a weekday between 7.30am and 10am, using the Victorian Integrated Survey of Travel and Activity (VISTA): Victorian Department of Transport (2016).

128. Grattan analysis of ABS (Census, 2017a), inflated to 2019 dollars using CPI. 'Income' refers to personal income from all sources, and 'driving' means that the person's mode of travel to work was 'car, as driver', as defined in ABS (2016).

129. 'Private vehicle' means commuting by 'car, as driver', 'car, as passenger', 'taxi', 'truck', or 'motorbike/scooter', as defined in ABS (ibid).

vehicle, and they tend to earn 34 per cent more than the CBD-bound public transport users.¹³⁰

And these higher-income workers tend to come from higher-income households, with 62 per cent more income per person within that household compared to households where nobody would be exposed to a congestion charge.¹³¹

4.1.2 Low-income workers don't actually drive further

Our recommendation, spelt out in detail in our next report, is that congestion charging be extended to key arterial roads and urban freeways about five years after the CBD cordon has been established.

With corridor charges, and network-wide distance-based congestion charges, there is a legitimate concern that this could mean undue or disproportionate expense for lower-income families, particularly if they live in the outer suburbs and have to drive further along these charged corridors or through a charged zone to get to a job in the city.¹³²

But this notion contains several myths. It is a myth that most workers converge on the CBD to work. In Sydney and Melbourne, only about 15

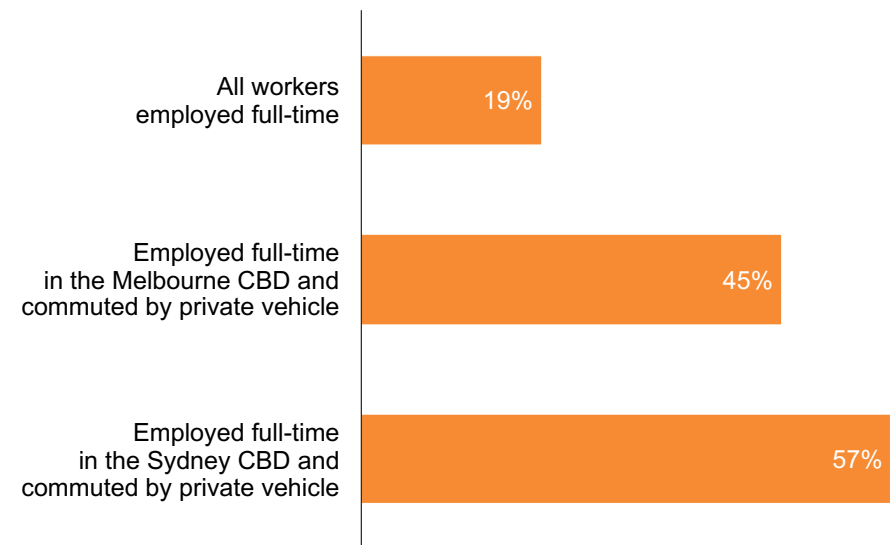
130. Based on full-time workers' incomes reported in ABS (Census, 2017a); 'public transport' here means any combination of train, bus, ferry, or tram.

131. Grattan analysis of Victorian Department of Transport (2016). The 2012-16 VISTA samples about 18,000 households, recording total income and usual number of household residents. This allows derivation of per capita household income, but not equivalised household income.

132. A typical statement of this sentiment, made by federal Urban Infrastructure Minister Alan Tudge in June 2019, was: 'It's not on my agenda. . . In some respects people are already paying the cost of going on the road because of the congestion they are facing. They are already struggling to come in from the outer suburbs into work in the city, and I don't think they should pay more.' See Wiggins and S. Evans (2019).

Figure 4.2: People commuting to the CBD daily by private vehicle are more than twice as likely to earn six-figure salaries

Proportion of full-time workers who reported a total weekly income equivalent to at least \$104,000 per year on the 2016 Census



Notes: The Sydney CBD is taken to be the 'Sydney - Haymarket - The Rocks' SA2, as defined by the ABS. The Melbourne CBD consists of the 'Melbourne', 'Docklands', and 'Southbank' SA2s. Commuters who travelled by 'car, as driver', 'car, as passenger', 'taxi', 'truck', or 'motorbike/scooter' are considered to have commuted by private vehicle.

Source: Grattan analysis of ABS (Census, 2017a).

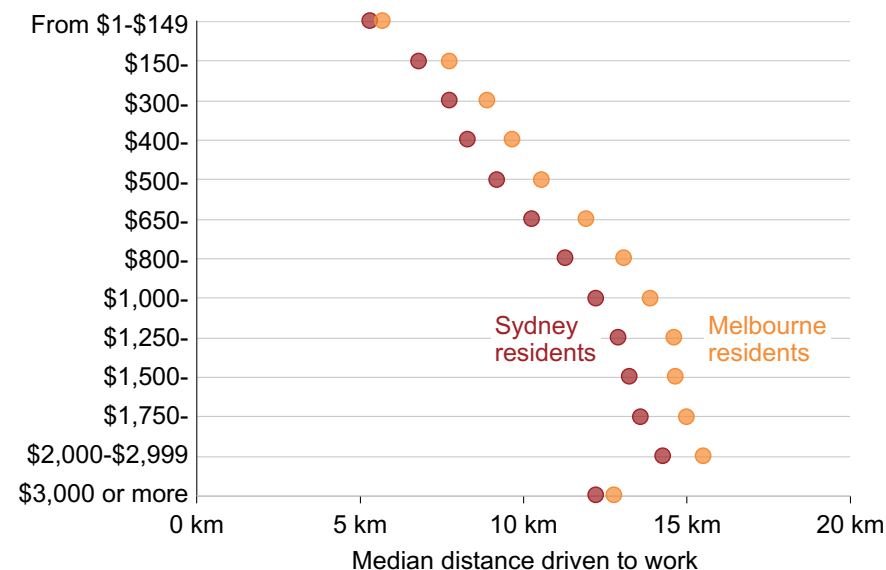
per cent of jobs are located in the CBD.¹³³ The second most important suburb for jobs in Sydney is Parramatta, with 2.3 per cent of the city's jobs; in Melbourne it is Dandenong, with 3.2 per cent.¹³⁴ Most jobs are dispersed all over the city, and so commutes are very divergent. In addition, most workers live close to where they work,¹³⁵ and about 30 per cent work in the suburb where they live or the one next door.¹³⁶

It is also a myth that lower-income workers drive further. In fact, it is typically higher-income workers who drive further to work (see Figure 4.3).¹³⁷ And those who drive long distances tend to have higher incomes – higher-income drivers are willing to travel further to get to their high-paying job.¹³⁸

The exception to this broad relationship is that the best-paid commuters (with weekly incomes higher than \$3,000 per week) tend to live closer to work than those earning \$2,000 to \$2,999 per week (see Figure 4.3). This could be because people on the highest incomes can more easily afford to live where they want, allowing them to choose homes closer to work.

There's a lot of underlying variability to distances travelled and their relationship to income – because, of course, many factors influence housing and work location choices. But it is simply not the case that low-income workers drive further.

Figure 4.3: Higher-income workers tend to drive further
Total weekly personal income reported on the 2016 Census



Notes: Includes both full-time and part-time workers. People who reported home and work addresses greater than 250 km apart have been excluded. Only commuters who travelled by 'car, as driver', 'car, as passenger', 'taxi', 'truck', or 'motorbike/scooter' are included.

Source: Grattan analysis of ABS (Census, 2017a).

133. Terrill et al (2018, Chapter 2).

134. Ibid (Chapter 2).

135. For those who drive to work, more than half can get there by driving less than 12km in Sydney, or 13km in Melbourne: ABS (2018).

136. Terrill et al (2018).

137. IA (2018b, pp. 20–32); and BITRE (2019).

138. Not just in distance, but also time – BITRE (2016, p. xxiv) found that 'average commuting trip durations and the rate of prevalence of lengthy commutes both rise strongly and systematically with personal income'.

4.1.3 Car ownership is lower for lower-income families

Buying a car and keeping it on the road is costly, so it is no surprise that vehicle ownership is lower among lower-income households.

In Sydney, a quarter of households with a weekly equivalised income of less than \$500 don't own a car, and in Melbourne it's 21 per cent.¹³⁹ For many of these households, vehicle costs are just too high to justify. But for households with equivalised incomes greater than \$1,500 per week, vehicle ownership is at 94 per cent and 96 per cent in Sydney and Melbourne respectively.¹⁴⁰

And the number of cars a household owns also tends to increase with income.¹⁴¹

Providing access to roads for free can be thought of as a subsidy to people who are already better off:

Unpriced roads are a government benefit subject to a reverse means test: people with enough money to pay for vehicles, fuel, and insurance can use valuable urban land for free.¹⁴²

In contrast, the costs of roads are borne disproportionately by lower-income people. This is because lower-income people share the cost of free roads through the government services forgone. It's very expensive to build infrastructure that increases the amount of available

road space at peak times. But politicians and the public rarely bat an eyelid at spending millions of dollars on a new road, even though many of the taxpayers who contribute will never use it,¹⁴³ or the funds could have been better spent on something else.

New mega-highways – such as WestConnex and NorthConnex in Sydney, and the North East Link and West Gate Tunnel in Melbourne – will be tolled.¹⁴⁴ It makes sense to ask the people who benefit the most from these roads to pay for access, especially at the busiest times. But the same principle should be applied to all drivers, including the ones who benefit from existing free roads.

Consider an alternative reality where drivers who use in-demand roads pay for them, and those who don't pay nothing. Would we even entertain the thought of making in-demand roads free, thereby requiring the people who don't use them to subsidise the people who do?

4.2 Lower-income drivers have shown they can and do adapt

Media reports of motorists being 'slugged' with road tolls tend to focus on extreme case studies, such as a landscaper spending \$800 in a month,¹⁴⁵ or misrepresent a household spending \$83 per week on tolls in Sydney and \$49 in Melbourne as 'typical'.¹⁴⁶

139. Incomes are as reported on the 2016 Census. Equivalised household income can be viewed as an indicator of the economic resources available to each individual in a household: ABS (Census Dictionary, 2016). Households with a weekly equivalised income of less than \$500 represent 21 per cent and 23 per cent of all households in Sydney and Melbourne respectively: Grattan analysis of ABS (Census, 2017a).

140. Households with equivalised incomes greater than \$1,500 per week represent 29 per cent of households in Sydney, and 24 per cent in Melbourne. For the one-in-20 households that don't own a car in this group, it is generally not due to being unable to afford a car.

141. BITRE (2019, p. 7).

142. Manville and Goldman (2018).

143. Terrill et al (2016, pp. 36–46).

144. NSW Government (2015, p. 38); RMS and NorthConnex Company Pty Ltd (2015, p. 161); North East Link Authority (2018, Executive Summary, p. 5); and Victorian DEDJTR (2018, p. 17).

145. See, for example, Paterson and Tin (2017), Hutchinson et al (2019) and Hoh (2019).

146. These figures were published by the Australian Automobile Association, and appear to describe the cost to a hypothetical household that drives unusually far on toll roads. The Sydney estimate assumes one household member drives to the CBD on toll roads twice per week, incurring more than \$40 of tolls on each return trip. The Melbourne estimate assumes one household member drives to the CBD on toll roads each weekday: AAA (2018, p. 18). They have been

Such stories are extreme and unrepresentative. The extent of the exaggeration is evident from aggregate toll revenues. If the average household spent \$83 per week on tolls, NSW toll road operators would be earning \$7 billion in revenue from passenger vehicles each year, whereas in fact they collected less than \$2 billion last year, even including heavy-vehicles charges.¹⁴⁷

Likewise, Victorian toll operators would be reaping in more than \$4 billion annually, but CityLink – by far the larger of Melbourne's two existing toll roads¹⁴⁸ – generated \$0.8 billion in the 2017-18 financial year, including commercial vehicle charges.¹⁴⁹

The exaggeration is also evident from the fact that the best available data source on household expenses shows that of nearly 4,000 households surveyed across Sydney and Melbourne, only one household in each city recorded spending at least \$200 per week, or around \$800 per month, on road tolls.¹⁵⁰

Not only are they unrepresentative, but these stories treat people as helpless and unable to make choices about the value they place on driving on particular roads at particular times. In reality, it is evident that people can and do make decisions about what fees to incur and whether on any given day that particular trip, on that road, at that time, is worth the cost of the toll.

incorrectly reported as averages several times: see Wiggins (2019), Wray and Morgan (2018), M. Evans (2016) and City of Melbourne (2019, p. 97).

147. In the 2017-18 financial year, total NSW toll revenue is estimated to be \$1.68 billion. This includes \$166 million from the Sydney Harbour Bridge and Tunnel, \$174 million from the M4, and \$1,340 million from the remaining toll roads that were partly or wholly owned by Transurban: NSW Treasury (2019), Sydney Motorway Corporation (2018), Transurban (2018) and ABS (2019d).

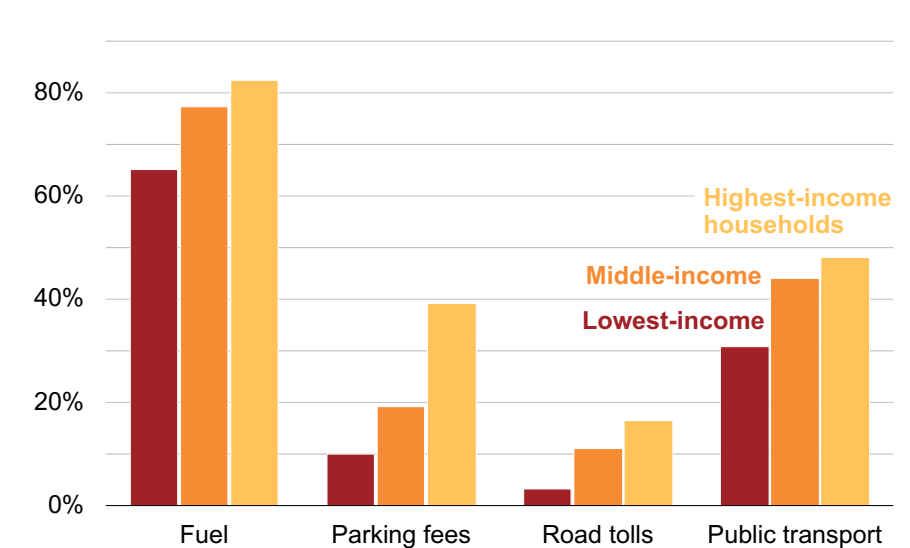
148. Loader (2016b).

149. Transurban (2018); and ABS (2019d).

150. Less than 2 per cent of households in Sydney and Melbourne spent the amount on tolls that the Australian Automobile Association described as 'typical': Grattan analysis of ABS (Household Expenditure Survey, 2017b) and AAA (2016b).

Figure 4.4: Most households don't use toll roads very often, especially households with lower incomes

Proportion of Sydney households that pay for each item fortnightly



Notes: Households have been categorised according to equivalised disposable household income. The 'highest-income third of households' is the collection of households containing the highest-income third of residents of the capital city; each third contains the same number of people, rather than the same number of dwellings. The pattern is consistent in Melbourne.

Source: Grattan analysis of ABS (Household Expenditure Survey, 2017b).

People's adaptations in the face of fees to drive is clearest in the case of tolls. Only 3 per cent of Sydney households in the bottom third of the income distribution incur road tolls each fortnight, compared with 16 per cent for households in the top third. By contrast, 65 per cent of these lower-income households incur vehicle fuel costs each fortnight, compared with 82 per cent of the higher-income households (Figure 4.4 on the previous page).

And in a given week, more than half of the money paid in tolls is paid by the highest-income third of households (Figure 4.5).

This implies that lower-income drivers either avoid toll roads or have less need to travel on them. It is similar with parking fees; higher-income households are three to four times more likely to pay them than lower-income households.

While case studies of tradespeople spending \$800 on tolls in a month may be eye-popping, they represent a tiny minority at best.

The adaptations that people make so as not to pay tolls or parking do come at a cost, if people spend longer driving a roundabout route, or travel at a less convenient time, or by a less comfortable mode, or opt not to travel at all. And the burden of such costs may fall more heavily on a lower-income driver than on a higher-income driver. These costs are real, but they are lower than the tolls or parking fees that are avoided.

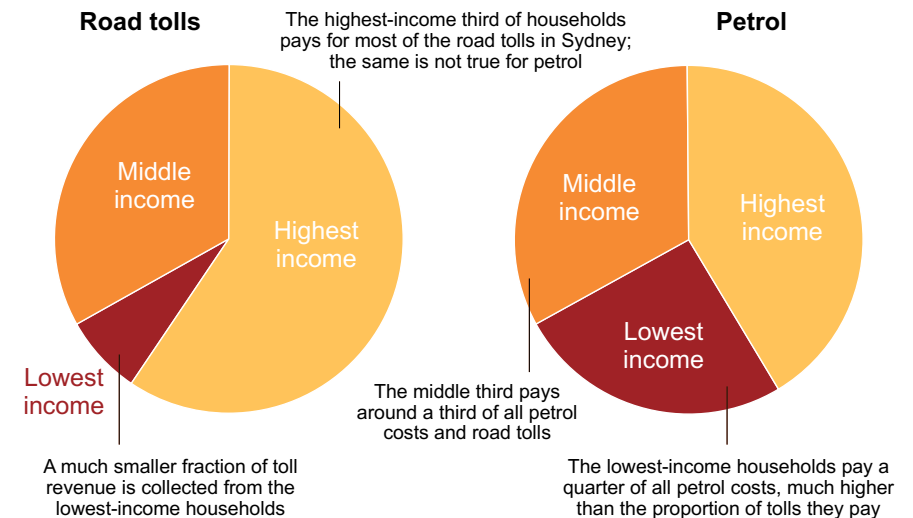
4.3 It's fair for heavy users of congested roads to pay more

Drivers who frequently use busy roads in peak periods today might respond to a congestion charge by changing their driving regime, or paying the charge. It depends for each driver on how much they value that particular trip at that particular time.

For the most part, frequent users do not need to be protected from the charge. Peak-period road space is in short supply, and it has to be

Figure 4.5: It's hard to avoid buying petrol, but lower-income households mostly avoid paying road tolls

Proportion of aggregate costs paid, by household income tercile, Sydney



Note: The trend for Sydney is consistent in Melbourne.

Source: Grattan analysis of ABS (Household Expenditure Survey, 2017b).

rationed somehow. It's rationed today by waiting in line at intersections or blockages, along with lower speed and less-reliable trips. It could more efficiently be rationed by a congestion charge. Roads could become more like other utilities, such as electricity or gas, where people pay for the amount they use, and, in some cases, pay more for peak than off-peak usage.

Nobody should be surprised if free access to a scarce resource that is in demand leads to unsustainable levels of usage. And even when usage is charged, the opportunity to manage demand in response to changing conditions is squandered if the price is always the same.¹⁵¹ In the electricity sector, some retailers charge consumers a higher rate during times of peak demand, usually the early evening.¹⁵² This encourages users to delay or forgo certain activities, such as using the clothes dryer or dishwasher, and reduces pressure on the electricity network at that time.

On the road, limited space results in congestion. If demand for a road is too high – such as during peak periods – then traffic speed slows and queues build, forcing drivers to pay with their time.

4.4 Low-income drivers with few alternatives can be protected from excessive impacts of congestion charging

Some people drive because they don't have suitable alternatives. They may not live close to public transport, they might have a mobility impairment that makes public transport impractical, or they might find public transport or cycling too inconvenient or unpleasant. It could also be not so much a lack of other methods of travel, but lack of flexibility about the timing of their trip, or where they need to go.

But even drivers who lack good alternatives contribute to congestion. It would undermine the effectiveness of a scheme to grant wide-ranging

151. INSW (2018a, pp. 55–56).

152. See, for example, Ausgrid (2019) and EnergyAustralia (2019).

exemptions. This became evident in central London, where exemptions granted to taxis and ride-sharing services contributed substantially to recent increases in traffic.¹⁵³

There is a special case for people with impaired mobility and low income who need to get to the CBD (or charged zone) in peak periods. Singling out people with mobility difficulties for special treatment reflects best practice overseas.¹⁵⁴

Unlike an exemption, a discounted congestion charge still encourages car users to consider their impact on congestion and to schedule their travel outside of peak times where they can. Water and electricity are not provided for free just because some users have low incomes – it is fairer for vulnerable users to pay a discounted rate.

In rare instances, some people will incur a greater charge than they can reasonably afford – whether through accident, negligence, or extenuating circumstances.¹⁵⁵ That's why utility providers offer hardship programs. Congestion charging should have a similar safety net built in.

153. Badstuber (2018). In April 2019, the exemption granted to non-wheelchair-accessible private hire vehicles was rescinded, but the exemption for taxis remains, whether or not the passenger needed a special vehicle: TfL (2019).

154. London, for example, exempts 'Blue Badge' holders from paying the charge. International Transport Forum (2018) notes that exemption of emergency vehicles and disability permit holders is a universal feature of congestion pricing schemes. Australian state governments may prefer to offer discounts or caps on charges instead, to account for the trips that a registered vehicle makes without the permit holder.

155. The arrangements governing toll roads have been criticised because people who failed to pay could end up with penalties running to hundreds of dollars per day of travel in Victoria and Queensland: Senate Economics References Committee (2017). Drivers who failed to pay were frequently dealt with in the criminal justice system rather than civil debt recovery: WEstjustice (2017). Recent legislative changes in Victoria mean that users can now be sent only one infringement per week, reducing the risk of exorbitant penalty debt: *West Gate Tunnel (Truck Bans and Traffic Management) Act 2019*.

Conclusion

Congestion is a big enough problem in Australia's largest cities to warrant a new approach. The most effective strategy available to state governments is to charge drivers a modest fee to drive on the highest-demand roads in peak periods.

Congestion charging is an effective way of rationing scarce road space, just as we ration other in-demand goods with prices. It is not undermined by 'leakage'; when a driver decides to delay their trip, it doesn't mean a new one emerges to take their place. There's now enough evidence to be confident that congestion charging has worked in cities around the world, and modelling shows it could work here too.

Congestion charging is the least painful way to manage congestion. It changes which drivers are on the road in peak periods, and encourages those who can be flexible to take their trip at another time. It's much cheaper than road construction, and even raises some money. Over the longer term, congestion charging encourages decisions about where to live and where to locate commercial premises that work better for individuals and the community.

Fears that congestion charging may be unfair on low-income people are overblown. Most of the drivers in peak periods in CBDs are much better off than average, and the better-off workers tend to drive further to work. For some particularly vulnerable people, we recommend special discounts, but by and large, there is nothing unfair in requiring heavy users of in-demand roads to pay their share.

The case for change is compelling. We recommend that state governments introduce congestion charging in the larger capital cities. In the first instance, NSW and Victoria should introduce a cordon charge around the CBDs of Sydney and Melbourne, and in the medium term add key arterial roads and urban freeways. Our next report, to be published next week, will explain in detail how this should be done.

Appendix A: Technology options for congestion charging

This Appendix explains the technologies that could be used for congestion charging, and their merits. The options are:

- Automatic Number Plate Recognition (ANPR).
- Dedicated Short-Range Communication (DSRC).
- Global Positioning System (GPS).
- Cellular technologies.
- Manual charging.

Each technology has its pros and cons. Table A.1 on page 46 compares their accuracy, ease of enforcement, flexibility, 'scalability', and convenience. Implementation and maintenance costs, as well as privacy implications, will be discussed more fully in the next report, to be published next week.

As outlined in Section 1.3.2, the most feasible option for a CBD cordon, and potentially for subsequent corridor charging, is ANPR.

A.1 What are the technologies?

Automatic Number Plate Recognition (ANPR)

ANPR cameras are fixed in position above or beside the road to allow clear sight of passing vehicles. If the road has more than two lanes, it is likely the cameras will be mounted on overhanging gantries to ensure they have complete coverage. The cameras illuminate and capture images of vehicles' number plates. Processors built into these cameras isolate and adjust the number plate images, and optical character recognition software is used to convert images to text.¹⁵⁶ Processors

156. Arnold and Harris (2013).

may compare multiple images of the same number plate to produce a more reliable reading.

ANPR technology is already a common feature on Australian roads. It is used for speed and red-light cameras, and on toll roads to capture the number plates of vehicles without a toll road in-vehicle tag. ANPR technology is also used in the London and Stockholm congestion charging schemes.¹⁵⁷

Dedicated Short-Range Communication (DSRC)

DSRC is the primary technology used to charge drivers on Australian toll roads. A DSRC-type congestion charge would look similar to the current Australian toll road system, with gantries and in-vehicle tags. These tags, a form of On-Board Unit (OBU) called transponders, are DSRC-compatible. Transceivers mounted on top of a gantry or on an existing roadside structure use radio or infrared signals to communicate with the transponder and register that the vehicle has passed by.¹⁵⁸

Singapore's congestion charging system uses DSRC technology. Vehicles are equipped with a transponder and an additional on-board unit containing a debit smartcard payment system. Drivers insert their smartcard into the OBU which automatically deducts payment after travelling in the congestion zone. The Singapore scheme relies on ANPR technology for verification.¹⁵⁹

In Austria, the heavy vehicle charging scheme primarily uses DSRC-enabled OBUs. Drivers can choose whether the payment is

157. Hyder Consulting (2009, pp. 24–26).

158. Palma and Lindsey (2011, pp. 1, 386).

159. Hyder Consulting (2009, p. 22).

direct-debited from credit stored on their OBU or whether they receive an invoice payable at a later date.¹⁶⁰

Global Positioning System (GPS)

GPS is the US government's set of satellites in the Global Navigational Satellite System, which also includes Russia's GLONASS, China's BeiDou, and Europe's Galileo. To use GPS for a congestion charging system, cars would need to have OBUs capable of receiving signals sent from these satellites.

Each satellite transmits information about the current time and its position at regular intervals. These signals can be intercepted by the car's OBU, which uses this information to pinpoint the car's location and to determine whether it is in a congestion charging zone.¹⁶¹

The OBU sends this time and location information, along with information identifying the vehicle, at regular intervals via a wireless network (most likely cellular) to a control centre.

Many cars on Australian roads already have GPS capabilities, which drivers use to navigate. GPS is also a feature of smartphones and has been used in Europe to implement road user charges for heavy vehicles, and in North America for Oregon's voluntary road user charge.¹⁶² To update its congestion charging scheme, Singapore plans to introduce GPS-enabled OBUs in cars.¹⁶³ The European and Singaporean examples could provide insights into whether this approach is feasible in Australia.

160. National Transport Commission (2012, p. 72).

161. Ibid (p. 31).

162. Hyder Consulting (2009, p. 117); and Oregon Department of Transportation (2017).

163. D'Artagnan Consulting (2018, Appendices, p. 11).

Cellular technologies

A cellular system would involve using the Global System of Mobile communications (GSM) to transmit information from mobile towers to GSM-enabled devices in a car, such as mobile phones.¹⁶⁴ A mobile phone would use this transmitted information to work out its location, and would send time, location, and identity information via a wireless (most likely cellular) network to a control centre, which could use the information to debit the driver's account.

Of the technologies listed here, cellular technologies are the least researched and developed for vehicle data collection. Cellular systems have not been used internationally for any form of road pricing (Box 3).

Manual charging

A manual congestion charging system involves drivers collecting a ticket or permit from terminals located outside the charging zone. The ticket or permit allows vehicles to enter and drive in the zone, and may include restrictions on the time and route taken. Alternatively, to reduce enforcement costs, manual entry gates can be installed at every entrance and exit of a congestion charging zone.

Before its current congestion charging system, Singapore used a manual system that required drivers of private vehicles entering the congestion zone to pay three Singaporean dollars a day for a sticker that was placed on the windscreen.¹⁶⁵ This system was regulated by ticket inspectors at checkpoints.

Manual charging has been superseded by technologies that cause less or no delay and that require less labour.

164. Hyder Consulting (2009, p. 30).

165. Hyder Consulting (2009, p. 26).

Box 3: Why can't we just use smartphones for congestion charging?

With constantly increasing functions and applications, smartphones are a vital tool for most Australians. Some might ask why we don't simply create an app that can track time and location, so as to charge drivers a congestion charge in the same way people pay for ride-sharing services.

This might look like a quick fix, but it's not as simple as it seems, for three reasons.

First, there is no law requiring every driver to have a smartphone. About 10 per cent of Australians do not have a smartphone, for various reasons.^a Unlike the in-vehicle tag used on Australian toll roads, which has one function only and collects one kind of data only, activating and using a smartphone comes with wider implications for privacy and data protection.

Second, even if every driver was obliged to have a smartphone, drivers would also have to ensure that their phone and its location services were switched on to receive and transmit information, and that the app

itself was running. This condition could be breached deliberately by people wanting to evade the charge, and innocently by people who changed their mind at the last minute before entering a congestion zone, but were unwilling to violate the basic road rule that prohibits mobile phone use while driving.

Third, since phones can easily lose connection without the user being aware of it, and apps can often stop working, this system would need to rely heavily on backup verification and enforcement technologies. The backup system would need to be able to identify those drivers who had incurred a charge but whose smartphones were unable to capture the charge – or who do not own a smartphone. This could end up as it did in Stockholm, where the secondary verification technology eventually replaced the primary technology, because the secondary technology was more convenient and effective.^b

While the idea of a smartphone app as the primary technology seems very convenient, the logistical and practical hurdles suggest a technology requiring less driver participation would be better.

a. Deloitte (2018).

b. Eliasson (2014a, p. 6).

A.2 The strengths and weaknesses of each technology

Table A.1 on the following page compares each technology across five dimensions.

Accuracy refers to how precisely and consistently the technology can capture data for the congestion charge. This includes how tamper-proof the technology is. Ease of **enforcement** refers to whether additional technology is needed to ensure that drivers are charged when the primary technology fails, or is deliberately evaded. **Flexibility** refers to the ability of the technology to be redeployed for other purposes, and also considers the technology's potential obsolescence. **Scalability** refers to the adaptability of the technology to different congestion charging schemes, and the ease with which it can be geographically expanded. And **convenience**, both for the driver and the operator, refers to the amount of activity required to set up and comply with the system.

While ANPR, DSRC, and GPS have weaknesses as well as strengths, they appear to be the three most feasible technologies for a congestion charge in Australian cities, with ANPR and DSRC more viable in the immediate future. The large amount of infrastructure required for DSRC makes it somewhat less attractive than ANPR as a primary technology.

A manual charging system is unlikely to be viable because of the inconvenience for drivers. Cellular systems should also be ruled out because of they are the least researched and least developed option for congestion charging purposes.

It should be noted that most schemes internationally include a combination of technologies. It is likely that, regardless of the primary technology, ANPR cameras will be required for verification purposes, because they provide visual evidence of a car's presence and movements in a congestion zone.

A.3 Which technology best suits each scheme?

A.3.1 Cordon

For a cordon charge, data must be collected at each of the entry points. If there is a charge for exit as well as entry, the technology must have the capacity to collect data in both directions.

Since cordons require technology only for the entry and exit points, and do not require information on the distance driven within the cordon, both ANPR and DSRC technologies, which have specified stationary data collection points, are sufficient for this form congestion charging.

While GPS technologies could also perform this entry and exit detection role, no city has yet used GPS for a widespread congestion charging scheme, and there remain technical and social barriers to its use (as outlined in Table A.1 on the next page). Issues related to privacy will be discussed in the next report, to be published next week.

Although both DSRC and ANPR can collect data for a cordon charge, DSRC would also require the back-up of ANPR for enforcement. ANPR has become more accurate and less expensive, and is now well-established as a stand-alone technology for congestion charging. It is the most effective and cost-effective option for cordon charging in Australian cities.

A.3.2 Corridor

The technological requirements for a corridor charge are similar to a cordon charge, in that data is collected at fixed geographical points. For a corridor charge, data must be collected at each of the entry and exit points of the designated roads. ANPR, DSRC, and GPS technologies are all sufficient to perform this function. A decision on which technology to choose will therefore rest on consideration of other factors, including implementation and administrative costs.

Table A.1: ANPR, DSRC, and GPS are the most viable data collection technologies

	ANPR	DSRC	GPS	Manual	Cellular
Accuracy	Increasingly accurate, but hampered by bad weather, or (un)intentional physical obstruction of number plates through dirt or damage.	Highly accurate, though reliant on a properly-functioning OBU.	Accurate to within a few metres, but the built-up nature of cities can create a canyon effect that causes temporary loss of signal.	Highly accurate: no concern with signal loss or difficulty identifying vehicles. Risk of forgery if tickets are used.	Less susceptible than GPS signals to the canyon effect and temporary signal loss, but accuracy requires a high density of cellular towers. Mobile phone could be switched off.
Enforcement	Can be used for both verification and enforcement.	Requires ANPR for enforcement.	Requires ANPR for enforcement.	Easily enforced if there are entry gates to charging zone. Otherwise requires ANPR or ticket inspectors.	Requires ANPR for enforcement.
Flexibility	Can double as red-light or speed cameras, or for general traffic monitoring. Unlikely to become obsolete soon due to its role in verification.	Companies are developing DSRC-enabled OBUs for use in vehicle-to-vehicle communication to prevent accidents and alert drivers to roadside hazards.	Can be used for navigational purposes. Unlikely to be eclipsed in the near future, given that cities are just starting to deploy it.	Limited scope for other use.	Mobile phones are widespread and often used for navigation. App could inform users of alternative transport options.
Scalability	Cameras rely solely on roadside infrastructure.	Transponders and enforcement cameras rely on roadside infrastructure.	Changing a congestion zone may require updating the OBU. Enforcement cameras rely on roadside infrastructure.	Enforcement relies on roadside infrastructure, as might ticket vending machines.	Updating a mobile app is easy and cheap. But a higher density of cellular towers is needed to boost location accuracy.
Convenience for driver	Cameras do not require any in-vehicle technology.	OBU required, although many cars already have transponders for toll roads.	Drivers must receive and install an OBU.	Tickets must be purchased before entering the congestion charging zone.	Mobile phone must be on and an app may need to be launched before each trip.
Convenience for operator	Some images may need manual identification by operators. Roadside infrastructure required. Low implementation risk because ANPR is well-established.	OBUs need to be distributed. Roadside infrastructure required. Low implementation risk because DSRC is well-established.	OBUs need to be distributed, and some ANPR cameras must be set up for enforcement, though these can be in convenient locations.	Operators must install charging terminals and a system to verify that cars entering the zone have tickets.	Enforcement cameras and additional cellular towers may need to be installed and maintained. Possibly more disputed charges.

Notes: Lighter colour indicates better performance. An OBU (on-board unit) is any device that drivers need to install in their cars.

Sources: Grattan analysis of Palma and Lindsey (2011), Mobility Pricing Independent Commission (2018) and NOAA (2019).

A.3.3 Network-wide distance-based charging

Unlike a cordon or corridor charge, network-wide distance-based charging requires frequent data collection on travel throughout the designated network.

If using ANPR or DSRC technologies, such a system would require many more stationary data collection points. GPS would be better equipped to collect this higher volume of data, because it does not depend on the presence of stationary data collection points.

Nonetheless, stationary data collection tools, such as ANPR cameras, might still be required for verification and enforcement.

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