Assessing incentives to reduce congestion in Israel

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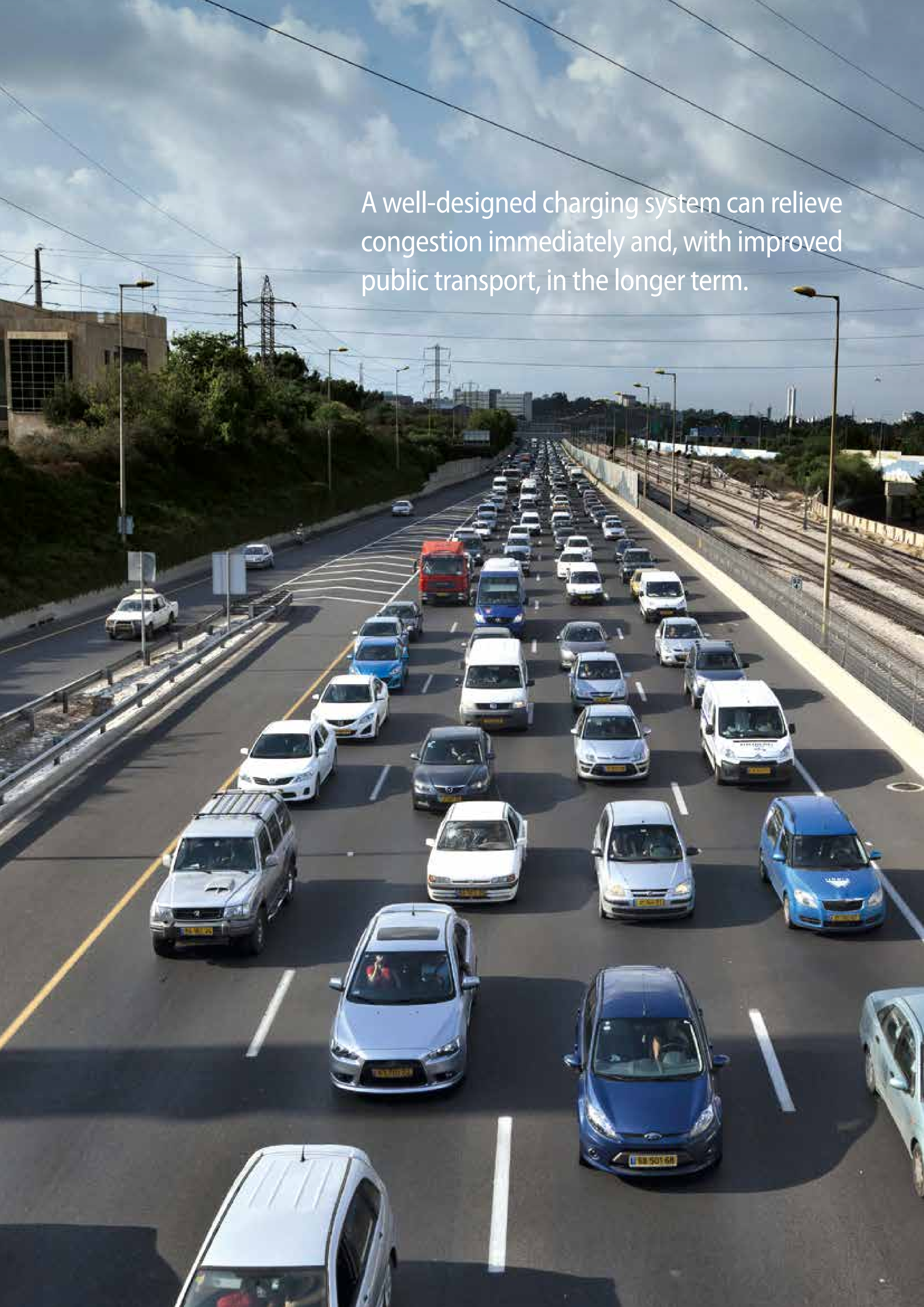
A well-designed charging system can relieve congestion immediately and, with improved public transport, in the longer term.

Foreword

Traffic congestion is a major problem in Israel. The availability of public transport is being increased to tackle the problem. Near-term improvements in public transport, such as more frequent and better buses, the main public transport service in Israel, will provide some congestion relief. However, it will take time to reap the full benefits of investing in public transport. To provide a near term solution to the congestion problem, an Inter-Ministerial Technical Committee is exploring the introduction of congestion charges that would provide incentives for reducing congestion.

This report builds on the extensive work conducted by the OECD on congestion charges to provide insights into the effectiveness of congestion charging systems and identify options that Israel could consider for the design and implementation of an effective congestion charging system.

The report highlights that a well-designed charging system can relieve congestion immediately and, with improved public transport, in the longer term. Revenues from congestion charges can facilitate additional investment in better public transport. Charges should be accompanied by measures to facilitate carpooling and other alternatives to cars, such as cycling. Equally important is to engage with the public and the business community to facilitate public acceptance and ensure that equity concerns are addressed.

The report was the result of the work of an interdisciplinary OECD team bringing together the Centre for Tax Policy and Administration, the Economics Department, the Environment Directorate, the International Transport Forum and the Public Governance Directorate.

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KEY MESSAGES

- Traffic congestion in the big metropolitan areas, especially in the Tel Aviv metropolitan area, is extensive and severe. Congestion is likely to worsen, undermining both productivity and wellbeing. The most efficient instrument available to manage this traffic is a congestion charging system.

- A well-designed charging system will relieve congestion immediately, as well as in conjunction with improved mass transit in the longer term. Only 5% or so of drivers need to change departure times out of the peak, carpool or leave the car at home to significantly improve travel time and travel time reliability in the short run. In the longer run, congestion charges will help steer users and planners towards more balanced and efficient urban mobility choices.

- Both systems under consideration--charges for entering three concentric rings (or cordons) in Tel Aviv and a kilometre charge which would be higher during congested hours--can lead to sizeable reductions in congestion and to time savings.

- The schemes are likely to have different distributional consequences, which need to be taken into consideration and carefully evaluated so that targeted complementary measures can be taken.

- Regardless of the scheme chosen, a GPS-based monitoring technology should be considered to increase the efficiency and leave enough flexibility to adjust the design as the system is implemented.

In the longer run, congestion charges will help steer users and planners towards more balanced and efficient urban mobility choices.

- Revenues from congestion charges can be significant. They can facilitate additional investment in better public transport. The economic case for public transport spending appears strong in Israel, and making a link will strengthen public support.

- Using revenues to cut car ownership taxes may help with acceptability by the public, but could weaken the contribution of these taxes to achieving environmental and mobility policy objectives. The result would be a net tax cut for those driving outside zones and hours where the congestion charge applies, but not for those paying the charge.

- Accompanying measures should be considered. These could include near-term improvements in the quality of bus services, the current main public transport service in Israel, measures to facilitate uptake of carpooling potential (national regulations currently restrict the development of ride sharing apps for profit) and improvements in the environment for cycling through traffic calming and reservation of space for cycle lanes. Other accompanying measures include allowing municipalities to set higher parking prices and removing income tax exemptions for fringe benefits that encourage car use.

- Public acceptance will be facilitated by clarity on the objectives of the charging scheme and by engagement with the public and the business community on the cost of congestion and what might be done to tackle it. This includes providing information on the rationale and benefits of the proposed scheme, communication linking the introduction of congestion charges with more investment in public transport, easy-to-understand metrics to show users the impact of the scheme and a design of the charge that addresses equity concerns while effectively improving peak hour driving conditions.

Introduction

Traffic congestion is a major problem in Israel. Congestion occurs when road capacity approaches saturation and drivers slow down to stay safe, or when queues develop at specific bottlenecks in the road network. At high levels of traffic, one more car on the network results in strong additional congestion. Travel times increase and travel time reliability decreases for all users. An individual driver will not take account of the extra costs imposed on other road users, and this leads to an escalation of congestion beyond economically efficient and tolerable levels.

The Government is addressing the congestion problem by increasing the availability of public transport. Public transport supply is currently insufficient, limited to buses with only a few dedicated lanes and a light rail line in Jerusalem. A few train services connect Tel Aviv Metropolitan area with the surrounding cities. A major programme of investment in light rail and underground metro lines has been agreed for Tel Aviv Metropolitan area and once built will greatly improve mobility. While some near-term improvements in public transport are envisaged, major capacity additions will take time to be realised. An Inter-Ministerial Technical Committee is exploring the introduction of congestion charges that would provide incentives for reducing congestion on the roads with some near term effects.

Congestion charges reflect the cost that drivers impose on other road users. They ensure that drivers base travel

decisions on the full cost of a trip, and not just their own cost. Charges increase trip costs and therefore reduce traffic, eliminating trips that are less necessary or can be undertaken at less congested times of the day. The result is that the road system functions more smoothly and efficiently. Without eliminating congestion, they significantly reduce excess travel time and improve travel time reliability.

Two alternative charging methods are currently being considered in Israel:

- ***Charges by "clicks":*** the Tel Aviv metropolitan area would be divided in three concentric rings around the centre, and any movement between rings would be subject to a congestion fee according to the time of travelling.
- ***Charges by usage***: an average cost of driving a kilometre would be set and each trip during congested hours would cost more than that average, while a kilometre driven during uncongested hours would cost less.

There are also plans to introduce a flat rate mileage tax for electric vehicles, to compensate for lost fuel excise duty revenue. Electric vehicles would pay this tax and the congestion charge. There is clearly potential to merge the two systems into one mileage charge differentiated by time and location, to address congestion, and by vehicle type, to compensate for the lost fuel excise revenue.

Other cities and countries have successfully introduced congestion charges, including London, Milan, Singapore and Stockholm. New York also decided in 2019 to introduce charges to enter Manhattan's most congested neighbourhoods.[1] Chicago and Los Angeles are considering the introduction of congestion charges (Gribbin 2019). Experience shows that charges are an effective way to improve travel conditions, and that they meet with public support if they are seen to cut congestion and if revenues are spent transparently and judiciously. Several existing systems combine charges with increased spending on public transport or local mobility more generally.

This report provides insights into the effectiveness of the congestion charging systems, related fiscal reforms and accompanying measures, on the basis of experience with congestion management systems in other places. It first presents the key features of the congestion problem in Israel and the extent to which congestion charges could help address it. The report then identifies options that Israel could consider for the design and implementation of an effective congestion charging system. The main features of these charging schemes in London, Milan, Singapore and Stockholm are presented at the end of the report.

1. "Congestion Pricing: N.Y. Embraced It. Will Other Clogged Cities Follow?", *The New York Times*, 1 April 2019, https://www.nytimes.com/2019/04/01/nyregion/new-york-congestion-pricing.html (accessed in April 2019).

Traffic congestion in Israel and policy strategy in a nutshell

Congestion is a problem and is likely to worsen unless action is taken. In the short run, major public transport improvements are out of reach and congestion charges can offer some relief. In the longer run, congestion charges can facilitate more balanced and efficient mobility choices.

In Israel, road traffic intensity, in terms of vehicle-kilometres driven per kilometre of road network, is much higher than in other OECD countries (figure 1, panels A & C), despite the low level of vehicle ownership compared to most OECD countries, accounted for by high annual vehicle mileage (figure 1, panel B).

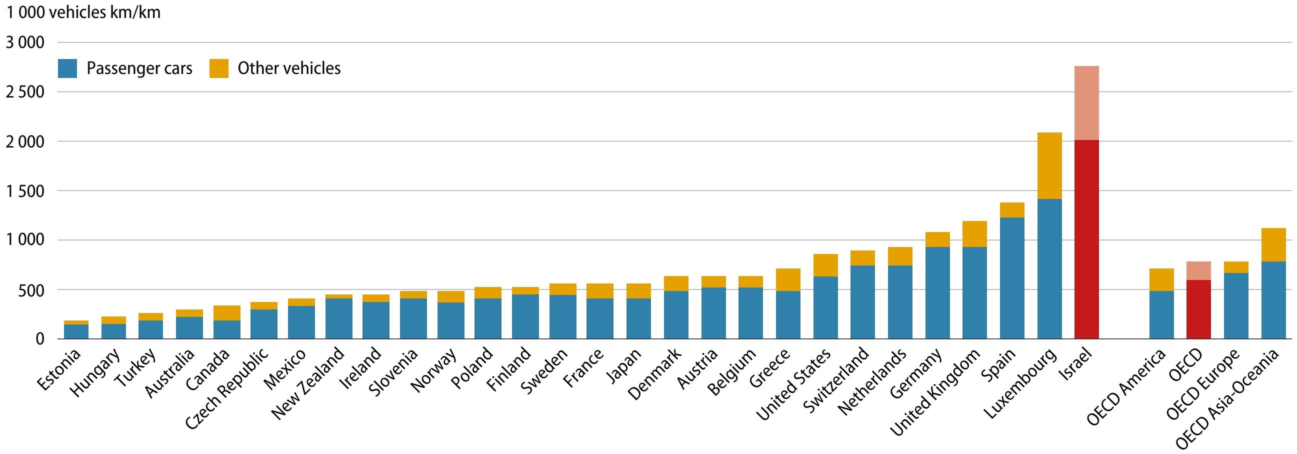
Costs of congestions in Israel are estimated at around 2% of GDP, above levels in other high-income economies where for example 1% is usually cited for the average cost of congestion in Europe and between 0.7% and 0.9% in the USA (table 1).

Table 1: **Estimated costs of congestion in selected countries**

Estimated costs (% of GDP)	Source	Notes
EU 1%	European Commission, Impact Assessment for the White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" SEC(2011) 358 final, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0358:FIN:EN:PDF See also European Commission Urban Mobility Policy Context, https://ec.europa.eu/transport/sites/transport/files/2017-sustainable-urban-mobility-policy-context.pdf	
UK 0.7% France 0.8% Germany 0.9% USA 0.7%	CEBR for INRIX 2014, The future economic and environmental costs of gridlock in 2030: An assessment of the direct and indirect economic and environmental costs of idling in road traffic congestion to households in the UK, France, Germany and the USA https://www.ibtta.org/sites/default/files/documents/MAF/Costs-of-Congestion-INRIX-Cebr-Report%20(3).pdf	Delay in relation to free flow from INRIX traffic flow data plus planning time cost and fuel cost
USA 0.9%	TTI 2015, 2015 Urban Mobility Scorecard, Texas A&M Transportation Institute and INRIX, https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-scorecard-2015.pdf	Delay in relation to free flow from INRIX traffic flow data plus planning time cost (buffer time) and fuel cost

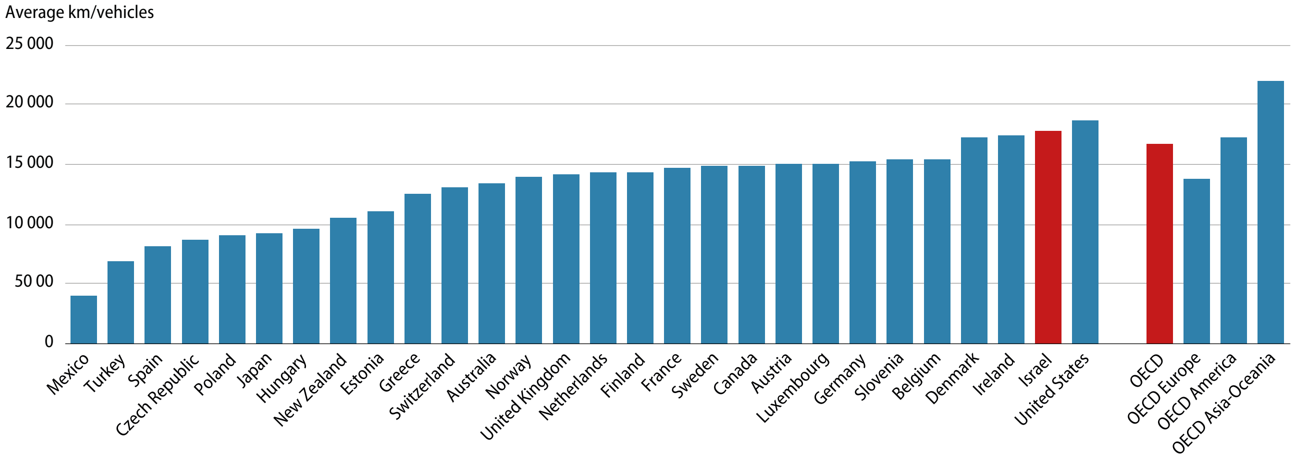
Figure 1: **Traffic density and car ownership in Israel**

PANEL A: Road traffic density per network length (2014 or latest available)



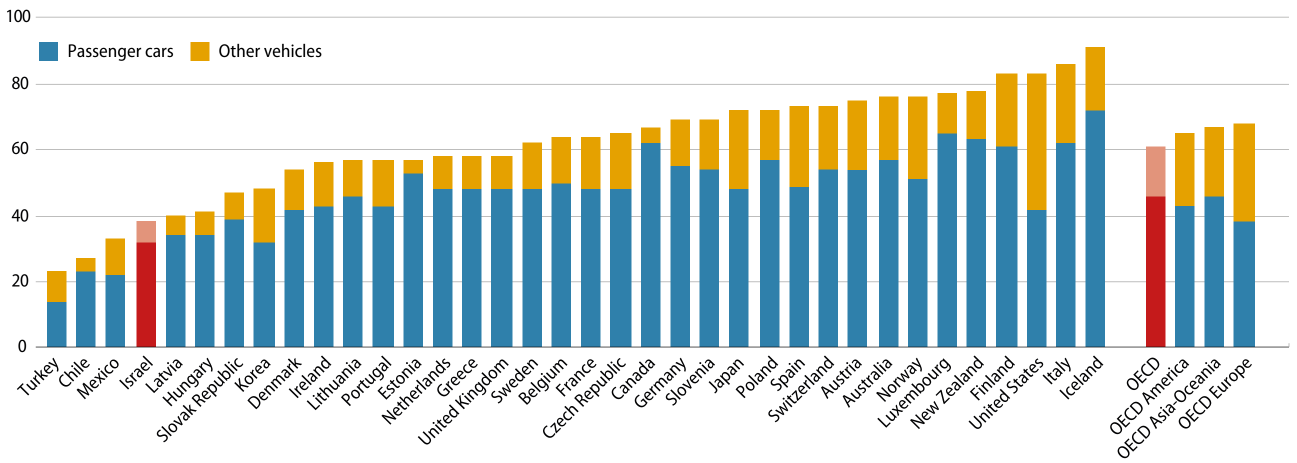
Source: OECD (2015), *Environment at a Glance 2015*, OECD Publishing.

PANEL B: Annual average kilometres per vehicle (2014 or latest available)



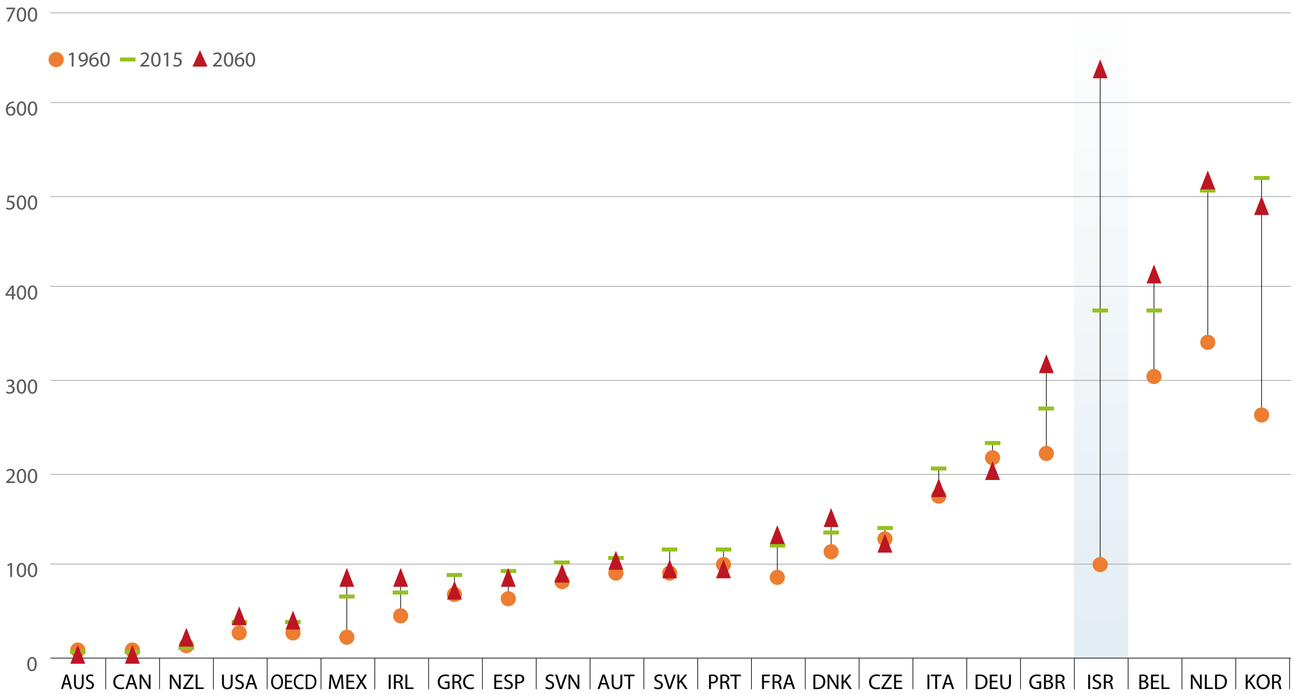
Source: OECD (2015), *Environment at a Glance 2015*, OECD Publishing.

PANEL C: Number of vehicles per 1 000 residents (2016)



Source: OECD (2015), *Environment at a Glance 2015*, OECD Publishing.

Figure 2: **Population density per square kilometre**



Source: OECD (2018a), *OECD Economic Surveys: Israel 2018*, OECD Publishing, Paris, https://doi.org/10.1787/eco_surveys-isr-2018-en.

Israel's congestion problem is likely to worsen considerably unless policy action is taken. Increasing incomes and population growth – projected at 1.8% per year in an already densely populated country (figure 2) – will cause vehicle ownership and transport demand to grow, including during peak hours in already congested places. Vehicle ownership has increased by 4.2% annually in recent years (Friedman 2019).

In the short run, public transport is not yet a broadly enough available realistic alternative in Israel. The share of travellers using public transport is low in metropolitan areas—around 20% - and is declining as a result of poor service quality and rising incomes. In the mid to long term, more and better public transport is needed to reverse the vicious circle in which public transport is considered an unappealing option for many and becomes increasingly less attractive especially as incomes rise, into a virtuous circle, where it offers a high-quality and convenient alternative to car travel for all in urban environments. Evidence shows that ample supply and high quality are more important for this to happen than low prices (OECD/ITF 2014, Proost 2018).

Limited availability of public transport in the short to medium run does not invalidate the case for congestion charges. Current peak hour car users can modify travel times, they can carpool, or they can forego car trips – or pay the charge and enjoy improved travel conditions. As public transport becomes more attractive, some can switch to this means of transport. In London, the introduction of the congestion charge was accompanied by improvements to bus routes and additional buses put into service. Surveys undertaken by Transport for London for its second annual congestion charge monitoring report, which examines modal shift in detail, suggest that the majority of the 30% of car trips foregone by car were replaced by bus trips (see box 1).

Evidence from London and Stockholm shows that congestion charges reduce traffic levels and that this results in more than proportional improvements of congestion. In Stockholm, traffic volumes fell by around 20% in the immediate aftermath of the introduction of the charge. Congestion, as measured by the difference between actual and free-flow travel time, declined by 25 to 30% in the inner city in the morning peak, 45% in

Box 1: CHANGES IN PUBLIC TRANSPORT IN LONDON IN 2003

Large-scale improvements to the bus network have seen an increase in usage, both in the congestion charging zone and more widely throughout London.

- A total of 106,000 passengers entered the charging zone on 560 buses during a typical weekday morning peak in Autumn 2003;
- This represents a 38 percent increase in patronage and a 23 percent increase in service provision compared with 2002. About half of the increased patronage is estimated to be due to congestion charging;
- Although average occupancies per bus have increased, the additional bus passengers are being accommodated. The reliability of bus services has improved markedly, both within the charging zone and more widely across London.
- Within the charging zone there were marked improvements in both the main indicators of bus service reliability: additional waiting time due to service irregularity fell by 30 percent; disruption due to traffic delays fell by 60 percent;
- Overall bus speeds within the charging zone improved by 6 percent; after allowing for time spent at bus stops, this is compatible with the improved speeds of general traffic within the charging zone. The improvement within the zone is greater than that observed in other areas of London.

Travel to central London by Underground has fallen during 2003.

- The Underground has experienced a reduction in the number of passengers exiting stations in and around the charging zone, a trend reflected across the network. In the morning peak period since charging was introduced there was a reduction in the average number of station exits within the charging zone of 8 percent from 513,000 to 473,000;
- It is likely that a small shift of car users to Underground, because of charging, has been more than offset by overall reductions in Underground travel to central London for reasons unconnected with congestion charging.

Travel to central London by National Rail remained broadly static between 2002 and 2003.

- Transport for London has observed no significant net change to the number of passengers entering central London on the National Rail network between 2002 and 2003.
- It is possible that a shift of car users to rail, because of charging, has been masked by background changes in the use of rail for travel to central London;
- Transport for London has found no evidence of systematic increases in 'railhead' parking at rail stations in inner and outer London associated with congestion charging.

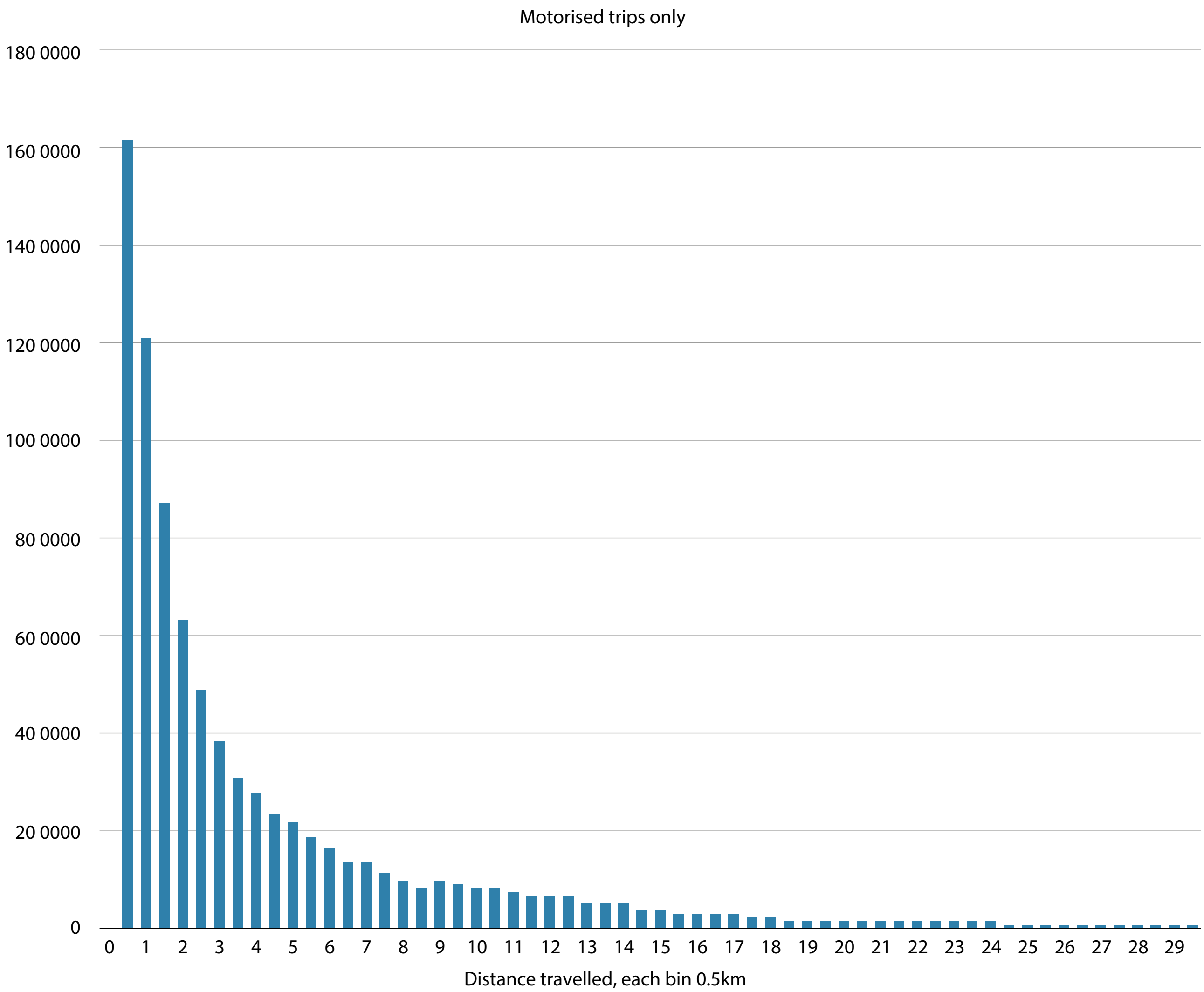
Source: Congestion Charging, Impacts monitoring – Second Annual Report, TfL April 2004 the afternoon, and up to 60% on arterial roads (based on Eliasson, 2014). In London, the immediate effect of the charge combined with the changes in bus supply was that traffic levels (across all vehicles) fell by 15% and that congestion declined by 30% (Santos and Shaffer, 2004). Hence, reducing peak hour traffic levels by, say, 5 to 10%, is likely to significantly improve travel conditions by a larger percentage. If 5% to 10% of current peak users can walk, cycle, reschedule or carpool, considerable congestion relief is within reach.

Evidence from Stockholm suggests that more than half of peak hour traffic is not for commuting (Eliasson 2014). While the timing of non-commuting trips can also be subject to schedule constraints, adapting schedules may be within reach for at least some. For example, in Tel Aviv the majority of trips by car in the peak are under 2 kilometres, suggesting that some of these trips could be reprogrammed (figure 3).

Car sharing could also be a viable option for some travellers, particularly given the currently low average occupancy rates in Israel – 1.2 compared to around 1.6 in other countries[1], meaning that over 80% of vehicles in Israel travel with no passenger.

1. Occupancy rates are estimated at 1.67 in the USA (see US DoT https://www.energy.gov/eere/vehicles/articles/fotw-1040-july-30-2018-average-vehicle-occupancy-remains-unchanged-2009-2017); occupancy rates are estimated on average at 1.45 in the EU (see European Environment Agency https://www.eea.europa.eu/data-and-maps/indicators/occupancy-rates-of-passenger-vehicles/occupancy-rates-of-passenger-vehicles)

Figure 3: **Distribution of motorised trips by travel distance in Tel Aviv**



Source: Preliminary analysis from Tel Aviv Travel Habit Survey (TTHS), Ministry of Transport and Ayalon Highways, 2017

Where to charge

Traffic is heavily concentrated in the big metropolitan areas, as is congestion. Careful modelling of traffic flows is necessary to ensure that the charge is levied where it can deliver improvements for users.

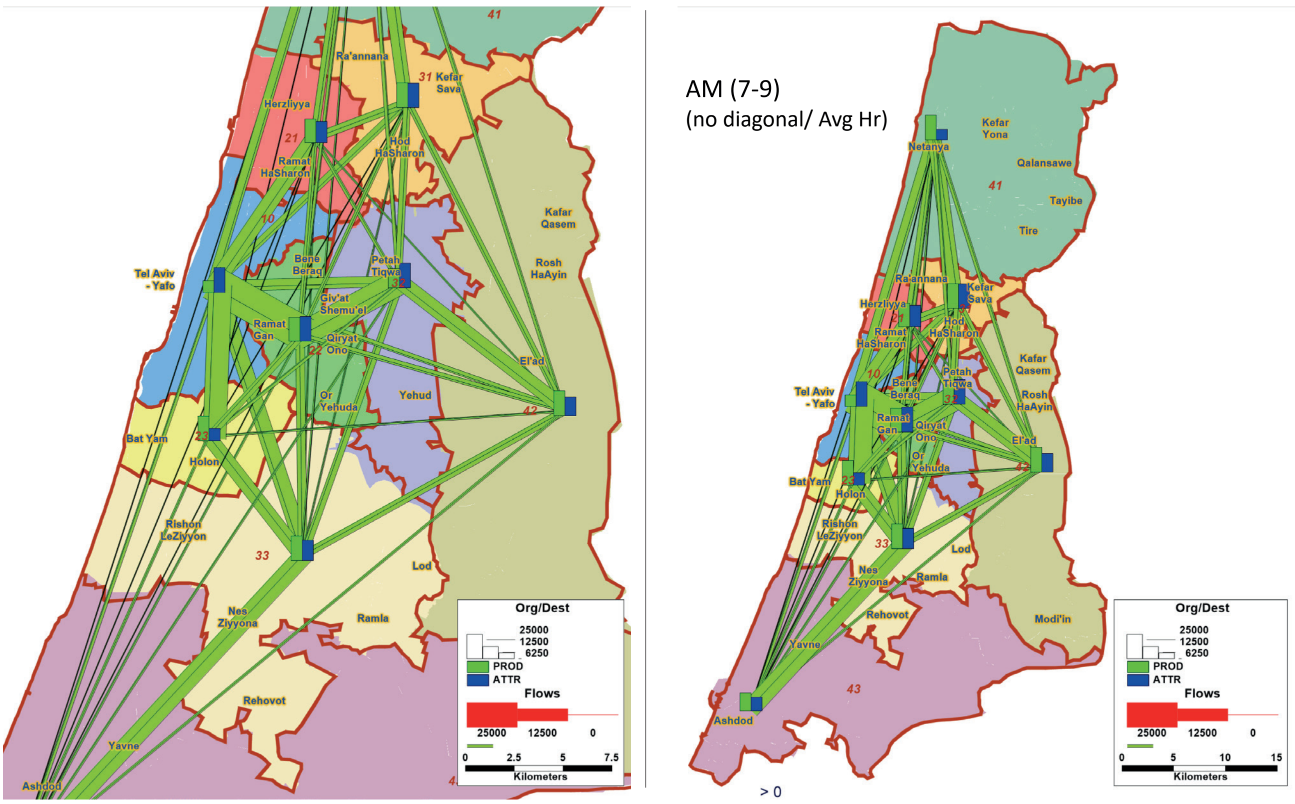
Congestion is strongest in the metropolitan area around Tel Aviv, where around 60% of the countrywide costs are estimated to occur. Congestion is particularly pronounced in the morning rush hour, between 6:30am and 9:30am in Tel Aviv in the direction of the inner centre (see figure 4).

These features would call for focusing congestion charging on Tel Aviv and possibly Jerusalem, where most of the congestion occurs. Factors to be considered would include:

- **Avoiding unnecessary complexity**: A local scheme focused on the Tel Aviv and possibly Jerusalem areas could be sufficient to address the most congested areas without having to design a more complex system, which would include other areas of the country where the problem is not severe enough to require policy action.
- **Minimising resistance** introducing a charge where there is no significant congestion would risk strengthening any perception that revenue raising is the underlying objective. More targeted systems reduce this risk; securing support in addition requires embedding charges in a broader policy package, e.g. through revenue use options and investment in public transport.

Nationwide congestion charges, as suggested in the Israeli case, have not been introduced except in Singapore, but the option has been considered in the Netherlands and the United Kingdom. In both cases it was ultimately abandoned despite advanced technical

Figure 4: **Traffic flows around Tel Aviv in the morning peak**



Note: The green segments map traffic flows originating from the districts (gzirot) of the Tel Aviv metropolitan area. The larger the segment, the greater the traffic flow.

Source: preliminary analysis from Tel Aviv Travel Habit Survey (TTHS), Ministry of Transport and Ayalon Highways, 2017

planning, mainly because too many objectives were combined, complicating tax reform. The region of Flanders (Belgium) is currently considering region-wide congestion charges as an alternative to local charges in the most congested parts of the network. A preliminary study was conducted in 2014 and more modelling is being conducted to better understand what the best option is – charges in all Flanders vs. local solutions for the most congested parts. Decisions on whether and how to charge have not been made, however, and the idea of charging is still under discussion.

Several European countries have introduced distance-based charges for heavy goods vehicles on the principal road network. For example, in Germany, the "LKW Maut" toll is a charge on the road wear caused by trucks, differentiated in relation to air emissions. It is levied nationwide through an electronic charge system but does not differentiate the charge by location, although this would be technically possible. A 2017 revision of the European Union legislation (so called "Eurovignette Directive"), which regulates road user charges across member States, encourages the use of electronic kilometre charging, differentiated to price transport more closely in line with social costs. The Directive anticipates scaling up existing truck charging systems to all-vehicle charges, but no European Union Member State is currently proposing to do this.

Congestion charges can be levied per kilometre driven or when crossing a geographic ring or a cordon (see section on how to charge below). The geographic rings currently considered for Tel Aviv are based on the zones used for census purpose by the Central Bureau of Statistics. This approach can provide a starting point for deciding where to set a cordon for charging and how to structure charge levels, but detailed modelling is indispensable to get the best results. Data from the 2017 Travel Habit Survey can provide the necessary information for conducting this analysis. Such analysis can estimate systems' effectiveness in terms of reducing congestion, assess economic efficiency and evaluate distributional impacts. Failing to conduct this analysis can lock the system into expensive schemes that do not provide sufficient congestion relief for users to benefit from the scheme and ultimately reject it.

How to charge

Both options currently considered could lead to congestion relief, but their distributional impacts can vary and need to be carefully assessed to determine the most appropriate design and implementation scheme. Traffic flows for Tel Aviv also suggest that charging only for the morning rush hour could be sufficient.

Two options for congestion charging are currently considered for Tel Aviv:

- The first option is based on three cordons ("clicks") around Tel Aviv, one around the central business district and another around the metropolitan area's interior part and another for the metropolitan area's middle part, within a radius of 5/10 km from the inner core of the city. Drivers would be charged a fee when they cross any of the three cordons, as long as crossings occur at times when the scheme applies..
- The second option is based on a kilometre charge, which would be differentiated across both space and time. Trips on peak traffic times would cost more than trips off peak, and trips closer to the centre will cost more than trips further from it.

The OECD conducted a preliminary analysis of the two proposed schemes based on 2015 aggregated data for Tel Aviv and taking into consideration two larger cordons than those currently considered by Israel and similar to an initial scheme considered by Israel. This analysis is not exhaustive and should be further refined and enriched with more disaggregated data on travel time, distance travelled and travel origins like those provided by the 2017 Tel Aviv Travel Habit Survey. The analysis highlights the following insights and design features to be taken into consideration as Israel advances in the design and implementation of the charging scheme and conduct more advanced modelling based on the 2017 Tel Aviv Transit Habit Survey (not available at the time of the analysis):

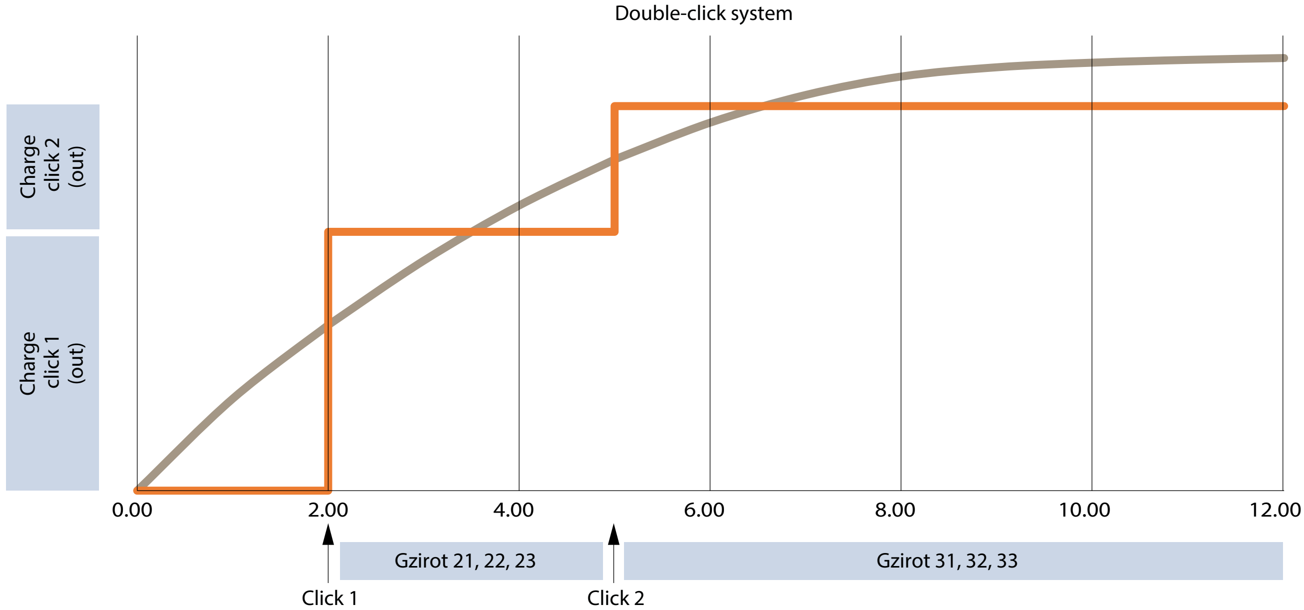
- The cordon scheme simulated in the analysis of the OECD could result in an unequal and inefficient treatment of trips within zones versus trips crossing zones, and could particularly favour population groups residing and working within the inner cordon, unless a system for charging within the cordon is put in place. The scheme may also lead to important distributional consequences in the long run, as it tends to increase land and housing prices within the cordon, favouring property owners in those areas. More concentrated cordons would have a stronger effect on traffic congestion. This is because more trips will have to cross the cordon and eventually be affected by the scheme.
- The kilometre charge is proportional to the distance driven. No trips are left unpriced, and drivers who mainly travel within zones are not disproportionately favoured by the policy. Differentiation of the charges by time of use and across space at least by zones is important for the economic efficiency of the system. A GPS-based kilometre charge system would be an effective way to achieve this if privacy concerns are appropriately addressed and is acceptable to Israeli users.

CORDON (OR CLICK) SYSTEM

The effectiveness and efficiency of a-cordon scheme depends on the extent to which trips that cause congestion are charged and by how much. Under the simulated double-cordon scheme, trips within the inner core are not charged. The reduction of the inner core would reduce this uncharged area but would not completely dispel the problem. Aggregated data for 2015 indicate that approximately 60% of the trips in Tel Aviv were within the inner core, which suggests that the lack of charging of trips within this zone would significantly undermine the effectiveness of the scheme (see figure 5).

The cordon scheme could result in an unequal and inefficient treatment of trips within zones versus trips crossing zones. Two trips originating from neighbouring locations (e.g. the one inside the cordon and other outside of it) and ending up to the same point will have very different monetary costs. Drivers of short distances who have to cross a charging point will face a steep increase in the average kilometre cost of their trips. The scheme will particularly favour population groups

Figure 5: **The efficiency of the double click system in capturing externalities from trips towards the inner core of Tel Aviv**



Notes: The grey curve displays the marginal external cost of a trip as a function of its distance; the orange piecewise curve displays the toll cost of a trip to the inner city as a function of its length.

Source: OECD schematic simulation based on geographical data provided by Israeli authorities.

residing and working within the inner cordon. The scheme may well also lead to important distributional consequences in the long run, as it tends to increase land and housing prices within the cordon, favouring landlords in those areas. Eliminating free on-street parking for residents and increases in parking fees might alleviate inequitable impacts but residents with off-street parking would benefit disproportionately. Charging for travel within the cordon would be the simplest alternative, with monitoring points within the cordon. London made this change, with its cordon charge becoming an area charge today (box 2).

A full implementation of the cordon scheme requires that unpriced alternative routes should not coexist with priced ones, or otherwise the efficiency of the scheme can be reduced substantially (Verhoef et al., 1996). In the context of Tel Aviv, this implies that traffic should be monitored and charged on all road segments that cross the cordons.

The effectiveness of a cordon scheme also depends on how extensive it is. A comprehensive system monitoring all entry and exit points from each zone is costly to build. The road network leading in and out of the analysed charging zones in Tel Aviv is complex, including major highways and urban roads of low capacity. The costs of placing gantries with automatic number plate recognition technology may be high and need to be factored in any ex-ante assessment of the two schemes.

Although a three-cordon system may be more effective than a single cordon, modelling will need to establish the

Box 2: **FROM CORDON CHARGE TO AREA CHARGE IN LONDON**

The London Congestion Charge is an area charging system that uses a single cordon around the central part of the city, charging a flat daily rate for driving a vehicle within the cordon. The system uses cameras (on posts and buildings rather than gantries) with automatic number plate recognition software to monitor vehicles entering the cordon. Cameras were added after the start of the system to monitor movement of vehicles also inside the cordon. Users register their vehicles and pay the standard daily charge ahead of use in the charging zone or prepay on a monthly or annual basis. The daily charge is currently GBP 11.50 or GBP 10.50 if an online automatic debit system for payment is subscribed to. Daily charges can be paid after use on the same day at the same rate or until midnight on the next charging day for GBP 14. Thereafter a penalty charge notice is served. The penalty is GBP 160, discounted to GBP 80 if payment is made within 14 days and increased to GBP 280 beyond 28 days.

merits of the additional cost of monitoring traffic at the outer cordon and the effects of reducing the overall radius of the area that is charged and adding a third cordon. The road network is increasingly complex with distance from the centre, including major highways and urban roads of low capacity. The costs of placing gantries with automatic number plate recognition technology at a sufficient number of control points on outer rings may be high and needs to be factored into any ex-ante assessment of the two schemes.

KILOMETRE CHARGE

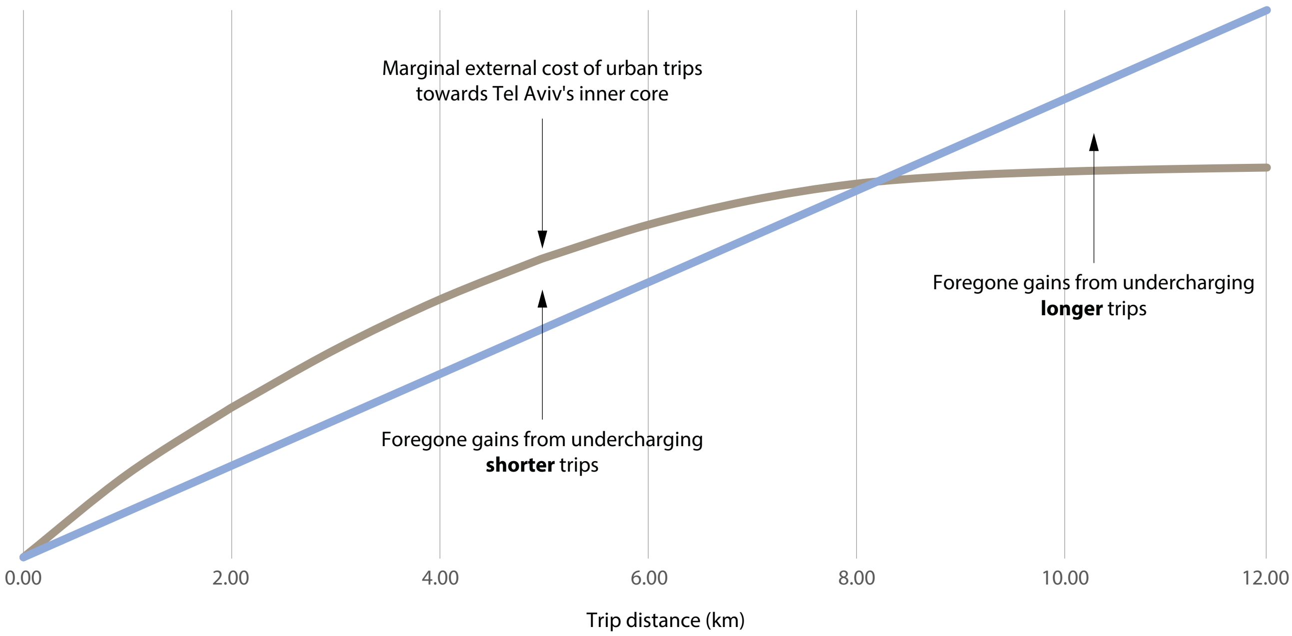
Under the kilometre charge option, no trips are left unpriced, and short-distance trips are charged a lower fee than long-distance ones. These elements could make the scheme more acceptable by short-distance commuters (see figure 6).

The effectiveness and economic efficiency of the kilometre charge depends on its precise design. The efficiency of the scheme can be significantly undermined if it is purely based on a monitoring system that only takes into consideration the distance travelled—for instance an odometer-based system with no variation over location, time or direction of trip. Trips in suburban and rural areas will be significantly overcharged; this will also hold for trips taking place in the evenings or at night or for reverse commuting trips.

These concerns would be addressed by the system currently considered by Israel, an on-board system (not odometer based) that would track the crossing of each cordons. The system would be similar to a GPS without however tracking origins or destination of the trip for privacy concerns. If this system could be turned into a full GPS once the scheme is accepted and privacy concerns are addressed, it could leave enough flexibility to transition to a more efficient kilometre-based charge. The potential efficiency gains from implementing a GPS-based kilometre tax system are illustrated in the upper panels of Figure 7. These display the efficiency of a flat kilometre tax that is differentiated twice. That is, the kilometre charge is higher in aggregate zones or gzirot 10, 21, 22 and 23 compared to that in the less congested aggregate zones or gzirot 31, 32 and 33. That differentiation is reflected in the slope of the total cost curves (red and green) which are steeper closer to the inner core (higher kilometre charge) and flatten out in the outskirts of a city (lower kilometre charge). Furthermore, the charge is differentiated within each zone, with highly congested road segments (probably those used for inward commuting) receiving a higher charge than those in which traffic is sparse (probably those used for reverse commuting).

The argument should be extended to a kilometre charge that is also differentiated between urban and rural areas, being substantially lower (possibly zero) in the latter case.

Figure 6: **The efficiency of the flat charge system in capturing externalities from trips towards the inner core of Tel Aviv**



Notes: The blue line displays the toll cost of a trip to the city centre, as a function of its length; grey curve represents the external cost of a trip to the city's centre, as a function of its distance.

Source: OECD schematic simulation based on geographical data provided by Israeli authorities.

TIMING

Preliminary data for Tel Aviv suggests a higher peak in the morning rush hour – from 6:30am to 9:30am. The peak is less pronounced in the afternoon for the 2-kilometre and longer trips that represent the majority of trips in the peak and those more likely to be reprogrammed. This in turn suggests that charging only for the morning peak and not for the afternoon would be feasible (figure 8). Morning charges will also indirectly reduce afternoon travel even if there is some latent demand in the afternoon.

OTHER CHARGING METHODS

Other methods can be taken into consideration (see table 2 below for a comprehensive overview of the road pricing methods). In addition to those considered by Israel, tolled lanes and additional charges for already tolled roads could be considered. However, this can provide congestion relief only on the relatively small part of the road network that is tolled. Highway 6 (north south) is tolled and one lane of highway 1 (east west) is tolled with a continuously varying congestion charge. The lane runs 13km from the international airport to Tel Aviv. The lane is used by drivers that pay a variable congestion charge, by shuttles serving a park and ride lot on the motorway and by cars with four or more occupants after registering at the park and ride facility. The system works well in providing congestion free access to Tel Aviv on the highway from Jerusalem, one of the country's most congested roads.

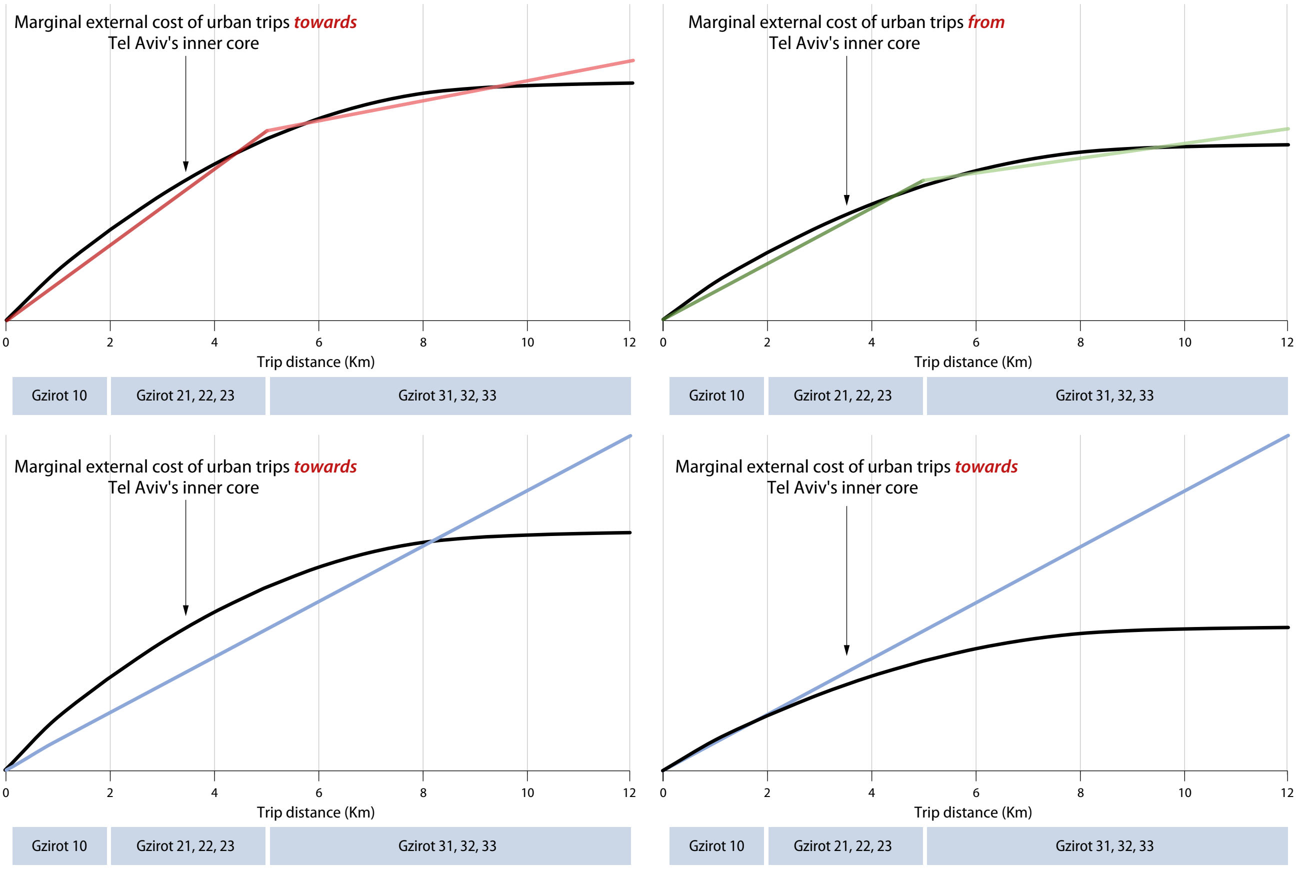
Table 2: **Options for differentiating road-pricing systems**

Type*	Main characteristics	Options	
		Scheme coverage	Fixed or variable charges
Cordon charging	Charge for each crossing of a cordon delimiting the charging zone in a city	Location and size of cordon	• Time of day • Day of the week • Number of trips • Vehicle type • Direction of travel
Area charging	Daily charge for driving into or within a defined area but no additional charge for crossing cordon more than once	Size and location of area/s	• Time of day • Day of the week • Vehicle type • Distance travelled
Corridor charging	Charges for passing points along a corridor in a city	Number and location of charging points	• Time of day • Day of the week • Number of trips • Vehicle type • Direction of travel
Variable tolls	Peak charges for already tolled highways and bridges	Local, Regional, National (dependent on toll network)	• Time of day • Day of the week • Vehicle type • Distance travelled
Tolled lanes	Tolled lane on un-tolled road segment, often discounted/exempt for high occupancy vehicles	Number and location of charging points	• Time of day • Day of the week • Vehicle type • Vehicle occupancy
Electronic time, distance and placebased charging	Uses transponders or satellite GPS units to enable charging of any use of the entire road network or a specified part of the network	Local, Regional, National, specifically congested routes	• Time of day • Day of the week • Vehicle type • Distance travelled

Note: It is possible to combine features of more than one of the categories identified in this column and most road pricing systems do this in practice. For example, area charges usually employ a cordon.

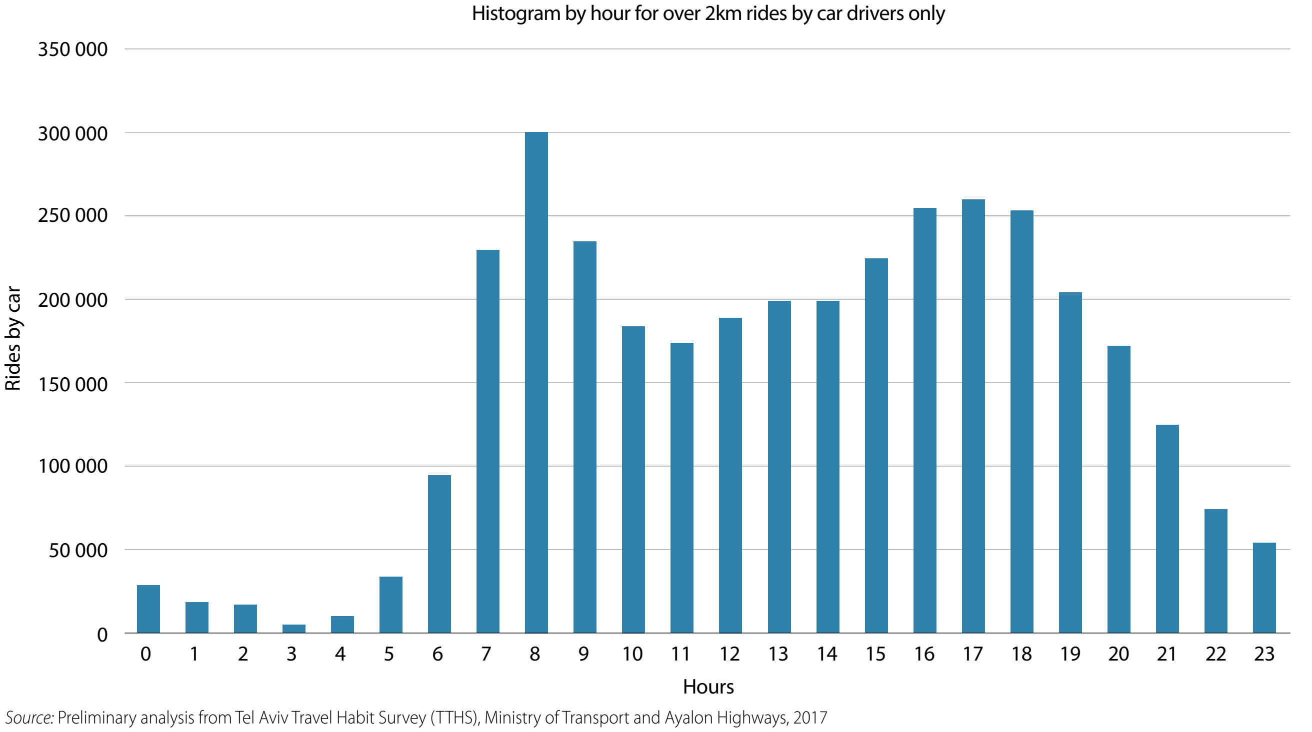
Source: OECD/ITF 2018d

Figure 7: **GPS-based versus odometer-based kilometre tax**



Source: OECD schematic simulation based on geographical data provided by Israeli authorities.

Figure 8: **GPS-based versus odometer-based kilometre tax**



Source: Preliminary analysis from Tel Aviv Travel Habit Survey (TTHS), Ministry of Transport and Ayalon Highways, 2017

How much to charge

Charges need to be high enough to cut traffic where congestion is excessive. The level of the charge could be reviewed periodically by the relevant administrative authority. Few exemptions should be granted.

Estimates of the appropriate level of congestion charges for the morning peak in Tel Aviv are being constructed using two different models – one simple and transparent, the other very detailed and state-of-the-art – which produce similar results.

The extra delay caused by one more morning peak trip is estimated between NIS 0.8 to 2.1 per kilometre, for a trip from the outskirts to the core of Tel Aviv, with a central value of NIS 1.5 per kilometre. A charge of approximately NIS 1.5 per kilometre can therefore be expected to eliminate excessive congestion. This translates to approximately NIS 32 per morning peak hour trip of average length (this would be approximately 5.5 times the price of a single ticket on public transport in Tel Aviv).

Several features of the simple model suggest that the resulting central estimates for prices in the peak may be on the low side. Many trips are under 2 kilometre. Charging these at NIS 3 (EUR 0.75) might not have a lot of effect

Willingness to pay should be also carefully assessed. Experiments using apps are currently being conducted to test drivers' willingness to pay when entering congested areas simulating the response to a congestion charge. Results from these experiments can offer essential insights on the most appropriate level of the charge and the effect on the actual behaviour of drivers.

The charge might also need to be periodically updated depending on the response of drivers and the impact on congestion. Some flexibility and autonomy could be left to the relevant authorities in periodically adjusting the charge without the need for a legislative change. The green taxation system could provide a source of inspiration, with, for example, a provision in the legislation creating the congestion charge requiring a regular review and update of the congestion charge.

Lower charges for carpooling are not needed as carpooling is expected to increase following the introduction of the charge. Higher occupancy rates reduce the charge per person, providing an incentive to car-pool.

More generally, there should be a general principle of "no exemptions", with all vehicles subject to the charge except in a very few cases (i.e. emergency services). The no-exemption policy should extend to company cars, including for business travel, where any refunding of the congestion charges should be discouraged as this would weaken the effect of the charge especially in Israel where company cars are quite common. In Stockholm, until recently congestion charges were refunded to users of company cars. Company cars account for 28% of peak traffic vehicle kilometres in Stockholm compared to 41% for private cars. When the peak congestion toll was raised in 2016, private car traffic declined 12% whereas company car traffic increased 4% (Börjesson 2017).

The basic principle should be that every vehicle contributes to congestion, including taxis and delivery trucks or vans. If a large enough number of vehicles are excluded, the policy may prove ineffective. Exemptions can also create competition policy issues as in London, where taxis are exempt but Transport for London (TfL) started to charge ride-hailing services like Uber or Lyft in April 2019.

One category of vehicle for special treatment is buses. These might be charged in relation to the congestion for which they are responsible or exempt as the key alternative to travel by private car. In London, vehicles with nine or more seats are eligible for 100% discount of the Congestion Charge. Vehicles need to be registered with TfL for the discount if not already licensed with the national licencing agency as a bus[1].

1. Transport for London, "Discounts and exemptions", https://tfl.gov.uk/modes/driving/congestion-charge/discounts-and-exemptions (accessed in April 2019).

How to use the revenue

Revenues from congestion charges can be significant. Accordingly, good revenue use is critical for the economic case for congestion charging and for public support.

The revenues generated by the charge depend on the level of the charge and size of the zone charged, and on the behavioural effect that it triggers. A back-of-the envelope calculation suggests an order of magnitude for gross revenues of around NIS 2M per day or roughly half a billion per year. This calculation is based on extrapolations of the charges applicable in the Stockholm congestion pricing system and aggregate data on traffic in the Tel Aviv region, for a two-click system around Tel Aviv as exemplified above, with a charge of approximately NIS 8 for crossing the inner cordon and NIS 6.80 for crossing the outer cordon.

The following main options exist for using the revenues generated by a congestion charge envisaged in Tel Aviv:

- ***Improving public transport in metropolitan Tel Aviv.*** Spending on items closely related to where charges occur tends to improve public acceptance. This approach was at the core of the London argument for charging: charges would improve travel conditions in the city centre (for cars and for buses) and would generate much needed funds for public transport. Congestion charges are one component of an urban mobility policy, and the commitment is to improved mobility, including the stipulation that "the net revenues from the Congestion Charge are spent on improving transport in line with the Mayor's Transport Strategy.[1]"
- ***Cutting car sales taxes or annual car ownership taxes.*** While this may help improve acceptability of the charge, caution is warranted to not weaken too strongly the useful contributions that ownership taxes make to emissions mitigation and mobility policy (figure 9). Singapore, for example, relies not only on congestion charges but also on taxes on the acquisition of vehicles to manage mobility. The share of annual tax revenues from car ownership in total transport tax revenue in Israel is not out of line with that in other OECD countries, but the purchase tax revenue share is high (see figure 10). Effective rates on ownership presently amount to approximately 60% of the Cost Insurance Freight import price.

1 http://content.tfl.gov.uk/tfl-annual-report-and-statement-of-accounts-2016-17.pdf, footnote to table c) on p. 175. Transport for London's gross revenue consisted for 80.5% of fare revenue in 2017, and 4.9% of congestion charge revenue, with the remaining 15% coming from smaller sources. The net income from congestion charging amounted to 163.9 million pounds in 2017, which is 66% of the gross revenue of 249.6 million pound.

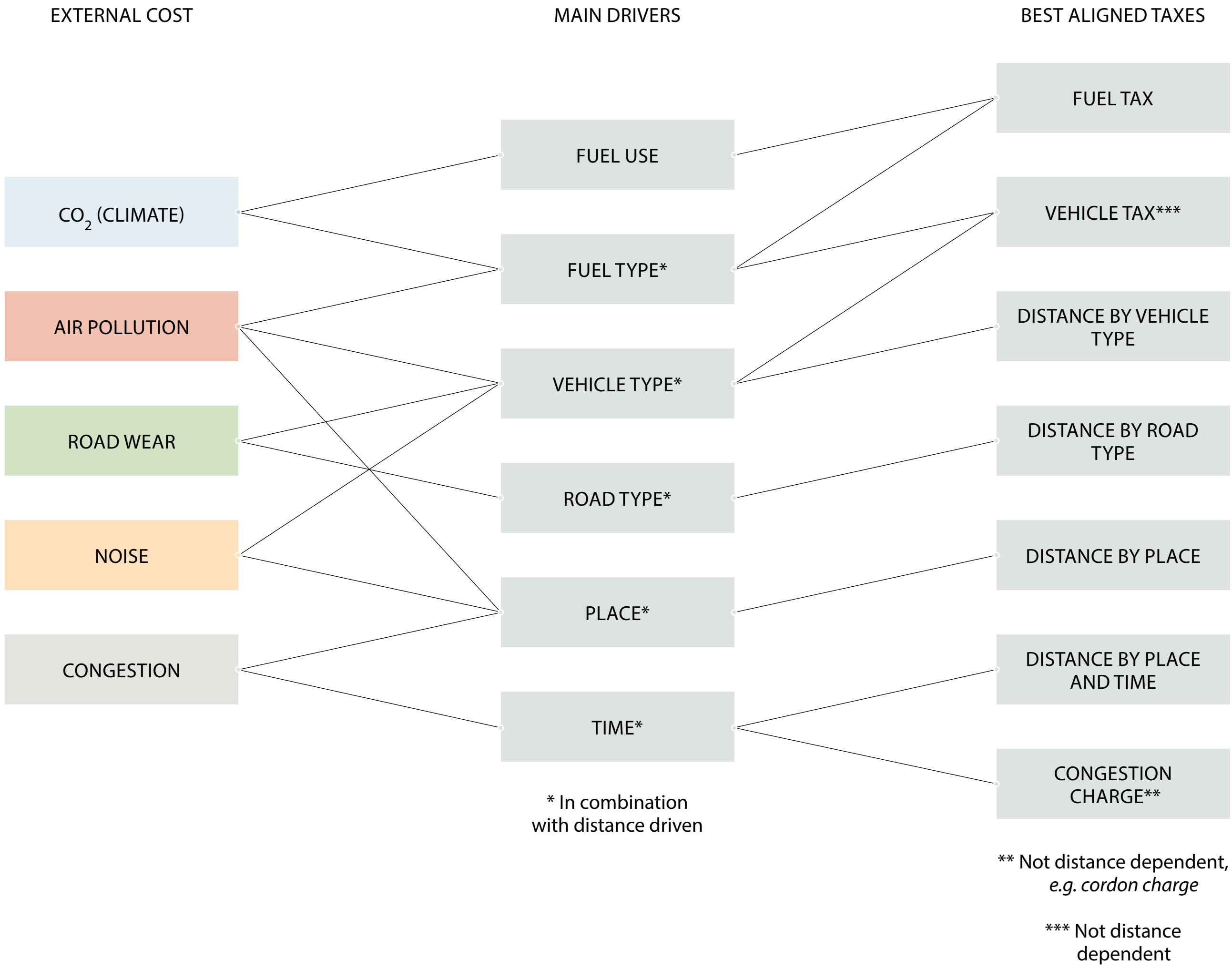
When ownership-related taxes are high, there may be scope for reducing them while increasing usage-based taxes, subject to containing adverse effects on the size and environmental profile of the vehicle fleet. In addition, when the base of the congestion charge is narrow, swapping ownership taxes for usage-based taxes disadvantages a small group of drivers paying charges, compared to the current situation. The size of the ownership tax cut also is scaled by the available revenue, which in turn depends on the coverage of the charge.

- ***Cutting taxes on labour income.*** The tax burden on labour is high in many OECD countries, and when many peak hour drivers commute to work, congestion charges can exacerbate their tax burden. This can be avoided by using congestion charging revenues to cut labour taxes. However, improving public transport and facilitating carpooling also mitigate upward pressure on effective labour-plus-commuting taxes while retaining the effectiveness of the congestion charge.

The average tax wedge on labour income in Israel is at the low end among OECD countries. The tax wedge divides the sum of personal income tax and social security contribution net of family benefits by total labour costs. For a single worker, it amounted to 22.1% in Israel in 2017, compared to 35.9% on average across the OECD. For a one-earner married couple with two children, the tax wedge at average earnings was 19.5% in 2017, against 26.1% for the OECD on average.[2] Many families in Israel pay no income taxes. On balance, this suggests a weak case for using congestion revenues to cut labour taxes, and to focus on improving metropolitan transport systems instead.

2 http://www.oecd.org/tax/tax-policy/taxing-wages-israel.pdf

Figure 9: **External costs, drivers of external costs and tax instruments**

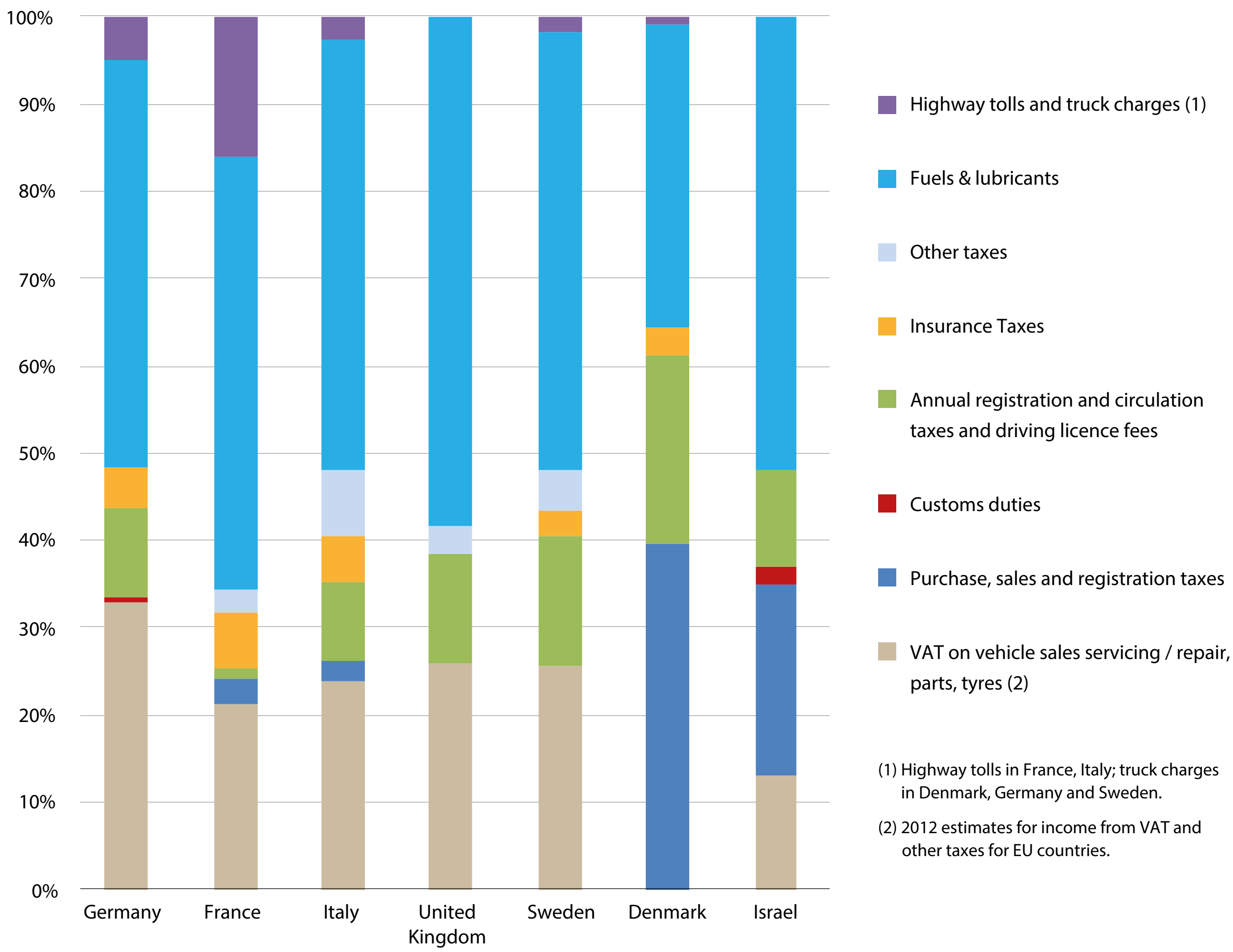


Source: Van Dender 2019

Decisions on the use of revenues from congestion charges also involve a stance, either explicit or implicit, on whether or not congestion charging is revenue neutral. Commitments to revenue neutrality may have *prima facie* appeal in terms of improving public acceptance, but are fraught with difficulties in practice, including for the following reasons:

- Revenue-neutrality can be taken to mean raising the same amount of revenues from transport users or having the same amount of revenue to spend available to governments. These numbers can differ strongly, because congestion charging systems are relatively costly to introduce and to operate. Cost to revenue ratios range from 5% to 35%, where the higher figure is more reflective of actual experience and the lower anticipates declining technology costs.
- Revenues from congestion charges can accrue to different levels of government than the revenues from other transport taxes, and this makes revenue-neutrality a more complex proposition.
- Revenue-neutrality refers to aggregate revenue. While this is of concern to government, the politically salient issue for drivers more likely is what happens to their individual tax bill. Aggregate revenue-neutrality can co-exist with a wide range of distributional impacts of congestion charging. If revenue-neutrality is confounded with 'no increase in the tax burden', this risks causing problems of credibility.

Figure 10: **Structure of tax revenues from on car ownership and use 2016 (Israel 2012)**



Source: ACEA Tax Guide (2018), MoF (2013).

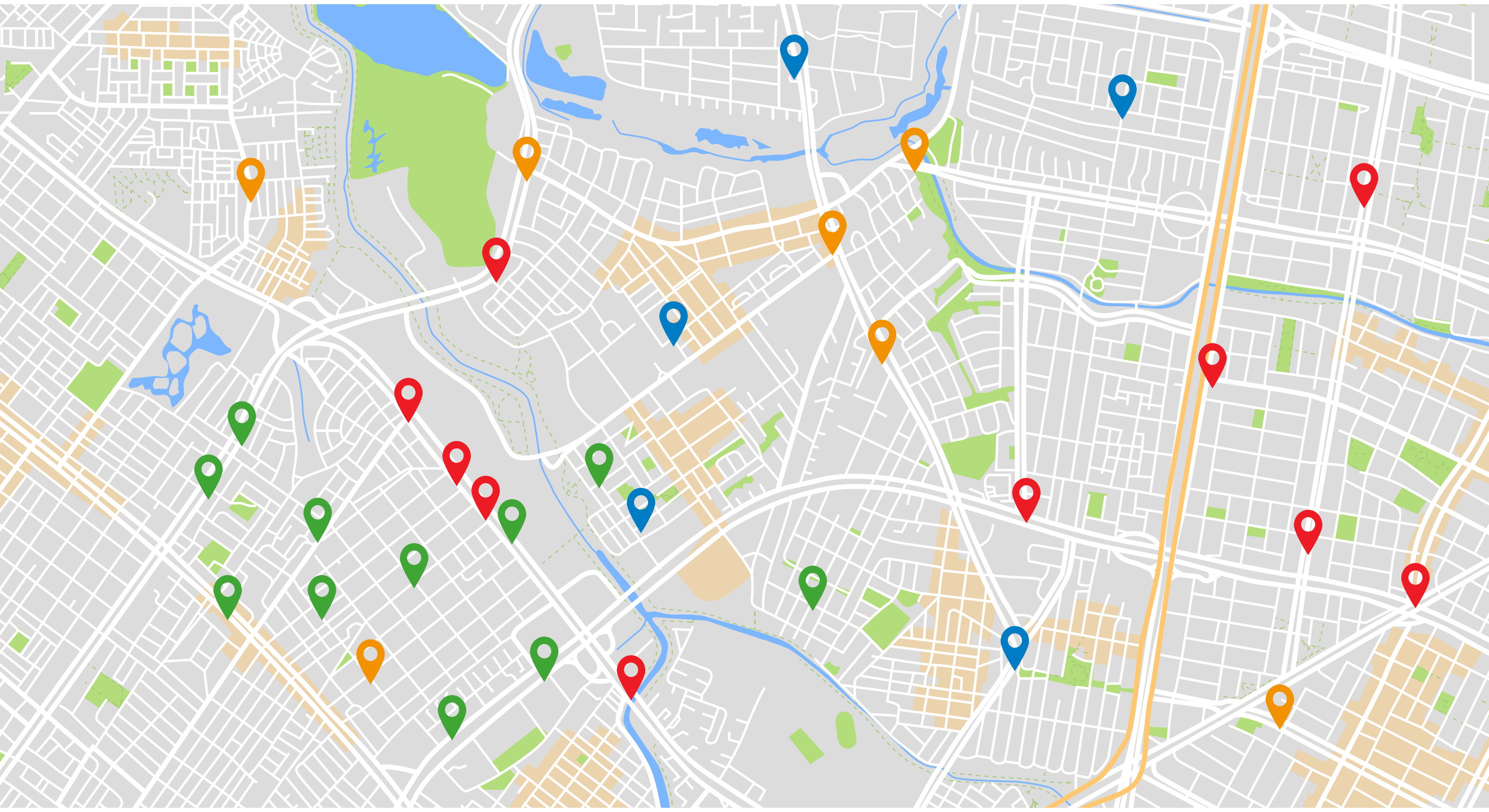
Which technology to use

GPS-based technology can make any charging system more efficient. All options require similar data protection safeguards.

Regardless of the chosen scheme, Israel should consider the adoption of GPS-based monitoring technologies. They are likely to substantially increase the efficiency of both schemes by adding a substantial degree of pricing flexibility.

Taking a long-run cost perspective, it is useful to avoid lock-in to systems that are difficult to adapt when charging policies change, e.g. with extensions to broader geographical areas or higher resolution charges, and GPS based systems are highly adaptable. Visual intrusion from systems heavily reliant on roadside equipment mounted on gantries also need to be taken into account.

Data privacy considerations need to be addressed. Congestion charge processing systems must conform with data protection legislation. The requirements adhered to by Transport for London (TfL) in levying the London Congestion Charge are extensive. The basic provision for protecting individual privacy is deletion of records after payment. Automatic Number Plate Recognition cameras are used to monitor vehicle travel within the charging zone. This includes reading vehicle registration number and taking a photographic image of the vehicle. The IT system checks whether the road user charge has been paid for the vehicle or if it is registered under a discount, automatic payment or exemption scheme. If the charge has been paid or a discount/ exemption applies, the vehicle registration number and images are deleted by midnight of the next working day. All other images are retained for enforcement purposes. Congestion charging is just one of many systems that TfL uses that are subject to extensive data protection requirements, including closed circuit video monitoring for security. Details are provided on the Authority's website (TfL 2019).



Which measures to accompany congestion charges

Improvements in public transport and more efficient parking policies can enhance the effectiveness of congestion charges and public acceptance.

PUBLIC TRANSPORT

Improvements in public transport services, particularly by bus, will be important to achieving efficient and sustainable mobility in and into Tel Aviv. The major investments in metro and light rail systems underway will transform mobility in the longer term. In the short term, bus services can be improved, as the roads will be less congested following introduction of congestion charging. Supply should be increased, as in London and Stockholm, to reduce waiting times and increase the number of seats available. The quality of service has a stronger influence on bus use than ticket prices. Quality of service on metros, in terms of crowding, comfort, reliable departure and wait times, is has a greater impact on demand than lower fares (table 3). The same pattern holds with buses. Convenience also matters. Research conducted by the Bank of Israel shows that the proximity of bus and train stations and the frequency of service significantly increase the probability of using public transport in Israel (Suhoy and Sofer 2019). Quality of service should not be sacrificed to offer low fares as the result is likely to be a spiral of declining ridership.

Table 3: **Metro elasticities of demand**

Demand with respect to	Short run elasticity	Long run elasticity
Fares	-0.047	-0.331
Quality of service	0.072	0.507

Source: Graham 2009.

PARKING POLICIES AND TAX TREATMENT OF PARKING AND COMPANY CARS

In Israel, on-street parking prices in cities are very low or zero for many car users. This subsidises car use by failing to charge for the public space consumed. Considerations should be given to a more efficient parking management, where the gap between on-street and garage parking prices is significantly reduced. Low on-street parking prices compared to garage ones create strong incentives for cruising for on-street parking spots, which exacerbates congestion.

Parking management and pricing policies complement congestion charges. Both are necessary to reduce in-vehicle time losses and ensure the efficient use of road and curb side space. In the absence of congestion charges, parking pricing can be used to discourage car trips to specific destinations. However, parking tariffs can neither account neither for the distance driven nor for the route taken to reach a given destination. Furthermore, they leave pass-through trips, which can be an important cause of congestion, unpriced. This entails that they are much less effective than road pricing instruments in reducing congestion.

Setting efficient parking tariffs is necessary to prevent cruising for parking – which can significantly aggravate congestion in busy downtown areas – while also ensuring high occupancy rates. Prices for on-street and public garage and workplace parking should reflect the social costs of parking space construction, the opportunity costs of alternative land uses, environmental costs and the costs of cruising for parking (Russo, van Ommeren and Dimitropoulos, 2019). The latter are the time costs that a driver occupying a parking space imposes on those who are in search of a vacant space in that vicinity. These costs increase with the attractiveness of the location where the parking space is located. Given fluctuations in demand, a dynamic parking pricing system is required, where tariffs vary over space and time using information on occupancy in surrounding areas.[1]

Employers often provide parking to their employees for free or at very low rates. The exemption of the value of employer-paid parking from employees' taxable income is an implicit incentive for commuting by car. Any other tax-exemption related to company car ownership or use similarly subsidises car use. It is important to consider removing such income tax exemptions, or make them applicable to the costs of commuting by other modes. To further discourage driving to work, it is also worthwhile to encourage employers to offer parking cash-outs – the cash equivalent of the parking subsidy – to employees who do not benefit from employer-paid parking. In California, for example, firms that rent parking spaces for their employees are required by law to offer parking cash-outs to commuters who do not benefit from free or subsidised parking (Shoup, 2005). Many of these reforms are in the realm of income taxation, where the challenge is to make the tax treatment of different forms of income more neutral. Aligning income tax policy with mobility objectives contributes to the effectiveness of mobility policy.

1. Enforcement of on-street parking policies is key for their effectiveness. Digital solutions, such as licence plate recognition technologies, can significantly improve the monitoring of parking space use and reduce enforcement costs. Higher fines for parking violations can help increase compliance with parking policies.

How to engage with the public

Congestion charges have faced opposition and were rejected in some cities. But they have also been met with public support, resisted the test of referenda and figured prominently on the programmes of politicians who were successfully elected or re-elected.

Public opinion can be hostile to congestion charges. Drivers and the general public more broadly may feel that they are being charged for something they already pay for, that the measure will be ineffective in reducing congestion, that the technology will be unreliable and infringe privacy, that the poor suffer disproportionately from the charge, and that the government is simply looking for another way to raise revenue.

Attempts to introduce congestion charges have failed in some cities. This was the case for example in Edinburgh, United Kingdom, in 2005, where in a local referendum, 74% of residents voted against a planned cordon charge. This was because the charge was poorly designed in that only a minority of voters would have benefited from reduced congestion (OECD/ITF 2018d).

In Israel, a number of factors could give rise to public opposition:

- **First**, drivers in Israel are not used to road pricing in general, given the small number of toll roads. However, the same applied to London and Singapore when their respective charging schemes were introduced.

- **Second**, the quality and availability of public transport are such that most citizens do not view buses as a viable alternative to cars. However, reduced congestion will improve travel on buses and there are measures that can accompany congestion charges and improve bus services relatively quickly. Additional bus services can be added to reduce wait times. Demand responsive services using detailed data on actual and potential usage can be used to reroute buses to better respond to users' needs. App-based van pooling services can complement bus services at lower cost (OECD/ITF 2018b).

- **Third**, attempts to change the structure and level of charges associated to car use have failed in the past, most notably in relation to introducing congestion charging in Tel Aviv (2010) and reforming fuel taxes (2011). Significant protests erupted in 2011 linked to rising cost of living and housing costs in particular. In this context, the direct benefits of faster travel times should be highlighted together with reduced delays to public transport and reduced pollutant emissions.

There have also been cases in which congestion charges won public backing such as in London, through a Mayoral election, and in Stockholm through a referendum on charging following trial implementation. Engaging and consulting with citizens helped improve public acceptance in these cases (see box 3).

Political support for congestion charges has broadened since introduction in London, Stockholm and Milan. In London, the mayor who introduced congestion charges was re-elected in 2004. In Stockholm, no politicians have campaigned against the policy since its introduction and public opinion remained constantly positive. In Milan, the current mayor campaigned on the explicit promise to keep the area charge and won the city elections in 2016. In London and Milan local government was responsible for the introduction of charging whilst in Stockholm it was the national government.

In New York, the State government is making plans to introduce congestion pricing for Manhattan's central business district (CBD) as part of the FY2020 Budget. In January 2018, an Advisory Panel set up by the Governor and tasked with formulating proposals to create a dedicated funding stream to mass transit and reduce traffic, revived the idea of a congestion charge for New York City in order to raise revenues for the underfunded subway.

The Panel advised that congestion pricing be introduced gradually, starting with taxis and for-hire vehicles, followed by trucks and eventually all vehicles entering the CBD. It also stressed that "fair and frequent review and opportunities to make modifications when necessary" as "critical to earning and maintaining public support for the congestion reduction program" (Fix NYC, 2018).

In Israel, the charging scheme is expected to be functioning in 2021. This timeline is tight compared to London, Milan and Stockholm, where it took around

Box 3: **GAINING PUBLIC BACKING IN LONDON, MILAN AND STOCKHOLM**

After being elected, the mayor of **London** who had campaigned for the introduction of congestion charges began an eighteen-month long consultation effort. The consultations led to a number of exemptions, namely for taxis, motorcycles and mopeds, public service vehicles with more than 9 passengers, local government service vehicles, military and recovery vehicles and vehicles used by disabled persons. A standard charge was applied to all other vehicles, despite initial plans to charge trucks at a three times higher rate than cars. Crucially, vehicles registered to residents of the central zone received a 90% discount, although the charging zone has relatively few residents compared to the daytime population of the area, which is dominated by office workers.

In **Milan**, a vote took place prior to the introduction of the congestion charge and voters supported the measure by a majority of 79%. The referendum question bundled the introduction of congestion charges with proposed improvements in public transport. Considerable exemptions were also made in Milan, including heavy discounts for residents of the central area, free access to taxis and motorcycles, lifting the charge at 6pm on Thursdays, in parallel with late openings to encourage citizens to shop in the city centre. Both the exemption of taxis from the congestion charge and the earlier termination of the charge's schedule on Thursdays were suspended in February 2019.

In **Stockholm**, a vote took place after an initial trial period had resulted in a 30% reduction in traffic. Citizens supported the policy by a majority of 53%. The Stockholm charging trial was introduced despite both main political parties ruling out a congestion charge in their election campaigns. The government was formed with the minority ecology party that insisted on a congestion charging trial for its support. A crucial part of the political consensus that was developed on charging was a ten-year infrastructure package worth around 10 billion euros, brokered by regional and national politicians. This allocated central funds to longstanding proposals and earmarked part the revenues from the charges for a new road bypass around Stockholm. A large increase in investment in bus services was also part of the package.

five years from conception to implementation. Full deployment of congestion pricing in New York is currently envisaged to take between two and five years. While the short timeline is justified given the severity of the problem, it makes engagement and communication with stakeholders a high priority so that charging can become the new normal and meet with increasing public support (see figure 11).

A full engagement strategy would involve gauging perceptions of a broad diversity of stakeholders. A wide spectrum of consultation tools should be used (e.g. surveys, experiments, public assemblies) as not all stakeholders have the same access to the resources and opportunities to express their views to government.

In the short run, focus groups could help gather the views from a representative sample of the population. Experiments using apps are currently being conducted on how much drivers would be willing to pay for less congestion. These experiments could be used to also test different policy options in a relatively rapid and particularly effective way.

More targeted consultation and engagement efforts should aim to cover the majority of population categories affected by the new policy, for instance through face-to-face meetings with the representatives of those categories. While precise statistical representativeness may be hard to achieve, at a minimum policy makers could hear from the most affected groups, including existing commuters by both car and public transport, employers and business associations, citizens living both within and along the edge of the congestion charging area (if a cordon approach is adopted), citizens in communities with poor public transport links who rely on their car to access jobs and services, freight companies involved both in large-scale logistics and in last-mile delivery, taxi drivers, local authorities in the areas affected by the charge.

A timeline for engagement and consultation could help citizens contribute to the engagement efforts. Clear timelines will also give the public enough time to prepare for the new policy, including making choices about purchasing/selling cars, organising car-pooling or exploring public transport alternatives.

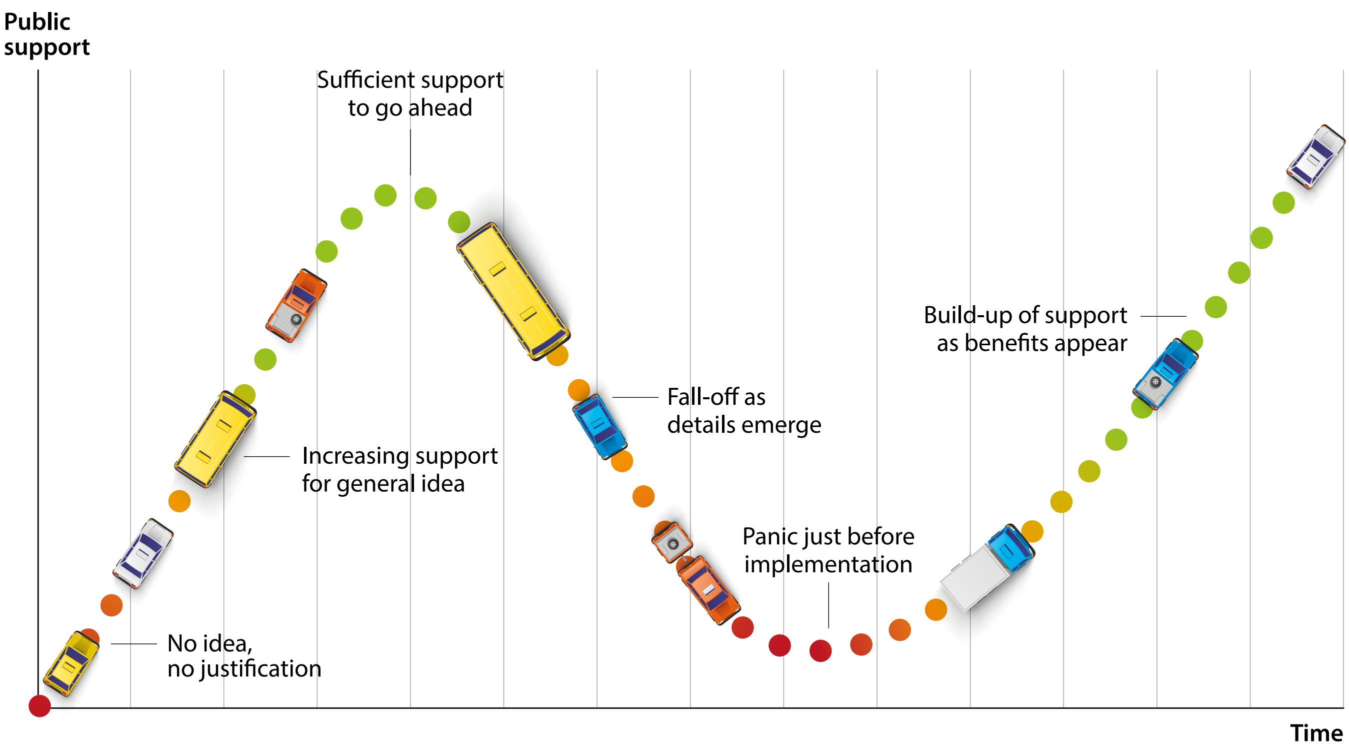
It will be important to communicate the expected benefits in a way that resonates with the public. This will focus on the consequences of congestion. Drivers are currently frustrated with the time wasted in traffic, and faster commuting will be a benefit that the population can relate to.

If the level of the charge can be reviewed periodically as recommended above, it will be important to gather sufficient evidence during implementation in order to measure and communicate success. It will be paramount to measure key outputs in a way that is consistent with the public messages delivered ahead of the introduction of the policy. By way of example, should faster commuting be the key benefit of the public narrative, it would be important to present measurable goals such as a reduction in travel time or increased speed at the onset, following through with initial success stories as the first results materialise.

The metrics against which success can be measured depend on the completeness of the planning and traffic management tools employed. For instance, Singapore uses congestion charging to fine tune the system. Road pricing is used to stabilise traffic speeds and journey time reliability in an integrated transport and land-use planning system, managed with a complete range of instruments: parking pricing, on and off-street parking space management, auctioned permits for car purchase, a vehicle ownership quota to restrict fleet growth, extensive public transport systems and land use development projects conditional on expanding public transport services. Congestion tolls are reviewed every three months based on traffic speeds at each charging point and adjusted where necessary to maintain speeds around 20-30 km/h on city roads and 45 65 km/h on expressways. Accordingly, the targets are based on traffic flow modelling of optimal speeds and correspond closely to theoretical speeds for minimising the space consumed by traffic (ITF 2018d, Chin 2010).

Such precise targets will not be possible in an environment like Tel Aviv where fewer of the levers to manage traffic are employed. However, modelling should be able to establish what level of congestion relief will be attained. In London, for instance, reduction in delays in travelling were used and communicated to the public, providing evidence of the success of the scheme. In line with TfL's expectation, delays were reduced 30% in 2003, 2004 and 2005, a figure revised to 33% after weighting by concentration of traffic (TfL 2008). The world is not static and many external factors can change and affect traffic over time. For example, in London in 2006 delays increased although traffic volumes remained constant, with roadworks and building construction works the biggest causes (an important factor in situations where major investments in light rail and underground railways will disrupt road networks). These factors and impacts were communicated and clarified to users to maintain a "no surprise" and open communication channel with the public.

Figure 11: **Public attitudes to congestion charging over the project development span**

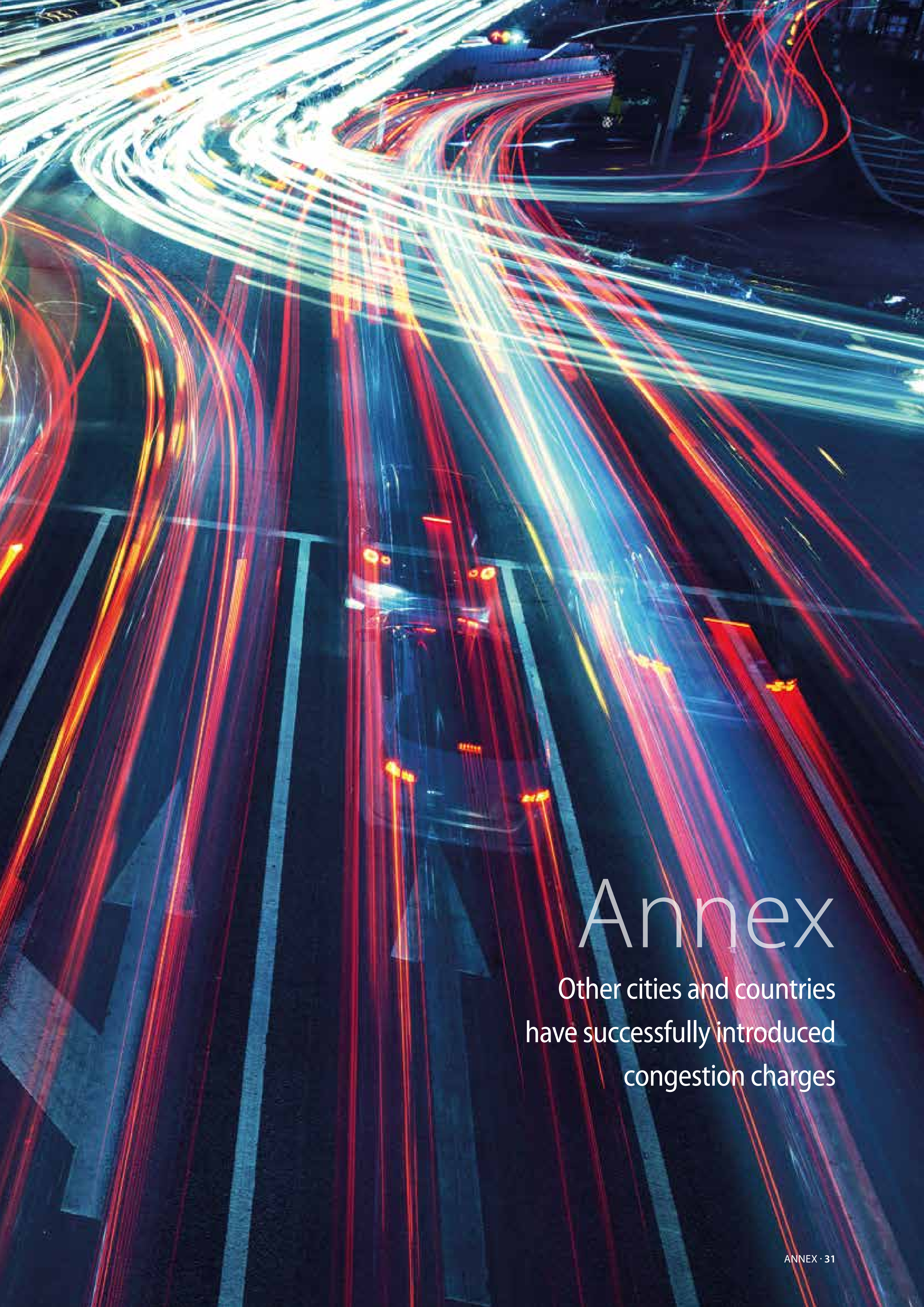


Source: Goodwin (2016).

Conclusions

Congestion charges are an effective way of tackling traffic congestion if carefully designed. Road users can respond flexibly to charges even before public transport services are scaled up. Accordingly, a well-designed charging system will help relieve congestion in the short term, as well as in conjunction with improved mass transit in the longer term. Key success factors include the introduction of accompanying measures to support mobility, clarity on the objectives of the charging scheme and effective communication and engagement with the public to foster acceptance.

A key insight from international experience is that congestion charging should be an integral element of a long run vision and strategy for more sustainable mobility and a more reliable transport system. Such strategy should aim at managing the negative side effects of transport, including congestion, air pollution, noise, greenhouse gas emissions and inefficient use of scarce urban land. The development of such strategy (not addressed in this report) should take into account the effects of all forms of mobility pricing, including congestion charges, on urban development. It should also consider the effects of urban development on mobility patterns. More broadly, a long run strategy should integrate impacts of disruptive technological and business model changes in road transport, including those related to electrification, automation and shared mobility services.



Annex

Other cities and countries have successfully introduced congestion charges

Annex: Main features of London, Milan, Singapore and Stockholm charging schemes

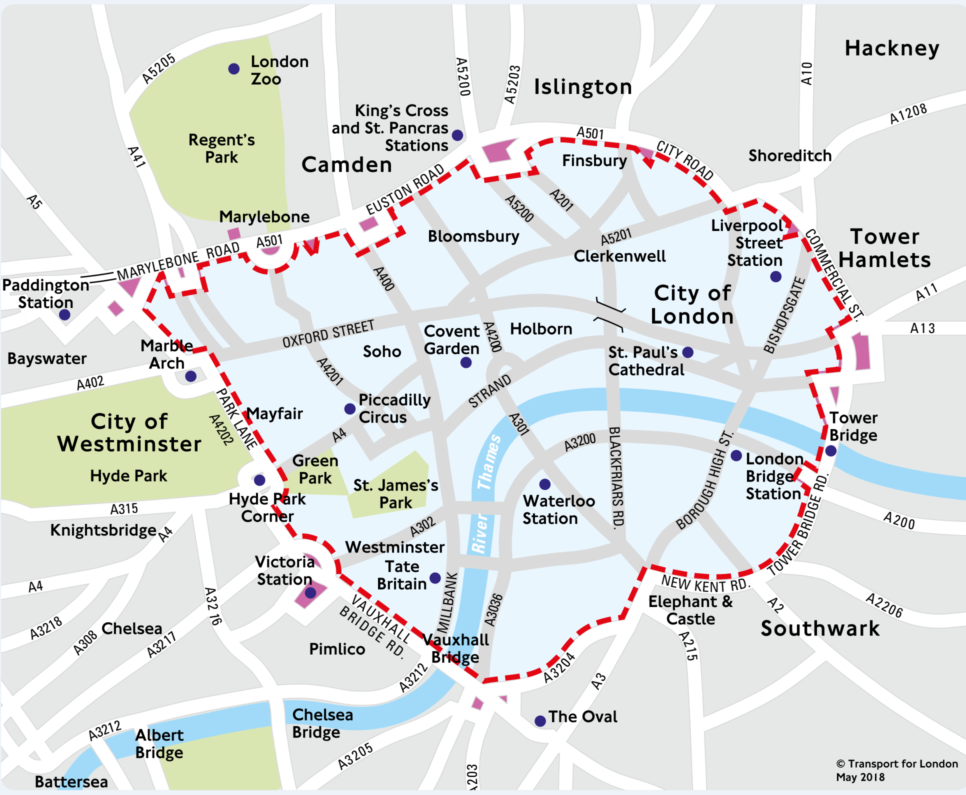
THE LONDON CONGESTION CHARGE

London introduced its congestion charge cordon in 2003, it consists of an area charging system that uses a single cordon around the central part of the city, charging a flat daily rate for driving a vehicle within the cordon – which covers a 21-square kilometre zone. This measure was implemented to reduce congestion, improve air quality and public health, as well as to provide funds towards public transit improvements, and to ensure journey time reliability for both car and bus users. s.

The system uses cameras (on posts and buildings rather than gantries) with automatic number plate recognition software to monitor vehicles entering the cordon. Users need to register their vehicles by phone or internet and can pay the daily rate in advance or after entry to the cordon; the payments can easily be made by telephone, text message, online, by post, at shops or registering for auto pay. Residents are eligible to pay by monthly or annual payments at a 90% discount, but account for a relatively small share of users. The charge has risen in stages from £5 in 2003 to £11.50 today. There is no charge on weekends, or holidays nor at night (from 18.00 to 7.00), and taxis are exempt. The initial investment in the charging system was USD 214 Million, and in 2017 net revenues accounted for USD 210 Million.

The congestion charge was accompanied by improvements to public transport. Bus routes were improved and 300 new buses were incorporated in order to increase their frequency. The impact was noticeable. Investments were made to improve biking and pedestrian infrastructure and 8,500 new park-and-ride spaces were created. Revenues from the charge are spent on these improvements, on better road maintenance and on investment in the underground metro system. The use of revenues for the improvement of public transport is no doubt one of the reasons for public support for congestion charges in London.

Congestion Charge area / Ultra Low Emission Zone in central London



Congestion Charge zone

Charging zone boundary

Additional residents' 90% discount area for Congestion Charge

Main roads within the zone

Source: Transport for London, https://tfl.gov.uk/modes/driving/congestion-charge/congestion-charge-zone?intcmp=40404 (accessed May 2019).

The congestion charge reduced the number of vehicles circulating inside the cordon by 18%, and traffic remained constant thereafter (TfL 2008). In addition, congestion charging delivered substantial decongestion benefits, with reductions of roughly 1/3 in "excess travel times" – that is to say delay in relation to travel under uncongested conditions early in the morning (TfL 2008).

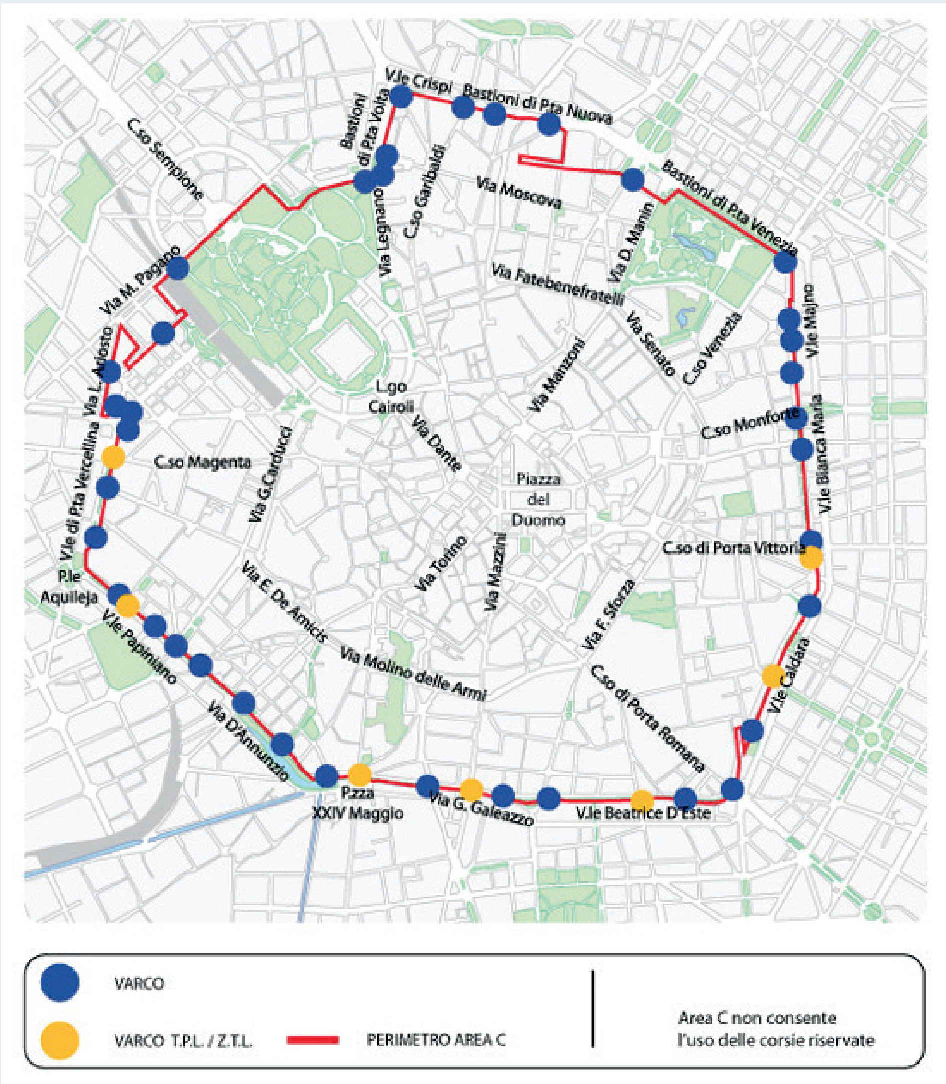
Originally, the congestion charge was an electoral pledge of the first Mayor of Greater London, responding to chronic complaints about transport conditions. This measure was seen as the most visibly successful policy of his first term in office – allowing him to be re-elected. It is important to note that to succeed, preparatory work was undertaken in engaging with the public and media to establish the degree to which congestion was viewed as a threat to economic growth and to wellbeing, and as the problem was discussed, the policy received increasing support.

MILAN AREA C CHARGING SYSTEM

The scheme, known as Area C, was launched in January 2012 and involves the charge of a flat fee of EUR 5 for all passenger light-duty vehicles entering the historical city centre, an area of 8.2 km2 (4.5% of the area covered by of the Municipality of Milan). The fee is paid only upon the first entry of a vehicle on a weekday (Monday to Friday) and only if that occurs between 7:30 and 19:30. Users pay a flat fee per day, regardless of their number of entries in the course of it. Like London, charging is based on cameras on gantries with automatic number plate recognition technology installed on the 43 gates to the city centre.

One of the system main goal is to improve air quality and public health; this is why very polluting vehicles are banned from entering the area. In contrast, two-wheelers, hybrid vehicles and vehicles with zero

Area C congestion charge area in central Milan



Source: City of Milan, Area C, https://www.comune.milano.it/documents/20126/526561/Mappa+varchi+AreaC.jpg/6872745b-e014-8f85-c75f-ece230a7492a?t=1546937188631 (accessed May 2019) emissions are currently exempt from the charge – such as electric cars for instance. So are also certain types of light commercial vehicles. Residents of the area where the charge applies are granted forty free daily entries per year, and pay a lower daily fee (EUR 2) from the 41st daily entry onwards.

Area C replaced a pollution charge system called Ecopass introduced in 2008, applied to the same area, to reduce traffic and air pollution - the vehicles were charged a fee determined by their vehicle engine emission standards. Initially Ecopass had strong positive effects on air pollution and congestion, but not in the long run, as road users opted for cleaner (at least in type approval terms) vehicles, which were exempt from the charge – in 2015 only 15% of vehicles in the area were subjected to the charge. This induced the municipal authorities to move to a congestion pricing system, which would be effective not only in curbing congestion, but also in reducing non-exhaust emissions – like pollution coming from brake, tyre and road wear and from road dust resuspension.

The proposals to upgrade the scheme to a congestion charge was presented in a consultative referendum open to all urban residents. The proposal included a plan of action to enhance public transport and alternative mobility, to extend the road charge to more vehicles and to progressively widen of the area subjected to the pricing. The referendum was approved by 79.1 % of voters.

The charge raises around 35 million USD annually. Half of the revenue covers operating costs, while the remaining part funds public transport improvements. Some of the accompanying measures came immediately into effect, such as increased bus frequency and higher parking fees. Other measures, such as extensions of the subway network, and measures to promote sustainable mobility services, had a much longer-term perspective.

The results were significant. Regarding motor vehicle traffic volume, the congestion charge reduced vehicle entries to the city centre by about 14.5% (Gibson and Carnovale, 2015). The charge was also responsible for geographical substitution, with traffic along roads within 1 km of the Area C perimeter increasing by 18% more than traffic in roads within the congestion charge area (Gibson and Carnovale, 2015).

In terms of air pollution, the congestion charge has been found to lead to important reductions of all major air pollutants from road transport, at least in the short term. It has reduced carbon monoxide concentrations inside Area C by 6% and suspended particulate matter concentrations outside the area by 17% (Gibson and Carnovale, 2015). The congestion charge has also been found to effectively promote shifts to green transport modes. For instance, daily bike-sharing use increases by at least 5% – less road traffic congestion makes cycling safer and more pleasant (Cornago, Dimitropoulos and Oueslati, 2019).

ELECTRONIC ROAD PRICING IN SINGAPORE

The Singapore scheme was the world's first congestion charge. In 1975, the Land Transport Authority introduced a paper permit based area wide licencing system, with a cordon around the centre of the city to manage congestion. This was combined with increased parking charges in central areas and park and ride bus services to provide an alternative to travel by car to the city centre. In 1998, the system was upgraded with electronic road pricing (ERP) to make it the most effective urban congestion charging system in operation.

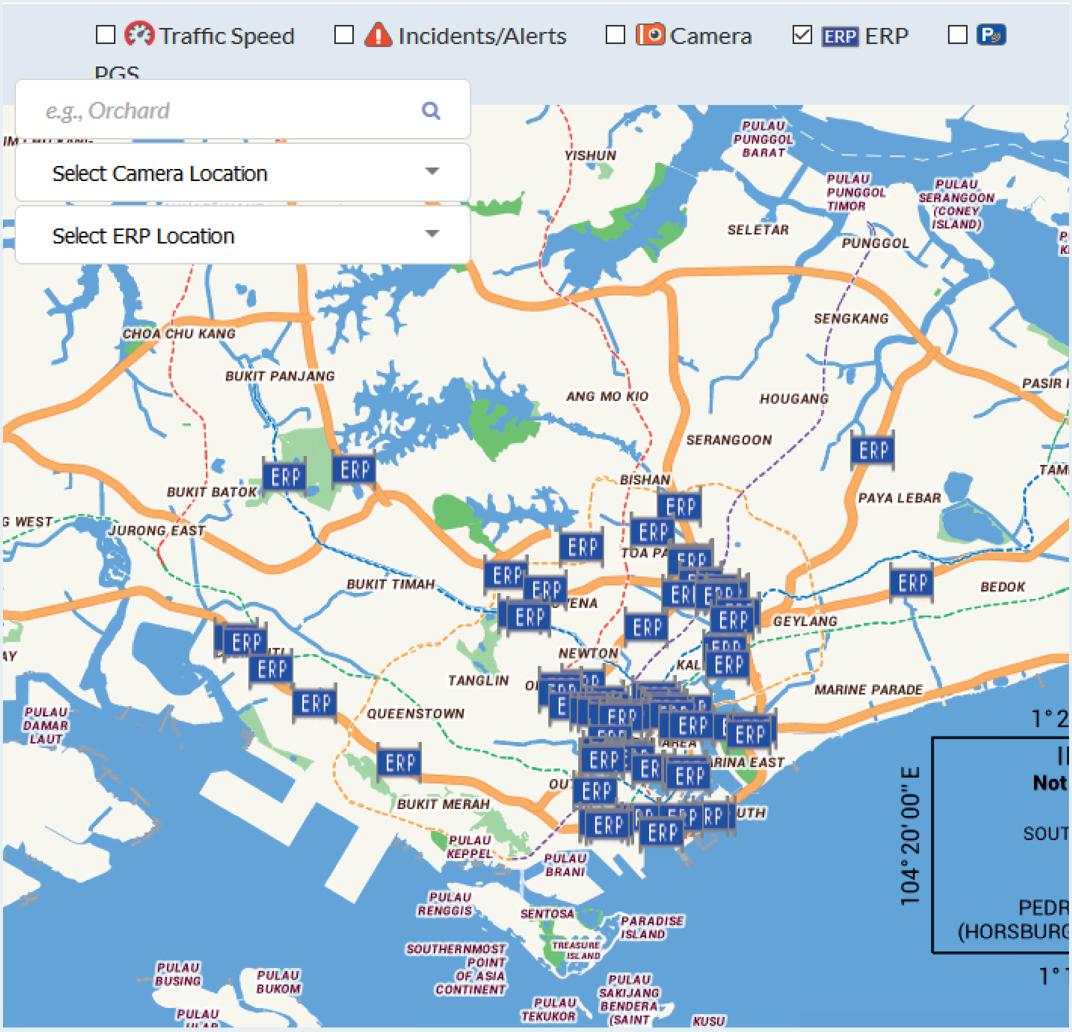
The ERP system applies area-wide congestion charging in the central cordon and extends pricing along expressways and arterial roads, with charging points added progressively to manage traffic flows as the city grows. Population increased by 44% between 1998 and 2016. Road pricing was developed hand in hand with development of public transport. Housing and commercial developments are authorised only in conjunction with extensions to bus services. Public transport is well developed, including metro lines, but as in London the highest share of overall passenger traffic is carried by bus.

All Singapore-registered vehicles are required to fix a small on-board unit on the dashboard, containing a transponder and a smart card reader. The units costs USD 110 and are covered by a 5-year warranty. The pre-paid smart card must be loaded and separates the identity of the driver from the car. The on-board unit communicates with radio transmitters mounted on gantries at the fifty plus charging points. Enforcement uses automatic-number-plate-recognition cameras, also mounted on the gantries. Peak, off-peak and shoulder price rates are applied at the charging points. In central areas there are three peak periods, the third being early in the afternoon to manage the return to work after lunchtime. The charge rates vary by road and time period, and may range from 0 to 3 dollars per pass.

Prices are set to manage traffic volume to maintain optimal traffic speeds (modelled by the Land Transport Authority) across the road network; 20-30 km/h on city roads and 45-65 km/h on expressways. Prices are reviewed every quarter and raised if necessary to maintain network speeds. This has been achieved consistently since introducing ERP in 1998. This rules based pricing system has been a key factor in the relatively positive public attitude to congestion charging (ITF 2018d). In 2015, the total net revenue collected from the ERP system was something over USD 100 million (Ong 2018). The initial investment was USD 110 million (Provonsha 2017).

The government plans to introduce satellite tracking of vehicles in 2020, with a system called ERP 2.0 (ITF 2019). Most gantries will be removed. New on-board units will communicate with satellites in the same way as navigation systems, with signals supplemented by radio communication with transponders in the units at locations with weak satellite signals. The on-board unit will monitor the location of the vehicle and automatically calculate the road pricing charge once the vehicle crosses the virtual boundaries of the system. The new system will maintain some of the existing pricing points and structure initially. Enforcement cameras will be installed with complementary beacons to ensure vehicles have working on-board units fitted, and capture the vehicle's licence plate in case enforcement action is required due to non-compliance. The on-board units will also provide real-time information to travellers on congestion levels. The investment required is reported to be USD 409 million. In principle, the new system will allow further differentiation of charges by time of use and location on the network and extension of the system to cover the entire network. Every kilometre driven could then be subject to an appropriate charge, taking efficiency to the theoretical maximum for congestion pricing.

ERP congestion charge system in Singapore



Source: Singapore Government, ERP, https://www.onemotoring.com.sg/content/onemotoring/home/driving/ERP.html (accessed May 2019)

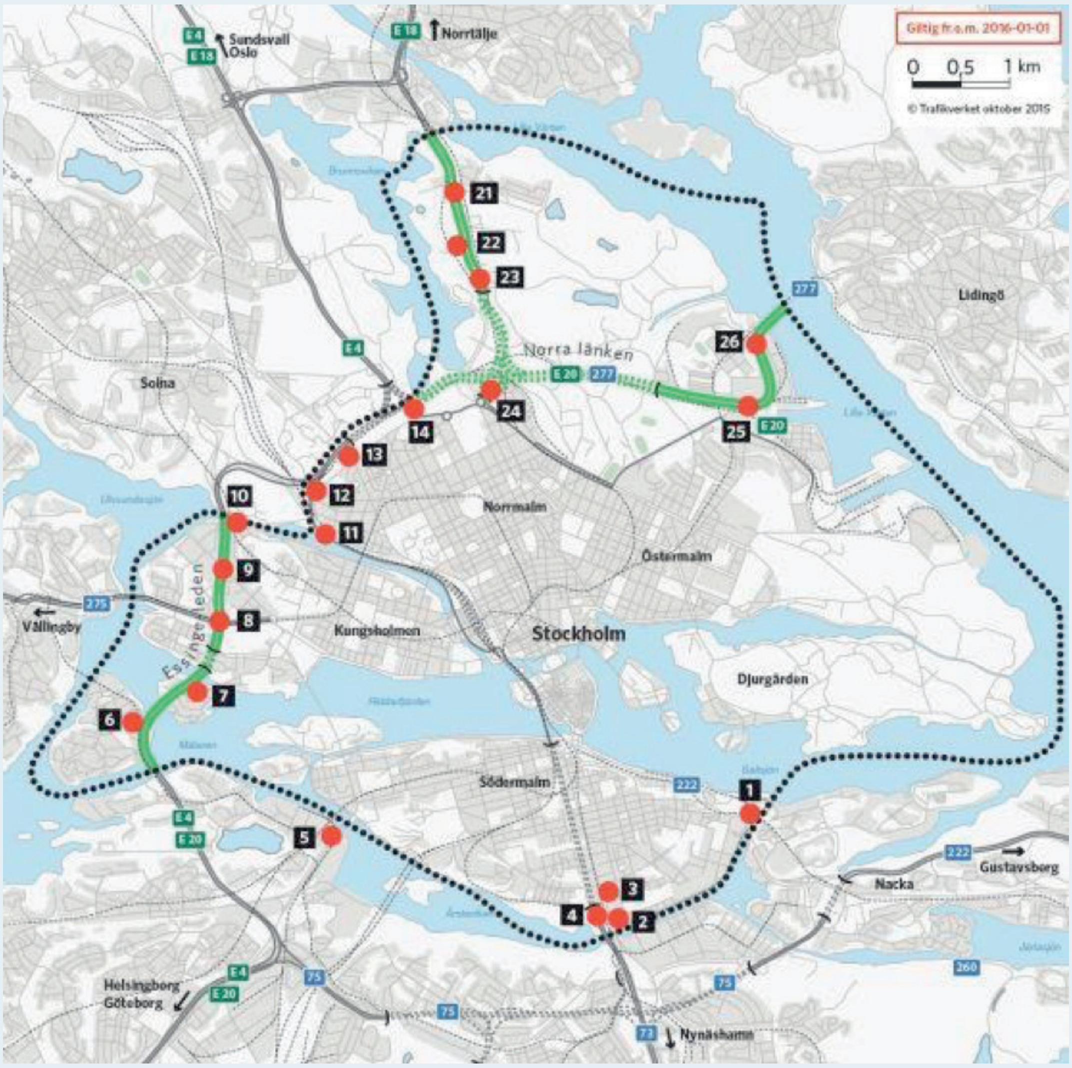
STOCKHOLM'S CONGESTION CORDON TAX

The Stockholm Congestion Cordon Tax was launched in 2007 after a successful trial in 2006, the scheme uses automatic number plate recognition to control entry and exit to the city centre –a 35-km^2 zone. The system uses cameras on overhead gantries at entrance points, pavement markings, and street signage. The primary purpose of the congestion tax is to reduce traffic congestion and improve the environmental situation in central Stockholm. The funds collected will be used for new road constructions in and around Stockholm.

The Stockholm Congestion Cordon Tax uses 18 charging points located at the main bottlenecks on the arterials leading into the central parts of the city. These are manly located on bridges over water and form a cordon determined by the physical geography of the city, which is located on and around a number of islands. Cameras on gantries with automatic number plate recognition software monitor vehicles passing the charging points. Vehicle owners are sent a monthly invoice for charges incurred.

The price of passing a control point in either direction is roughly USD 1.1 to -2.15, depending on the time of day: peak rate USD 2.15, shoulder rate USD 1.6 and standard USD 1.1. These rates were increased in 2016 to USD 4.14, USD 2.7 and respectively USD 1.1 in the off-peak period in the middle of the day. Peak charges apply between 07.30 and 08.30 and from 16.00 to 17.30. The maximum amount a vehicle is charged per day is capped at USD 7.10 .The cost is the same in both directions, and each passage is charged. There are exemptions for buses, foreign cars and traffic to and from the island of Lidingö, resulting in about 15% of passages being free of charge. There is also no charge on weekends, public holidays or the day before public holidays.

Congestion Cordon Tax area in Stockholm



Source: Eliasson 2017.

Before implementation, over ten systems were evaluated -besides cordon charging- by detailed modelling of their impacts, with most discarded because the model prediction indicated that they would cause severe second-best problems: for instance, causing more congestion in the network. The Stockholm cordon, surrounding the inner city, where the bottlenecks are located, cuts through the water. The water acts as a natural border, preventing the cordon from inducing undesirable barriers and route choice effects. This makes Stockholm is the ideal city for congestion charges.

The charging system began with a trial subject to referendum. Before implementation, public support for congestion pricing had fallen below 40 percent. After a six-month trial period in 2006, roughly 52 percent of Stockholm residents voted to make it permanent in a referendum. After seeing the results of the scheme, public support for road pricing stood at nearly 70 percent in 2011 (Eliasson 2014).

In Stockholm congestion charging reduced traffic crossing the cordon by 22%. In consequence, travel times declined substantially inside and close to the inner city. On arterials, delay times fell by one third during the morning peak period and by one-half during the afternoon/evening peak period. Stockholm reports a 30% reduction in excess travel time at the peak in the centre and 30 to 50% on arterial roads - excess travel is calculated with respect to free flow traffic (Eliasson 2014, 2009). The changes in monitored speeds suggest a free flow speed for arterials of 52-55 km/h and on the larger roads inside the cordon just over 31 km/h (Raux 2014)

The Stockholm Congestion Cordon Tax net revenues accounts for USD 155 million, and required an initial investment of USD 237 million. Geography makes Stockholm's operating costs lower than other city's charging systems, as London's - in part because only 18 control points are required, whereas a myriad of access points are monitored in London. In Stockholm the operation cost are USD 12 million with respect to USD 105 million in London (Provonsha 2017; Badstuber 2018).

Outline of congestion charging systems in London, Milan, Stockholm and Singapore

	Metropolitan Population			Pricing Scheme		
	Launch year	2016	Δ	Outline	Primary goals	Accompanying measures
London Congestion Charge	7.3M in 2003	8.7M	19%	The cordon pricing scheme uses automatic number plate recognition to control entry to a 21 km^2 zone. Vehicles are registered by phone call or internet with payment in advance or after entry. Late payers are fined and traced through the national vehicle register. The system consists of overhead gantries, cameras at all entrance points, pavement markings, and street signage.	• Reduce congestion • Improve air quality and public health • Improve journey time reliability for car and bus users • Funding for public transit improvements	• 300 new buses • Improved routes and frequency of buses • 8,500 park-and-ride spaces • Bike and pedestrian infrastructure • Taxis exempt
Milan Congestion Charge (Area C)	3M in 2011	3.2M	6.6%	The cordon pricing scheme uses automatic number plate recognition to control entry to an 8.2 km^2 zone, the historical city centre. The system consists of overhead gantries at 43 entrance points, pavement markings, and street signage. The system was launched in 2012, replacing a pollution charge existing from 2008.	• Reduce congestion • Improve air quality and public health	• Extension of the metro network • Improved frequency of buses • Increased parking fees and coverage of parking pricing • Bike and pedestrian infrastructure (bike-sharing system, bike lanes) • Two-wheelers, hybrid and zero-emission (electric) vehicles exempt. • Discounts for residents and certain types of commercial vehicles.
Stockholm Congestion Cordon Tax	1.9M in 2007	2.1M	10%	The cordon congestion tax scheme uses automatic number plate recognition to control entry and exit to a 35 km^2 zone. The system uses cameras on overhead gantries at entrance points, pavement markings, and street signage. The scheme was launched in 2007 after a successful trial in 2006.	• Reduce congestion • Improve air quality and public health • Improve journey time reliability for car users	• 197 new buses • 16 new bus routes • 2,800 new park-and-ride spaces • Bike/pedestrian infrastructure • Taxis and for-hire vehicles, such as Uber, also pay the tax
Singapore Electronic Road Pricing	3.9M In 1998	5.6M	44%	Electronic road pricing on specific routes with pricing adjusted periodically to maintain speeds. Vehicles are required to have an in-vehicle unit with transponder and pre-paid smart card reader on the dashboard. Units are monitored at gantries and fees deducted from the smart card. The ERP scheme was launched in 1998, replacing a paper licence based cordon scheme first implemented in 1975.	• Reduce congestion • Improve journey time reliability for car users	• Parking fees in CBD doubled • Buses added, frequency increased • HOV+4 lanes established • 15,000 park-and-ride spaces created.

1. Between mid-September 2012 and February 2019, pricing was restricted from 7:30 to 18:00 on Thursdays

2. Croci (2016) and https://milano.repubblica.it/cronaca/2017/01/19/news/milano_area_c-156363158

Payments		Investment, Annual costs and revenues		
Payment	Hours of operation	Initial investment	Operating cost	Net revenues
Flat daily fee of £11.50, USD 15 Payments can be made by telephone, text message, on line, by post, at shops or registering for auto pay.	07:00-18:00 – Monday-Friday There is no charge on weekends, Bank Holidays, or between Christmas Day and New Year's Day, nor at night 18:00 to 06:59.	GBP 162 million USD 214 Million	GBP 80 million USD 105 million in 2017	GBP 160 million USD 210 million in 2017
Flat daily fee of EUR 5, USD 5.53. Fees have to be paid by the end of the day of entry. Payments can be made by telephone, text message, on line, at authorised shops and banks, at parking meters, or registering for auto pay.	07:30-19:30 – Monday-Wednesday, Friday[1] There is no charge on weekends, public holidays, during public strikes, for two weeks in August, two weeks around Christmas and New Year's Day, nor at night –19:30 to 07:29	EUR 7 million (excluding sunk costs, Croci 2016)	EUR 14 million (Croci 2016)	EUR 15.7 million in 20162
Variable price by time of day. Highest peak period price per passage is SEK 35, USD 4.14. Maximum payments per day are capped at SEK 60, USD 7.10. Monthly invoice for total charges incurred with payment by mail, online or direct debit.	06:30-18:30 –Monday-Friday There is no charge on weekends, public holidays or the day before public holidays, nor during July, nor at night 18:30–06:29.	SEK 1.9 billion USD 237 million	SEK 100 million USD 12 million	SEK 1.3 billion USD 155 million
SGD 0-4.00, USD 03.00 per pass at 78 points in and around the CBD. Rates vary by road and time period. In-vehicle unit costs $150, USD 111, free when fitted in pre-start-up period.	07:00-20:00 – Monday-Saturday There is no charge on Sundays, public holidays, or after 13.00 the day before a public holiday.	SGD 200 million USD 110 million	SGD 25 million USD 18.5 million	SGD 150 million USD 100 Million

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Traffic congestion is a major problem in Israel. The Government is increasing the availability of public transport to tackle the problem. Near-term improvements in public transport such as more frequent and better buses, which are the main public transport service in Israel, will provide some congestion relief. However, it will take time to reap the full benefits of investing in public transport. To provide a near term solution to the congestion problem, an Inter-Ministerial Technical Committee is exploring the introduction of congestion charges that would provide incentives for reducing congestion.

This report builds on the extensive work conducted by the OECD on congestion charges to provide insights into the effectiveness of congestion charging systems and identify options that Israel could consider for the design and implementation of an effective congestion charging system.

The report highlights that a well-designed charging system can relieve congestion immediately and, with improved public transport, in the longer term. Crucial is to link revenues from congestion charges to improving public transport. Charges should be accompanied by measures to facilitate carpooling and other alternatives to cars such as cycling. Equally important is to engage with the public and the business community to facilitate public acceptance and ensure that equity concerns are addressed.

The report was the result of the work of an interdisciplinary OECD team bringing together the Centre for Tax Policy and Administration (CTP), the Economics Department (ECO), the Environment Directorate (ENV), the Public Governance Directorate (GOV) and the International Transport Forum (ITF).

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