Decarbonisation and the Pricing of Road Transport

Summary and Conclusions

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Roundtable

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The International Transport Forum

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At the ITF, Rex Deighton-Smith drafted the report with inputs from the Roundtable Chair and participants. Stephen Perkins (ITF) provided direction and quality control. David Prater (ITF) copy-edited the report and prepared it for publication.

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Executive summary

What we did

This report assesses the options for reforming vehicle and road use taxes. The shift to electric vehicles (EVs) and continuing improvements in the fuel efficiency of internal combustion engine (ICE) vehicles will drastically diminish revenues from fuel taxes, requiring a fundamental change to taxation in the transport sector. The report identifies potential packages of taxes and charges that could generate revenue more efficiently and maintain and enhance incentives for the transition to a sustainable transport system.

What we found

The rapid electrification of the vehicle fleet and increasingly stringent fuel economy standards are accelerating a long-term decline in fuel-tax revenues. Commitments by many countries to end the sale of ICE vehicles will intensify this trend and cause significant revenue shortfalls. Efficient and equitable new taxes should address these shortfalls.

Well-designed vehicle and road-user taxation reforms can achieve significant economic efficiency benefits. There are sound economic efficiency arguments for using fixed charges or general taxation to meet the fixed costs of the road system, such as construction costs. However, user charges are the most efficient means to recover the variable costs of road use, including road wear, congestion, pollution, and other external costs.

If EV use remained untaxed, these vehicles' lower marginal cost per kilometre compared to ICE vehicles could significantly increase their average travel distances. This would exacerbate congestion and undermine sustainable urban mobility policies. Not taxing EV use would also raise an equity issue, as their owners would make little or no contribution to road infrastructure costs.

Some jurisdictions have already begun to reform the taxation of vehicles and road use (see Figure 1 for a summary). One example of these reforms is vehicle registration surcharges for EVs, often calculated to be equivalent to the average loss of fuel tax per vehicle. Another is simple, undifferentiated distance-based charges, implemented via low-cost means such as reporting odometer readings or using dedicated distance recording devices without location tracking. Such systems operate in Australia, New Zealand and the United States and are applied mainly to EVs.

Undifferentiated charging systems can offset the loss of revenue from fuel tax and provide practical experience of road-user charging, potentially paving the way for the future adoption of charges differentiated by time and place. Distance-based charges share with fuel tax the advantage of linking the amount of tax paid by each motorist to the extent of their road use. However, flat-rate distance charges do a poor job of making motorists take into account the costs their road use imposes on others (i.e. external costs), because most of these costs differ substantially according to time and place.

The external costs of vehicle use are significantly higher in urban areas and at peak times. Taxes that seek to internalise them should stimulate an efficient response that reduces such costs to an optimal level. Fuel taxes do this well for carbon dioxide (CO_2) emissions as they provide incentives for technological advances in vehicle and engine design, and the choice of powertrain, and reduce overall traffic volumes. Conversely, fuel taxes are not effective in addressing congestion because they cannot influence departure times, change route choices or differentiate between peak and off-peak fuel consumption.

In the short term, local congestion charges can usefully complement simple distance charges. They yield significant economic efficiency benefits and have already proven effective in several cities. Distance charges differentiated by time and place can deliver further efficiency and equity gains. However, to implement such systems substantial technical challenges must be overcome and legal and system design issues addressed. It is also necessary to communicate the benefits of these policies effectively to ensure public acceptance.

Tax expenditures targeted at increasing the electrification of road traffic also require reform. The increasing competitiveness of electric cars reduces the need for incentives to encourage a shift in consumer demand towards EVs. Conversely, incentives are needed to accelerate change in harder-to-decarbonise vehicle fleets such as buses and trucks and to ensure the availability of adequate charging infrastructure. Significant scope exists to improve the effectiveness of policies in this area.

What we recommend

Reform fuel taxes

Fuel taxes are an efficient means of making drivers pay the climate-related costs of the use of fossil-fuel-powered vehicles. Governments should continue to impose them for as long as these vehicles are in use. Revisions to their levels should ensure that the drivers of these vehicles pay the full cost of their carbon emissions, and of their air and noise pollution.

Supplement fuel taxes with distance-based charges

Action to supplement declining fuel-tax revenues is urgent. Governments should apply undifferentiated distance-based charges in the short term. These can be collected via simple distance-reporting technologies using either vehicle odometers or low-cost, in-vehicle devices. Such charges could be confined to electric vehicles or applied to all vehicles, with an offsetting adjustment to fuel taxes applied simultaneously to avoid double taxation.

Consider opt-in arrangements for the introduction of new distance-based charges

An appropriate policy response to the fact that EVs do not pay fuel taxes is to end tax exemptions for registering or using EVs and apply surcharges to those taxes for EVs. Drivers of electric cars could be offered a choice between paying such registration surcharges and opting into a distance-based charging system. Allowing drivers to choose between familiar registration charges and new distance-based charges could help to address concerns over the acceptability of the latter.

Introduce congestion charges where required

There is a pressing need to address the growing social costs of congestion in dense urban areas. Pricing peak time road use in inner-urban areas can encourage more efficient use of road space and make journey times more reliable. These charges should be presented positively, as ”sustainable mobility” or "decongestion" charges. This can aid acceptability by clarifying their policy purpose. Simple cordon- or area-based charges can capture most of the potential benefits with low systems costs and fewer technical challenges than more sophisticated GPS-based systems. Adopting such approaches can enable more rapid implementation of congestion charging.

Consider earmarking congestion charging revenues for improving public transport and active mobility

Earmarking the revenue generated to fund improvements to public transport services and safer conditions for walking and cycling in metropolitan areas can improve the acceptance of congestion charges. This will contribute to the modal shift towards more sustainable transport. However, governments should earmark revenues for broad programmes rather than specific projects or purposes. This will provide needed flexibility to direct funds to their most productive uses.

Set the level of road-user charges to meet sustainable transport objectives

Electrifying the vehicle fleet is not sufficient to make a transport system sustainable. Traffic demand management and modal shift are also required. This implies using the tax system to ensure all drivers bear the full costs their car use imposes on others. If the current taxation level is too low to achieve this, new road-user charging systems should entail higher taxes.

Make introducing differentiated distance-based charges a policy priority

In the short term, the need to replace diminishing fuel-tax revenues makes the use of undifferentiated distance-based charges necessary. However, governments should acquire the technical capacity to adopt, charging systems that differentiate by time and place, given the additional benefits these systems offer. Charges could also be differentiated by vehicle mass and energy efficiency, but the benefits of this additional differentiation should be weighed against the additional implementation costs, and issues of complexity and public acceptability.

The high external costs heavy-goods vehicles impose – and the much lower number of affected vehicles and routes – suggest that initially applying a differentiated distance-based charging system exclusively to the freight transport sector would be a practical and cost-effective approach. Governments should also develop appropriate legal frameworks to support the adoption of distance-based charges, including rules addressing privacy concerns.

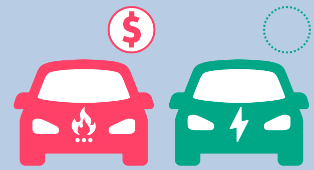
Reform incentives for the uptake of electric vehicles to better align with policy goals

The rapid decline in prices for electric cars relative to those of fossil-fuel-burning vehicles increasingly weakens the case for incentives that encourage their adoption. Governments should redirect tax expenditure towards supporting the transition to low-carbon vehicles in harder-to-decarbonise fleets, such as buses and trucks, and ensuring adequate charging infrastructure is available to support the large-scale shift to electric vehicles.

Figure 1. The problem of declining fuel tax revenues and potential solutions: A summary

The problem: Fuel tax revenue is declining

Government taxes on the fuel internal combustion engine (ICE) vehicles burn have long been the largest single source of revenue from vehicles and road use. Owners of electric vehicles (EVs) do not pay fuel taxes, and as the EV share in vehicle fleets increases, fuel-tax revenue will decline rapidly.



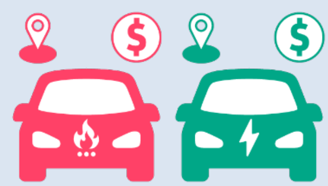
Potential solutions

Vehicle registration surcharges for electric vehicles

Some jurisdictions have introduced vehicle registration surcharges for EVs. They have recently become widespread in the United States, and have also been introduced in the Canadian province of Saskatchewan and in Singapore. These surcharges are often calculated to be equivalent to the average loss of fuel tax per vehicle. Where used, they typically co-exist with positive incentives for EV adoption.

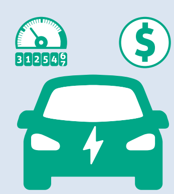
Congestion charges

Several cities, mostly in Europe, impose charges on all road vehicle owners entering and travelling in busy city centres, to reduce congestion. Congestion charges can usefully complement simple distance charges, raising substantial revenue and yielding large economic efficiency benefits. Earmarking the revenues towards road and/or public transport investments is known to make them more publicly acceptable.



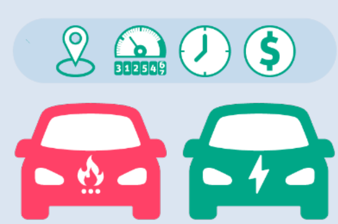
Distance-based charges

Some governments have introduced simple distance-based charges for road users. These largely apply to EVs, with some temporary exemptions to avoid reducing EV take-up. Revenue is collected via low-cost means (e.g. reporting odometer readings). Such charges can offset lost fuel-tax revenue and provide experience of road-user charging, paving the way for differentiated charges. However, flat-rate charges do a poor job of making motorists consider the costs their road use imposes on others.



Differentiated distance-based charges

Distance charges differentiated by time and place (and potentially other factors including vehicle mass and power) could deliver added efficiency and equity gains. However, they have not been implemented anywhere to date. This type of charge poses more complex challenges, both technically and in terms of legal and system design issues. Governments would also need to communicate the benefits of such schemes effectively to ensure public acceptance.



The problem of declining fuel-tax revenue

Governments have historically levied a range of taxes and charges on road users. These include taxes on the import, purchase and ownership of vehicles; user charges for specific infrastructure facilities (e.g. tolled bridges and roads); and fuel taxes. Many larger cities tax commercial parking services; some have introduced cordon charges to address congestion and pollution issues. Heavy goods vehicles (HGVs) are also subject to these charges, although they often benefit from partial rebates. In some jurisdictions, HGVs also pay time or distance-based charges for access to all or part of the road network. In most countries, vehicle and road-user tax revenues contribute to general government expenditure, but a few countries earmark (or "hypothecate") these revenues to fund spending on road infrastructure.

Fuel taxes have long been the largest single source of government revenue from the road transport sector. They are relatively equitable and efficient taxes compared, for example, to taxes on labour (ITF, 2018). The link between vehicle usage and the amount of tax paid moderates vehicle use and provides an incentive to purchase more fuel-efficient vehicles. Fuel consumption is directly correlated with carbon dioxide (CO_2) emissions and more weakly linked to other tailpipe emissions. Fuel taxes are also relatively easily and cheaply implemented.

The revenues derived from fuel taxes have been declining for some time, as the average fuel economy of the vehicle fleet has improved, while tax rates have remained static or even declined in real terms. This decline in revenue is accelerating as government policies in response to the climate emergency drive rapid electrification of the vehicle fleet.

The marginal cost per kilometre of using electric vehicles (EVs) can be an order of magnitude lower than that of internal combustion engine (ICE) vehicles, even in countries such as the United States, which has low fuel-tax rates (Doll, 2021). Thus, if EV use remains untaxed, the average distance travelled by passenger vehicles will likely increase significantly. This increase would exacerbate congestion problems and reduce the size of the decarbonisation benefits associated with the electrification of the fleet, as increasing vehicle-kilometres would partly offset the lower (but non-zero) emissions of EV use.

Therefore, governments urgently need to reform vehicle and road user taxation. New and improved taxes are required to address the expected decline in fuel-tax revenues, provide incentives consistent with the achievement of key policy objectives, and move to a sustainable and equitable transport system that offers high levels of accessibility for all.

Revenues from fuel taxes have been declining as a proportion of total government revenues for over two decades. In the United States, average fuel-tax revenue per vehicle mile fell 34.4% between 1994 and 2018, from USD 0.032/mile to USD 0.021/mile (Boesen 2020). In Europe, the proportion of total tax revenue provided by fuel tax more than halved, from 10% to 4.4%, between 1995 and 2020. Fuel tax now accounts for only around half of all road-user taxation in Europe, with vehicle ownership-related taxes making up the remainder (ACEA, 2021a; Transport and Environment, 2022).

The main contributors to these declines have been improvements in average fuel efficiency and a decrease in the real tax rates imposed. Fuel efficiency improvements averaged around 1.5% per year in Europe between 2000 and 2019 (Odyssey-Mure, 2021a) and 0.75% per year in the United States between 1994 and 2018 (Boesen, 2020). Improvements in fuel efficiency over this period, therefore, reduced the amount of fuel tax currently being collected by 28% in Europe and 18% in the United States.

Improved fuel efficiency has seen transport energy consumption grow much more slowly than gross domestic product (GDP) in most OECD countries. Between 2013 and 2019, the European Union saw a 0.6% decline in transport energy consumption per unit of GDP. Moreover, absolute reductions in transport energy consumption between 2007 and 2013 reversed the increases recorded between 2000 and 2006, although rises have again been recorded since 2014 (Odyssee-Mure, 2021c). In the United States, transport energy consumption peaked in 2007, albeit it had neared the previous peak value by 2019 before recording significant pandemic-related falls (US Energy Information Administration, 2023).

Declining real fuel-tax rates typically reflect the setting of taxes in terms of nominal amounts rather than percentage values. For example, the US federal fuel-tax rate has been set at the same nominal rate (USD 0.184/gallon) since 1993, implying a 45% decline in its real rate by 2021 (Peter G. Petersen Foundation, 2021). US state and local fuel taxes vary widely, with a federal fuel tax of USD 0.184/gallon supplemented by state taxes ranging between USD 0.09 (Alaska) and USD 0.54 (California). Overall, however, these taxes have remained broadly static, with a 27.9% increase in real revenues between 1992 and 2018, driven by a 26.4% increase in consumption (Statista, 2022a; Tax Policy Center, 2022). Average EU petrol excise rates show a somewhat different pattern, increasing substantially during the 1990s before declining 12.4% between 2000 and 2018 (European Environment Agency, 2019).

The long-term decline in fuel-tax revenues will accelerate as governments adopt increasingly stringent policies in response to the climate emergency. Achieving net-zero emissions by 2050 and meeting the ambitious interim targets for emissions reductions adopted in many ITF member countries, requires a rapid switch to EVs. Policies enacted in many ITF member countries to ban or heavily tax the sale of ICE vehicles in many ITF countries within little more than a decade reflect this urgency. For example, a 2019 EU regulation applies a tax of EUR 95/gram of excess CO_2 emissions to each car a manufacturer sells. From 2035, the base level of CO_2 emissions will be zero (European Parliament and Council, 2019: Article 8).

Increasingly stringent emissions regulations should also accelerate the rate of increase in fuel efficiency in ICE vehicles. Other policies favouring shifts towards sustainable modes should also reduce average vehicle-kilometres travelled, while post-Covid moves towards more flexible working arrangements could reinforce this trend.

A recent UK paper models the expected speed and extent of the decline in fuel-tax revenues. It shows that if the UK Government adopts the Climate Change Committee’s recommended actions to meet the government’s net-zero by 2050 commitment, fuel-tax revenues will decline by GBP 10 billion by 2030 and GBP 30 billion by 2040 (Lord and Palmou, 2021). By comparison, total fuel-tax revenue in the 2021/22 fiscal year was GBP 28 billion. A recent UK Treasury analysis stated: “Without changes in policy, the government expects these revenues [from fossil fuel-related taxes] to decrease to zero by 2050” (HM Treasury, 2021).

Offsetting revenue losses of this size via changes in other generally applicable taxes would require large rate increases. Lord and Palmou (2021) calculate that an increase in the value-added tax (VAT) rate of around 4% would be needed to offset the expected loss of fuel-tax revenue in the United Kingdom. A UK Parliamentary Committee calculated that, were income taxes to be used to offset the revenue loss, a 5% increase in the average rate would be needed (UK House of Commons Transport Committee, 2022). Such increases in general taxation are unlikely to be politically acceptable in most countries.

Efficiency considerations imply that replacing declining fuel-tax revenues with new and increased road user taxes is a preferable response. As noted, declining fuel tax per vehicle-kilometre (and the absence of a distance-related tax for EVs) reduces the marginal costs of driving and provides incentives to increase the intensity of vehicle use. If not addressed through other distance-related charges, this incentive will increase the external costs of vehicle use. It would also create an equity issue due to EV drivers' non-contribution to general taxation or road infrastructure costs.

While the move to electrification and the associated decline in fuel-tax revenues is expected to occur later in low- and middle-income countries (LMICs), its impact on government finances in these countries will be even greater, on average. While oil and fuel taxes represented 6.8% of total taxation on average in high-income countries in 2019, they accounted for 10.2% in middle-income countries. In some LMICs (e.g. Thailand), more than one-quarter of tax revenue comes from taxation on oil and fuel products (Benitez, 2021). That said, many LMICs heavily subsidise motor fuels. For this group, the move to EVs may improve rather than negatively affect the budget position.

Why tax vehicles and road use?

Choices regarding the preferred tax, or mix of taxes, to offset declines in fuel-tax revenue must reflect governments' underlying policy objectives. This section outlines three general objectives underpinning the taxation of vehicles and road use.

First, from an economic efficiency perspective, vehicle and road-user taxation aims to internalise the external costs associated with road transport, thus removing incentives for over-consumption. However, for many governments, the primary focus has been on a second objective: to ensure road users contribute substantially to road infrastructure costs, consistent with the user-pays principle. A third objective, pursued by some governments, is to generate general revenue from products with relatively inelastic demand. Doing so implies less distortion of the allocation of resources than taxing other activities with more elastic demand.

Understanding the relative size of infrastructure and external costs is essential when considering these three objectives. Recent research for the European Commission (EC) estimates the infrastructure and external costs associated with the different transport modes, as well as the extent to which they are currently internalised or recovered via the tax system. The definition of infrastructure costs adopted includes investments in new infrastructure, renewal costs of existing infrastructure, spending on infrastructure maintenance, and operational expenditures enabling the use of transport infrastructure. The annual infrastructure cost is defined as being "equal to the sum of the annual depreciation and financing costs" (Wijngaarden et al., 2019).

Using this definition, the EC estimated the total infrastructure costs for passenger cars for the 28 European Union member countries in 2016 as EUR 98 billion. By contrast, the external costs associated with passenger cars were estimated to be more than five times as large, at EUR 565 billion. Taxes on passenger cars were estimated to have raised a total of EUR 267 billion, equal to around half of the external costs. Taxes cover an even smaller percentage of these costs in the case of most other transport modes (Wijngaarden et al., 2019). These calculations were based on the relatively high fuel taxes (and some other vehicle charges) in the EU. They suggest that cost-recovery levels in most other jurisdictions would be significantly lower.

Internalising the external costs of motoring

The external costs of road transport include climate impacts, air and noise pollution, and crash and congestion costs. Some economists also treat government expenditure on road infrastructure, and the costs of road-focused policing, as external costs. (e.g. Freebairn 2022). Because these external costs are substantial, significant economic efficiency benefits arise if taxes on road users correspond to the marginal external costs of their road use – that is, the costs their road use imposes on others. This is because the higher post-tax cost of road use makes them take into account the costs their road use imposes on others.

Taxing external costs (through so-called Pigouvian taxes) also reduces pay-back periods for mitigation measures such as fuel economy and pollution-control technologies. The higher relative price of motoring that results, particularly at times and places where external costs are higher, leads to changes in road-user behaviour. External costs are both lower and redistributed to the road users who cause them.

Fuel taxes have been a major factor driving fuel-economy gains, with associated air-pollution benefits. However, limited attempts have been made to internalise other externalities via the tax system. Understanding the relative size of the externalities associated with passenger vehicle use and how they vary in different use contexts is essential when assessing the ability of various substitutes for a fuel tax to internalise them. The EC (2019) provides a breakdown of the total external costs of passenger vehicle use in Europe, summarised in Table 1. It shows that the two largest external costs associated with passenger car use arise from crashes, which account for 37% of the total, and congestion, which accounts for 35%. Climate costs rank third, at 10%.

Crash costs are best addressed using road-safety and insurance policies. Climate and congestion costs can best be addressed via fuel taxes and differentiated distance charges. Recent trends have seen congestion costs rising (ITF, 2021) and increasing urbanisation and densification suggest that this trend will continue without significant policy change.

Climate costs, while ranking third at present, can also be expected to increase significantly for ICE vehicles for two reasons. First, recent changes in the methods used to determine guideline values for shadow carbon prices in several ITF countries have led to much larger values than previously. Second, the upward trajectory for shadow carbon prices will continue, given the emission-reduction trajectories needed for countries to meet their Nationally Determined Contributions under the Paris Agreement process between now and 2050 (ITF, 2022).

Conversely, the climate-related costs of EVs are substantially lower and will decline further with the progressive decarbonisation of the electricity generation sector. These costs can best be internalised through their integration into comprehensive carbon pricing (emissions permit) systems, as is currently done in the EU, rather than directly via vehicle or road-user pricing.

Table 1. Total external costs of passenger car use in the European Union

Cost category	Cost (EUR billion/year)	Percentage of total
Crashes	210.2	37.2
Congestion	196.1	34.7
Climate	55.6	9.8
Air pollution	33.4	5.9
Noise	26.2	4.6
Habitat damage	25.9	4.6
Well-to-tank emissions	18.1	3.2
Total	**565.5**	**100.0**

Note: Data relate to 2016 and cover all 28 European Union members at the time. Well-to-tank emissions refer to emissions generated from the production and transport of fuel (or another energy source such as electricity) for transport vehicle use.
Source: EC (2019).

Cost differences by vehicle type and travel location

Table 2 provides estimates of the marginal external costs of passenger car use in the EU on a per vehicle-kilometre basis and compares the total marginal external cost in different contexts with the average amount of fuel tax paid. The marginal external cost is the additional cost imposed on others that is associated with a vehicle-kilometre travelled. It can be compared with the tax paid for this vehicle-kilometre to determine whether the tax system is providing the right incentives.

Table 2. Estimated marginal external costs versus fuel tax in European Union, 2016

<table>
<tr><th rowspan="2">Context</th><th rowspan="2">Type of vehicle</th><th colspan="5">Marginal external cost (EUR cents/kilometre)</th><th rowspan="2">Fuel tax (EUR cents/kilo metre)</th></tr>
<tr><th>Air pollution</th><th>Climate change</th><th>Noise and crashes</th><th>Congestion</th><th>Total</th></tr>
<tr><td rowspan="3">Dense traffic, metropolitan area</td><td>Fuel-efficient petrol car</td><td>0.22</td><td>1.57</td><td rowspan="3">3.00</td><td rowspan="3">Overcapacity: 66.3
Congested: 58.2
Near capacity: 47.2
Well below capacity: 0</td><td>4.8-71.1</td><td>5.3</td></tr>
<tr><td>Fuel-efficient diesel car</td><td>1.35</td><td>1.38</td><td>5.7-72.0</td><td>3.1</td></tr>
<tr><td>Full electric car</td><td>0.06</td><td>0</td><td>3.1-69.4</td><td>0</td></tr>
<tr><td rowspan="3">Dense traffic on rural motorways during the day</td><td>Fuel-efficient petrol car</td><td>0.13</td><td>1.35</td><td rowspan="3">0.45</td><td rowspan="3">Overcapacity: 29.4
Congested: 22.6
Near capacity: 15.9
Well below capacity: 0</td><td>1.9-30.5</td><td>4.6</td></tr>
<tr><td>Fuel-efficient diesel car</td><td>0.72</td><td>1.24</td><td>2.4-31.0</td><td>2.9</td></tr>
<tr><td>Full electric car</td><td>0.06</td><td>0</td><td>0.5-29.1</td><td>0</td></tr>
</table>

Notes: Carbon dioxide (CO_2) emissions are priced at EUR 100/tonne. The CO_2 content of gasoline is 2.392 kg/litre and of diesel 2.64 kg/litre. The fuel tax for the 15 members of the European Union prior to the 2004 EU enlargement (EU-15) is 0.8968 EUR/litre for gasoline and 0.6418 EUR/litre for diesel (EEA, 2021). No carbon emissions are registered for the use of electric cars as emissions from electricity production are assigned to the power sector, capped by the Emissions Trading Scheme, and priced into the cost of electricity. Additional detail from EC (2019).

Source: Proost (2022), derived from European Commission (2019) and EEA (2021).

Table 2 shows that the highest per-kilometre costs are those of congestion, which can be as high as EUR 0.663/km in metropolitan areas. By contrast, noise and crash costs average EUR 0.03 in the metropolitan context and EUR 0.0045 in urban areas, while air pollution costs range up to EUR 0.0135/km and climate change costs range up to EUR 0.0157/km. However, while congestion costs are potentially high, they are also highly variable. Van Dender (2019) cites UK data estimating that only around 10% of vehicle-kilometres are driven in heavily congested conditions, where costs are towards the upper ends of the ranges identified in Table 1.

Table 2 also shows that most categories of external cost differ widely between urban and rural contexts: noise and crash costs, taken together, are on average more than six times as high in urban areas, while air-pollution costs are around twice as high in urban areas. This implies that taxes designed to internalise such costs must be able to distinguish between these different contexts to function efficiently.

Climate, air pollution, and noise costs vary significantly with the vehicle's fuel source, while congestion and crash costs do not. Air pollution costs are five to six times higher for diesel cars than petrol cars, while they are more than twice as high for petrol cars as for EVs. Climate costs are broadly similar for petrol and diesel vehicles (slightly higher for the former), while the *external* climate costs associated with using EVs are zero (see note under Table 2). Again, taxes that seek to internalise such costs must distinguish between these contexts to function efficiently.

Figure 2 compares average external costs with current European tax levels using EC data. It shows that taxes over-recover the marginal external costs of petrol vehicles operating in uncongested environments. Taxes are approximately equal to external costs in uncongested urban contexts and significantly higher in rural contexts. Conversely, while taxes broadly cover the external costs of diesel cars in uncongested rural areas, they recover only about half of these costs in uncongested urban areas.

The difference between these external costs reflects the higher air-pollution costs associated with diesel fuel use and the lower tax rates applied to diesel on average. Figure 2 also shows that, while the external costs of EVs are significantly lower than those of ICE vehicles in uncongested environments, in congested environments, there is little difference (European Environment Agency, 2021).

The external costs of EVs are minimal in uncongested rural environments and only about half of the size of the external costs of petrol vehicles in uncongested urban environments. Hence, the absence of taxes on EV use has limited efficiency costs in these contexts. In congested environments, external costs substantially exceed current tax levels for all vehicle types. This reflects the limited use of congestion charges and the fact that congestion is the predominant source of external costs in such environments. Adopting congestion charging thus has substantial potential to yield economic efficiency gains.

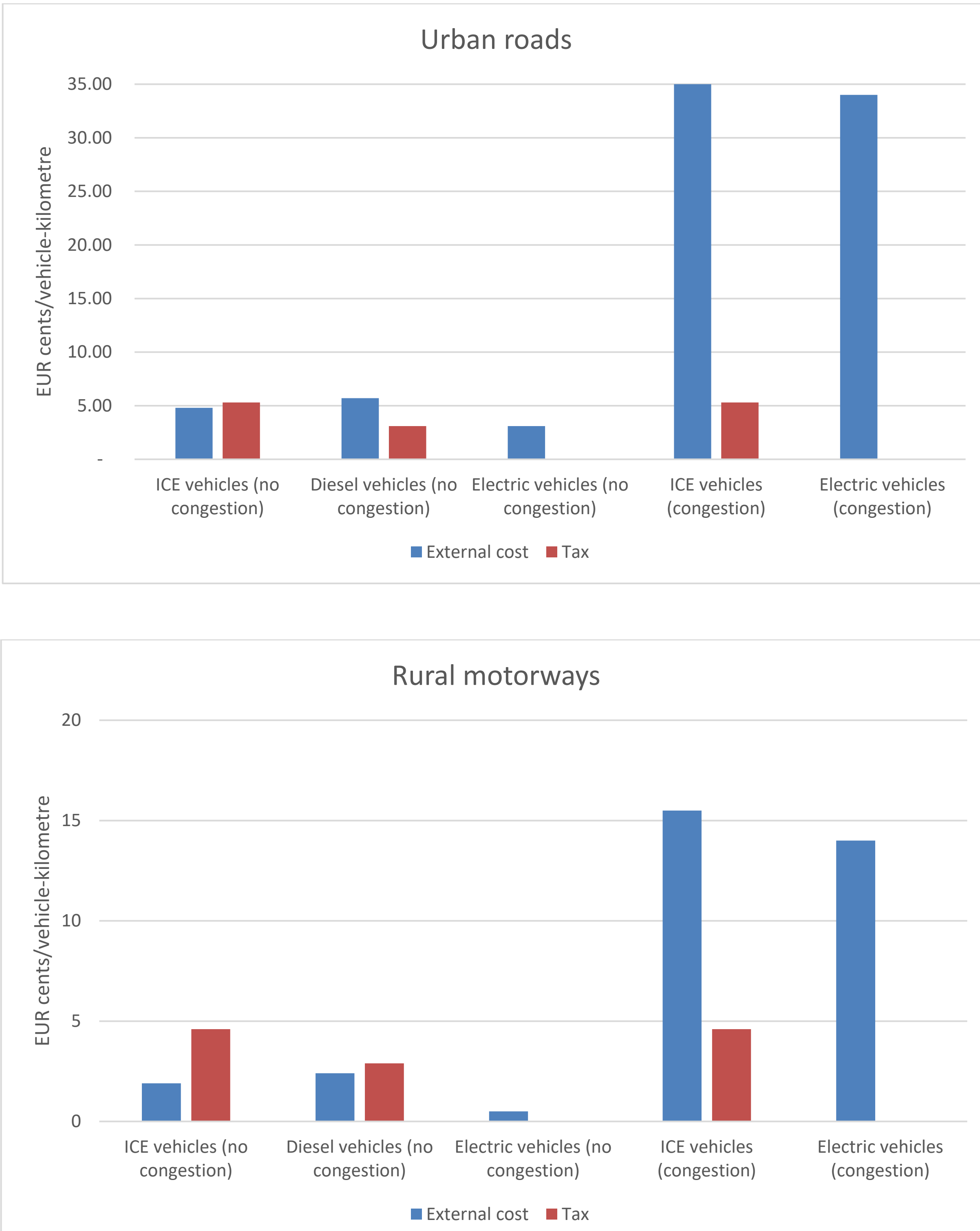
Significantly, these comparisons use average EU fuel taxes, which are high compared to most other jurisdictions. According to the OECD Tax Database (n.d.), in 2019, taxes in EU countries averaged 58% of the final consumer price, compared with 36% in Australia and only 19% in the United States. This implies that there is a much lower level of recovery of external costs in many or most other jurisdictions.

In summary, most of the major external costs of road use differ substantially according to time and place. External costs are significantly higher in urban areas and at peak times. Taxes that seek to internalise (or recover) these costs must similarly be capable of being differentiated by time and place if they are to yield a large proportion of the available efficiency benefits.

Taxes and charges that seek to internalise external costs should stimulate an efficient response that reduces the externality to an optimal level. Fuel taxes do this well for CO_2 emissions, as they encourage technological change in vehicle and engine design and choice of powertrain and reduce the overall traffic volume. Conversely, they cannot address congestion effectively, as they cannot incentivise changes in departure time or route choice or differentiate between peak and off-peak fuel consumption.

Climate cost is the only major external cost that does not vary with time and place. However, climate costs, which are substantially larger for ICE vehicles, are effectively internalised if fuel taxes are set at appropriate levels, as is largely the case in Europe.

Figure 2. Comparison of external costs and taxes in Europe



Note: ICE: Internal combustion engine. External cost data and fuel taxes are based on the external cost study of the EC (2019) and represent average conditions for the European Union.

Sources: Proost (2022). Data drawn from EC (2019).

The user-pays principle

The user-pays principle is an equity-based concept applied by many governments in major expenditure areas where only a subset of the population benefits from the expenditures made or where the extent of use of the assets varies widely. It is relatively rare for governments to formally earmark vehicle-related tax revenue to fund road infrastructure. However, justifications for such taxes often refer to the user-pays principle.

When applied to road infrastructure funding, this principle implies that the amount an individual pays in vehicle-related taxes should be proportionate to the extent of their road use or, more precisely, their contribution to variable road maintenance costs. There are sound economic efficiency arguments that the fixed costs of the road system (i.e. the construction costs) should be covered by fixed charges or general taxation (Eliasson, 2022). User charges are most efficient for recovering the variable costs of road use, including road wear, congestion, and other external costs.

There is little difference between light vehicle in the extent of the road damage costs they impose. This suggests that a proportionate contribution to infrastructure costs would be based on the number of kilometres travelled. Conversely, for heavy vehicles, road damage costs vary substantially with the mass per axle and its distribution between the axles. They are also generally much higher than for light vehicles, per kilometre travelled. The high proportion of variable road maintenance costs attributable to heavy vehicles and the wide variability in costs per vehicle-kilometre explain the increasing adoption of distance-based charges for trucks that are differentiated according to vehicle type. For example, one new European regulation is expected to phase out time-based road-use permits (vignettes) for heavy-duty vehicles on the core Trans-European Transport Network (TEN-T) by 2030, replacing them with a distance-based approach differentiated by vehicle class (Council of the European Union, 2021).

Given the limited variation in variable road maintenance costs imposed by different types of light vehicles, fuel taxes perform quite well in establishing proportionality between tax paid and contribution to road infrastructure costs. Any replacement for fuel tax should therefore share this characteristic if it is to perform similarly in relation to the user-pays criterion. Simple distance-based charges share this characteristic of ensuring direct proportionality between the extent of road use and the amount of tax paid. By contrast, vehicle import and purchase taxes, and annual registration fees do not. These fees constitute fixed costs for motorists, with no link between the amount paid and the distance travelled. Moreover, some researchers have argued that a high fixed-cost tax regime induces a “sunk-cost” effect, increasing owners’ tendency to use motor vehicles (see e.g. Ho, Png, and Reza, 2018).

Raising general revenue

A third objective of road and vehicle user taxation that is sometimes cited, or can be inferred from actual practice, is raising general government revenue. The appropriateness of this objective can be assessed using efficient taxation principles. In particular, this involves evaluating the extent to which these taxes give rise to deadweight losses, their administrative or implementation costs, and their equity impacts.

General taxation principles imply that if external costs have been fully internalised, the choice of additional taxes intended to raise general government revenue should avoid altering relative consumer prices so that household consumption patterns are not distorted (Van Dender, 2019). This, in turn, implies limiting the scope of taxes on the consumption of specific goods and services to internalising externalities and using general consumption taxes to raise general revenue.

The general direction of tax reform in OECD countries in recent decades has been consistent with this theoretical view. Governments have shifted away from raising revenue via the taxation of individual categories of goods and services and towards using generally applicable types of value-added tax (VAT).

Balancing taxation objectives

The analysis in this section suggests that if the amount of revenue raised by the taxes needed to internalise the external costs associated with road and vehicle use is insufficient to pay for the maintenance of road infrastructure, there is a question as to whether additional, sector-specific charges are appropriate. Eliasson (2022) notes that, in practice, there are numerous areas of major public expenditure (e.g. public transport, bike lanes, and various cultural institutions) where the user-pays approach is not fully adopted. Elisasson suggests that additional taxes to recover infrastructure costs would not necessarily be justified if the revenue from externality-based taxes proves insufficient.

In practice, given the high external costs of road vehicle use, the revenue derived from Pigouvian taxes designed to internalise them fully would at least equal the cost of road infrastructure expenditure. Börjesson et al. (2023) calculate the revenue effects of imposing optimal Pigouvian taxes in the Swedish context and conclude that, under the given assumptions, "optimal marginal cost pricing yields a revenue that covers the optimal infrastructure spending".

Data from the EC (2019) appears to support this view, as the reported average infrastructure cost per vehicle-kilometre is EUR 0.033, while average fuel taxes, as calculated by Proost (2022), vary between EUR 0.029 and EUR 0.053 (see Table 2). Charges to internalise congestion costs would generate significant additional revenue. This suggests that a tax regime based on the efficient internalisation of externalities would fully fund infrastructure expenditure and contribute significantly to general revenue.

Additional data from the EC (2019) also supports this conclusion. The external costs of passenger transport by road in Europe are estimated at 4.2% of GDP on average for EU countries. After removing the contribution of buses, coaches and motorcycles, the external cost of passenger car use is estimated to average 3.8% of GDP. By contrast, the International Road Federation (2021) estimates that, on average, European countries spend between 0.8% and 1.2% of GDP on road transport infrastructure.

The merits of distance-based charging

Distance-based road-user charging has long been considered a relatively efficient and equitable approach to taxing transport (Börjesson, Asplund, and Hamilton, 2023; Infrastructure Partnerships Australia, 2019). It is used on tolled highways, for heavy-vehicle use of some untolled highway networks, and to manage congestion on several routes. Political acceptance has limited its wider use until now, but the increasing social costs imposed by congestion and the urgent need to replace fuel-tax revenue are changing this calculus.

The US Government is encouraging tax reform by funding pilots of road-user charging schemes via the Surface Transportation System Funding Alternatives (STSFA) grant programme. The National Conference of State Legislatures (NCSL) and the Federal Highways Administration are collaborating to enable information exchange regarding the results of these pilots. To date, 14 state and regional pilots have been conducted. At least three US states – Oregon, Utah, and Virginia – have adopted distance-based charges as a permanent feature of their tax systems (National Conference of State Legislatures, 2022a).

In the United Kingdom, a recent report by the House of Commons Transport Committee (2022) recommends that “the Government must set out a range of options to replace fuel duty and vehicle excise duty. One of those options should be a road-pricing mechanism that uses telematics technology to charge drivers . . . according to distance driven, factoring in vehicle type and congestion”.

This recommendation highlights that distance-based charges can differ widely in their design and ability to achieve taxation objectives. In its simplest form, a distance-based charge applies a single tax rate per vehicle-kilometre to all light vehicles. More complex charges can be differentiated in several dimensions, most commonly by time, place, and vehicle type.

Different types of distance-based charges vary significantly in their potential ability to address the identified taxation objectives. Undifferentiated distance-based charges share with fuel tax the characteristic of creating a direct link between the extent of a motorist’s road use and the amount of tax paid. Therefore, even a simple road-user charge is a good substitute for a fuel tax in this respect. It also provides a strong link between the tax paid, and the size of climate-related costs generated.

However, undifferentiated distance-based charges perform poorly in internalising the other external costs of road use, as already discussed, because these vary widely with time and place. They also raise equity issues, as drivers living outside metropolitan areas may have fewer, if any, alternative forms of transport available. Moreover, if applied to ICE vehicles as a substitute for fuel tax, distance charges perform less well on efficiency grounds. As noted, fuel taxes provide a strong link between tax paid and the extent of the climate and (to a lesser extent) air-pollution externalities created. They thereby create incentives to purchase more fuel-efficient vehicles. Because an undifferentiated distance-based charge does not share this characteristic, it performs less well than a fuel tax when applied to ICE vehicles.

A spatially and temporally differentiated distance-based charge can, at least in theory, efficiently internalise a range of external costs. That is, it can enable a close matching of the size of the external costs associated with specific journeys and the charges levied. Such differentiation is needed to efficiently address the following:

- congestion, which is confined mainly to city centres
- crash costs, which vary in terms of urban versus rural travel and between motorways and other roads
- noise costs, which vary between urban, suburban and rural contexts, with traffic density and the time of day
- air pollution costs, which also differ in terms of urban versus rural travel, due to the larger health impacts resulting from higher population exposures in urban areas.

Few differentiated distance-based charges are yet in operation. This reflects three specific challenges:

1. **Technical issues.** Singapore's experience in extending its road-user charging system suggests roadside infrastructure is needed to supplement GPS-based tracking systems in areas where there is dense high-rise development (Theseira, 2020).
2. **Cost issues.** Dedicated tracking technologies will impose greater system costs than a simple distance calculation in the current and immediately foreseeable environment.
3. **Acceptability issues**. These concern both the principle of road-user charging and the privacy issues arising from the use of GPS-based systems, which necessarily record individual vehicle movements.

Eliasson (2022) notes that while the size of external costs is highly context-specific, there are practical limits to how finely any charging system can differentiate charges by time, place, or other dimensions. Greater differentiation increases system costs. Therefore, the net (of system cost) efficiency benefits of moving to a more sophisticated charging regime may be significantly smaller than the gross benefits. This implies that policy makers should only invest in a more sophisticated and costly system if the increase in system costs is more than compensated by the efficiency or equity performance improvements it can provide (Eliasson, 2022).

The following section discusses the limited experience with simple distance-based charging systems and other recent policy initiatives to address the decline in fuel-tax revenue due to increasing EV adoption.

Emerging practices in supplementing fuel taxes

Recognition that EV owners do not contribute fuel-tax revenue has led a small but growing number of jurisdictions to adopt EV-specific charges, in some cases on a trial basis. These almost invariably take the form of vehicle ownership surcharges or simple "flat-rate" distance-based charging systems. Notably, such charges typically co-exist with positive incentives for EV adoption. Indeed, positive incentives have sometimes been expanded in conjunction with the adoption of the EV-specific charge. In general, incentives reduce the initial purchase cost of an EV, while EV-specific charges increase the cost of ongoing ownership or use. This section discusses three types of reform aiming to supplement fuel taxes: vehicle ownership tax surcharges, undifferentiated distance-based changing systems, and congestion charging.

Vehicle ownership tax surcharges

Registration surcharges for EVs have recently become widespread in the United States. According to the National Conference of State Legislatures (NCSL, 2022b), 30 US states levy these additional charges on battery electric vehicles (BEVs, or fully electric vehicles), while 14 also impose them on plug-in hybrid electric vehicles (PHEVs). The fees for BEVs range from USD 50-225 per year, while fees for PHEVs range from USD 32-100. A minority of states have indexed these fees to inflation. The revenue is usually earmarked for transport funding, although a few states have also dedicated a proportion of the revenue to developing EV charging infrastructure.

The Canadian province of Saskatchewan adopted a CAD 150 fee for EVs in October 2021 and appears to be the only Canadian jurisdiction to have done so to date. Singapore has also adopted an "Additional Flat Component" on its road tax. This applies specifically to EVs and increased to SGD 700 per annum in 2023, an amount calculated as being equivalent to the fuel duty payable on around 1 060 litres of petrol. The policy is described as transitional, pending the introduction of a distance-based charge. In addition, the differential basis for calculating the standard road tax amount for EVs and ICE vehicles (power output versus engine capacity) tends to result in significantly higher charges for EVs.[1]

No other examples of such surcharges have been identified. Indeed, the widespread adoption of these fees in the United States is notable in that discounts on, or waivers of, annual registration fees are frequently among the incentives adopted by governments in Europe and elsewhere (e.g. Australia) to promote EV uptake.

Undifferentiated distance-based charging systems

Two major features of undifferentiated distance charging are simplicity and ease of implementation. Since a single rate per kilometre is applied to all travel, determining the charge payable does not require sophisticated tracking equipment. Instead, it can be based on periodic reporting of odometer readings, an approach already adopted for some tax compliance purposes. This has several benefits, including potentially low implementation costs and high expected reliability in implementation, with minimum delay, and tried and tested approaches to preventing tampering. It also avoids the privacy concerns associated with the geolocation element of a GPS-based system.

One advantage of undifferentiated distance-based charges over vehicle ownership tax surcharges is that they incorporate proportionality between the amount of tax paid and the extent of road use (i.e. distance travelled). A limited number of charging schemes of this type are currently in use, but there appears to be a growing trend towards adopting them in at least a few countries. This section discusses eight such schemes established in three countries: Australia, New Zealand, and the United States. Iceland (see Box 1) also plans to adopt a distance-based charge for road use in the near future.

Seven of the eight existing schemes have been adopted in the past three years, by sub-national governments. The exception is the New Zealand scheme, which has been in place since 1978, and initially applied primarily to diesel vehicles. All eight schemes apply only to a subset of the vehicle fleet. A notable difference between them is that distance recording is via the vehicle odometer in Australia and New Zealand but uses a dedicated electronic device in the United States.

Distance-based charging in New Zealand

New Zealand's road user charge (RUC) potentially provides the greatest insight into the operation of such schemes, given its long history. The RUC applies to all vehicles using untaxed fuels. In practice, this has historically meant diesel vehicles, as New Zealand's fuel-taxation system does not include diesel fuel. It was initially adopted primarily to ensure heavy vehicles contribute to the cost of the road infrastructure damage for which they are responsible, with very few light vehicles being diesel fuelled at the time of introduction. However, diesel cars now account for 20% of the passenger vehicle fleet.

EVs are notionally subject to the RUC requirement, given that the electricity used to charge them is also untaxed. However, they currently benefit from an exemption, originally scheduled to expire in 2021 but recently extended to 2024. The intent of the exemption is to avoid creating a disincentive to EV take-up in the short term, with the RUC to apply to EVs once they have achieved significant market penetration.

Diesel vehicle users must obtain an RUC licence, with licences purchased in 1 000km units. The licence system is based on vehicle type and weight. All light vehicles (i.e. two-axle vehicles under 3.5 tonnes in weight) pay the same licence fee. RUC licences state the starting and finishing odometer readings. They must be displayed on the vehicle windscreen, enabling enforcement by checking the current odometer reading against the finishing reading on the licence (New Zealand Transport Agency 2023).

Box 1. Distance-based charging in Iceland

Iceland plans to adopt a distance-based road charge. It is expected to apply to all vehicles, in contrast to existing charges elsewhere, and would substitute for the fuel tax. The charge will be undifferentiated implemented via odometer readings and integrated in the annual vehicle inspection system. The revenue from the charge will be earmarked to fund a new bus rapid transit scheme which will form the backbone of the public transport system in the Reykjavik region. The scheme is intended to promote a significant shift toward public transport. Acceptability is not expected to be a major issue, as the national association of vehicle owners has already expressed support for the initiative.

Source: Hermannsson (2023).

A US Government delegation reviewing the system noted that this allowed police to check that the licence was up to date during annual vehicle inspections and routine traffic stops. However, it concluded that "compliance under New Zealand's RUC system is largely based on the honor system, with some external enforcement mechanisms" (Binder, 2019). In contrast, heavy vehicles typically use electronic distance recording devices ("hubdometers") linked to software allowing users to purchase distance licences automatically.

Government policy currently seeks parity between the level of fuel excise and RUC rather than providing incentives to choose one or the other fuel source. It is unclear whether the same approach will be taken when the RUC extends to EVs in 2024. In the 2019/20 fiscal year, light diesel vehicles contributed around NZD 700 million of the NZD 1.8 billion raised by the RUC. The NZD 1.8 billion RUC contribution represented slightly less than half of that year's total NZD 3.9 billion receipts of the National Land Transport Fund. The remainder came from fuel excise (NZD 1.2 billion in 2020), registration and other vehicle-related fees.

Distance-based charging in the United States

In the United States, state fuel taxes fund around 40% of transport spending. As noted above, the federally supported Surface Transportation System Funding Alternatives (STSFA) grant programme facilitates the implementation of pilot programmes to explore alternative funding sources to fuel tax, with ten including road user charges. The NCSL and the Federal Highways Administration collaborate to enable information exchange regarding the results. As of April 2022, 14 US states had received funding for pilot schemes.

At least three states – Oregon, Utah and Virginia – have moved beyond pilot programmes and adopted distance-based charges as a permanent feature of their tax systems (NCSL, 2022a). All three are "opt-in" schemes. That is, each of the three states has adopted a registration surcharge for vehicles that pay little or no fuel tax. They then offer the option of participating in their respective distance-based charging schemes on the basis that participants are exempted from liability to pay the registration surcharge.

Oregon's OReGO scheme is available to drivers of EVs and other vehicles with a rated average fuel consumption better than 40 miles per gallon (mpg; 17km/L) and commenced in January 2020. It charges enrolled vehicles an RUC of USD 0.019/mile but exempts them from the registration surcharge of USD 110 per year. Thus, the surcharge value equals approximately 5 790 miles (9 320km) of RUC payments – a distance slightly less than the state's average vehicle mileage (6 300 miles). The opt-in scheme provides incentives for EV owners who travel long distances to pay the surcharge and those who travel limited distances to pay the RUC. ICE vehicle drivers who opt-in to OReGO also receive credit for fuel tax paid, thus reducing their RUC liability (Oregon Department of Transportation, 2022).

Utah has adopted a very similar scheme. The main difference is that it applies only to alternative fuel vehicles (i.e. BEVs, PHEVs and conventional hybrids). The RUC is USD 0.0152/mile, and the registration fee otherwise payable is USD 123 for BEVs, USD 53.25 for PHEVs and USD 20.50 for conventional hybrids. A major difference between the two schemes is that Utah caps the amount payable via the RUC at the same level as the registration charge. Thus, there are larger incentives for BEV and PHEV owners to opt into Utah's RUC since there is no possibility of paying more (Utah Department of Transportation, 2022).

Virginia has applied a highway use fee (HUF) to all passenger vehicles with a rated fuel consumption better than 25mpg (10km/L) and given those liable to pay the fee the option of enrolling in a distance-based charging scheme called the Mileage Choice Program (MCP). However, whereas the registration surcharges adopted in Oregon and Utah are flat amounts, the HUF varies with the vehicle's fuel efficiency. The amount payable is calculated as follows:

1. The notional fuel tax payable by each vehicle eligible to pay the HUF is calculated using its rated fuel consumption and the stated average annual mileage of 11 600 (18 668km).
2. The notional fuel tax payable by a vehicle with the average rated fuel consumption for the current fleet (23.7mpg) is calculated using the average annual mileage.
3. The HUF is levied at 85% of the difference between the notional fuel tax paid by the vehicle type in question and the notional fuel tax paid by a vehicle with the average rated fuel consumption.

The HUF applies to 1.7 million vehicles, equivalent to 25% of the light vehicle fleet. It raised USD 53 million in the 2021/22 fiscal year.

Owners of vehicles subject to the HUF in Virginia can avoid the fee by opting into the MCP, which requires drivers to pay a per-mile fee (set as the vehicle's HUF divided by 11 600). As with the Utah programme, the maximum fee payable by drivers opting for the MCP is equal to the HUF liability that the vehicle would otherwise incur. The MCP commenced on 1 July 2022. The HUF was part of a package of short-term responses to declining fuel-tax revenue, including an increase in the fuel-tax rate and its indexation to inflation. The longer-term objective is to move all drivers to a mileage-based road-user fee programme (Cummings, 2022).

In all three states, distances travelled are reported via in-vehicle devices supplied by Emovis, although Virginia also allows for reporting via manufacturer-installed vehicle telematics. Devices appear to be provided without charge but are subject to fees for loss, damage, or non-return (e.g. USD 95 in Virginia). Invoicing arrangements differ: In Oregon, invoicing occurs quarterly, and payment is made online via credit card. In Utah, an account with a pre-paid balance is established, with automatic charging and deduction of funds in set increments to maintain the pre-paid balance above a set threshold.

None of the schemes report location data to registration authorities. In Utah, distance reporting devices are not GPS-equipped. Users can choose between GPS-equipped and non-equipped devices in Virginia; in the former case, location data may be reported to police in the context of criminal investigations. Charges are incurred for distances driven both within and outside the billing state. However, the Utah state government has noted its intention to differentiate between in-state and out-of-state mileage in the future, as technology allows (Utah State Department of Transportation 2022).

Distance-based charging in Australia

Four of Australia's eight sub-national governments – New South Wales, South Australia, Victoria, and Western Australia – legislated the introduction of distance-based charging between 2020 and 2022. All these schemes apply exclusively to EVs. However, only Victoria has implemented the charge to date. The remaining three states have scheduled implementation for 2027, in all cases arguing that the delay is intended to prevent short-term disincentives to the take-up of EVs. The following describes Victoria's charging scheme. However, the charges adopted in the other jurisdictions are similar, and the implementation systems adopted are likely to be similar.

Victoria's charging scheme applies to BEVs and PHEVs. The charge was set at AUD 0.025/km for BEVs and AUD 0.02/km for PHEVs, with the lower rate for PHEVs reflecting their contribution to fuel-tax revenue. Charging commenced on 1 July 2021, and payment is made during the annual vehicle registration renewal or on the sale of the vehicle. The charges are subject to yearly indexation to inflation.

Owners must provide photographs of their odometer reading as part of the annual vehicle registration renewal and on vehicle purchase and sale to enable the calculation of the tax. Invoices are issued in response to the odometer declaration. The registration authority's website and mobile phone application are the default means for managing the declaration, invoicing and payment process. The charge applies to the total distance driven in the relevant period within Victoria and other Australian states, as is the case with the US schemes described above. This latter element has been somewhat controversial but appears inevitable, given the simple technology used to calculate the charge.

The Victorian Government states that the tax per kilometre paid via the distance-based charge will be around 45% less than the average tax per kilometre paid via fuel tax. This is broadly consistent with the estimate of Freebairn (2022) that the current fuel excise is equivalent to an RUC of around AUD 0.044km. The government argues that the lower external costs of EVs (i.e. their reduced air and noise pollution) justify this lower average rate.

Conversely, some opponents of the charge note that BEVs may pay a higher tax per kilometre than some highly fuel efficient "conventional" (i.e. non-PHEV) hybrid vehicles. US research has identified similar concerns, with researchers arguing that the likelihood that drivers of more fuel-efficient cars will pay more under a distance-based charge than a fuel tax creates an equity problem by penalising environmentally conscious motorists (NATSEM, 2016).

Political considerations

Policy advisory bodies in Australia have advocated the introduction of road-user charging since the 1990s (Infrastructure Partnerships Australia, 2019). However, the Victorian scheme was initially strongly criticised, with critics focusing on the adoption of an EV-specific charge in a context where there were few government incentives for EV take-up. This opposition included an open letter opposing the charge from 25 EV manufacturers, charging suppliers and industry groups, which described the charge as "the worst EV policy in the world" (Australia Institute, 2021).

Despite this, the New South Wales Government, initially strongly critical of the Victorian legislation, and two other state governments (South Australia and Western Australia) legislated almost identical charging schemes within the following year. All four governments adopted new incentive packages for zero or low-emission vehicle (ZLEV) uptake around the same time as their distance-based charging legislation. This suggests a perceived need to balance the new distance-based charges for EVs with enhanced incentives.

However, the near-simultaneous publication of similar incentives by all four of the states and territories that have not announced distance-based charging schemes suggests the existence of a broader political imperative. Australian governments may perceive a need to "catch up" in this policy field, where the country has lagged internationally. Comparing the packages' content and the size of the individual incentives available does not suggest any link between the scale of the incentives offered and the adoption of a distance charge (Deighton-Smith, 2022).

Less than 2% of new vehicle registrations in Australia in 2021 were of ZLEVs. Therefore, the Victorian Government moved to implement distance-based charging for EVs at a time when the affected group would be small. Given the limited revenue likely to be generated in the short term, this appears to reflect a view that early adoption – as recommended by some proponents of such charges (see e.g. Infrastructure Partnerships Australia, 2019) – would improve the acceptability of the policy. That is, the extent of the opposition from immediate losers from the policy will be limited, as they are few. Moreover, ICE drivers concerned about EV owners "free riding" on fuel-excise revenues may view the policy favourably.

Conversely, the three states that significantly delayed the introduction of their distance-based charges argued that in doing so they would avoid creating disincentives to EV take-up at an early stage in the transition of the vehicle fleet. The expected shift towards price parity between ICE and EV within the next several years arguably supports this approach. Statements from these governments also suggest a belief that these charges will appear more legitimate or acceptable at a time when significant erosion of fuel excise revenue has occurred.

Regardless of their differing approaches to implementation timing, Australian state governments seem to have taken the strategic view that timely adoption of the principle of distance-based charging as soon as possible should take priority rather than first developing a sophisticated charging mechanism that can address pollution and congestion externalities. As noted, the Australian charges are likely to yield only limited revenue in the near term. Perhaps because of this, governments have made no specific statements regarding the hypothecation of this revenue.

Congestion charging

Proost (2022) summarises current congestion-charging schemes, which are found mainly in Europe. As shown in Table 3, only eight schemes are operating, although the earliest were adopted several decades ago. The schemes in operation have generally been judged successful in reducing congestion and generating net revenue, and public support for them has tended to increase over time. While the political risks associated with congestion charging have continued to impede their wider adoption, some cities have recently developed congestion charging proposals. For example, New York City expects to implement a congestion charge in early 2024 (New York City Council, 2023). This perhaps suggests a new impetus to adopt the reform is developing.

Table 3. Examples of cities that have introduced congestion charging

Urban area (year)	Stated objective	Use of revenues
Singapore (1975, 1998)	Congestion	Not hypothecated.
Bergen, Norway (1986)	Financial, environmental	Initially, only for financing local road projects, then 45% for road construction and 55% for improving environmental quality and road safety.
Oslo, Norway (1990)	Financial	Investments in local road capacity and public transportation projects.
Trondheim, Norway (1991)	Financial and congestion	Financing local road infrastructure (road capacity), with some earmarking for public transportation and cycling and walking.
London, United Kingdom (2003)	Congestion	Financing local public transportation (80%), road safety (11%) and cycling and walking (9%).
Stockholm, Sweden (2006+2007)	Congestion	Financing local road infrastructure and public transportation.
Milan, Italy (2008 and 2010)	Environmental, then congestion	Financing local public transportation and cycling and walking.
Gothenburg, Sweden (2013)	Congestion, environmental, financial	For financing local road infrastructure and public transportation.

Source: Proost (2022), derived from Baranzini, Carattini and Tesauro (2021).

Table 3 also highlights the stated objectives of each congestion charge. While none is described explicitly as a substitute for fuel-tax revenues, the three Norwegian schemes have explicit financial, congestion and environmental objectives. Most also earmark scheme revenues towards road and public transport investments. To this extent, these congestion charges could be considered de facto substitutes for fuel-tax revenue, although a different level of government generally collects them.

Congestion charges can generate significant revenues from road users in the long term and therefore act at least to some degree as a substitute for declining fuel taxes. That said, Singapore's experience suggests congestion charges will likely yield significantly less revenue than is currently obtained from efficient fuel taxes. In the 2010s, Singapore's fuel-tax revenues were about five times as large as road-pricing revenues, despite a comprehensive road-pricing system based on efficient traffic-flow objectives (Theseira, 2020). Moreover, acceptability considerations will tend to limit the availability of these revenues to projects in the areas where the charges are levied.

Improving public acceptability

Taxation reforms are typically politically challenging to implement due to factors as diverse as issues of trust in political institutions and a tendency to status quo bias among taxpayers. Tax reform in the road transport sector has often been impeded by some groups' high expenditure on road transport and the propensity for oil-price volatility to yield sudden, large changes in motoring costs. The adoption, by many ITF countries, of substantial short-term reductions in fuel taxes in response to recent cost-of-living pressures highlights this dynamic.

Distance-based charges constitute a substantial reform in this field and have historically been considered particularly challenging to implement. However, the increasingly apparent problem of declining fuel-tax revenue appears to have increased public and political willingness to consider this alternative. As noted above, government and parliamentary initiatives in the United States and the United Kingdom are moving in this direction, and recent research on public attitudes suggests a relatively high level of support for such taxes.

A recent UK Campaign for Better Transport (2022) survey found that 60% of respondents recognised the need for tax reform in the road/vehicle user sector, and 49% supported adopting distance-based charges, compared to only 18% who were opposed. Perhaps surprisingly, support was higher among motorists than non-motorists (52% versus 43%), although this was due to a higher proportion of undecided non-drivers.

The most convincing arguments for distance-based charging were:

- the need to ensure EV drivers pay tax like all other road users (65% of respondents)
- the ability of a distance-based charge to reward those who drive less, yielding environmental benefits (61%)
- the need to ensure those who cause the highest external costs pay for them (60%)
- the need to improve the transparency of vehicle/road user taxation (58%)
- the need to offset falling fuel-tax revenue (56%).

Notably, the survey found little difference between the acceptability of odometer- and GPS-based charging systems.

The main reason for people initially opposing reform was concern about the impact on people with no choice but to drive. More than two-thirds of respondents (69%) stated that cheaper and better public transport would increase their support for distance-based charges, highlighting the need to improve the availability of alternatives to enhance fairness.

Careful consideration of the design of new taxes and charges and their presentation to the public are major factors in ensuring acceptance and, thus, in the successful and timely implementation of the policy. Proost (2022) identifies several major acceptability issues and strategies in relation to vehicle taxation reforms. He focuses on the acceptability issues arising in adopting the theoretically preferable reform involving distance-based charges differentiated by time and place. The following discussion draws on Proost (2022) and several other sources, as indicated, to provide an overview of acceptability issues.

A threshold issue is the sometimes-significant differences between proposed reforms' objective benefits and costs and their subjective values, as seen by the affected population. These differences may be due to several factors, including loss aversion (where potential losses are valued more highly than potential gains) and status quo bias. Understanding the sources of these differences between subjective and objective assessments enables policy makers to develop strategies to increase understanding of the impacts of policy changes and improve acceptance.

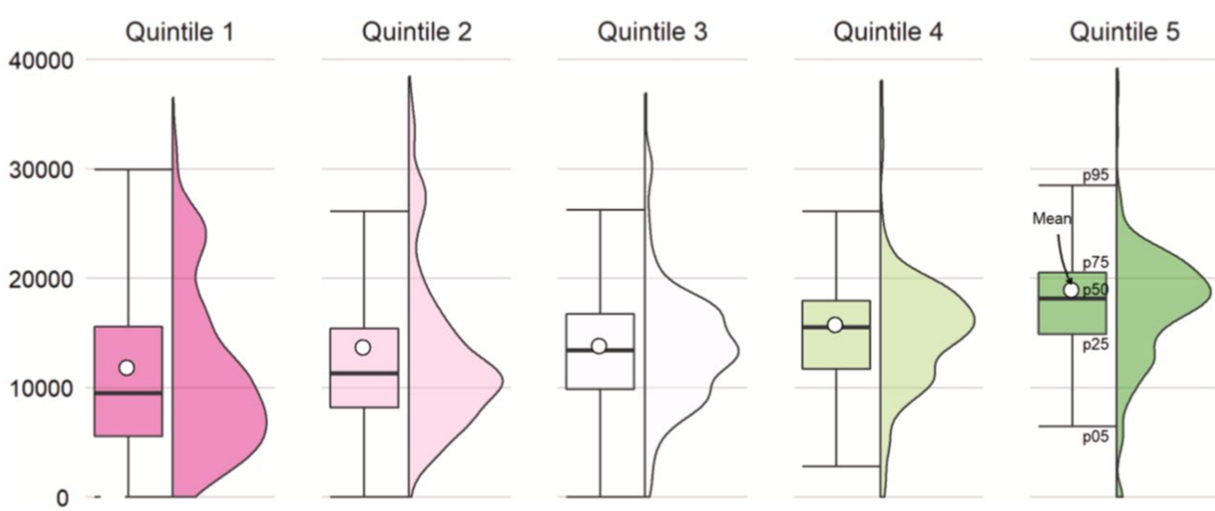
Proost (2022) also notes that a tax reform's acceptability depends on both its expected impact on the individual concerned and its perceived fairness.

Accounting for heterogeneity within groups

A core issue regarding the distributional impact of distance-based charging is the heterogeneity of the effects within groups. The main areas of concern are generally the different impacts on urban and rural populations and different income groups. However, other considerations, including gender, household type, occupation, and location, may also be significant (Proost, 2022).

Research shows that higher-income households travel significantly further by car on average, although the extent of these differences between income groups varies widely by country. For example, the highest income quintile travels 2.7 times as far by car as the lowest quintile in the United Kingdom (UK DfT, 2016) but only 1.5 times as far in Flanders (Proost, 2022). The higher distances travelled by higher-income households imply that both fuel taxes and distance-based charges are broadly progressive in their impact. However, Figure 2 demonstrates that, while mean and median distances travelled per household increase with income quintile, there is wide variation around these central values for all quintiles. The lowest income quintile exhibits the second largest degree of variation.

Figure 3. Distribution of annual mileages by income group in the Flanders region of Belgium



Source: Heyndrickx, Vanheukelom and Proost, 2021.

Table 4. Distance travelled by car in the United Kingdom by rural-urban classification

	Classification	Distance (miles)
Urban	London	2 038
	Urban conurbations (ex-London)	3 373
	Urban city and town	4 344
Rural	Rural town and fringe	7 353
	Rural village, hamlet and isolated dwelling	8 465
Average		5 023

Source: UK DfT (2020).

This variation within quintiles is correlated with several other household characteristics, including household type, age and geographical location. The latter is an important factor, with UK data showing that the distance rural village and hamlet dwellers travel by car is more than four times that of London residents. A continuum exists between the degree of urbanisation and car use, as shown in Table 4.

This heterogeneity within groups necessarily complicates the design of tax reform policy packages (e.g. revenue recycling measures) to address inequities and increase acceptability. However, it also highlights the potential for tax reform to yield improvements in distributional outcomes compared to current arrangements. For example, a distance-based charge set at a lower rate for rural dwellers would yield distributional gains, recognising the higher average distances covered by this group while being justifiable on efficiency grounds due to the lower external impacts of motoring in rural areas.

Designing more acceptable congestion charges

Proost (2022) shows that the direct benefits most drivers receive due to the application of a congestion charge are significantly smaller than the amount paid via the charge. This is to be expected, as congestion costs comprise the delays experienced by the individual driver and the delays their use of the roads inflicts on the many other drivers using the road simultaneously. It implies that the use of charging revenues will be a major factor in determining acceptability. Those who pay the charge need to receive significant benefits, funded by using that revenue if they are to be personally better off. Moreover, those "priced off" the road by the charge do not pay it directly but suffer a loss due to its existence. They must also receive some offsetting benefit to be better off overall.

Proost notes that, theoretically, the most direct way to make drivers share in the benefits of congestion charges would be via a scheme of grandfathered "peak mobility rights". These are sometimes referred to as credit-based congestion pricing (CBCP) or tradeable driving credits (TDC). An example can demonstrate the operation of these instruments. Assume one wants to reduce the number of weekly peak trips by 20%. A congestion toll achieves this by making all drivers pay for all peak trips, increasing the price until 20% of trips are substituted to another mode or a non-peak period.

In the grandfathered rights alternative, all peak-period drivers would receive free rights to undertake 80% of their current number of peak trips and must bid for the rights to undertake additional trips. This option reduces the average cost imposed on drivers and creates the potential for drivers who reduce their peak period trips by more than 20% to make a net financial gain. One would expect gaming by excessive driving before the system is introduced, but De Borger, Glazer and Proost (2022) show that this is a minor problem if one sticks to the initial allocation.

A grandfathered rights scheme could also lead to objections based on perceived inequity (e.g. between new residents and holders of grandfathered rights). However, Proost argues allocating part of the rights to newcomers – a technique used frequently for pollution rights – can effectively address this issue. As suggested above, unlike a congestion charge, a grandfathered rights scheme would not generate net revenue for the government. Therefore, a trade-off exists between the potentially greater acceptability of the grandfathered rights and the fiscal benefit of the congestion charge. However, Proost notes that, when considering this factor, it is essential to bear in mind the need to use a significant proportion of the revenue to provide offsetting benefits for those paying the charge. This implies that congestion charges have little potential as a new source of general, as opposed to local, government revenue.

An alternative means of enhancing the acceptability of congestion charges is to use the revenues to improve local public transport services or infrastructure for active transport (e.g. walking, biking, and scooters). De Borger and Russo (2018), using a model calibrated to the specifics of the city of Milan, show that for a range of scenarios, earmarking revenues for public transport mitigates the effect of the urban toll on commuting costs, raising voter support. They also conclude that a cordon close to the city centre is more likely to gain support than one covering a wider urban area. Börjesson et al. (2012) report that the political and public acceptability of the Stockholm congestion charge significantly increased when the proposal to move from a trial to a permanent charge was presented as part of a package that included significant new investments in local rail and road infrastructure.

Adopting this approach can have additional acceptability benefits. Proost notes that the stated goal of adopting the urban toll can go beyond addressing congestion. It can also include the provision of needed increases in funding for local transport infrastructure or even as being predominantly an environmental initiative – for example, by explicitly linking congestion charging to the broader transport decarbonisation agenda.

Proost (2022) also highlights other lessons for acceptability from experience in implementing congestion charging. One is that limiting the maximum daily charge payable by residents of the tolled area is a commonly adopted strategy to improve acceptability. While this necessarily reduces the efficiency impact of the charge (by enabling "uncharged travel"), it addresses potential equity concerns, particularly for those with lower incomes but limited ability to substitute to other travel modes. However, Singapore's experience moving from a flat daily cordon charge under the Area Licensing Scheme to a cost-per-entry charge under the Electronic Road Pricing system was that most commuters were better off. This is because they typically enter the cordon only once daily, and the cost per entry fell significantly under the new scheme, arguably improving its acceptability (Theseira, 2020).

Previous research indicates that almost all cities that have introduced congestion charges have seen attitudes to the initiative become more positive after its introduction (ITF, 2021). For example, Börjesson et al. (2012) found that support for the Stockholm charge increased progressively from 40% in 2005 to 53% following a 2006 trial and 70% in 2011, almost four years after the charge was made permanent. Some have argued that this suggests the benefit of adopting a trial of the proposed initiative. However, Proost notes that previous research (e.g. De Borger and Proost, 2012) finds that there is also likely to be strong opposition to a trial among potentially affected populations, suggesting that this approach is also politically risky.

Börjesson et al. (2012) also cite evidence suggesting that familiarity with road-user charging may reduce the general reluctance of populations to accept the pricing of a previously unpriced good. This implies that adopting a simple distance-based charge as part of an initial round of reforms may help pave the way for the subsequent adoption of congestion charges, either as a separate charge or by moving to a time-and-place differentiated distance-based charge.

A high-occupancy toll (HOT) lane, which enables drivers to pay a toll to use an uncongested lane on an otherwise congested road, is arguably a specific variant of a congestion charge (ITF, 2021). However, it can also be seen as a fee for the right to use a premium service. Proost notes that while HOT lanes are a less efficient version of a congestion charge, they have high levels of acceptability among users if the revenues finance additional capacity. This has frequently been the case in the United States, where they are mainly used. Another factor is that HOT lane users directly experience the congestion they are paying to avoid. Hence, they are immediately conscious of the benefit they obtain in exchange for the charge. Standard congestion charges do not share this characteristic.

Varying distance-based charges between urban and rural areas

Proost (2022) argues that fundamental political dynamics impede the adoption of spatially differentiated distance-based charges, as those in regions paying higher charges will not benefit sufficiently from expenditures funded by their additional payments to yield high levels of acceptability. He cites a Dutch proposal to adopt differentiated distance-based charges, which failed when several regions unhappy with its provisions voted against it, as an example of this dynamic. US research also shows consistently lower levels of public support for spatially differentiated charges than for undifferentiated charges (NASEM, 2016).

One potential means of addressing this issue is to adopt a uniform distance based-charge at the national or sub-national level and supplement it with charges levied by lower-level governments. As Proost (2022) argues: "A federal distance tax with additional regional taxes can be a solution if there is some federal control on the use of the regional distance tax revenues to avoid tax exporting."

Other ways to vary distance-based charges between urban and rural areas include applying differential vehicle-kilometre rates according to where vehicles are registered or introducing tax-free mileage allowances (Campaign for Better Transport 2020). Such mechanisms could readily be adopted as part of an otherwise undifferentiated distance-based charge. Doing so would imply applying a lower rate or providing a higher allowance to vehicles with a registered address in a non-urban area. Compared with current fuel taxes, this would yield an equity gain because, on average, rural populations drive longer distances and have lower incomes than metropolitan populations. At the same time, an efficiency cost is incurred when rural vehicles commute mainly to the city.

Balancing efficiency and acceptability

The distance-based charges discussed in the previous chapter are either revenue-neutral or slightly revenue-negative. Affected vehicles are charged less than, or equal to, the amount that an ICE vehicle would pay in fuel tax. For example, Utah caps payments under its scheme at a level equivalent to the annual fuel-tax liability of the average vehicle, and Virginia's charge effectively provides a 15% discount compared with the fuel-tax liability. In Australia, Victoria's current distance-based charge will yield only around 55% of the average fuel-tax revenue. The other Australian states with legislated charges have set them at similar levels.

This approach appears to have been adopted in the interests of improved acceptability. Many proponents of alternative road/vehicle user charges have explicitly argued that revenue neutrality is essential to achieving this goal. For example, the report of the UK House of Commons Transport Committee (2022) recommends that: “To promote fairness and public acceptance, any alternative road charging mechanism must (a) entirely replace fuel duty and vehicle excise duty rather than being added alongside those taxes, and (b) be revenue neutral with most motorists paying the same or less than they do currently.”

Revenue neutrality may facilitate implementation in the short term. However, the economic efficiency benefits of internalising external costs as far as possible imply a need to increase the overall taxation of private vehicle use while better differentiating these taxes. Continuing to charge fuel tax enables the higher climate and pollution externalities generated by ICE vehicles to be taxed efficiently, while EV drivers pay distance-based charges at lower rates, reflecting the lower external costs they impose. Additional locally applied congestion charges, applied to all vehicles, would reduce and redistribute localised congestion costs. Earmarking part of the revenues raised to expand and develop public and active transport would help ensure the acceptability of such increased taxes and further encourage a modal shift away from the private car.

The distributional benefits of distance charging

The non-taxation of EVs and significantly lower taxation of hybrid vehicles under current taxation arrangements have a much more regressive impact than fuel taxes. The higher average price of new EVs and hybrids, and the limited availability and higher price of used EVs and hybrids, mean that the owners of these vehicles (who avoid paying fuel taxes) disproportionately come from higher-income groups. By contrast, the fuel-tax system demonstrates only limited regressivity. While higher-income groups benefit from driving newer and more fuel-efficient cars, the rate of increase in fuel efficiency is too low to make this a significant distributional consideration (Proost, 2022).

A potential benefit of a move to distance-based charges is that, if spatial differentiation is adopted, it will be possible to address a regressive aspect of the current fuel-tax system – namely, that rural dwellers pay more due to the higher average distances they drive while, on average, having lower incomes than urban dwellers. Communicating these distributional benefits of moving to a distance-based charge may significantly improve its acceptability.

While a distance-based charge would have some distributional benefits over current arrangements, there are also distributional concerns. The House of Commons report argues that government should consider tailoring the design of such a charge to address these concerns. It suggests options “in the interests of societal fairness, such as providing an annual allowance of free travel miles or gearing the system to support vulnerable groups, such as those with mobility issues, and people who reside in the most remote areas” (UK House of Commons Transport Committee, 2022).

The Campaign for Better Transport (2022) also identifies options to improve the distributional performance of distance-based charges. These include reducing the impact on vulnerable groups by applying lower rates per kilometre travelled; providing a tax-free allowance of a certain number of kilometres; or even providing complete exemptions for some groups on a time-limited or a permanent basis. Its report finds that tax-free allowances are popular among survey respondents and focus groups. Conversely, complete exemptions tend to divide opinion, as some think people might use these to game the system.

Ddifferentiating taxes to promote more sustainable vehicle choices

Given the potential efficiency benefits of a differentiated distance-based charge, there is a clear case for applying it to both ICE vehicles and EVs. By avoiding creating the impression that the distance charge discriminates against EVs – a concern levelled at some simple, EV-specific distance-based charges – such an approach could potentially have acceptability benefits. However, equity requires ICE vehicles should face higher total road-user charges to address their larger climate, pollution, and noise impacts.

A differentiated distance-based charge could also ultimately distinguish between EVs based on their relative efficiency, thus providing incentives for adopting more efficient EVs. This differentiation could be based on the vehicle's energy efficiency (i.e. km per kilowatt-hour, KwH) or weight. Less efficient EVs increase electricity demand in a context in which there are significant challenges in expanding the grid and will tend to result in greater resource use due to the need for larger battery packs. The argument for differentiation by weight is that heavier vehicles impose higher costs via increased emissions of unburned fine particles (from tyres and brake materials), increased road wear and crash damage costs.

Proost (2022) argues that any additional charge components applied to ICEs should be based on the economy-wide carbon price, which is currently somewhat lower than the EUR 300/tonne price implicit in current European fuel taxes. An alternative approach would be to retain a fuel tax while subjecting ICE vehicles and EVs to the same distance-based charge. In this case, governments should reduce the fuel tax to a level commensurate with the climate (and differential noise and air pollution costs) associated with ICEV use. Such an approach also provides the opportunity to reform the relative taxation level of diesel and petrol fuels so that the tax rates applied reflect the external costs associated with each fuel.

This approach can be consistent with the continued use of policy measures to promote EV adoption. Separate EV incentives, such as purchase subsidies or registration discounts, can offset the impact of the distance-based charge. This approach is preferable to continuing to exempt EVs from road user taxes on both equity and efficiency grounds.

The need for timely reform

Proost (2022) points to the risk that delaying tax reforms will lead to increasingly severe distortions that become progressively more difficult to correct. This can occur if changes in the market lead to strong behavioural responses, which tax authorities seek to reverse, rather than prevent in the first instance. He uses the example of diesel fuel taxation in this regard. New technologies emerged in the 1990s, which made diesel cars significantly more competitive.

However, European governments generally failed to respond to the rapid adoption of diesel cars by imposing higher diesel fuel taxes that reflected the higher external air pollution costs imposed by these vehicles. This initial delay in tax reform led to a situation in which the political cost of reform subsequently became extremely high, given high levels of market penetration by diesel cars, particularly among drivers covering high average distances (e.g. in rural areas). As a result, reforms to the tax treatment of diesel fuel have been limited and gradual, and diesel taxation generally remains sub-optimally low relative to petrol taxes.

The rapid increases in the market share of EVs seen in many countries in recent years and the expected acceleration in their adoption due to recent policy changes and increased competitiveness suggest a risk that many countries may be approaching a similar "tipping point." That is, delaying adopting distance-based charging may significantly increase the political cost of this reform due to the rapidly growing number of losers from such a tax reform. The House of Commons report acknowledges this issue. It argues that “the Government must make it clear to motorists who purchase electric vehicles that they will be required to pay for road usage, as is currently the case for petrol and diesel vehicles” (UK House of Commons Transport Committee, 2022).

Introducing road pricing reforms in stages

While temporally and spatially differentiated distance charges constitute the best approach to reforming road user taxation in theoretical terms, there are both technical and practical impediments to their short-term adoption. As Proost (2022) argues: “The big bang implementation of a distance charging system that replaces fuel taxes and implements time and location-specific charges may not be the best way to phase in the reform. The risk of failure and massive opposition of car drivers may be a big hurdle. One can imagine different more gradual trajectories that consider efficiency and acceptability criteria”.

Proost identifies four possible steps in this regard:

- Step 1: Only EVs and PHEVs are included. This requires policy makers to decompose the gasoline and diesel taxes into carbon and non-carbon parts. Only the non-carbon part is charged to EVs via a distance charge. This is revenue-neutral if the distance charge replaces the lost fuel tax.
- Step 2: Apply a distance tax to all cars to internalise non-climate externalities. Fuel taxes are reduced to the level needed to internalise climate-related externalities. There is no need for compensation, as the average tax on vehicle-kilometres does not change. There is a slight loss of tax revenue as more fuel-efficient cars will pay slightly less tax.
- Step 3: Apply a distance tax to all cars but differentiate it according to the region where the car is driven. Fuel taxes are again set to internalise climate externalities, and the distance charges address non-climate externalities.
- Step 4: Two options are available here. The first option is to apply a distance tax to all cars but to differentiate its size according to the congestion level. It is mainly relevant to metropolitan areas. The distance tax is increased on top of the non-climate externalities. Peak period drivers are compensated via spending on improved public transport infrastructure and reduced vehicle ownership taxes. The second option is not to include congestion costs in the distance taxes but to grandfather tradable peak driving rights to all initial drivers. This option is revenue neutral.

Proost argues that an appropriate phased introduction of distance-based charges aimed at maximising acceptability could be to move progressively through each of these steps. In broad terms, Steps 1 and 2 are effective at addressing the loss of fuel-tax revenue due to the changing composition of the vehicle fleet, but only Steps 3 and 4 can increase economic efficiency through improved internalisation of the external costs of road transport.

The Campaign for Better Transport (2022) proposes another staged implementation option. It involves first applying an undifferentiated distance charge to EVs only, then replacing fuel and emissions-based vehicle taxes with a per-mile emissions-based charge (subject to a tax-free distance allowance). Finally, a “smart” distance-based charge would be adopted, differentiated by emissions, location, and time.

Improving public understanding of the reforms

A review of US research on public attitudes to distance-based charges finds that public understanding of the current system of road user taxation is very limited (NASEM, 2016). It suggests that this impedes acceptance of the need for reform generally and the benefits of distance-based charges. Proost argues the importance of improving public understanding of the proposed reforms and suggests achieving this by presenting detailed simulations of the impacts of various proposals, perhaps supplemented by pilot programmes. The latter may be essential where trust in government is low.

A recent public opinion survey in the United Kingdom (Campaign for Better Transport, 2022) also underlines the importance of engaging the public in a detailed discussion about the scheme and how to address their concerns. It reports that the level of support for distance-based charging increased by 8% between the beginning and end of the survey. This was due to the provision of additional information on current vehicle taxation practices and issues and the workings of a distance-based charge as part of the survey process.

The NASEM (2016) report provides a degree of support for the potential utility of pilot schemes as a mechanism for increasing acceptability. It finds that while opinion surveys reported levels of public support for distance-based charges were generally low, ranging between 8% and 50%, a subset undertaken with pilot programme participants reported substantially higher levels of support, ranging between 37% and 71%. The “opt-in” nature of the three distance-based charging schemes implemented at the state level in the United States may reflect this dynamic. Such an approach increases familiarity with the workings of a distance-based charge without compelling participation.

Comparing distance-based charging systems

Since at least the early 1990s, policy leaders and academic experts have advocated for the adoption of distance-based charges as a crucial, productivity-enhancing reform (see e.g. Infrastructure Partnerships Australia, 2019). The case for differentiating these charges temporally and spatially has also been made over an extended period. Despite this, no such schemes have been adopted. However, the recent emergence of clear evidence of the impact of EVs on fuel-tax revenues has led to rapid moves to adopt simplified distance-based charges in several jurisdictions. Implementing differentiated charges comes with technical and acceptability challenges and much higher administrative costs. Therefore, policy makers should have a clear view of the relative benefits and costs of simple and differentiated distance-based charges. They should also consider using them in conjunction with other taxes and policy instruments to address their policy objectives.

Replacing fuel-tax revenue

Both simple and differentiated charging models can address the objective of replacing lost fuel-tax revenue. The models adopted in three US states have set charges at levels at or near average fuel-tax payments and have apparently been implemented without major controversy. Their formulation on an opt-in basis, as an alternative to a registration surcharge, may be one reason for this. Another may be that the schemes only compensate for the lost state (i.e. federal) fuel-tax revenue, while low overall rates of fuel taxation in the United States mean these charges are relatively modest.

Internalising external costs

An undifferentiated charge cannot seek to internalise the external costs of motor vehicle use in a targeted way. This raises the question of how well a combination of a simple distance-based charge and other charges focusing on internalising specific external costs could approximate the outcomes achieved by a fully differentiated charge.

Congestion costs

Congestion is one of the two largest categories of external costs, accounting for more than one-third of the total. Despite this, Proost (2022) identifies only eight cities in Asia and Europe that have adopted generally applicable congestion charges. In addition, HOT lanes, which provide drivers with a choice as to whether to pay for congestion-free travel, are used relatively frequently in the United States (ITF, 2021).

The potential efficiency and revenue gains from adopting congestion charges more widely are substantial. Under a theoretically optimal differentiated charge, an additional congestion-related charge would apply to each kilometre driven in congested conditions, with the charge varying dynamically with the extent of the congestion. This would ensure a close relationship between the external congestion cost and the charge paid at any time. The nearest equivalent to such a charge currently in operation is the dynamic tolling used in several HOT lane systems in the United States. Such charges appear to be accepted in the US context.

However, the ITF has previously noted (2021) two significant factors influencing the acceptability of dynamic tolls: 1) real-time information on pricing changes and 2) the (frequent) opportunity to opt out of paying the changed toll by exiting the HOT lane. The latter appears to be impossible to achieve in a context where all congested roads are tolled, rather than there being parallel tolled and untolled road lanes. This implies that acceptability issues could preclude using dynamically variable tolls in the context of differentiated distance-based charging.

While an inability to use dynamically variable tolls would reduce the theoretical benefits of this aspect of the system to some extent, the experience of Singapore suggests that the loss may not be substantial. There, and in Stockholm, time-varying congestion charges are calibrated according to the time of day (in intervals of 30 minutes or less), with historical traffic flow data used to determine the toll for each period. Traffic flows have generally been relatively stable, so the tolls set come close to achieving the target traffic flow rates, and the bulk of the available economic benefit is realised.

In practice, congestion charges typically use cordon or area-based charging as an implementation mechanism rather than charging for each kilometre driven in congested conditions. While these approaches entail a theoretical efficiency loss, they have been preferred because they:

- avoid the technical challenges of adopting a distance-based approach
- entail substantially lower implementation costs
- avoid the acceptability concerns associated with dynamic pricing
- avoid the privacy-based concerns related to using GPS-based tracking to levy charges.

Moreover, because of the spatial concentration of congestion, simple cordon-based charges can achieve much of the potential benefit of a theoretically optimal congestion charge in many cities, at least in net terms.

Börjesson, Asplund, and Hamilton (2023) note that 90% of the revenue from an optimal congestion tax in Sweden would be collected on 10% of the road network. Given this and the high administration cost of a GPS-based nationwide kilometre tax, extending the current Automatic Number Plate Recognition (ANPR) based system would “approximate the optimal congestion tax with relatively high accuracy”. They also cite Ekström et al. (2014) as concluding, in the Stockholm context, that it is possible to achieve 96% of the welfare gain of an optimal road-pricing system (kilometre tax) by locating toll stations on only 70 links in Stockholm County. The existence of large economies of scale in ANPR-based systems also implies that net revenue will increase as a proportion of gross revenue as congestion charging expands in scope.

Börjesson, Asplund, and Hamilton (2023) also note that the collection costs of congestion charges based on automatic number plate recognition (ANPR) and dedicated short-range communications (DSRC) are low relative to gross revenue, citing system costs of 15% of gross income in Sweden, 9% in Norway, and 35% in London, as well as an 18% system cost in respect of the parking charges regime in Stockholm. While no GPS-based system of spatially/temporally differentiated congestion charges is yet in operation, most experts believe that the costs would be substantially higher, at least in the short to medium term.

Eliasson (2022) notes that the relatively simple congestion charges adopted to date have generally proven successful in significantly reducing congestion costs and generating significant net revenue.

Determinants of acceptability

A simple cordon or area-based congestion charge levied separately is more transparent than one integrated into a spatially and temporally differentiated distance-based charge. This may increase its acceptability as the size and incidence of the charge are more easily understood. Research suggests that the public prefers such charges to be publicised in advance and to remain stable over time. Therefore, adopting a stand-alone congestion charge and a simple distance-based charge could be a desirable first step in a longer-term reform programme. It could help build familiarity with and willingness to accept a congestion charge before attempts are made to move to an integrated system.

Revenue from a separate congestion charge can also be more clearly earmarked for specific purposes. As noted above, Proost (2022) argues for the need to recycle congestion charging revenue to those who pay, to achieve acceptability, or to use grandfathered peak driving rights. The ITF (2021) also argues that earmarking revenue for purposes such as improving local urban public transport can significantly enhance acceptability. This may be particularly important when congestion charging is first adopted, given that experience shows that support for congestion charges tends to increase progressively following their adoption as people accumulate practical experience of their impacts and modify their travel behaviours over time (Borjesson 2022).

A stand-alone congestion charge can also be presented more positively as a “decongestion charge” or a “sustainable mobility charge” (ITF, 2021). More broadly, the charge, and the earmarked expenditure of the resulting revenue, can be presented as a tool to enhance urban liveability.

Earmarking congestion charging revenues for local public transport investments can also enhance the stability of funding for public transport systems in a context in which major new investments are needed. Xuto et al. (2022) show that:

> How subsidies are generated can have varying impacts on funding stability and sustainability - dedicated taxes and cross-subsidies from road charges are typically better than direct grants as they are secured by legislation. They also reduce political changes and avoid competing claims from other types of government spending (health, education), as compared with grants.

However, funding stability will come at a cost to efficiency unless the bundle of public transport investments chosen performs at least as well in benefit-cost terms as the competing claims for the use of public funds. This is a fundamental objection to hypothecation on general public finance grounds.

In sum, combining a simple (national) distance-based charge and passage or cordon-based congestion charges could yield a high proportion of the potential efficiency benefits of a theoretically optimal differentiated charge while being significantly more acceptable to users and the public.

Climate externalities

As noted, the EC (2019) estimates that climate externalities constitute the third most significant element of the total external cost of passenger car use. Fuel tax is a highly efficient means of internalising this externality if set at the appropriate level. According to Proost (2022), the current level of fuel taxes in Europe is (more than) sufficient to achieve this purpose. He argues: “As the fuel tax is proportional to the quantity of carbon emitted, it is the full fuel tax that acts as a carbon tax. The fuel tax works as a EUR 300 EURO per tonne CO_2 carbon tax”.

By comparison, even a differentiated distance-based charge will inevitably be less efficient in internalising climate costs for ICE vehicles, as it is unlikely to be feasible to link such a charge as effectively with actual emissions for individual vehicle types. For ease of implementation, charging bands are more likely to be adopted than model-specific charges. That said, this may be a problem of limited duration, at least for some jurisdictions. For example, the EU has adopted ambitious carbon emissions standards for new cars, including a zero-carbon emissions target for 2035.

Proost (2022) notes that, in the EU, the carbon emissions associated with the electricity that fuels EVs are effectively incorporated into the price of electricity because they are within the scope of the European ETS. Hence, there is no basis for seeking to internalise them through separate costs levied on EV use. Some have argued that the tax system should encourage the take-up of lighter, less powerful EVs, since these embody significantly lower emissions from the production process and in connection with the generation of the electricity they consume. Others (e.g. Pardi, 2022) have highlighted the additional externalities of larger, heavier vehicles in terms of congestion and crash costs.

This implies that governments should continue to internalise climate externalities for ICE vehicles via fuel taxes. However, there is no need for a distance-based charge to address climate externalities in the case of EVs.

Air pollution

The air-pollution costs associated with petrol and diesel cars are around twice as large per vehicle-kilometre in urban areas as in rural areas (Table 2). This is primarily a product of the higher levels of human exposure to local pollutants in the urban context rather than differences in emissions levels per se. Fuel tax makes tax payments proportionate to emissions levels but does not account for this urban versus rural distinction in the size of the externality.

A simple distance-based charge is inferior to a fuel tax in this regard, as there is no link between the emissions performance of different vehicles and the amount paid. A spatially differentiated charge could theoretically address this issue but would be highly complex.

In contrast to ICE vehicles, the air pollution costs of an EV are essentially the same in both contexts. They are substantially lower than petrol or diesel cars, as they are limited to particulate pollution derived from vehicle tyres and brakes. This implies that if a distance-based charge is to be applied only to EVs, the effective internalisation of air pollution costs does not require a spatially differentiated charge. It also suggests that it will continue to be more efficient to internalise the air pollution costs associated with ICE vehicle use via fuel taxes.

Fuel taxes are generally preferable to taxes on vehicle purchase and ownership in respect of this externality, since the size of the externalities involved vary with vehicle use, while the purchase and ownership of the vehicle do not, of themselves, give rise to externalities. Recently, however, some countries (e.g. France and Singapore) have used vehicle purchase taxes, sometimes in combination with positive incentives, to encourage the purchase of less polluting vehicles. France's revenue-neutral "feebate" system taxes purchases of vehicles with relatively high CO_2 emissions and subsidises the purchase of low-emission vehicles. The measure has been assessed as providing modest net benefits, although the system's focus on CO_2 has increased local pollution costs by favouring diesel vehicles (Durrmeyer, 2022).

Crash costs

As shown in Table 1, crash costs constitute Europe's largest external cost of passenger vehicle use, accounting for around 37% of the total. In contrast to climate and air pollution costs, crash costs could be higher for EVs than ICE vehicles since EVs are significantly heavier, on average, due largely to battery weight. Research suggests that a 50% increase in vehicle mass is associated with a 50% increase in fatality risk for vulnerable road users (VIAS Institute, 2022). People travelling in lighter vehicles also face increased risks when hit by heavier vehicles.

Conversely, increased vehicle weight provides greater occupant protection in collisions with other vehicles or objects, indicating a reduction in injury risk in certain kinds of crashes. Therefore, the size, and perhaps the direction, of the net impact of vehicle weight on overall fatality and injury risk are less clear. Research suggesting that driving a larger car is associated with more risk-taking behaviour while driving and in other aspects of life – the so-called "car cushion effect" (Claus and Warlop, 2022) – further complicates the picture. This potential behavioural impact further complicates any assessment of the external impacts of vehicle mass.

Despite these uncertainties, some jurisdictions have adopted additional mass-based vehicle taxes, which appear to respond to both crash risk and environmental concerns associated with heavier vehicles. For example, Norway has imposed a tax of EUR 1.2 per kilogramme, exempting the first 500kg, as part of its initial vehicle registration tax. The Belgian region of Wallonia has taken a similar step and also includes power output in its tax calculations. While this element of its tax structure may be largely environmentally determined, it may also partly respond to research evidence suggesting that injury risk for vulnerable road users increases somewhat where more powerful vehicles are involved in crashes (VIAS Institute, 2022).

Crash costs also demonstrate wide spatial variation. The EC (2019) estimates that the marginal crash costs of passenger cars are EUR 0.0141/km on urban roads, which is more than twice their marginal cost of EUR 0.0063 on other non-urban roads and nearly six times the marginal cost of EUR 0.0025 on motorways.

Over the long term, sustained improvements in vehicle and infrastructure safety standards have seen steady declines in fatalities and injuries per vehicle-kilometre. This logically suggests that total crash costs per vehicle-kilometre are also declining. However, changing methodological approaches have seen a progressively wider range of crash costs included in these calculations, making the size of this effect difficult to observe in practice.

Recent data suggests France has seen relatively significant declines in crash costs per vehicle-kilometre over the past decade. Data published by ONISR (2022) includes two sets of estimates of total crash costs for 2010 and 2019 (see Table 5). The first set is derived from the so-called Quinet report (Quinet, 2013); the second from the VALOR project (Schoeters et al., 2021). In each case, the costs are updated in line with changes in GDP/capita (for the value of a statistical life estimate) and adjusted for inflation.

Table 5. Changes in crash costs per vehicle-kilometre in France, 2010-19

Year	Quinet report (EUR, billions)	VALOR report (EUR, billions)	Vehicle-kilometres (billions)	Cost per vehicle-kilometre (EUR, 2019 values)	
				Quinet report	VALOR report
2010	48.2	74.5	398.1	0.121	0.187
2019	48.6	73.5	428.1 (2018)	0.113	0.172
Reduction (EUR)				0.008	0.015
Reduction (%)				6.6%	8.0%

Sources: ONISR (2022), Statista (2022b).

The two reports show broad stability in total crash costs, but an increase in total vehicle-kilometres travelled of around 7.5% over the period means that crash costs per vehicle-kilometre can be estimated to have declined by between 6.6% and 8.0% over the period. This decline is consistent with long-term trends towards declining fatality rates per vehicle-kilometre and passenger-kilometre. It is likely to continue as traffic regulation, vehicle and road design, and driver behaviour evolve, along with technological progress.

Road-user taxes have little ability to internalise crash costs since they cannot create strong incentives to change driving behaviours. At the margin, increasing road user costs will reduce traffic levels and thus crash frequency. In practice, governments use other policy tools, such as speed limits and enforcement of other safety-related rules, to change driving behaviours. Road improvements and vehicle design standards can also reduce the consequences of crashes. The fact that almost all drivers have vehicle insurance largely externalises the property component of crash costs. However, the fact that premiums are typically risk-differentiated in broad terms through premium-setting mechanisms that take drivers' history into account, as well as their choice of vehicle, provides some positive behavioural incentives.

The position in relation to injury and fatality costs is more variable, with these being integrated with property loss insurance in some jurisdictions and charged separately in others. In some jurisdictions, these separate insurance premiums are "community rated"; that is, a single premium applies to all insured drivers as part of a "no-fault" based system. Such systems seek to control costs by avoiding costly litigation over responsibility for specific vehicle crashes but necessarily mean that no incentives exist via higher premiums resulting from past crash involvement.

Some insurance providers consider exposure risk by varying premiums according to the distance driven. However, such differentiation is typically limited, with a few distance bands used to adjust base premiums (e.g. in France). Recently, insurers have offered lower premiums to drivers who accept the installation of devices that monitor driving style (e.g. rapid acceleration/braking) and can inform future premium setting.

Data show that crash costs are significantly higher (per vehicle-kilometre) in urban areas than in rural areas. While insurance premiums often differ according to whether the insured vehicle is garaged in an urban or a rural area, the degree of differentiation seems generally smaller than the cost differences identified in the next section would suggest.

Noise costs

While Table 1 shows that noise costs account for around 4.6% of the total external costs of passenger car use in Europe, Table 6 shows the variation of these costs by time and area. Noise costs at night are typically around twice as high as during the day, regardless of context (i.e. urban/rural). Costs are around twice as high in light traffic conditions as in dense traffic, reflecting the greater marginal impact of an additional vehicle in thin traffic.

In thick traffic, urban noise costs are more than an order of magnitude higher than suburban costs, which are, in turn, around an order of magnitude greater than noise costs in rural areas. These differences reflect the number of people exposed to the noise and the greater degree of disturbance typically caused at night.

Table 6 also shows that only a spatially differentiated distance charge can seek to approximate an efficient internalisation of noise costs. However, the number of different dimensions in which noise costs vary is such that it is unlikely that any charging system would be highly effective in matching charges levied and actual noise costs imposed across the full range of circumstances.

Table 6. Marginal costs of noise for passenger transport in Europe, 2016

		Marginal cost per passenger-kilometre (EUR cents)		
Time of day	Traffic	Urban	Suburban	Rural
Day	Dense	0.5	0.03	0.004
	Thin	1.1	0.07	0.009
Night	Dense	0.9	0.05	0.007
	Thin	2.1	0.13	0.015

Source: EC (2019).

In summary, applying undifferentiated distance-based charges to EVs (and other vehicles not subject to fuel tax) constitutes an effective and equitable means of replacing losses of fuel-tax revenue due to an eroding tax base. Supplementing such a charge with the adoption of cordon or area-based congestion charges can yield significant efficiency benefits by internalising one primary source of the external costs of motor vehicle use. It can also generate substantial additional revenue that can be earmarked for expanding urban and suburban public transport systems – a necessary step towards achieving the modal change needed to achieve a sustainable transport system.

As the discussion in this section indicates, adopting a spatially and temporally differentiated distance-based charge could allow other externalities to be internalised effectively. Thus, there are additional potential efficiency gains from adopting such a charging system, but technical challenges and issues of complexity and acceptability must be resolved.

Road transport pricing in the broader policy context

The effectiveness of tax reforms also depends on the broader transport policy environment. As Proost (2022) notes: "To address transport externalities, road infrastructure (congestion, crashes), regulation on vehicle emissions (air pollution, climate change) and on vehicle safety equipment (crashes) as well as regulation of road use (low emission zones, speed limits, priority rules) are important complements to tax instruments." While this report has focused on reforming passenger vehicle taxation, this section highlights some critical policy linkages and complementarities.

Taxation of heavy-goods vehicles versus light vehicles

There are important differences between distance-based charging applied to passenger vehicles and heavy-goods vehicles (HGVs), which yield differing policy conclusions in some areas. HGVs impose much larger non-congestion external costs due to the amount of road damage for which they are responsible.

Table 7 illustrates this point with data from Sweden. It shows that the total externalities per vehicle-kilometre of a large HGV (with trailer) are more than an order of magnitude higher than those of a passenger vehicle when congestion costs are excluded, with road damage costs accounting for more than 50% of the total. More importantly, whereas existing taxes over-recover the external costs for passenger cars, they under-recover the costs associated with large HGVs.

Table 7. Road traffic externalities in Sweden, excluding congestion costs

	Cost (SEK/kilometre)		
Externality	Passenger car (gasoline)	Heavy-goods vehicle (diesel)	Heavy-goods vehicle and trailer (diesel)
Wear and tear	0.04	0.43	1.76
Crashes	0.02	0.26	0.26
CO_2 emissions	0.19	0.73	1.10
Other emissions	0.01	0.10	0.10
Noise	0.02	0.07	0.18
TOTAL	**0.28**	**1.59**	**3.43**
TOTAL excl. emissions	**0.08**	**0.76**	**2.23**
TAX	**0.48**	**1.29**	**1.94**

Source: Eliasson (2022).

Therefore, the net benefits of a differentiated distance-based charge applied specifically to HGVs are likely to be significantly greater than those of a system that includes all road vehicles. Because the decarbonisation of the heavy-vehicle sector is expected to occur substantially later than for the light passenger vehicle fleet, a significant fall in fuel-tax revenues from this sector is unlikely in the short to medium term. However, Table 7 shows that substantial efficiency gains are achievable by reforming the tax system to better internalise the external costs associated with heavy-vehicle use.

While tax reform in this area has been highly controversial, several European countries have adopted or are currently implementing distance-based charges for heavy vehicles. For example, the Netherlands is introducing a charge that distinguishes between three vehicle mass categories and seven emissions performance levels (Dutch Ministry of Infrastructure and Water Management, 2022). The average amount payable is estimated at EUR 0.149/km – similar to the damage cost for an HGV with trailer, as reported in Table 7. Adopting distance charges for light vehicles could potentially have the ancillary benefit of enhancing the prospect of gaining support for heavy-vehicle distance charges in some countries.

Reforming tax expenditures supporting electric vehicle adoption

Most OECD countries have adopted fiscal incentives for the adoption of EVs. These have included direct grants to subsidise the initial purchase price, partial or total exemptions from purchase taxes, reduced or eliminated annual registration fees, and rebates on user charges, including road tolls and parking fees.

EV sales have grown rapidly as the EV sector has developed and come to compete with ICE vehicles more effectively in terms of performance, convenience, and price. This growth has led to rapid and substantial increases in the budgetary costs of these programmes. In the 2022 edition of its *Global EV Outlook*, the International Energy Agency (IEA) states: "Public spending on subsidies and incentives for EVs nearly doubled in 2021, to nearly USD 30 billion" (IEA, 2022). This rate of cost increase will likely accelerate in the absence of policy changes.

Policies such as the EU average fuel efficiency standards will increasingly drive manufacturers to increase EV sales. At the same time, the prices of EVs and equivalent ICE vehicles are rapidly converging. Tax reforms of the type proposed in this report, which increase the cost of owning and operating ICE vehicles relative to EVs, would further strengthen this dynamic. EVs' continually improving competitive position also implies that government subsidies will have a diminishing impact on consumer decisions to choose them over ICE vehicles.

All these factors suggest the need to reform EV subsidies. So, too, does the accumulating evidence of their relative inefficiency as carbon-abatement tools. Data from an increasing range of countries shows that EV subsidy packages' effective carbon-abatement cost far exceeds standard benchmarks for effective policy action. One analysis of Norway's extensive suite of incentives for passenger EVs concludes that, as of 2019, the implicit marginal economic cost per tonne of CO_2 abated was EUR 1 370. For light and heavy commercial vehicles, it was significantly lower, but still substantial, at EUR 640 and EUR 200, respectively (Fridstrøm, 2021).

Canada's federal EV subsidy programme has an implicit cost of CAD 355 per tonne of CO_2 abated, while the total cost, including provincial subsidies, ranges from CAD 512 in Newfoundland to CAD 964 in Quebec (Gessaroli, 2022). A 2021 analysis found that the equivalent costs in the EV market in the United States are between USD 581 and USD 662 per tonne of CO_2 abated (Xing, Leard, and Li, 2021).

These factors are already leading governments to begin reforming EV subsidy programmes. The UK Government closed its EV grant scheme to new applications in June 2022. It has refocussed funding on public charging infrastructure and subsidies for vehicles in other sectors where the EV transition is less advanced (UK Government, 2022). It also announced in November 2022 that EVs would cease to be exempt from vehicle excise tax from 2025 (HM Treasury, 2022).

China announced in 2017 that it would phase out its EV subsidies in favour of a scheme requiring manufacturers to ensure that a certain percentage of their sales were of EVs to avoid penalties, with the percentage to rise over time. The phase-out of subsidies was originally to be completed by 2021 but will now continue until the end of 2023 (Chinese Ministry of Finance, 2022).

Finland has also moved to re-orient its subsidies towards commercial vehicles, including HGVs. It is providing no funding for EV purchase subsidies in 2023. The Minister for Transport has announced that, given the slower EV uptake in the commercial vehicle sector, subsidy schemes will henceforth target vans and trucks (Finnish Ministry of Transport and Communications, 2022). The German Minister of Finance has also advocated ending government EV subsidies (Zeit Online, 2022).

The Singapore Government has let tenders for the provision of public charging infrastructure. The terms require operators to pay a concession charge per kWh sold in exchange for the right to install charging equipment in government-owned car parks. Other subsidies have targeted co-payment of the installation cost for EV chargers in multiple-unit dwellings (condominiums).

These policy reforms are broadly consistent with the IEA's recommendation for a gradual phase-out of EV subsidies as sales expand. The IEA recommends replacing EV subsidies with policies such as differentiated taxation of vehicles and fuels based on environmental performance and regulatory measures to enable the clean vehicle industry to thrive (IEA, 2021). As the IEA argued:

> Budget-neutral feebate programmes – which tax inefficient internal combustion engine vehicles to finance subsidies for low emissions or EVs purchases – can be a useful transition policy tool. Stringent vehicle efficiency and/or CO_2 standards have promoted EV adoption in most leading EV markets and should be adopted by all countries seeking to hasten the transition to electromobility (IEA, 2022).

Links with other vehicle and road-user taxes

Freebairn (2022) argues that a broad reform of vehicle and road user charging could yield a more effective and efficient means of incentivising EV uptake than an explicit purchase subsidy regime while at least replacing lost fuel revenue. His proposed tax mix is based on linking specific external costs with specific taxes and involves:

- setting annual vehicle registration charges at a level intended to contribute to the fixed costs of providing road infrastructure
- applying a single road user charge to both EVs and ICE vehicles, with axle-weight-based differentiation between vehicle classes
- removing import duties (including Australia's "luxury car tax") to eliminate disincentives to update to vehicles with better environmental performance
- removing taxes on vehicle transfers, thereby encouraging consumer optimisation of vehicle choices over time
- reforming fuel tax so that it acts to internalise the costs of climate and air pollution, ideally within the context of a consistent taxation policy covering all petroleum products

- applying a simple congestion charging regime, with peak and shoulder pricing applied to central activity districts and congested arterial roads, collected via number plate recognition technology.

The principle of reforming vehicle and road user taxation to internalise the external costs of road transport better should be applied consistently throughout the tax system. This implies identifying and reforming existing tax expenditures – both implicit and explicit – that effectively subsidise the use of road vehicles. Tax concessions for company cars are a crucial area for reform in many countries.

Van Dender (2019) argues, "Removing or reducing the favourable tax treatment of company cars and the deductibility of commuting will also strongly contribute to more efficient transport and location choices." Proost (2022) highlights the potential size of the efficiency gains available via these reforms. Research suggests that abolishing this preferential tax treatment could achieve half the welfare gains of congestion tolls in countries with a high penetration of company cars.

Similarly, while the taxation of parking spaces is becoming more common, parking charges in major cities are rarely set at levels that reflect the opportunity cost of this scarce urban space. The ITF (2021) has previously recommended the reform of parking pricing by adopting this principle.

Tax reform in low- and middle-income countries

The issue of high dependence on fuel taxes is particularly significant in low- and middle-income countries (LMICs). Fuel taxes appeal to governments in earlier stages of economic development because they are both relatively easily administered and quite progressive in contexts where only higher-income groups have access to motor vehicles (Van Dender, 2019). Data show that taxes on oil and fuel represented an average of 10.2% of total taxation in middle-income countries in 2019, compared with 6.8% in high-income countries. Some LMICs (e.g. Thailand) raise more than a quarter of tax revenue from such taxes (Benitez, 2021). Fuel-tax rates are typically lower in absolute terms than in higher-income countries but higher relative to per capita GDP.

This high dependence on fuel taxes suggests that the budgetary positions of governments in LMICs will also be vulnerable to declining fuel-tax revenues. However, these declines in fuel-tax revenue are likely to occur over a more extended period for at least two reasons.

First, the relatively high cost of EVs, the challenges of developing charging infrastructure, and relatively low petrol prices (due to implicit and sometimes explicit subsidies) imply a slower move from ICEs to EVs. Even within Europe, EV sales and the development of charging infrastructure are highly correlated with GDP per capita (ACEA, 2021b), implying still slower dissemination in lower-income countries. Moreover, continuing increases in motorisation (i.e. the proportion of the population with access to a private vehicle) will yield offsetting increases in fuel-tax revenues.

Second, there will be scope to increase fuel-tax rates over time in many countries. While fuel tax is an important revenue source in LMICs, tax rates are often relatively low, implying fuel is subject to implicit subsidies. This typically reflects a concern to avoid major welfare losses by pricing motoring beyond the reach of lower-income groups. However, many LMICs have a growing middle class, which does not need access to (implicitly) subsidised petrol. Narrowing the scope of fuel subsidies by basing them on the person's identity rather than providing it to all via the pump price could offer significant opportunities to increase revenue. However, such moves are often politically sensitive, suggesting the need for careful programme design.

Conversely, the medium-term outlook suggests significant improvements in the average fuel efficiency of LMIC fleets may occur relatively quickly. Increasingly stringent fuel economy/emissions standards in high-income countries could have substantial spill overs, given the globalised nature of vehicle production. Rapid electrification of vehicle fleets in high-income countries could also mean relatively new and efficient ICE vehicles are more widely available as inexpensive second-hand imports to LMICs, leading to rapid declines in consumption per vehicle.

Another possible factor is that the increasing market presence of ultra-low-cost Chinese-designed and manufactured EVs may lead to rapid electrification, at least in middle-income countries. These vehicles may not meet North American or EU regulatory standards but are competitive relative to other low-cost passenger transport options in LMICs. For example, the Wuling Hongguan Mini EV has reportedly sold nearly one million units in China, and basic versions sell for less than USD 4 500 (Car New China, 2023). When combined with industrial policy in many LMICs to develop an automotive sector, this could lead to electrification of the vehicle fleet much sooner than expected if such vehicles are manufactured in LMICs.

Governments in LMICs often tax vehicle purchase and ownership, as this is simpler than taxing their use. On average, import taxes on motor vehicles in LMICs are high relative to OECD countries. Such taxes are easily applied and collected and function as luxury goods taxes. They are economically efficient due to the low elasticities of demand for luxury vehicles, which tend to function as positional goods. They are also progressive since the upper middle classes primarily pay them.

Many countries may have opportunities to increase reliance on these taxes. Importantly, there is significant scope to improve the form of import and purchase taxes so that their incentive effects align better with government policy objectives. This could involve differentiating tax rates according to emissions levels rather than engine size or vehicle age. Greater use of ownership taxes may also be feasible. While such taxes are higher, as a percentage of GDP, in LMICs than in high-income countries, they are only around one-quarter of the high-income country average in absolute terms.

Benitez (2021) identifies moves in some LMICs to reform the structure of these taxes to provide incentives for decarbonisation while maintaining the overall level of tax revenues. For example, Indonesia’s 2019 reform to vehicle sales taxes provided tax reductions to ZLEVs. Thailand adopted a package of tax incentives for such vehicles in 2021 by structuring vehicle excise taxes according to their emission levels. It is also developing a fuel-tax reform that will link rates to emissions.

There is also potential to use congestion or parking charges as revenue stabilisation measures in LMICs, particularly given the highly congested nature of many major cities in these countries. Recent reforms in Colombia provide an example. Bogotá’s congestion pricing initiatives provide funding for public transport and micromobility initiatives. A 2022 pilot programme tested phone-based apps to better address administration and enforcement issues (Civitas REVEAL, 2022).

Conclusion

The rapid and accelerating decline of fuel-tax revenue in all developed economies requires urgent reform to vehicle and road user taxation. The importance of fuel tax to overall government revenue underlines the urgency of such reform. Increasing public concern regarding the equity implications of EV users' non-payment of motoring taxes is also becoming a significant factor.

A second driver of the need for reform is the need to move travel habits in a more sustainable direction. The tax system currently performs poorly in internalising the external costs of road passenger transport, but available tax options can significantly improve this performance. The costs of kilometres driven in the circumstances with the highest external costs must increase in relative terms. At the same time, the overall price of fossil-fuel-powered road transport relative to more sustainable modes must also rise.

Distance-based road-user charges can both substitute for lost fuel-tax revenue and better internalise external costs. Recent evidence suggests that increased recognition of the above problems significantly increases public support for these taxes.

A simple, undifferentiated distance charge can address the tax revenue issue. Moreover, if the rate per vehicle-kilometre varies according to the car's registered address, the possibility of adopting lower rates for people in regional and rural areas arises. As these groups typically drive longer distances and have lower average incomes, there is a clear equity gain, compared with fuel taxes, which could enhance the acceptability of such charges.

However, flat-rate distance charges perform poorly in internalising the external costs of vehicle use because most differ substantially according to time and place. Better internalising external costs requires either adopting spatially and temporally differentiated distance charges or supplementing simple distance charges with other taxes or policy tools – notably, congestion charges, urban tolls or tradable peak driving rights.

Several impediments to adopting differentiated distance charges remain in the short term. These include technical issues, particularly regarding using GPS-based systems in densely populated cities. Other impediments include the substantially higher system costs currently associated with differentiated charges and larger acceptability concerns due to privacy issues and concern over the transparency of highly variable charges.

Given this, and the need for urgent action to address the above issues, some jurisdictions have moved to adopt alternative reforms in the short term. These include vehicle registration surcharges for EVs, calculated to be equivalent to the average loss of fuel tax per vehicle. Other examples include the use of simple, non-differentiated distance-based charges. While experience with these tools is limited to date, there are positive signs concerning practicability and acceptability.

In the short term, these systems can both compensate for the loss of revenue from fuel tax and provide practical experience of road-user charging, thus helping to increase its wider acceptability over time and potentially paving the way for the future adoption of differentiated charges. Given their potential efficiency advantages, governments should also work on developing the technical capacity for differentiated road-user charging systems and on legal frameworks to respond effectively to privacy concerns.

Road transport pricing should be addressed in the broader urban policy context, including through road space reallocation. Road-user pricing reform should also include greater use of distance- and mass-based charging for HGVs, which account for the largest part of the variable costs of road maintenance.

Finally, tax expenditures targeted at driving electrification should be rationalised and updated. The increasing competitiveness of electric passenger vehicles means that shifting from subsidising EVs towards incentives for harder-to-decarbonise vehicles such as buses and vans, and ensuring adequate charging infrastructure, will improve policy effectiveness.

Notes

1 In Singapore, road taxes for electric vehicles (EVs) are based on power output, while for internal combustion engine (ICE) vehicles they are based on engine capacity. As an example, in 2023 a 2-litre ICE vehicle (e.g. the BMW 330i) making 180 kilowatts (kw) pays SGD 1 212 in road tax, whereas an EV making 180kw pays SGD 1 972 and a standard Tesla Model 3, a close competitor to the BMW, pays SGD 3 226.

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Participants provided their affiliations at the time of their participation in the Roundtable meeting.

Decarbonisation and the Pricing of Road Transport

This report assesses the options for reforming vehicle and road use taxes. The shift to electric vehicles and continuing improvements in the fuel efficiency of internal combustion engine vehicles will drastically diminish revenues from fuel taxes, requiring a fundamental change to taxation in the transport sector. The report identifies potential packages of taxes and charges that could generate revenue more efficiently and maintain and enhance incentives for the transition to a sustainable transport system.

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