

Research paper

## Distance-based charges in Great Britain

Allan Peñafiel-Mera , Georgina Santos \*

School of Geography and Planning, Cardiff University, Glamorgan Building, King Edward VII Avenue, Cardiff CF10 3WA, UK



## ARTICLE INFO

## Keywords:

Distance-based charge  
 Distance-based tolls  
 Vehicle miles travelled fee  
 VMT charge  
 VMT toll  
 VMT tax  
 VMT fee  
 Mileage-based user fee  
 MBUF  
 Kilometre tax  
 Mileage tax  
 Road user charging

## ABSTRACT

We estimate the reduction in tax revenues that would result from the electrification of road transport in Great Britain over the period 2025–2050 and a revenue-neutral distance-based charge to recoup these revenues. Our model uses the assumptions and data from the Common Analytical Scenarios produced by the [Department for Transport \(2023a, b\)](#). We find that under fast decarbonisation scenarios the revenues from fuel duty, VAT on the pre-tax price of fuel and on fuel duty, practically disappear, and under slow decarbonisation scenarios, they decrease substantially by 2050. The decrease is between 40% and 50%. Our revenue-neutral distance-based charge is designed to vary with vehicle type and trip purpose (work/non-work), and ranges from 0.4–3.8 pence per km in 2025, to 2.2–34.6 pence per km in 2050, depending on the vehicle type/trip purpose combination, the scenario, and the elasticity assumed. Importantly, although it applies on top of the fuel duties and is payable by both electric vehicles and fossil fuel vehicles, electric vehicles continue to offer significant cost savings.

## 1. Introduction

Fuel duties averaged 4.2% of total tax revenues in the UK between 2014–15 and 2023–24 ([HM Revenue & Customs, 2024a](#), Table 5)<sup>1</sup> and 1.2% of GDP in the same period ([Department for Transport, 2024a](#); [HM Treasury, 2024a](#)). Fuel duties are therefore important for government finances. The problem is that the receipts from fuel duties as a percentage of total tax revenues and as a percentage of GDP are in decline ([Adam and Stroud, 2019](#); [Corfe, 2022](#); [Corlett and Marshall, 2023](#); [Santos and Cornford, 2024](#); [Office for Budget Responsibility, 2022, 2023, 2024](#)). For example, fuel duties as a percentage of total tax revenues decreased from 5.3% in 2014–15 to 3% in 2023–24 ([HM Revenue and Customs, 2024a](#), Table 5), and as a percentage of GDP, they decreased from 1.4% to 0.9% ([Department for Transport, 2024a](#); [HM Treasury, 2024a](#)).

Although this decline can be mainly attributed to improvements in fuel economy and to the duties not having kept up with inflation,<sup>2</sup> it can also be attributed, at least in part, to the electrification of the vehicle fleet, which is slow but steady. The decline over 2022–2024 was exacerbated by the 5 pence temporary cut in fuel duties. In addition, zero-emission cars accounted for 16% of all new car registrations in the UK

in 2023 ([Department for Transport and Driver and Vehicle Licensing Agency, 2024](#)). The sale of petrol and diesel is decreasing, along with fuel duty revenues for the Treasury ([Office for Budget Responsibility, 2023](#)), and when electric vehicles become the dominant type of propulsion, fuel duty revenues will all but disappear ([Adam and Stroud, 2019](#); [Corfe, 2022](#); [Corlett and Marshall, 2023](#); [Santos and Cornford, 2024](#)).

Fuel duty revenues go to the consolidated fund and are used to fund public services, such as schools, hospitals and the armed forces ([House of Commons Transport Committee, 2022](#)). Therefore, the declining revenues from fuel duties pose an important problem for the Treasury in the UK, which is likely to be replicated in other countries where fuel duties are relatively high, as is the case in several European countries.

An obvious, quick, although, admittedly, blunt, way of getting around the problem would be to express fuel duties in pence per mile and use that value to determine the level of a distance-based charge. This is what [Corlett and Marshall \(2023\)](#) do when they suggest a distance-based charge for electric vehicles of 6 pence per mile plus VAT. They argue that fossil fuel vehicles should continue to pay fuel duties, as fuel duties would continue to target CO<sub>2</sub> emissions and are simpler to collect ([Corlett and Marshall, 2023](#), p. 5). Regardless of whether the

\* Corresponding author.

E-mail address: [SantosG@Cardiff.ac.uk](mailto:SantosG@Cardiff.ac.uk) (G. Santos).<sup>1</sup> HM Revenue & Customs reports tax receipts for the whole of the UK, which includes England, Wales, Scotland, and Northern Ireland.<sup>2</sup> Petrol and diesel duties were frozen in 2011–2012 so they have decreased in real terms.

same 6 pence per mile plus VAT were levied on fossil fuel vehicles instead of the fuel duty or not, the policy would not be revenue-neutral, but would imply an increase in revenues, as fossil fuel vehicles would continue to pay roughly the same, and electric vehicles would now face an equivalent charge. This, in turn, could potentially constitute a disincentive to own an electric vehicle. That said, [Corlett and Marshall \(2023, p. 5\)](#) argue that electric vehicles would still have lower operating costs.

In the present paper, we use the Common Analytical Scenarios from the UK Department for Transport ([Department for Transport, 2023a](#)) to model fuel duty revenues and a distance-based charge from 2025 to 2050. Although there may be arguments in favour of revenue-needed goals rather than revenue-neutral goals ([Sin et al., 2021](#)), we focus on revenue neutrality, in line with [Wang and Miao \(2018\)](#), [Corfe \(2022\)](#), [Metcalf \(2023\)](#), [Nelson and Rowangould \(2024\)](#), [Noll et al. \(2024\)](#), [Wood \(2024\)](#), [Cheon \(2025\)](#), [Rahman et al. \(2025\)](#), and [Wei et al. \(2025\)](#). Public and political acceptability in the UK is likely to prove an important hurdle ([Butcher and Davies, 2020, p. 8](#)), but ensuring that there is no change in the total amount of revenue collected by the government may help increase support.

The distance-based charge in the present study is therefore revenue-neutral, and is designed to recoup the fuel duty revenues that will be lost. We make the following contributions. First, we provide a comparative framework on a possible range of values for a distance-based charge based on official government scenarios and projections, which can serve as a starting point for policy design. Second, we show that the revenue contribution from different vehicle types and trip purposes varies with the assumptions made, including the elasticity. Third, we propose a methodology to calculate the distance-based charge, which can be replicated with updated data for Great Britain, and also for other countries, if equivalent parameters can be sourced. Fourth, we provide policy recommendations based on our methodology and results. Although the study focuses on Great Britain, the methodology we develop and the results we find have a much wider policy significance, especially to governments of countries transitioning into decarbonisation of road transport, and in particular, to countries prioritising electrification of road transport.

In [Section 2](#) we critically review previous work. In [Section 3](#) we describe the Common Analytical Scenarios. In [Section 4](#) we describe the data we use and introduce our models. In [Section 5](#) we discuss our results, and in [Section 6](#) we conclude and provide policy recommendations.

## 2. Previous work

### 2.1. A brief overview of petrol and diesel duties in the UK

Fuel duties were introduced in 1909 ([Finance Act, 1910](#), Chapter 8, Paragraph 84),<sup>3</sup> repealed in 1920 ([Finance Act, 1920](#), Chapter 18,

<sup>3</sup> “As from the thirtieth day of April nineteen hundred and nine, there shall be charged, levied, and paid on motor spirit imported into Great Britain or Ireland a duty of Customs at the rate of threepence per gallon. // As from the first day of June nineteen hundred and nine, there shall be charged, levied, and paid on motor spirit made in Great Britain or Ireland, an Excise duty at the rate of threepence per gallon, and there shall be charged on a licence to be taken out annually by a manufacturer of motor spirit and by a dealer in motor spirit an Excise duty of one pound and an Excise duty of five shillings respectively. But a person may sell motor spirit in a quantity not exceeding one pint at one time to one person without taking out a licence as a dealer in motor spirit.” ([Finance Act, 1910](#), Chapter 8, Paragraph 84).

Paragraph 12)<sup>4</sup> and reinstated in 1928 ([Financial Statement, 24 April 1928](#), 216 cc861–3). They have never been earmarked, as the British Treasury has always been reticent to earmarking ([Newbery and Santos, 1999, p. 105](#)), probably because this would restrict the government’s freedom to decide how tax revenues should be spent each year, and would prevent the funds from being spent in areas where there is greater need ([Santos, 2005, p. 13](#)). The rates changed over the years, to keep up with inflation,<sup>5</sup> and to facilitate the achievement of government objectives. For example, the higher duty on leaded petrol increased the share of drivers buying unleaded petrol from 5% in 1988 to 63% by 1993 ([Newbery and Santos, 1999, p. 117](#)).<sup>6</sup>

Revenues from fuel duties as a percentage of GDP and as a percentage of total tax revenues and social contributions have changed (increasing and decreasing) over the years, reaching a maximum of 2.15% and 6.63%, respectively, in 1999.<sup>7</sup> Between 1993 and 1999 fuel duties were automatically increased by a fixed percentage over inflation, a mechanism known as the “escalator,” introduced by the Conservatives and continued by the Labour government. This escalator increased from 3% in 1993 to 6% in 1997. In November 1999, the escalator was abolished, and from then onwards, increases were decided on a budget-by-budget basis ([Santos and Catchesides, 2005, p. 103](#)). After several increases between October 2003 and January 2011, the fuel duty on petrol and diesel was reduced to 57.95 pence per litre in March 2011 and frozen until March 2022, when it was temporarily reduced by 5 pence, to 52.95 pence per litre, with that reduction still in place as of October 2025 ([HM Revenue and Customs, 2025](#)).

In 2023, revenues from fuel duties as a percentage of GDP and as a percentage of total tax revenues and social contributions were 0.93% and 2.57%, respectively.<sup>8</sup> This is less than half of what they were in 1999, when the “escalator” was stopped. Since fuel duties have not increased since 2011, they have decreased in real terms. This decrease in real terms became more pronounced with the temporary reduction of 5 pence. In addition, fuel economy has improved over the years, and the share of alternative fuel vehicles has increased, so the tax base has shrunk.

The problem of a shrinking tax base is not exclusive to the UK. Many countries face similar challenges, especially those attempting to reduce GHG emissions from road transport. The section that follows concentrates on the work that has been conducted for the UK and other countries in this area.

### 2.2. Approach to the literature

To ensure that we did not miss any important piece of academic work or grey literature insight in the area of declining fuel tax revenues and distance-based charges, we organised the literature search systematically. This is not a systematic literature review because it is not aimed at synthesising the literature in the field or answering any research question; it is simply aimed at providing a solid background to the present study, with a focus on declining fuel tax revenues and distance-based charges, and identifying the gap in knowledge that the present study addresses ([Paré and Kitsiou, 2017](#)). We explain the process we followed

<sup>4</sup> “Repeal of customs duties on motor spirit and motor spirit dealers’ licence duties: As from the first day of January nineteen hundred and twenty-one the customs duties on motor spirit imported into Great Britain or Ireland and the excise duty on licences to be taken out annually by dealers in motor spirit shall cease to be chargeable” ([Finance Act, 1920](#), Chapter 18, Paragraph 12).

<sup>5</sup> As explained further down, fuel duties have not been increased to keep up with inflation since 2011.

<sup>6</sup> Leaded petrol was eventually banned in the UK at the end of 1999 ([Santos et al., 2010, p. 10](#)).

<sup>7</sup> Numbers calculated by the authors based on data from the [Office for National Statistics \(2024a, b\)](#).

<sup>8</sup> Numbers also calculated by the authors based on data from the [Office for National Statistics \(2024a, b\)](#).

in [Appendix 1](#).

### 2.3. Declining fuel tax revenues and the idea of a distance-based charge

Fuel tax revenues are in decline in many countries, partly due to the increase in fuel efficiency and partly due to the market penetration of alternative fuel vehicles, especially electric vehicles. [Hajiamiri and Wachs \(2010\)](#), [Jenn et al. \(2015\)](#) and [Davis and Sallee \(2020\)](#) estimate the loss in fuel tax revenues that would result from an increase in the share of electric vehicles in the United States. [Jia et al. \(2019\)](#) do the same for the state of Virginia, [Kolpakov and Sipiorka \(2020\)](#) for the state of Florida, [Konstantinou et al. \(2023\)](#) for the state of Indiana, and [Nelson and Rowangould \(2024\)](#) for the state of Vermont. [Meloche et al. \(2025\)](#) concentrate on Quebec and Ontario in Canada, and [Wood \(2024\)](#), on Canada as a whole. [Hensher et al. \(2021\)](#) focus on the Greater Sydney Metropolitan Area in Australia. [Bonilla et al. \(2022\)](#) concentrate on Mexico, [Bakirtas et al., \(2024\)](#) on Turkey, and [Santos and Cornford \(2024\)](#), on the UK. The percentage reduction in fuel tax revenues calculated for these countries and regions within countries varies depending on the assumptions on electric vehicle market penetration, the baseline and the time-period considered, amongst many factors.

Globally, in 2023, electric vehicles were responsible for a reduction of US\$12 billion in petrol and diesel tax revenues, whilst they generated around US\$2 billion in electricity tax revenues, yielding a net loss of US\$10 billion ([International Energy Agency, 2024](#), p. 152). These losses could reach between US\$105 billion and US\$110 billion by 2035, depending on the increase in the share of electric vehicles globally ([International Energy Agency, 2024](#), p. 152).

Given this problem, several countries are introducing or considering the introduction of tax changes or charges on electric vehicles, including annual vehicle tax, registration fees, and distance-based charges, amongst others ([Smyth and Chu, 2024](#)).

Many states in the US have special registration fees for electric vehicles, often in addition to the traditional vehicle registration fees ([Igleheart, 2023](#); [Minnesota Department of Transportation, 2024](#)). Most of the revenues are allocated to the state transportation fund, with a few states also allocating part to support other priorities, including electric vehicle infrastructure ([Igleheart, 2023](#); [Jaros and Hoffer, 2023](#); [Minnesota Department of Transportation, 2024](#)).

There have also been academic discussions proposing revenue recoup via congestion charges combined with car ownership taxes ([Börjesson et al., 2023](#)), or a tax on electric vehicle battery charging ([Keford, 2023](#); [Chang and Woo, 2024](#)); or a purchase tax or an annual tax ([Noll et al., 2024](#)). Indeed, several states in the US have already implemented or are about to implement electric vehicle charging fees at public stations ([Jaros and Hoffer, 2023](#); [Minnesota Department of Transportation, 2024](#)).

A distance-based charge/fee/toll/tax (DbC), also known as Vehicle Miles Travelled (VMT) charge/fee/toll/tax, Mileage-Based User Fee (MBUF), Kilometre tax, or Mileage tax, is a charge levied on the distance driven by a vehicle.<sup>9</sup> These types of charges have also recently become the subject of much attention. The idea is not new and has been under discussion for years, as shown by [Forkenbrock \(2005\)](#), [Lindsey \(2010\)](#), [Greene \(2011\)](#), [Robitaille et al. \(2011\)](#), [Weatherford \(2011\)](#), [Larsen et al. \(2012\)](#), [Moradi and Al-Deek \(2012\)](#), [Zhang and Lu \(2012, 2013\)](#), [Bergeron \(2013\)](#), [Meurs et al. \(2013\)](#), [Munnich et al. \(2013\)](#), and [Hensher and Mulley \(2014\)](#), to cite just a few. There have also been several pilots and experiments, such as those reported in [Evans and Firth \(2007\)](#), [Kim et al. \(2008\)](#), [Sjöström and Larsson \(2010\)](#), and [Buckeye](#)

<sup>9</sup> This type of charge is sometimes also called Road User Charge, but strictly speaking, a Road User Charge can be based on factors other than distance. For example, a Road User Charge can be based on vehicle weight, vehicle emissions, time of day, (prevailing) congestion levels, type of road used (urban road, rural road, or major road, minor road), amongst others.

[et al. \(2023\)](#), amongst others. Distance-based charging has typically been proposed in the name of efficient road use and the replacement of fuel taxes ([Lindsey, 2010](#); [Wang and Miao, 2018](#)).

This renewed interest in DbC stems from the erosion of fuel tax revenues ([Bose et al., 2021](#); [Metcalf, 2023](#); [Ji et al., 2024](#); [Noll et al., 2024](#); [Smyth and Chu, 2024](#); [Todts, 2024](#); [Wood, 2024](#); [Cheon, 2025](#); [Hriday et al., 2025](#); [Levis et al., 2025](#); [Meloche et al., 2025](#); [Muresianu and Hoffer, 2025](#); [Rahman et al., 2025](#)).

[Noll et al. \(2024\)](#) estimate and compare three taxes on electric vehicles: a revenue-neutral acquisition tax (which can take, for example, the shape of a registration fee or a purchase tax), a revenue-neutral annual tax, and a revenue-neutral DbC (all of which would raise the equivalent revenues that the fuel tax on fossil fuel cars would have raised) in California, Denmark, Germany, Japan, and Switzerland. They find that taxing electric vehicles can delay the transition, and that the delay would be higher with an acquisition tax. They conclude that a DbC is often perceived as an optimal instrument because it is in line with the “user pays” principle.

[Langer et al. \(2017\)](#) compare a fuel tax and a DbC at federal level, both designed to raise a given amount of revenue in the US. They conclude that the DbC has the potential to be more efficient. The efficiency they suggest is linked to the possibility of varying the DbC with traffic volume, type of road, time of day, pollution levels, driver riskiness, and any other external cost. They also find that an urban-rural differentiated DbC charge would be more progressive as urban drivers impose higher externalities and would therefore pay a higher DbC, provided the DbC was linked to the external costs of driving. [Muresianu et al. \(2024\)](#) estimate a nationwide DbC in the US that would produce more than enough revenue to replace federal and state fuel taxes. [Metcalf \(2023\)](#) models the replacement of federal (not state) fuel taxes with a revenue-neutral DbC in the US and also finds that it would be slightly progressive for household incomes below US\$200,000. He also finds that the DbC would benefit rural drivers and would have virtually no impact on Black and Hispanic households. [Knittel et al. \(2025\)](#) conduct a similar exercise and also find that the DbC would be modestly progressive. They also find that rural areas and the centre of the country, which tend to have lower average fuel efficiency, would pay less, and urban areas and coastal regions, where EV adoption is highest, would pay more.

[Wang and Miao \(2018\)](#) simulate a revenue-neutral flat DbC for the US, with a rate estimated for each state. They find that a DbC would yield more stable revenues relative to fuel taxes, as these are set to decrease. In contrast with [Langer et al. \(2017\)](#) and with [Metcalf \(2023\)](#), they find that a DbC would be slightly more regressive than a fuel tax, although the difference would be negligible. The reason for the difference between [Langer et al. \(2017\)](#) and [Wang and Miao \(2018\)](#) is that the former assume that the DbC would be higher for urban drivers, who impose higher external costs, whereas the latter do not differentiate between urban and rural driving, or their respective externalities. In addition, both [Wang and Miao \(2018\)](#) and [Metcalf \(2023\)](#) report the distributional impacts of a revenue-neutral flat DbC as “slightly” regressive and “mildly” progressive, respectively, indicating that the differences are negligible.

[Rahman et al. \(2025\)](#) compare the distributional impacts of fuel taxes and a revenue-neutral DbC for different income segments and two geographic groups (urban and rural), in California, Iowa, New York, and Texas. They find that with fuel taxes and with a flat DbC that does not differentiate by fuel efficiency, rural households pay more than urban households, and higher-income groups pay more than lower-income groups. They also find that the gap narrows with a DbC, with rural households paying less because, typically, vehicles in rural households drive longer distances but also have lower fuel efficiency than vehicles in urban households, in line with [Wang and Miao \(2018\)](#) and [Metcalf \(2023\)](#). They conclude that households in California, Iowa, New York, and Texas would pay less on average with a DbC than with the current fuel tax system, but this is only because electric vehicles would also be

contributing to raise the same amount of revenues and households owning electric vehicles are still a minority in the US.

Glaser et al. (2023), on the other hand, highlight that fuel taxes are regressive and have become more regressive over the years because higher-income households tend to use less fuel as they are the ones that can afford electric vehicles. For this very reason, they find that replacing fuel taxes with a household-level DbC would increase the average burden on households in the top income deciles. This progressive shift would become larger with time, as electric vehicles become more common amongst higher than lower-income groups in the US, an intuitive conclusion in line with the findings by Todts (2024) for the UK. Cheon (2025), on the other hand, finds that whilst less fuel-efficient vehicles would benefit from the petrol tax being replaced with a DbC, and more efficient vehicles, such as electric vehicles, would incur losses, results by income level suggest that the DbC would be more regressive than the petrol tax, in line with Wang and Miao (2018). That said, he concludes that replacing fuel taxes in the US with a revenue-neutral DbC would slightly increase consumer surplus, and that a uniform federal DbC would lead to varying outcomes across states largely due to differences in vehicle fuel efficiency.

Not surprisingly, Kastrouni et al. (2015) find that households with higher fuel-efficiency vehicles or on higher incomes would increase their payments if a DbC were to replace fuel taxes in the US, and Welch and Mishra (2014) find that replacing the state fuel tax with a DbC in the state of Maryland would increase travellers' welfare, especially the welfare of those in lower-income groups and those in rural areas. Ju et al. (2024) find that replacing the fuel tax in the state of Texas with a DbC would decrease the distance travelled by lower-income households. They also find that it would decrease average rural household payments and increase average urban household payments. On similar lines, Nelson and Rowangould (2024) conclude that replacing the state fuel tax with a revenue-neutral DbC in the state of Vermont would yield, on average, lower tax burdens for rural and low-income households than for urban and high-income households.

Ji et al. (2024) explore how state-level DbC pilots and programs in the US could be integrated with tolling systems. They find that the tolling industry and the DbC implementations could reduce their administrative costs and benefit from the increased scale of operations.

Wood (2024) presents preliminary estimates of a revenue-neutral DbC for Canada using 2021 data, allowing for a reduction in distance travelled by drivers in response to the DbC. He highlights that DbC rates in each province and territory differ because of differences in provincial/territorial fuel tax rates and differences in fuel efficiency, and concludes that it would be important to estimate a DbC that internalised all distance-based externalities, which brings the problem of efficiency into the discussion. Indeed, a DbC designed to recover the declining revenues from fuel taxes, is not necessarily an instrument that will achieve efficiency. Börjesson et al. (2023), for example, find that the differences in congestion and other external costs across Mälardalen, a country-like very urbanised region in Sweden, are so large that they would be better internalised with a congestion tax combined with another instrument, such as a vehicle ownership tax. This is an intuitive conclusion, although the DbC could be differentiated to approximate different marginal external costs, such as congestion, air pollution<sup>10</sup> and accidents (Wood, 2024). The problem is that a fine-tuned DbC to match external costs would be associated with higher administrative costs (Börjesson et al., 2023, p. 59) as it would need to be differentiated by vehicle type, time and place (Todts, 2024), an issue that a DbC linked to external costs as suggested by Langer et al. (2017) would also face.

It should be borne in mind, however, that a uniform DbC on electric vehicles designed to recover tax revenues may not internalise external costs perfectly but it may help reduce congestion to some extent, which

would result from the lower mileage costs of electric vehicles relative to petrol and diesel vehicles (Sallnow and Plowden, 2022). Hensher et al. (2021), for example, model a DbC on electric vehicles focusing on the Greater Sydney Metropolitan Area in Australia for a period post-2040, when electric cars are expected to exceed 20% of the total fleet. They find that a carefully designed charge on electric vehicles would reinstate the lost fuel duty revenues and would help contain an increase in car use that would otherwise come as a result of the switch to electric vehicles.

The state of Victoria in Australia introduced a zero and low-emission vehicles DbC in 2021, but in 2023, the High Court deemed the charge unconstitutional (Byrne, 2023). As of 2025, the state of New South Wales (NSW) is planning to implement an almost identical DbC in 2027 or when electric vehicles reach 30% of all new vehicle sales, whichever comes first (NSW Government, 2025). They are also working to assess the implications that the High Court decision regarding the DbC in Victoria could have on the DbC in NSW (NSW Government, 2025). Interestingly, the Federal Government is advancing plans for electric vehicle owners to pay a new road-user charge, which would be a DbC, with some claiming it could be expanded to all vehicles, like in New Zealand (Collis, 2025), a case we discuss below.

Corfe (2022) estimates a revenue-neutral DbC for the UK. He models different free mileage allowances, which impact the value of the DbC. To keep revenues constant, he proposes a DbC of 8 pence per mile if a 1,000-mile allowance were introduced, 10 pence if a 2,500-mile allowance were introduced, and 16 pence if a 5,000-mile allowance were introduced.

Corlett and Marshall (2023) calculate a DbC for the UK by simply expressing the fuel duty not as pence per litre but pence per kilometre, with the help of data on fuel consumption per distance travelled, and arrive at a figure of 6 pence per mile plus VAT. They argue that this DbC could apply to electric vehicles, with fossil fuel vehicles continuing to pay the fuel tax for as long as they continue to be on the roads. The policy would therefore not be revenue-neutral and could potentially act as a disincentive to own an electric vehicle, although Corlett and Marshall (2023, p. 5) highlight that electric vehicles would still be cheaper to run.

Al-Deek and Moradi (2015) design four variants of a DbC to replace the total fuel tax (which is composed of a federal, a state, and a local tax) in the state of Florida in the US. The variants are: (a) a DbC equivalent to the current tax, i.e., the current fuel tax is expressed in cents per mile, on similar lines of what Corlett and Marshall (2023) do, (b) a DbC based on area type, making it higher for urban areas, (c) a DbC based on time of day, making it higher for peak periods, and (d) a DbC based on congestion, making it higher for urban areas during peak periods. They find that revenues from different DbC designs can be higher than revenues from fuel taxes, with the highest of all being a higher DbC for urban areas during peak periods, as would have been expected.

Rodriguez and Pulugurtha (2021) estimate a DbC for the city of Charlotte, North Carolina, in the US to replace or complement the fuel tax and reduce the local transport finance deficit. They develop several variants, including factors accounting for vehicles' weight, and find that the DbC would be capable of reducing the transport finance deficit. Hridoy et al. (2025) also focus on North Carolina. They conduct a survey amongst car users to understand if they would change their car use if a DbC were introduced, and find that they would if the rate were high, although the sensitivity varies with socio-demographic characteristics and trip purpose.

Sin et al. (2021) estimate a DbC for Pennsylvania in the US and demonstrate the difference and importance of revenue-neutral versus revenue-needed as goals, and conclude that a DbC should be based on revenue-needed. This is a contentious issue, once public and political acceptability come into the discussion.

Wei et al. (2025) explore the impacts of a DbC on commercial vehicles in California relative to state fuel and weight fees and find that for revenue-neutral scenarios, the burden would be shifted from larger to smaller commercial vehicles, relative to the fuel tax, there would be

<sup>10</sup> Electric vehicles produce particulate matter resulting from tyre and brake wear and road abrasion (Quarmby et al., 2019; Wood, 2024).

little economy-wide impacts, and the distributional impact on consumers would be negligible.

As pointed out above, these ideas have gone beyond academic exercises and have started to take shape in the real world. Norway is contemplating the introduction of a national DbC (Norwegian Tax Administration and Norwegian Public Roads Administration, 2022, p. 119) in steps, with light Norwegian zero-emission vehicles in Step 1, paying a flat DbC, followed by heavy vehicles and foreign vehicles over 7.5 tonnes in Step 2, which will also need to pay the DbC, differentiated by area (sprawled built-up, conurbation, big city) and time of day (Norwegian Tax Administration and Norwegian Public Roads Administration, 2022, p. 5).

In 2018, the state of Utah in the US passed legislation on an alternative fuel vehicle fee in addition to the annual registration fee that all vehicles pay (Utah Department of Transportation, 2022) and in 2022 they introduced the option of a DbC, known as the Utah's Road Usage Charge (National Conference of State Legislatures, 2022). Alternative fuel vehicle owners have the choice to pay per distance driven instead of paying the alternative fuel vehicle fee (Utah Department of Transportation, 2022).

On similar lines, the state of Hawaii, passed legislation in 2023, creating a DbC for electric vehicles from July 2025, and eliminating the annual state vehicle registration surcharge they pay, although electric vehicle owners will be able to choose between paying a registration surcharge or the DbC until June 2028 (Hawai'i State Legislature, 2023).

In Iceland, a DbC for electric vehicles is in place (Iceland Government, 2024). It was introduced in January 2024 (Adam, 2024) as fuel tax revenues were decreasing (Iceland Government, 2023), and will be expanded to all vehicles, including petrol and diesel vehicles in 2025 (European Commission, 2025). Similarly, in New Zealand, a DbC for electric vehicles was introduced in April 2024 (New Zealand Transport Agency, 2024a) or better say, the exemption they had enjoyed since 2009 was terminated because they reached around 2% of New Zealand's light vehicle fleet (New Zealand Transport Agency, 2024b). Importantly, the government agreed in 2025 to a series of legislative changes that will enable the replacement of petrol taxes with electronic road user charges based on distance and weight (Bishop, 2025). As of 2025, petrol vehicles pay a tax on petrol, whereas diesel, electric, and heavy vehicles pay a road user charge based on distance (Bishop, 2025). However, the road user charge system is paper-based, and requires drivers to monitor their odometers and pay the road user charge in 1000 km chunks (Bishop, 2025). That is why the government of New Zealand plans to reform the rules and move to a user-friendly electronic system (Bishop, 2025).

Despite some pro-motorist voices that argue that “these are still early days” and that “losing a few billion pounds in fuel duty is a price worth paying to save the planet” (RAC Foundation, 2023), it is clear that the reduction in fuel duty revenues is an important problem not just in the UK but in countries transitioning to road transport electrification. A DbC is clearly a feasible and viable option in the UK to recoup fuel tax revenues. The government needs to rethink how it taxes motoring as a matter of urgency, before revenues are eroded and expectations of electric vehicles not paying taxes become ingrained (Adam and Stroud, 2019; Corfe, 2022).

The idea of national road pricing in the UK, supported by a feasibility study on road pricing (Department for Transport, 2004) and the Eddington Report (Eddington, 2006) was abandoned in 2007 following an e-petition on the official No. 10 Downing Street website with 1.8 million signatures asking the government to scrap the plans (Glaister, 2018; Butcher and Davies, 2020). Almost 20 years on, there is more public and political awareness of the importance of road transport electrification in the fight against climate change and the inevitable reduction of fuel tax revenues. Offering a minimum number of free miles per year (King and King, 2017; House of Commons Transport Committee, 2022; Corfe, 2022; Smith and Clougherty, 2023), could help to ease equity concerns (Bose et al., 2021; House of Commons Transport Committee, 2022).

### 3. Common analytical scenarios

All our estimates pertain to the future, and for this, we use scenarios. The scenarios we use are the Common Analytical Scenarios (CAS) produced by the Department for Transport (2023a, b). Scenarios are representations of possible futures, and this approach is especially useful in the present study because it is not possible to predict the future of transport with any certainty (Department for Transport, 2023b, point 3.36). Areas of uncertainty include population growth, economic growth, economic activity distribution across regions, technological advances and uptake, social and behavioural change, and vehicle fleet decarbonisation (Department for Transport, 2023b, point 3.45).

There are seven CAS plus a Core Scenario. The Core Scenario is the scenario used in the Transport Analysis Guidance (TAG) Databook (Department for Transport, 2024b), which was first launched in 2013, and has been and will continue to be regularly updated. The seven CAS are described in the TAG Uncertainty Toolkit (Department for Transport, 2023b), and are summarised in Table 1, which also includes a description of the Core scenario.

We use these scenarios and their assumed mode and energy shifts, but we do not model the mode and/or energy shift that would likely result from the introduction of a DbC, and this constitutes a limitation of our study.

### 4. Data and models

#### 4.1. Data

##### 4.1.1. Indices

To ease the understanding of the formulae used in the present study, some of which include variables with up to six indices, we present all the indices we use in Table 2.

##### 4.1.2. Shares of distance travelled by energy and trip purpose

The data for the share of distance travelled by different vehicle types running on petrol, diesel and electricity,  $\xi_{stme}$ , was extracted from the CAS Databook (Department for Transport, 2023a) for the TC, VL and MB scenarios, and from the TAG Databook for all the other scenarios. We combined this data with the shares of distance travelled for work and non-work purposes,  $\tau_{um}$ , which we took from TAG Table A1.3.4 (Department for Transport, 2024b).<sup>11</sup>

The shares of distance travelled by different vehicle types running on energy  $e$ ,  $\xi_{stme}$ , follow two different projections: one applies to the CO, HE, LE, RE and BC scenarios, and the other, to the TC, VL and MB scenarios. The source of each dataset is presented in Table 3 and the values are displayed in Fig. 1.

Under the slowest electrification scenarios (CO, HE, LE, RE and BC), although the distance travelled by cars using electricity grows over time, it does not exceed 70% of the total distance, and for LGVs it does not exceed 45% by 2050. HGVs continue to drive on diesel, with zero electrification. Under the fastest electrification scenarios (TC, VL and MB), on the other hand, 100% of the distance travelled by cars and almost 100% of the distance travelled by LGVs and HGVs is travelled on electricity by 2050.

##### 4.1.3. Travel distances and speeds

Fig. 1 shows the projections of  $\xi_{stme}$ , which are the shares of distance travelled by different vehicle types running on petrol, diesel and electricity under the different scenarios over the modelled period, 2025–2050.

The datasets of distance travelled, and average speed were extracted from the National Road Traffic Projections (NRTP) Workbook

<sup>11</sup> We assumed the shares of work and non-work trips were the same for all scenarios and remained constant over the modelled period.

**Table 1**  
Description of the Core Scenario and the seven Common Analytical Scenarios.

Scenario	Narrative
Core	This scenario projects current trends into the future, and assumes there are no fundamental shocks or changes. GDP, population and employment trends are assumed to be those in the Annual Parameters Table of the TAG Databook (Department for Transport, 2024b).
High Economy	People become richer than we currently expect. The increase in immigration and population exceeds official forecasts. In 2050, the population in Great Britain reaches 77.7 million, and the GDP is 10% higher and employment is 12% higher relative to core assumptions.
Low Economy	There is low immigration and low population growth. In 2050, the population in Great Britain reaches 64.6 million, and the GDP is 31% lower and employment is 7% lower relative to core assumptions.
Regional	People migrate from London, the South East and the East of England looking for more affordable housing. This causes lower employment and population growth in these regions relative to the rest of the country. Productivity and relative competitiveness increase in regions outside London, the South East and the East of England. Population and employment in regions outside London, the South East and the East of England grow at the same rate as in the whole country or more, and population and employment in London, the South East and the East of England grow at a lower rate than before, so the whole country's growth rate remains the same.
Behavioural change	There are changes in the travel behaviour of young people, and increased flexible working and online shopping. Overall trip rates fall. Fewer young people hold a driving licence. There is an increase in Light Goods Vehicle trips reflecting an increase in deliveries from online shopping.
Technology	Connected autonomous vehicles enter the fleet in the 2020s and represent up to 50% of it by 2047. This makes road travel extremely attractive and accessible. Trip rates by the elderly increase after 2031. The nature of a driving licence changes due to connected autonomous vehicles, and this means that there is a drastic increase in licence holders after 2031, reaching 92% by 2061. There is a high uptake of electric vehicles. The perceived costs of travel time falls. Car occupancy can be zero for empty running trips by connected autonomous vehicles.
Vehicle-led Decarbonisation	There is no intervention by the government to increase electric vehicle costs (no distance-based charge, for example). As a result, there is a high uptake of electric and other zero-emission vehicles, and in this scenario, the uptake is higher than in the Core. There is no adjustment made to current costs of public transport. In this scenario and in the Core scenario, electric vehicles are relatively cheaper to run thanks to the lack of fuel duty, so transport users switch to electric cars and electric light good vehicles, away from petrol and diesel and also from other modes, including public transport. This leads to increased road traffic on the network.
Mode-balanced Decarbonisation	An unspecified intervention and/or market forces equalise the operating costs of electric vehicles with the operating costs of petrol and diesel vehicles. There is still a high uptake of electric and other zero-emission vehicles mainly due to the ban on the sale of new petrol and diesel vehicles, not because of a cost advantage. Since operating costs are equalised, the costs of car travel are not cheaper than the costs of public transport travel. The share of public transport is higher than in the Core scenario because it is a more competitive choice.

Note 1: The core scenario is not described on the TAG Uncertainty Toolkit, but consists of central projections and assumptions made in the TAG Databook (Department for Transport, 2024b).

Note 2: The fleet assumptions from the TAG Databook (Department for Transport, 2024b) used in the Core scenario do not include the 2030 ban on the sale of new petrol and diesel vehicles or the removal of the exception from vehicle excise duty on zero-emission vehicles. The sale of new petrol and diesel vehicles will be banned from 2030, with all new cars and vans being fully zero emission by 2035 (Department for Transport, 2025). The exception from vehicle excise duty on zero-emission vehicles was removed in 2025 (UK Government, 2025). Source: TAG Uncertainty Toolkit (Department for Transport, 2023b, pp. 50–51).

**Table 2**  
Indices, descriptions and values.

Index and description	Index values (Code)
$s$ denotes the CAS	Core (CO) High Economy (HE) Low Economy (LE) Regional (RE) Behavioural Change (BC) Technology (TC) Vehicle-led Decarbonisation (VL) Mode-balanced Decarbonisation (MB)
$t$ denotes the year	2025, 2026, ..., 2050
$u$ denotes the trip purpose <sup>a</sup>	Work trips (W) Non-Work trips (NW)
$m$ denotes vehicle type <sup>b</sup>	Car Light Goods Vehicle (LGV) Rigid or Other Goods Vehicle 1 (OGV1) Articulated or Other Goods Vehicle 2 (OGV2) Public Service Vehicle (PSV)
$e$ denotes the energy used by the vehicle	Petrol Diesel Electricity
$l$ denotes the elasticity	High elasticity Low elasticity

<sup>a</sup> Both value of time and vehicle operating costs are different for work and non-work trips. The difference in vehicle operating costs is relevant in the present study because vehicles travelling for work purposes can reclaim the VAT paid on fuel, fuel duty or electricity.

<sup>b</sup> In the UK, OGV1 is a 2 or 3-axle rigid vehicle and OGV2 is a 4-axle rigid vehicle or articulated vehicle with any number of axles. According to those definitions, the sets of OGV1 and Rigid vehicles are not identical, and the sets of OGV2 and Articulated vehicles are not identical either. Some of the datasets needed for the present study use the OGV1 and OGV2 classification, whilst others use the Rigid and Articulated vehicles classification. To standardise those differing datasets, we made the simplifying assumption that OGV1 equals Rigid and OGV2 equals Articulated.

**Table 3**  
Groups of scenarios by energy shares.

CAS	$\xi_{stme}$
Core	Slower electrification of the fleet.
High Economy	According to the CAS Databook (Department for Transport, 2023a), for these scenarios, the mileage split matches the shares of vehicle kilometres by fuel type from TAG Table A1.3.9 (Department for Transport, 2024b).
Low Economy	
Regional	
Behavioural Change	
Technology	Faster electrification of the fleet.
Vehicle-led Decarbonisation	This option corresponds to the information provided in Tables MB1, VL1, and T4 of the CAS Databook (Department for Transport, 2023a).
Mode-balanced Decarbonisation	

(Department for Transport, 2022). Several simple manipulations had to be performed, as follows. First, since the NRTP Workbook (Department for Transport, 2022) does not include any data for Scotland, distance travelled from the NRTP Workbook was increased to include Scotland, assuming that the share of total distance travelled by mode in Scotland relative to total distance travelled by mode in Great Britain would stay constant, which is a reasonable assumption bearing in mind that these shares stayed constant over the period 1993–2021.<sup>12</sup> Fig. 2 shows the resulting total distance. Second, the NRTP Workbook (Department for Transport, 2022) provides data for the years 2015 and 2025, and then in

<sup>12</sup> These shares have stayed virtually constant, as can be seen in Appendix 2, which shows the share of distance travelled in England, Wales and Scotland over 1993–2023, on the basis of data from Table Regional Traffic: by vehicle type (Department for Transport, 2024d).

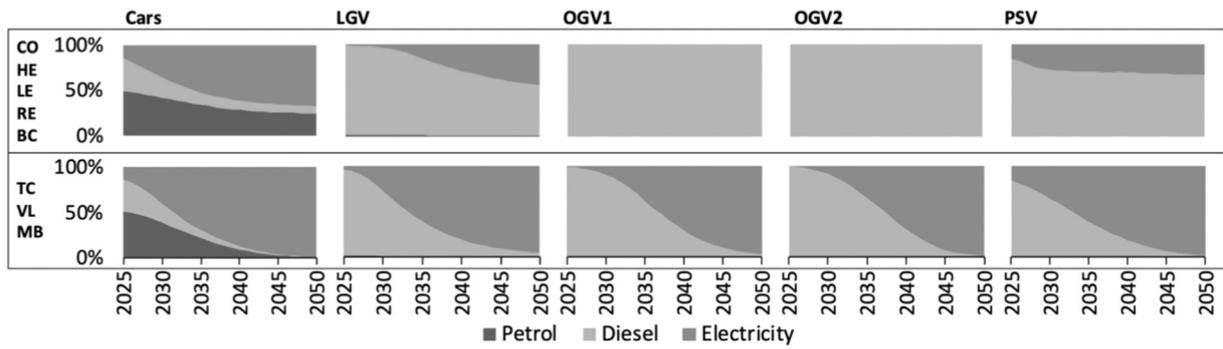


Fig. 1. Projections of the shares of distance travelled by different vehicle types running on petrol, diesel and electricity under the different scenarios, Great Britain, 2025 to 2050. Note: The corresponding scenarios are shown on the left. Source: TAG Table A1.3.9 (Department for Transport, 2024b) for CO, HE, LE, RE and BC, and Tables MB1, VL1, and T4 of the CAS Databook (Department for Transport, 2023a) for TC, VL and MB.

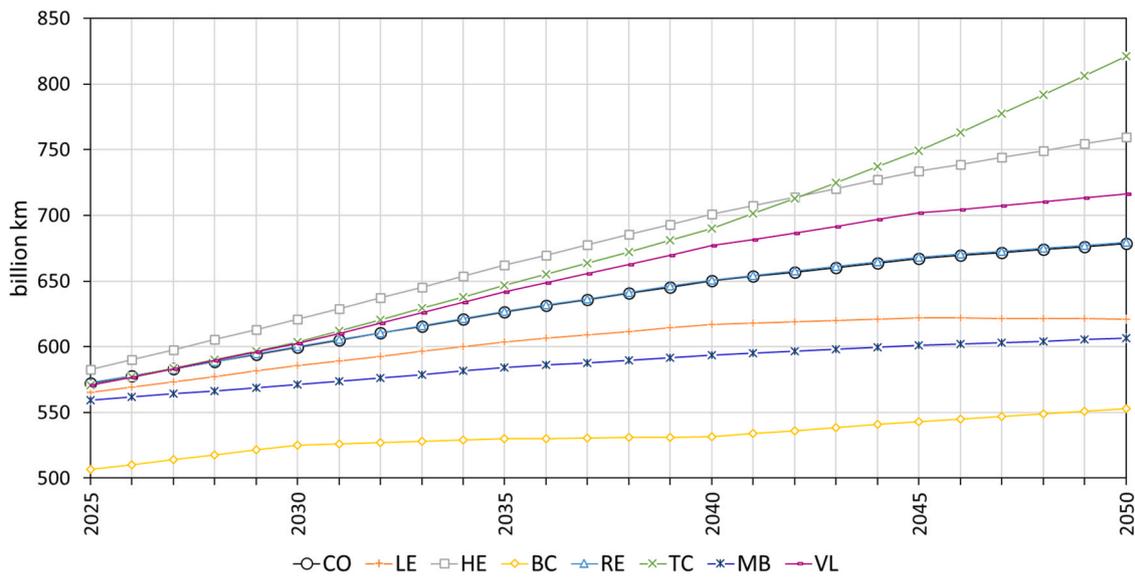


Fig. 2. Total projected distance driven under the different scenarios, Great Britain, 2025–2050. Source: Department for Transport (2022).

five-year intervals (e.g., 2030, 2035, through to 2060). The values for the intermediate years were calculated using linear interpolation between the years for which there was data. Third, all values in miles (for distance and speed) were converted to kilometres. Fourth, the projections of distance travelled in the NRTP Workbook (Department for Transport, 2022) are provided for HGV, which combine OGV1 and OGV2. We used data from the road freight statistics (Table RFS0110, Department for Transport, 2024c), which differentiates between distance travelled by Rigid goods vehicles and Articulated goods vehicles, to divide HGV into OGV1 (i.e., rigid) and OGV2 (i.e., articulated).<sup>13</sup> Fifth, average speeds by mode were calculated as a weighted average of the speeds on different types of roads (A road, Minor Road, Motorway and Trunk). The weights correspond to the shares of the distance travelled on each road type according to the NRTP Workbook (Department

for Transport, 2022). Finally, average speeds in Scotland were assumed to be the same as average speeds in England and Wales.

The models introduced in the following sections require the distance to be disaggregated, either by energy (petrol, diesel, electricity) or by trip purpose (work, non-work), or sometimes by both. We disaggregate distance travelled, denoted  $M$ , by energy and trip purpose, using Eq. (1); by trip purpose only, using Eq. (2), and by energy only, using Eq. (3).

$$M_{stume} = M_{stm} \tau_{um} \xi_{stme} \tag{1}$$

$$M_{stum} = M_{stm} \tau_{um} \tag{2}$$

$$M_{stme} = M_{stm} \xi_{stme} \tag{3}$$

We distinguish between modelled and historical distance travelled by using a dot on top of the variable:  $\dot{M}_{stm}$ . Hereafter, variables including a dot on top will be used to describe recorded data. In the case of  $\dot{M}$ , the dataset is historical road traffic data (Department for Transport, 2024d). The data is provided by vehicle type (car, LGV, OGV1, OGV2, and PSV).

<sup>13</sup> As explained in footnote b of Table 2, we made the simplifying assumptions that (a) all OGV1 are rigid, even though in reality, a small percentage are articulated, and (b) all OGV2 are articulated, even though in reality, a small percentage are rigid. We had to make these assumptions because Table RFS0110 (Department for Transport, 2024c) does not differentiate between OGV1 and OGV2 but between rigid and articulated.

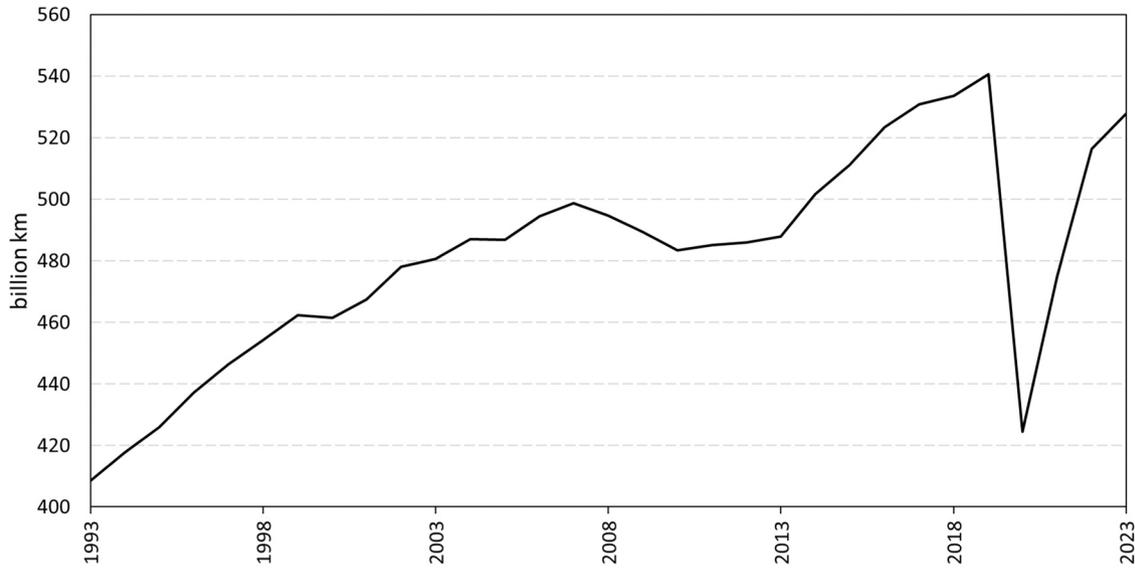


Fig. 3. Total distance travelled by all vehicles in Great Britain, 1993–2023. Source: Department for Transport (2024d).

Fig. 3 shows the total distance travelled ( $M$ ), including all vehicle types in Great Britain, from 1993 to 2023.<sup>14</sup>

#### 4.1.4. Parameters for unitary fuel and electricity cost, fuel duty and VAT

Following TAG Tables A1.3.12 and A1.3.13 of the TAG Databook (Department for Transport, 2024b),<sup>15</sup> we use Eq. (4) to forecast fuel (and electricity) costs, where  $\omega$  denotes unitary fuel (or electricity) cost, expressed in £/km,  $\bar{s}$  denotes average travel speed, and  $a$ ,  $b$ ,  $c$ ,  $d$  are cost parameters. Several sets of cost parameters are provided in the TAG Databook (Department for Transport, 2024b), one for each combination of vehicle type (car, LGV, OGV1, OGV2, PSV), trip purpose (work, non-work) and energy (petrol, diesel, electric). The parameters for work trips are contained in TAG Table A1.3.12, and those for non-work trips, in TAG Table A1.3.13 (Department for Transport, 2024b). The difference between them is that the former excludes VAT, as VAT can be reclaimed for work trips.

$$\omega_{stume} = \left( \frac{a_{stume}}{\bar{s}_{stm}} \right) + (b_{stume}) + (c_{stume} \bar{s}_{stm}) + (d_{stume} \bar{s}_{stm}^2) \quad (4)$$

Each of the cost parameters is obtained using Eq. (5)<sup>16</sup> (TAG Table A1.3.11, Department for Transport, 2024b), where  $\rho_{te}$  denotes fuel price,  $\delta_{te}$ , fuel duty, and  $\zeta_{teu}$ , VAT. Fuel price and fuel duty are expressed in £/litre, while VAT is a percentage. These three inputs were obtained from TAG Table 1.3.7 of the TAG Databook (Department for Transport, 2024b).

$$a_{stume} = \alpha_{stume}^w (\rho_{te} + \delta_{te}) (1 + \zeta_{teu}) \quad (5)$$

We use two sets of consumption parameters ( $\alpha^w$ ,  $b^w$ ,  $c^w$  and  $d^w$ ), one for each group of scenarios in Table 3. The dataset for the first group is calculated in TAG Table A1.3.11 of the TAG Databook (Department for Transport, 2024b), using TAG Tables “VoC Efficiency” and “Fuel

<sup>14</sup> The marked reduction in distance travelled in 2020 is the result of travel restrictions imposed during the COVID19 pandemic, and this is followed by a recovery which, as of 2023, had not reached pre-pandemic levels.

<sup>15</sup> The TAG tables assume that the 5 pence cut in fuel duty is stopped and the fuel duty returns to 57.95 pence per litre and grows with the Retail Price Index from calendar year 2024. This is not in line with the Autumn Budget 2024 (HM Treasury, 2024b), but it is not likely to affect the model results substantially.

<sup>16</sup> The example shows the formula for parameter  $a$ , however, the same formula applies to parameters  $b$ ,  $c$ , and  $d$ .

consumption.” The dataset for the second group is given in Tables T5, VL2, and MB2 of the CAS Databook (Department for Transport, 2023a) as values, without formulae.

We now disaggregate each of the terms of the cost parameters into sub-parameters that are specific to fuel price ( $\alpha^p$ ), fuel duty ( $\alpha^d$ ) and fuel VAT ( $\alpha^c$ ), as shown in Eq. (6).

$$a_{stume} = \underbrace{\alpha_{stume}^w \rho_{te}}_{\alpha_{stume}^p} + \underbrace{\alpha_{stume}^w \delta_{te}}_{\alpha_{stume}^d} + \underbrace{\alpha_{stume}^w (\rho_{te} + \delta_{te}) \zeta_{teu}}_{\alpha_{stume}^c} \quad (6)$$

For the case of work trips (i.e.,  $u = W$ ),  $\zeta_{teu}$  is 0%. This results in  $\alpha^c$ ,  $b^c$ ,  $c^c$  and  $d^c$  also being 0. In addition, since electric vehicles pay zero fuel duty in all the projected years,  $\alpha^d$ ,  $b^d$ ,  $c^d$  and  $d^d$  are also 0.

#### 4.1.5. Historical and projected GDP and fuel duty revenues

The GDP series, denoted by  $\Gamma_{st}$ , consist of three datasets: one that corresponds to the HE scenario, one that corresponds to the LE scenario, and one that corresponds to the CO scenario and all the other scenarios, RE, BC, TC, VL, MB. The HE and LE GDP projections were taken from Tables HE4 and LE4 of the CAS Databook (Department for Transport, 2023a). The GDP projection for the CO scenario and all the other scenarios was obtained from TAG Table “Annual Parameters” of the TAG Databook (Department for Transport, 2024b), following the assumptions from Table SG of the CAS Databook (Department for Transport, 2023a). These projections are displayed in Fig. 4.

The GDP for the years prior to 2025 was also sourced from TAG Table “Annual Parameters” of the TAG Databook (Department for Transport, 2024b). Historical fuel duty revenues were obtained from Table TSGB1310 (Department for Transport, 2024a). All monetary values in this paper are expressed in 2019 prices.

## 4.2. Models

### 4.2.1. Expected fuel duty and VAT revenues

Fuel duty is levied per unit of petrol and diesel purchased and VAT is applied after fuel duty, so, the pump price of a litre of petrol or diesel includes the pre-tax price plus the fuel duty plus 20% VAT both on the pre-tax price and on fuel duty (Office for Budget Responsibility, 2024).

**4.2.1.1. Projections using the shares of energy according to the common analytical scenarios.** In this section, Eq. (4) and the corresponding parameters resulting from Eq. (6), are used to disaggregate fuel (or

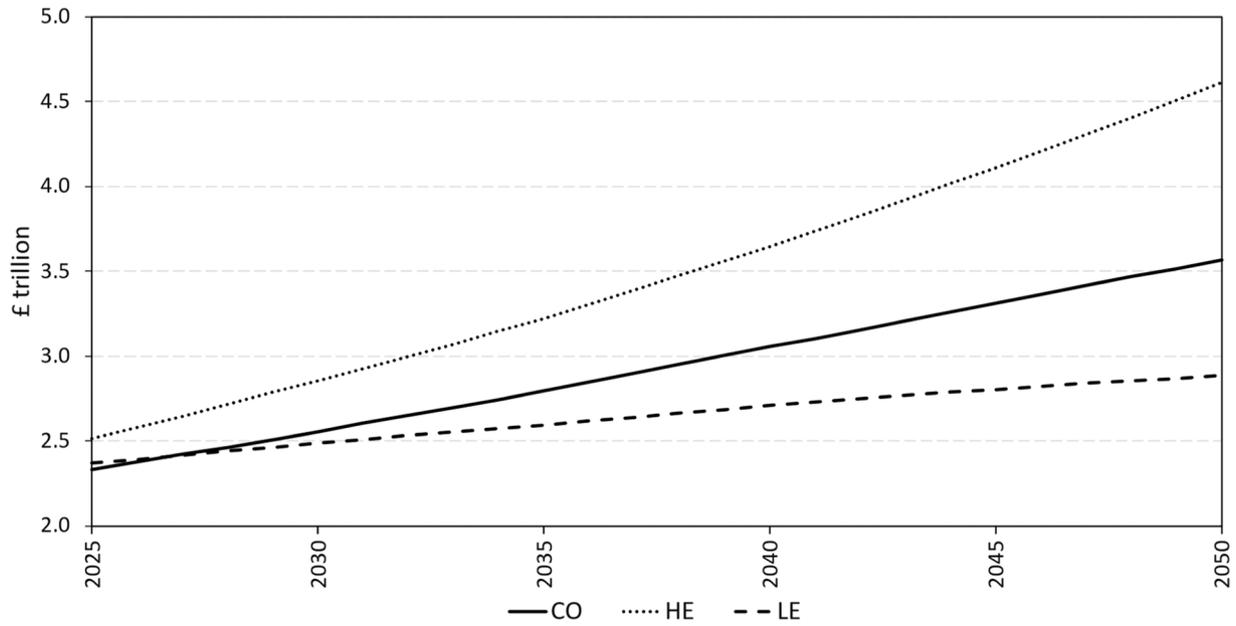


Fig. 4. GDP projections under the HE, LE and CO scenarios, Great Britain, 2025–2050. Note: Following the assumptions from Table SG of the CAS Databook (Department for Transport, 2023a), the GDP projection for the RE, BC, TC, VL and MB scenarios is the same as for the CO scenario. Source: CAS Databook (Department for Transport, 2023a).

electricity) costs into three components: fuel/energy price ( $\omega^p$ ), fuel duty ( $\omega^\delta$ ) and VAT ( $\omega^\epsilon$ ). All three components are expressed in £/km and are calculated using Eqs. (7), (8) and (9).

$$\omega_{stume}^p = \frac{a_{stume}^p}{s_{stm}} + b_{stume}^p + c_{stume}^p \bar{s}_{stm} + d_{stume}^p \bar{s}_{stm}^2 \quad (7)$$

$$\omega_{stume}^\delta = \frac{a_{stume}^\delta}{s_{stm}} + b_{stume}^\delta + c_{stume}^\delta \bar{s}_{stm} + d_{stume}^\delta \bar{s}_{stm}^2 \quad (8)$$

$$\omega_{stume}^\epsilon = \frac{a_{stume}^\epsilon}{s_{stm}} + b_{stume}^\epsilon + c_{stume}^\epsilon \bar{s}_{stm} + d_{stume}^\epsilon \bar{s}_{stm}^2 \quad (9)$$

For every year and every scenario, the aggregate revenue,  $R_{st}$ , is the sum of fuel duty revenues,  $R_{st}^\delta$ , and VAT revenues,  $R_{st}^\epsilon$ . Those values are calculated using Eqs. (10), (11) and (12).

$$R_{st} = R_{st}^\delta + R_{st}^\epsilon \quad (10)$$

$$R_{st}^\delta = \sum_{vt} \sum_{vm} \sum_{ve} M_{stume} \omega_{stume}^\delta \quad (11)$$

$$R_{st}^\epsilon = \sum_{vt} \sum_{vm} \sum_{ve} M_{stume} \omega_{stume}^\epsilon \quad (12)$$

We validated this model using historical data of the parameters involved (mileage and cost parameters) for the period 2015–2022.<sup>17</sup> The results predict 86.5% of the actual revenue collected over that period. Despite being 13.5% lower, the modelled revenues follow a similar pattern to that of the actual revenues, as can be seen on Fig. 5. Furthermore, this difference decreases in relative terms as the share of distance travelled on petrol and diesel decreases. For example, under the scenarios where by 2050 99% of the distance travelled is travelled on electricity, the difference between modelled and actual fuel duty revenues only applies to the remaining 1% of the distance travelled.

<sup>17</sup> Since we model Great Britain (i.e., England, Wales and Scotland), we excluded Northern Ireland from the validation, using its percentage contribution to total fuel duty revenues, which we calculated on the basis of data from the Office for National Statistics (2024c).

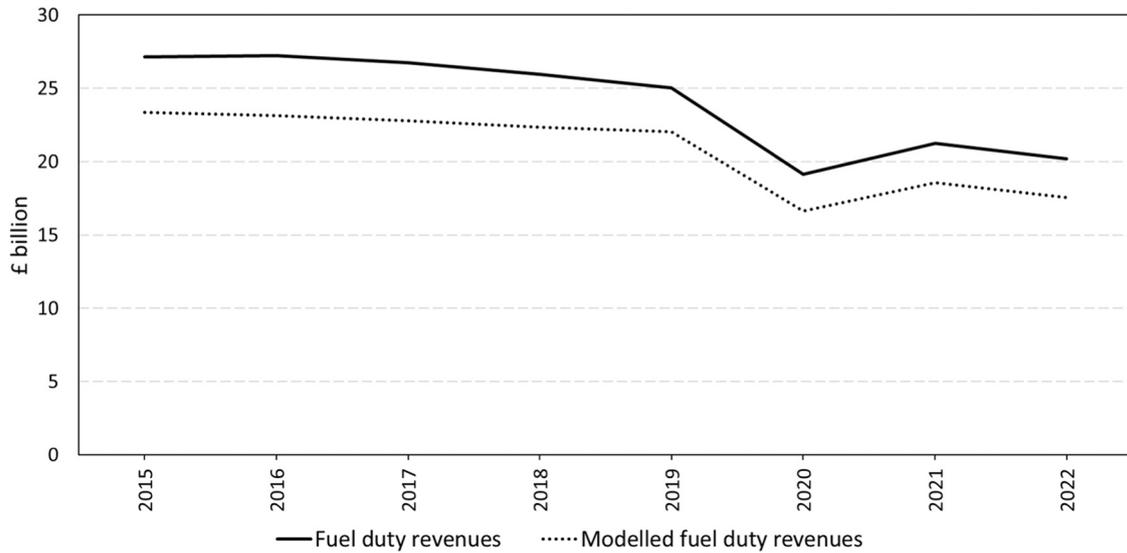
Since our model starts with revenues which are 13.5% lower than the actual revenues, but, as we explain in Section 4.2.2 we require the ratio of revenues to GDP to stay constant throughout the modelling period, and the ratio is estimated on the basis of past actual rather than modelled revenues, the gap between projected revenues and the revenue goal is larger than it would be if there were no difference between actual and modelled revenues. As a result, the set of Dbc estimated in the present study may be larger than the Dbc that might be required to close the gap between revenues and the revenue goal.<sup>18</sup> That said, the difference between our modelled revenues and the revenues that may actually be collected decreases over the modelling period as the share of distance travelled on electricity increases. The larger the share of distance travelled on electricity is, the smaller the size of the error and the more accurate the estimate of the Dbc are.

The 13.5% difference between actual and modelled revenues could be eliminated by introducing a correction factor in Eqs. (7), (8) and (9). However, this would impose additional constraints related to the revenue targets assigned to each vehicle type, and this would require further ad-hoc adjustments. We chose not to introduce any correction factor, mainly to stop the model from becoming too complex.

4.2.1.2. *Projection using the initial energy shares.* This model can be interpreted as an instance of the model presented in Section 4.2.1.1. Here, instead of using the shares  $\xi_{stme}$ , we assume that all the distance driven is driven by vehicles running on petrol or diesel (with none running on electricity). The purpose of this model is to project revenues over time assuming that the distance driven increases in line with the CAS assumptions, but all vehicles run on petrol or diesel and therefore pay fuel duty. We use 2022 as the reference year.<sup>19</sup> In 2022, 51.83% of the total distance driven by cars was driven on petrol, 43.44% was

<sup>18</sup> In addition to this, the fuel duty revenues lost from PSV in our model are recouped from other vehicle types, as detailed in Section 4.2.1.2, and this makes the Dbc payable by these other vehicle types higher than if PSV were to pay a Dbc.

<sup>19</sup> Choosing a different year as the reference year for the share of distance driven by petrol and diesel vehicles would have made virtually no difference, as shown in Appendix 3.



**Fig. 5.** Actual fuel duty revenues versus modelled fuel duty revenues, 2015–2022. Note: All values are expressed in 2019 prices. Source for actual fuel duty revenues: Table TSGB1310 (Department for Transport, 2024a).

driven on diesel, and 4.73% was driven on electricity; 1.96% of the total distance driven by LGV was driven on petrol, 96.93% on diesel, and 1.10% on electricity; 100% of the distance driven by OGV1 and OGV2 was driven on diesel; and 94% of the distance driven by PSV was driven on diesel, and 6%, on electricity (TAG Table A1.3.9, Department for Transport, 2024b). Since in this exercise we assume that all the distance was driven by petrol and diesel vehicles, the shares become 54.40% and 45.60% for cars, and 1.98% and 98.02% for LGV. No conversion is needed for OGV1 or OGV2, as all the distance was driven on diesel, or for PSV, as they will not pay the Dbc and therefore there is no need to calculate a revenue sub-goal for them. The rationale behind PSV not being required to pay a Dbc is that public transport should be considered the backbone of a sustainable transport system,<sup>20</sup> and policies should be designed to attract, rather than deter, passengers.

Let  $\xi_{s|2022|me}$  be the energy shares in 2022, assuming that the distances driven on electricity were instead driven on petrol or diesel, as assumed above. Then,  $M'_{stume}$  is the distance travelled under scenario  $s$ , in year  $t$ , for trip purpose  $u$  (work or non-work), by vehicle type  $m$  (car, LGV, OGV1, OGV2, PSV), running on energy  $e$  (petrol, diesel, electricity) as given by Eq. (13).

$$M'_{stume} = M_{stm} \omega_{um} \xi_{s|2022|me} \quad (13)$$

The resulting total revenues,  $R'_{stumu}$ , the fuel duty revenues,  $R^{\delta}_{stumu}$ , and the VAT revenues,  $R^{\zeta}_{stumu}$ , are obtained using Eqs. (14), (15) and (16).

$$R'_{stumu} = R^{\delta}_{stumu} + R^{\zeta}_{stumu} \quad (14)$$

$$R^{\delta}_{stumu} = \sum_{ve} M'_{stume} \omega^{\delta}_{stume} \quad (15)$$

<sup>20</sup> PSV are essential in a sustainable transport system because they can carry more people than cars, so fewer vehicles are needed to move the same number of people. The obvious environmental benefits of PSV relative to the private car when most road transport depends on fossil fuels can be ignored in a world where road transport has been electrified, but the benefits from reduced traffic congestion cannot. Traffic congestion will not disappear with the electrification of road transport. Furthermore, electric vehicles still produce particulate matter from tyre and brake wear and road abrasion (Quarmby et al., 2019; Wood, 2024), as already highlighted in footnote 10, so PSV have an environmental advantage even assuming full electrification.

$$R^{\zeta}_{stumu} = \sum_{ve} M'_{stume} \omega^{\zeta}_{stume} \quad (16)$$

The next step is to obtain the shares  $\theta'_{stumu}$ , which represent the contribution of each combination of vehicle type (car, LGV, OGV1, OGV2, PSV) and trip purpose (work, non-work) to the overall total revenue. The calculation of this share is given by Eq. (17). Revenues from PSV were excluded from the calculation because we assume that they will not pay any Dbc, should one be introduced, as explained above. Essentially, a Dbc on PSV would almost certainly be passed on to users, and therefore act as a disincentive to use public transport. The share of revenue expected from each combination of vehicle type and trip purpose excluding PSV (car work, car non-work, LGV work, LGV non-work, OGV1, and OGV2) is given by  $\theta$ . As explained above, OGV1 and OGV2 are assumed to make work trips only.

$$\theta'_{stumu} = \frac{R'_{stumu}}{\sum_{vm \neq PSV} R'_{stumu}} \quad \forall m \neq PSV \quad (17)$$

#### 4.2.2. Revenue goal

We designed the Dbc to be revenue-neutral. This is in line with most of the work that has been conducted in this area, including Wang and Miao (2018), Corfe (2022), Metcalf (2023), Nelson and Rowangould (2024), Noll et al. (2024), Wood (2024), Cheon (2025), Rahman et al. (2025), and Wei et al. (2025). Gaining public and political support for a Dbc may present a significant challenge in the UK (Butcher and Davies, 2020, p. 8). The condition of revenue neutrality, however, may go some way towards enhancing political feasibility and public acceptability, as it conveys that the purpose of the policy is not to increase tax revenues but to simply not lose any more than has been lost already.

To achieve this, the ratio of combined revenues from the Dbc, fuel duty and VAT on the pre-tax price of fuel, on fuel duty, and on the pre-tax price of electricity to GDP was required to stay constant throughout the modelling period, and equal to the value that the ratio of revenues from fuel duty and VAT on the pre-tax price of fuel, and on fuel duty<sup>21</sup> to GDP had in 2022.

There are two important caveats that need to be highlighted. First,

<sup>21</sup> Revenues from VAT on the pre-tax price of electricity should have also been included, but they were not, as we explain further down.

the year 2022 was an arbitrary choice. As explained in Section 2.1, the ratio has changed over time.<sup>22</sup> It reached a peak in 1999 and has decreased since then, except for 2008–2009, when the GDP in the UK fell due to the global economic downturn (Santos and Cornford, 2024). The greater the value chosen as a revenue goal, the more controversial it will be politically because the DbC will need to be higher, which is likely to trigger public backlash. An average of the ratios over the last five years, or the last ten years, or the last 20 years could have been used, but these averages would have been higher than the most recent ratios.<sup>23</sup> The ratio for the year 2022 seems a good compromise – it is higher than in later years, yet still low enough to possibly attract some public and political support. Second, data on revenues from VAT on the pre-tax price of fuel and on fuel duty do not exist.<sup>24</sup> Due to this lack of information, we had to estimate past VAT revenues.

We estimated revenues from VAT on the pre-tax price of fuel and on fuel duty based on historical fuel duty revenues. To do this, we used Eqs. (11) and (12), but with historical ( $M_{stum}$ ) instead of projected distance travelled, for the period 2015–2022. We also used the work/non-work shares of distance travelled,  $\tau_{um}$ , to refine the amount of fuel duty revenues upon which the VAT would be estimated. This allowed us to estimate historical revenues from VAT on the pre-tax price of fuel and on fuel duty,  $\hat{R}^c$ , based on historical fuel duty revenues,  $\hat{R}^d$ . We were unable, however, to estimate past revenues from VAT on electricity, as there were no values to base these on. For this reason, past revenues from VAT on electricity did not enter the calculation of the revenue goal. This is not too problematic as we would expect these revenues to have been very small because the share of electric vehicles in 2022 was only 4.73% (Department for Transport, 2024b) and many electric vehicles are charged at home, where the VAT on electricity is only 5%. Omitting revenues from VAT on the pre-tax price of electricity slightly reduces the error in the gap between the revenue goal and the modelled revenues that results from the 13.5% underestimate of modelled fuel duty revenues.

Fig. 6 shows the historical ratio of revenues from fuel duties and estimated VAT on the pre-tax price of fuel and on fuel duty to GDP,  $\frac{\hat{R}^c + \hat{R}^d}{F}$ . The ratio for the year 2022, which was used as the revenue goal, is 1.15%. In other words, all the revenues from the DbC, fuel duty and VAT on the pre-tax price of fuel, on fuel duty, and on the pre-tax price of electricity for each year between 2025 and 2050 should represent 1.15% of the GDP for that year.

The revenue goal projections,  $\hat{R}$ , formulated in Eq. (18), vary by scenario because there are three different GDP projections, as explained in Section 4.1.5.

$$\hat{R}_{sy} = 0.0115 \Gamma_{sy} \quad (18)$$

The overall revenue goal was then divided into sub-goals: a sub-goal was defined for each combination of vehicle type (car, LGV, OGV1, OGV2, PSV) and trip purpose (work, non-work). The relevant combinations were car work, car non-work, LGV work, LGV non-work, OGV1 and OGV2. All OGV1 and OGV2 were assumed to make work trips only, as already explained. As mentioned above, PSV were excluded from the calculation as they will not be expected to pay the DbC. The total distance driven by all vehicles excluded the distance driven by PSV because

<sup>22</sup> The values discussed in Section 2.1 include revenues from fuel duty and VAT on fuel duty but not on the pre-tax price of fuel.

<sup>23</sup> To get an idea of the impact of the year chosen (and its associated ratio of revenues to GDP) on the results of the model, we calculated the DbC using 2015–2021 as the reference year. As expected, the DbC gets higher when a higher ratio (earlier year) is used to set the revenue goal. The results of this exercise are presented and discussed in Appendix 3.

<sup>24</sup> The HMRC does not hold information on VAT revenues relating to specific products or services. Businesses are not required to provide details at a product level on their VAT returns (HM Revenues and Customs, 2024b).

our model expects other vehicle types to cover the fuel duty revenues that will be lost once the entire fleet of PSV is electrified. Also, as discussed in Section 4.2.1.2, all vehicles were assumed to run on petrol or diesel in order to calculate these revenue sub-goals.

The revenue sub-goals,  $\hat{R}_{stum}$ , were calculated using Eq. (19).

$$\hat{R}_{stum} = \hat{R}_{st} \theta_{stum} \quad (19)$$

The revenue sub-goal for each vehicle type and trip purpose was indifferent to whether the revenue came fully from a DbC and VAT on the pre-tax price of electricity or from a combination of DbC and fuel duty, plus VAT on the pre-tax price of fuel and on fuel duty.

#### 4.2.3. Distance-based charge

The DbC we model is assumed to apply on top of the fuel duties already in place, which still benefits electric vehicle owners as they continue to pay less than fossil fuel vehicle owners, as shown in Section 5.6.

$\omega$ , initially formulated in Eq. (4) as the aggregate unitary fuel-related cost, can alternatively be expressed as the sum of the components (price, fuel duty and VAT), as shown in Eq. (20).

$$\omega_{stume} = \omega_{stume}^p + \omega_{stume}^d + \omega_{stume}^c \quad (20)$$

The introduction of the DbC,  $\omega^x$ , alters the cost structure in Eq. (20), which becomes Eq. (21), with  $\omega^\phi$  defined as the new aggregate cost structure.

$$\omega_{stumel}^\phi = \omega_{stumel}^p + \omega_{stumel}^d + \omega_{stumel}^c + \omega_{stumel}^x \quad (21)$$

Note that  $\omega^\phi$  includes the index  $l$ . This is because it can reasonably be expected that the distance driven when a DbC is introduced will decrease. Since there are no estimates of the elasticity of distance driven with respect to DbC,<sup>25</sup> we assumed that drivers would perceive the introduction of a DbC or an increase in the DbC in the same way in which they would perceive an increase in the price of fuel. Thus, we used fuel cost elasticities ( $\epsilon_l$ ) in the calculations of the DbC. The elasticity values we used are  $-0.15$  ( $l = \text{Low}$ ) and  $-0.35$  ( $l = \text{High}$ ) to give a lower and upper bound of plausible values, following TAG Unit M2.1: Variable Demand Modelling (Department for Transport, 2024e, p. 70).

The new distance travelled,  $M^\phi$ , was obtained using Eq. (22), by applying the elasticity to the initial projections of distance travelled ( $M$ ). The percentage change in costs,  $\Delta\omega$ , obtained by means of the midpoint formula, is calculated in Eq. (23). In this case, the elasticity effect after the introduction of the DbC is addressed as an intra-year variation. The reason for not applying the elasticity to the distance travelled each year to the following year was that this would have over complicated the analysis.

$$M_{stuml}^\phi = M_{stum} \left( \frac{1 + \epsilon_l \Delta\omega_{stum}}{1 - \epsilon_l \Delta\omega_{stum}} \right) \quad (22)$$

$$\Delta\omega_{stuml} = \frac{\omega_{stum} - \omega_{stuml}^\phi}{2(\omega_{stum} + \omega_{stuml}^\phi)} \quad (23)$$

The DbC is designed such that the combined revenues from the DbC, fuel duty, VAT on the pre-tax price of fuel, on fuel duty, and on the pre-tax price of electricity achieve the revenue goal  $\hat{R}$ , considering the effect of the elasticity. The latter condition is granted by Eq. (24).

$$(\omega_{stuml}^x + \bar{\omega}_{stum}^d + \bar{\omega}_{stum}^c) M_{stuml}^\phi = \hat{R}_{stum} \quad (24)$$

The variables  $\bar{\omega}^d$  and  $\bar{\omega}^c$  above include all energy sources (petrol, diesel and electricity) as a weighted average, thus the missing index  $e$ . They are defined as shown in Eqs. (25) and (26), respectively.

<sup>25</sup> This is because real-world examples of DbC are still sparse.

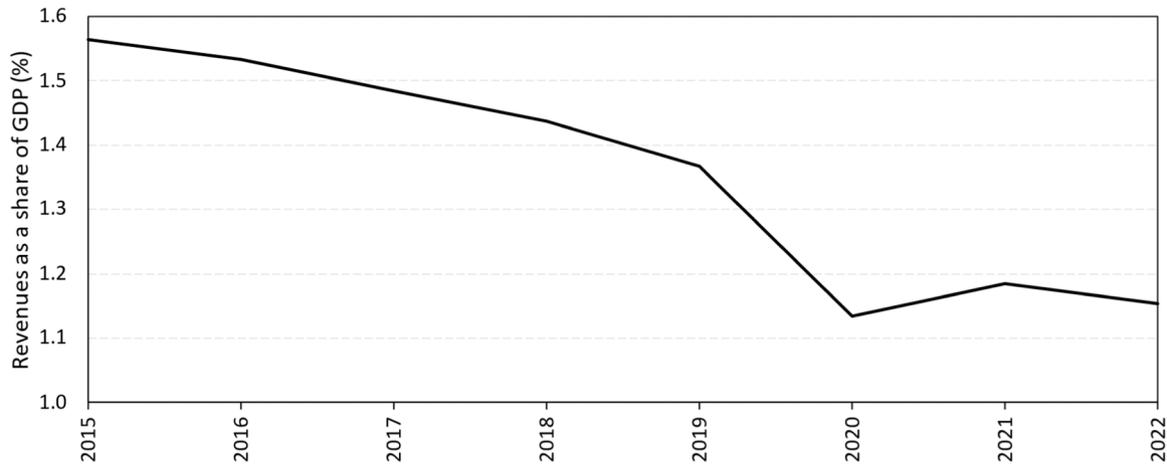


Fig. 6. Revenues from fuel duty, and estimated VAT on the pre-tax price of fuel and on fuel duty, as a share of GDP, 2015–2022. Source: computed on the basis of Department for Transport (2024a).

$$\bar{\omega}_{stum}^{\delta} = \sum_{\forall e} \omega_{stum}^{\delta} \epsilon_{stme} \quad (25)$$

$$\bar{\omega}_{stum}^{\zeta} = \sum_{\forall e} \omega_{stum}^{\zeta} \epsilon_{stme} \quad (26)$$

All the variables in Eq. (24), except for  $\omega^x$ , have been previously defined. Thus, solving Eq. (24) for  $\omega^x$  would lead to the DbC required to achieve the revenue goal  $\hat{R}$  while taking into account the elasticity of distance driven with respect to costs.<sup>26</sup> The positive root of the solution is presented in Eq. (27).<sup>27</sup> That solution is the DbC for each combination of scenario,  $s$ , year,  $t$ , trip purpose,  $u$ , and vehicle type,  $m$ , and elasticity,  $l$ .

$$\omega^x = \frac{-(2\omega M - (1 - \epsilon)\hat{R} + (1 + \epsilon)R)}{2(1 + \epsilon)M} + \frac{\sqrt{(2\omega M - (1 - \epsilon)\hat{R} + (1 + \epsilon)R)^2 - 8\omega M(1 + \epsilon)(R - \hat{R})}}{2(1 + \epsilon)M} \quad (27)$$

## 5. Results

### 5.1. Revenues from fuel duty, VAT on the pre-tax price of fuel and on fuel duty

The revenues from fuel duty, VAT on the pre-tax price of fuel and on fuel duty will decrease in line with the CAS's assumptions of energy shares in road transport. Under the scenarios that assume full electrification by 2050, revenues are expected to reach zero. Those scenarios are TC, MB and VL. The other scenarios, CO, LE, HE, BC, and RE, as can be seen in Fig. 7, experience a less pronounced revenue decline because electrification is slower and does not reach 100% by 2050. The revenue trajectory under scenario BC is lower than under scenarios CO, LE, HE, and RE because scenario BC incorporates the COVID19 effect as a permanent reduction in average annual distance travelled due to an increase in remote working. The revenue trajectory under scenario HE is the highest, yet revenues in 2050 are still over £9 billion less than in 2025.

The ongoing and future decrease in fuel tax revenues in the UK has been acknowledged in the academic and grey literature (Adam and Stroud, 2019; Corfe, 2022; Corlett and Marshall, 2023; Santos and

<sup>26</sup> As it is clear by now, costs include the pre-tax price of energy (petrol diesel or electricity), fuel duty, VAT, and DbC, but exclude time costs.

<sup>27</sup> The subindices have been suppressed to make the equation easier to read. The full formula, including all subindices, is presented in Appendix 4.

Cornford, 2024) and there have been multiple warnings from the Office for Budget Responsibility (2022, 2023, 2024) so the trends in Fig. 7 are not unexpected.

### 5.2. Revenues from the DbC

Fig. 8 shows that the revenues from the DbC would, unsurprisingly, increase over time, as the vehicle fleet is electrified. In 2050, they would range from £23 to £43 billion, depending on the CAS. Under the fast electrification scenarios, TC, MB and VL, by 2050 virtually all vehicles pay only the VAT on electricity and the DbC. Under the scenarios that do not assume 100% electrification by 2050, CO, LE, HE, BC, and RE, all vehicles pay the DbC but many vehicles continue to pay fuel duty (and VAT on the pre-tax price of fuel and on fuel duty) too.

### 5.3. Combined revenues

The projected revenues from the DbC and fuel duty, VAT on the pre-tax price of fuel, on fuel duty, and on the pre-tax price of electricity are shown in Fig. 9. The ratio of combined revenues to GDP is always 1.15. The target revenues measured in pounds vary because there are three different levels of GDP, which vary by CAS, and the composition of revenues, i.e., the contribution from the DbC, the fuel duty and the VAT, vary too, not just according to CAS, but also to the elasticity assumed. As explained in Section 4.2.3, the elasticity values we used are  $-0.15$  and  $-0.35$ , following Department for Transport (2024e, p. 70). For the high elasticity, which is still under 1, the reduction in distance travelled in response to the DbC is larger, both for electric vehicles and for fossil fuel vehicles, which also pay the DbC, as stated in Section 4.2.3. This larger reduction in distance travelled means that fossil fuel vehicles consume less fuel and therefore, the reduction in fuel duty revenues, VAT on the pre-tax of fuel and VAT on fuel duty, is larger than in the case of the low elasticity. As a consequence of that, in the case of the high elasticity, the DbC needed to make up for the lost revenues is higher and the contribution it makes to total revenues is larger too.

Fig. 9 also illustrates that revenues from fuel duty and VAT on the pre-tax price and on fuel duty will continue to be collected under the CO, HE, LE, RE and BC scenarios, none of which assumes full electrification in 2050. These revenues, however, are substantially reduced. Ironically, the reduction is greater when there is a DbC, as illustrated in Fig. 9, than when there is not a DbC, as illustrated in Fig. 7. The reason for this greater reduction is, as explained in the paragraph above, that the DbC causes a reduction in the average distance driven by all vehicles, including fossil fuel vehicles, with the consequent reduction in fuel consumed.

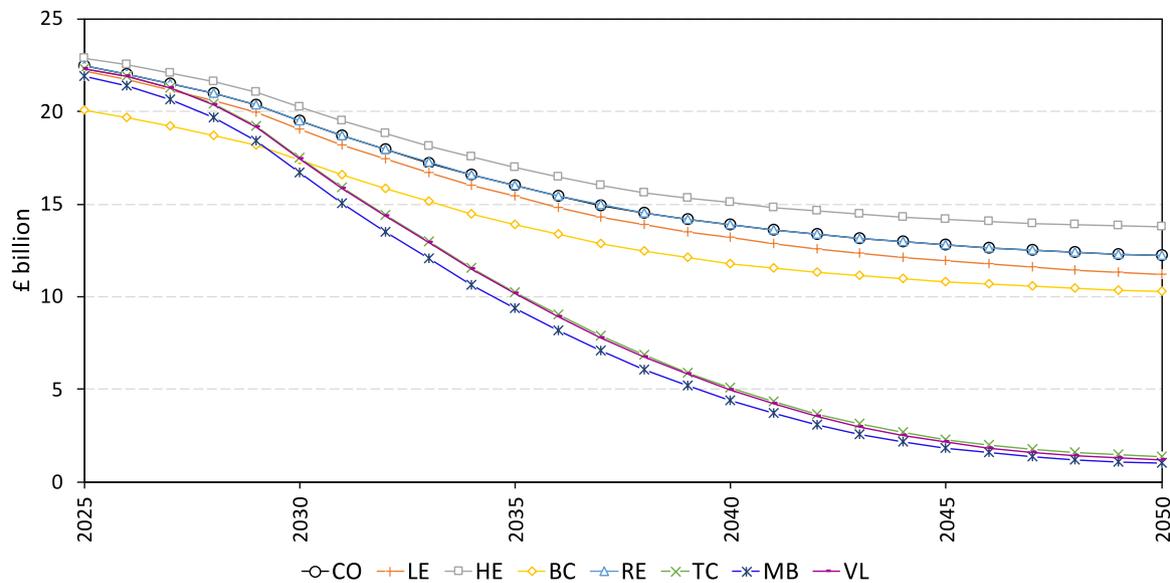


Fig. 7. Projections of revenues from fuel duty, VAT on the pre-tax price and on fuel duty under the different scenarios, Great Britain, 2025–2050.

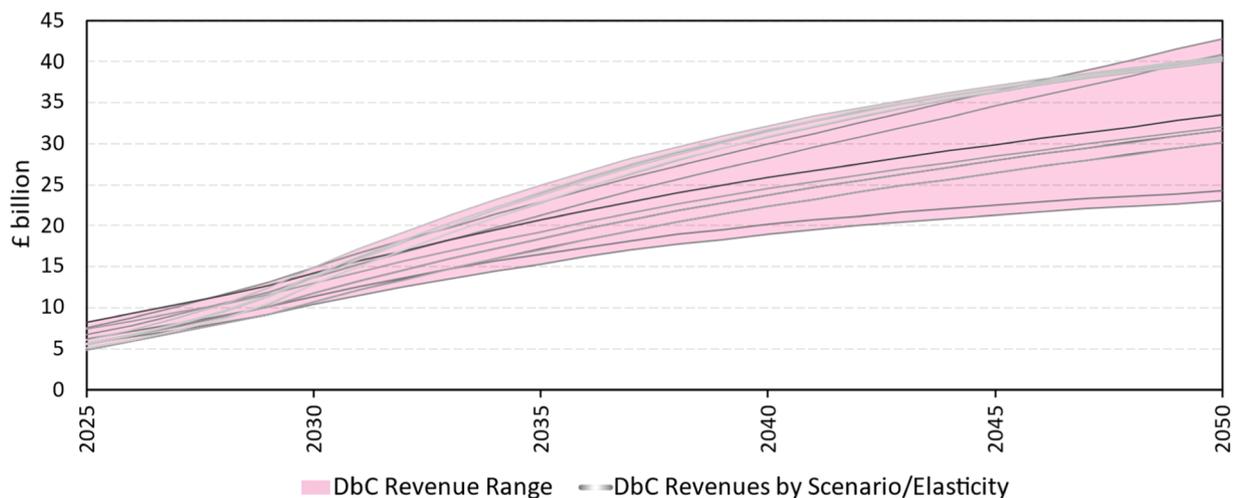


Fig. 8. Range of DbC revenues, including all scenarios, Great Britain, 2025–2050.

#### 5.4. Revenues from each combination of vehicle type and trip purpose

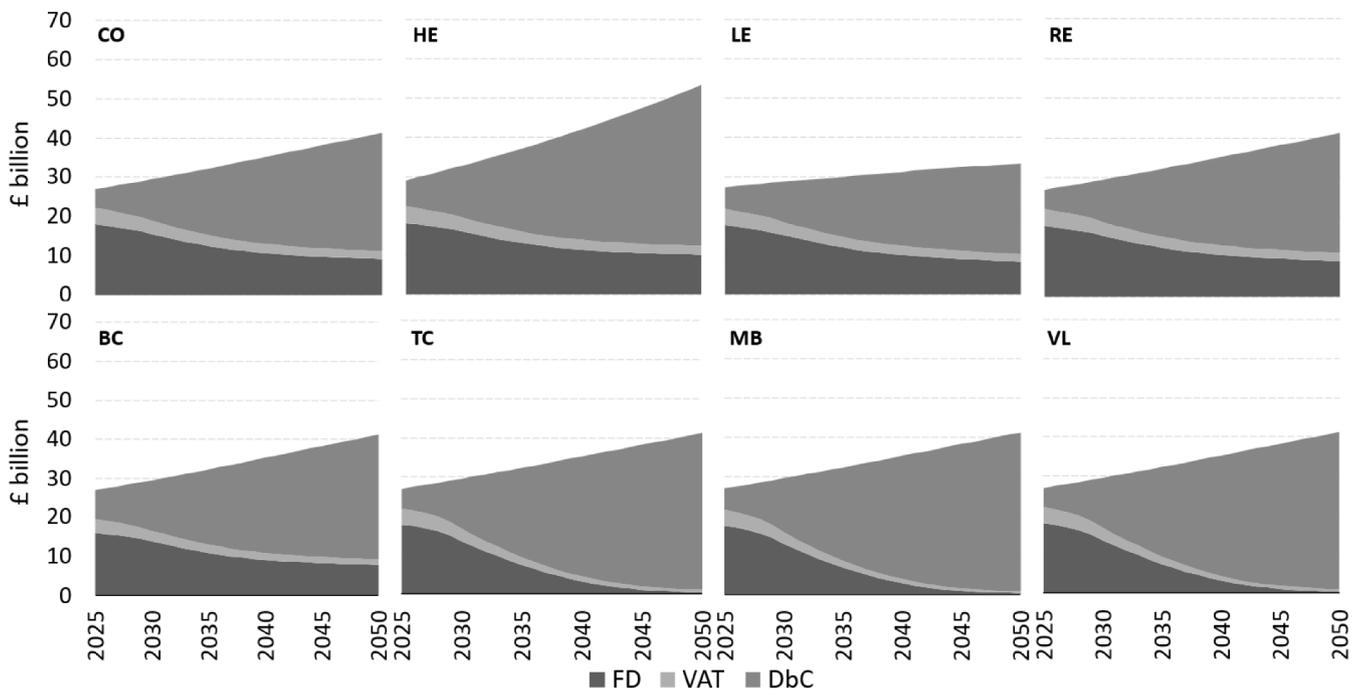
As explained in Section 4.2.2, the revenue goal was set as sub-goals for each combination of vehicle type  $m$  (car, LGV, OGV1, OGV2, PSV) and trip purpose  $u$  (work, non-work). Fig. 10 shows the predicted evolution of the share that each combination of vehicle type and trip purpose is expected to make to the overall revenues under each scenario with elasticities of  $-0.15$  and  $-0.35$ . The higher contributions come from non-work car trips, followed by work LGV trips, OGV2 trips, and work car trips. The contribution from PSV decreases in some scenarios and disappears in others. In our model, once PSV are completely electrified, they do not pay anything, as they are assumed to reclaim the VAT on electricity, and they are not expected to pay any DbC, as explained in Section 4.2.1.2.

#### 5.5. Distance-based charge estimates

The DbC estimates, expressed in pence per kilometre (p/km) and differentiated by vehicle type and trip purpose, are presented in Fig. 11, and summarised for the first and last year of the modelling period in Table 4. The results span a wide range, depending on the scenario, the

elasticity, and the vehicle type and trip purpose combination. The DbC for non-work car trips, for example, could start in the range of 1–1.9 p/km in 2025, depending on the scenario. This would mean, for example, that a car in 2025 would pay an annual DbC in the range of £106.74 to £205.90 for non-work trips, assuming an annual average distance of 10,782 km travelled, as was the case in England in 2023 (Department for Transport, 2024f). The results in Fig. 11 show that the estimated DbC for car non-work trips increases more rapidly than for other vehicle type/trip purpose combinations. The reason for this is that they transition to electric faster than other combinations across all scenarios. The faster the transition to electric vehicles is, the quicker the revenue goal increases for that combination. For that reason, in 2050 a non-work car could be paying a DbC in the range of 4.7–10.8 p/km, or £508.90 to £1165.53 per year. In contrast, the lower boundaries of the DbC for OGV1 and OGV2 remain fairly flat until 2050. These lower boundaries correspond to scenarios that assume slower electrification. Under these scenarios, OGV1 and OGV2 continue to rely on fossil fuels throughout the modelling period. The estimated DbC range for OGV2 is 1.3–3.7 p/km in 2025. This means that a trip from London to Edinburgh (534 km), for example, could generate between £6.72 and £19.44 in revenues per trip. The same trip in 2050, assuming full electrification of

High elasticity



Low elasticity

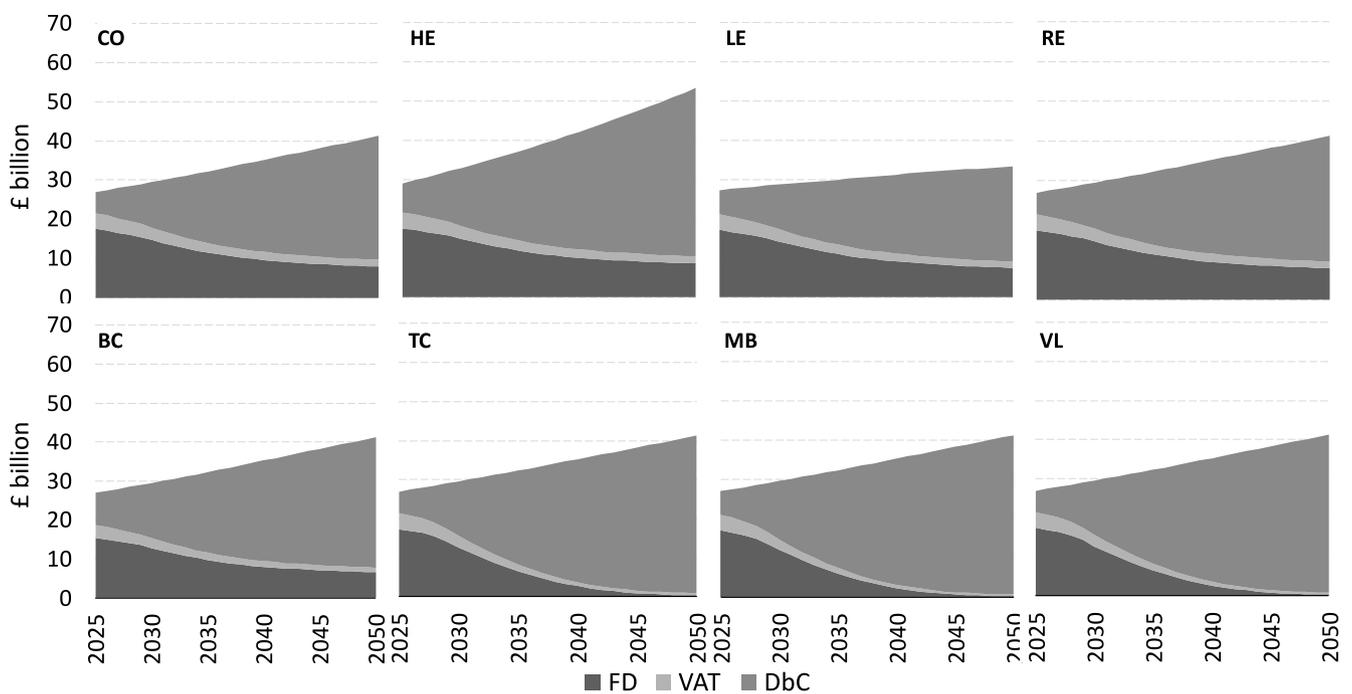


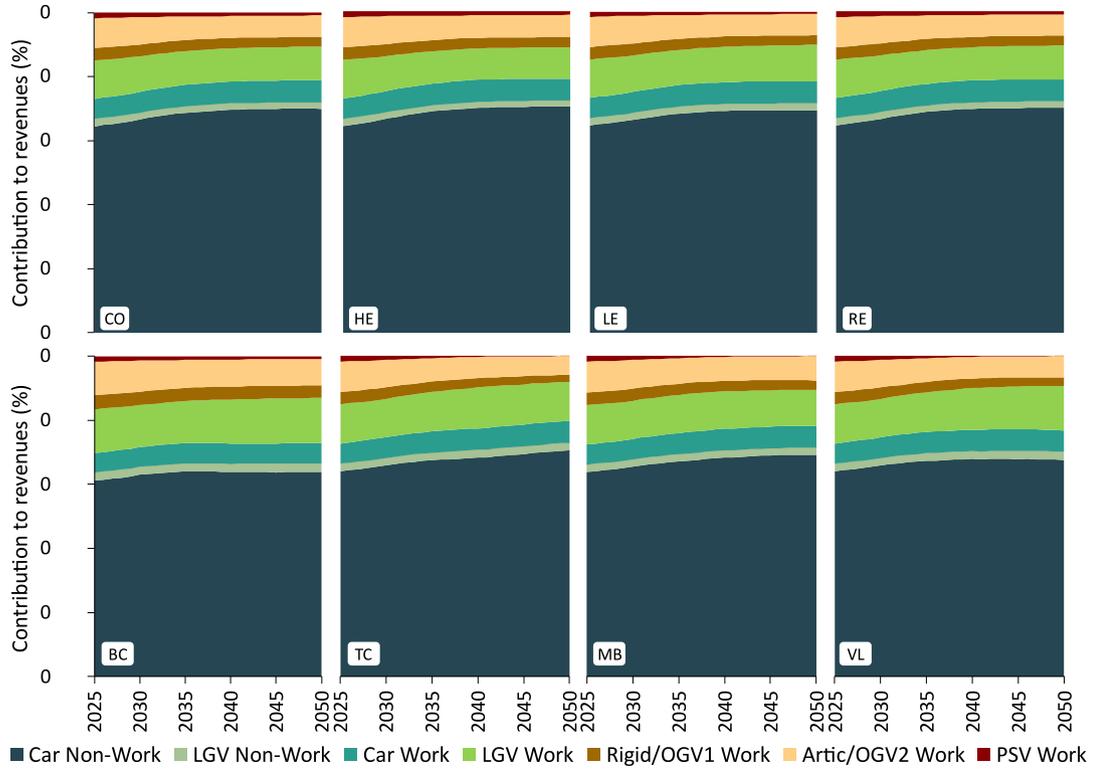
Fig. 9. Total revenues under the different scenarios, Great Britain, 2025–2050. Note: Total revenues include revenues from fuel duty, VAT on the pre-tax price of fuel, on fuel duty and on the pre-tax price of electricity, and DbC.

the OGV2 fleet, could cost between £19.38 and £184.88 in DbC charges.

As explained in Section 4.2.1.1, the ranges in Fig. 11 might be an overestimate of the DbC, designed in this study to close the gap in revenues, which may actually be smaller than the gap predicted by our model. In addition, the lost fuel duty revenues from PSV need to be recouped, and enter the revenue goal calculations but PSV are never required to pay a DbC, as explained in Section 4.2.1.2. The DbC

estimated for each vehicle type/trip purpose combination to hit the total revenue goal is, therefore, higher than it would be if our model did not underestimate fuel duty revenues, and we did not impose the restriction of PSV not paying the DbC and other vehicle types covering the loss of revenues from PSV. In the case of OGV1 and OGV2, this means that they pay a low but positive DbC even under scenarios where there is no electrification of the OGV1 or OGV2 fleets.

High elasticity



Low elasticity

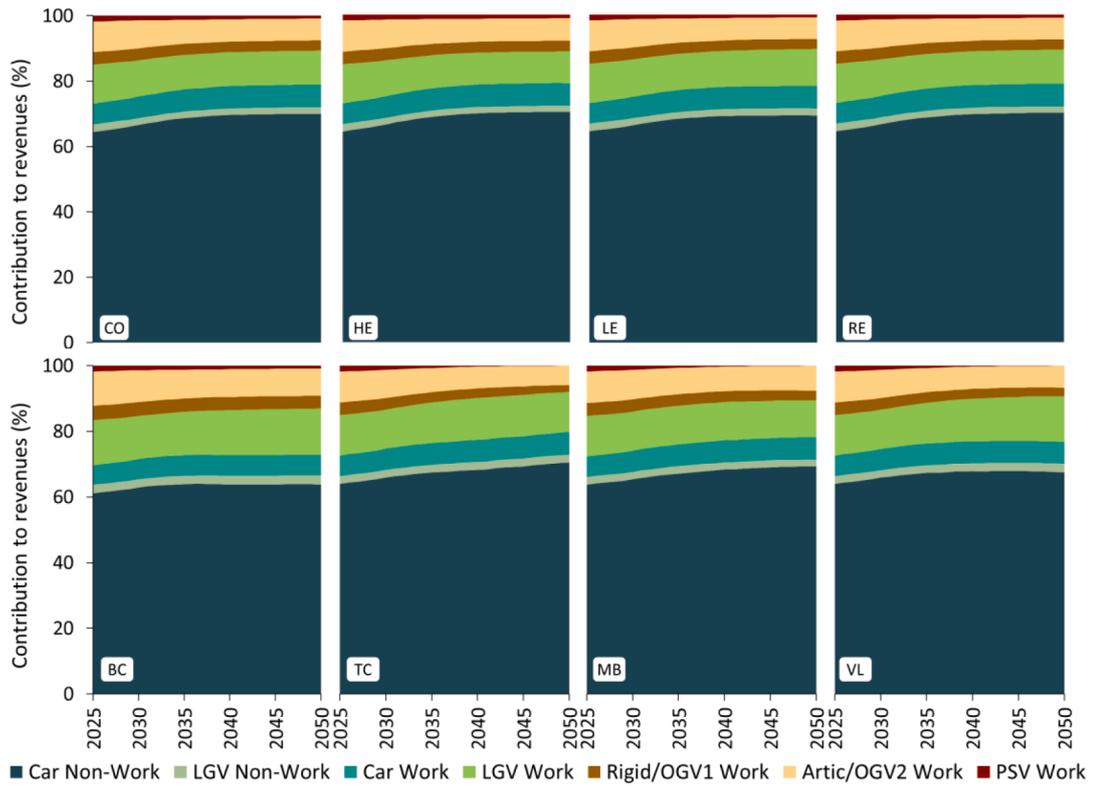


Fig. 10. Contribution to revenues by vehicle type and trip purpose under the different scenarios, Great Britain, 2025–2050.

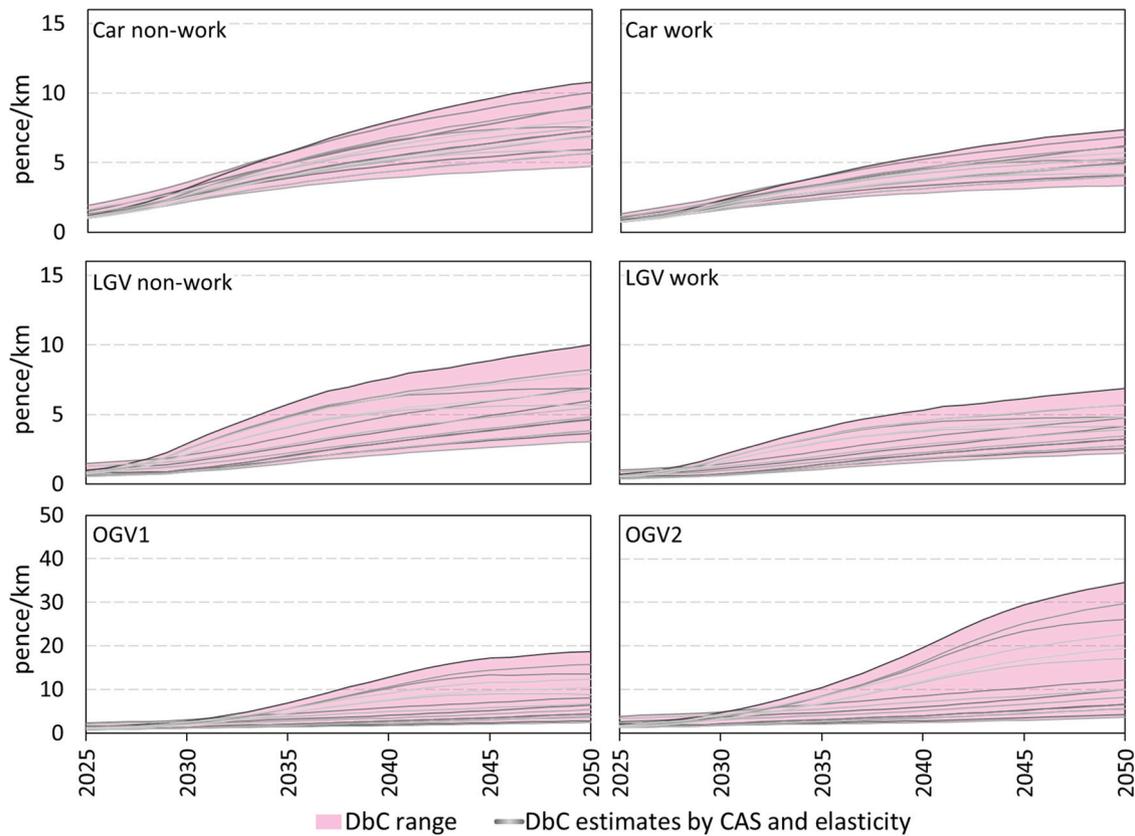


Fig. 11. DbC ranges by combination of vehicle type and trip purpose, including all scenarios and both elasticities, 2025–2050.

Table 4

Lowest and highest DbC estimates for 2025 and 2050 for each vehicle type/trip purpose combination (p/km).

	2025		2050	
	Lowest estimates (p/km)	Highest estimates (p/km)	Lowest estimates (p/km)	Highest estimates (p/km)
Car non-work	0.99	1.91	4.72	10.81
Car work	0.72	1.33	3.37	7.37
LGV non-work	0.52	1.47	3.05	9.98
LGV work	0.37	1.01	2.21	6.87
OGV1	0.74	2.27	2.40	18.68
OGV2	1.26	3.84	3.63	34.62

### 5.6. Relative costs

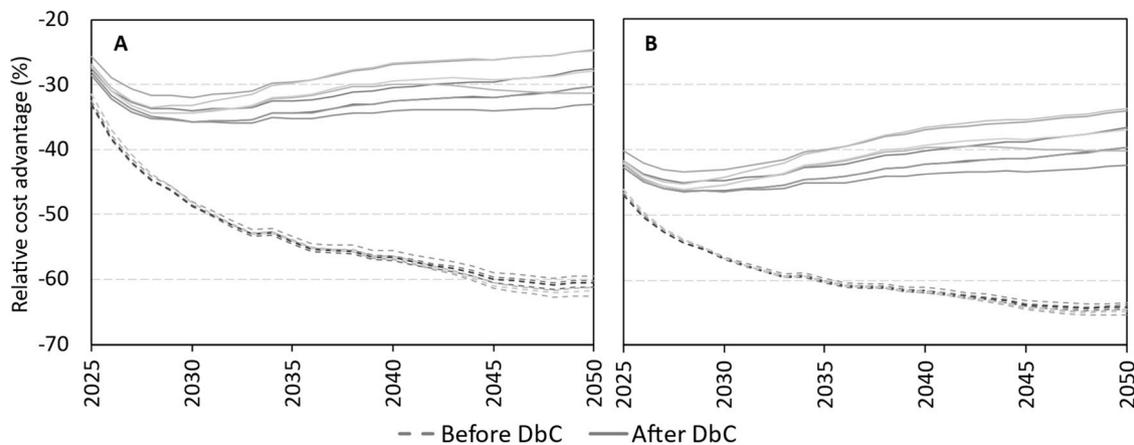
The difference in operating costs between fossil fuel vehicles and electric vehicles will narrow down if electric vehicles are liable to pay the DbC, but electric vehicles will continue to be cheaper to run. Fig. 12 shows how, even with the introduction of the DbC, electric vehicles will still be between 25% and 36% cheaper to operate when fuel costs and the DbC paid by fossil fuel vehicles is compared with the electricity and DbC paid by electric vehicles. When non-fuel costs are also taken into account, the difference is larger, between 33.7% and 46.5%, assuming non-fuel costs (oil, tyres, maintenance, depreciation) take the values suggested in TAG Table 1.3.15 (Department for Transport, 2024b).

### 6. Conclusions and policy recommendations

The idea of distance-based road user charges has gained momentum in recent years due to the reduction in fuel duty revenues (Bose et al., 2021; Metcalf, 2023; Ji et al., 2024; Noll et al., 2024; Smyth and Chu, 2024; Todts, 2024; Wood, 2024; Cheon, 2025; Hriday et al., 2025; Levis et al., 2025; Meloche et al., 2025; Muresianu and Hoffer, 2025; Rahman et al., 2025) resulting from the increase in fuel efficiency and the shift

towards electric vehicles. With the support of the Common Analytical Scenarios produced by the Department for Transport (2023a, b) and the projections and assumptions made in the TAG Databook (Department for Transport, 2024b), which make up a baseline or core scenario, we designed a distance-based charge that is revenue-neutral and is assumed to apply on top of the fuel duties already in place, which still benefits electric vehicle owners as they continue to pay less than fossil fuel vehicle owners. To ensure revenue neutrality, we imposed the condition that the ratio of combined revenues from the distance-based charge, fuel duty and VAT on the pre-tax price of fuel, and on fuel duty, and the VAT on the pre-tax price of electricity to GDP stayed constant throughout the modelling period, 2025–2050, and equal to the value that the ratio of revenues from fuel duty and VAT on the pre-tax price of fuel, and on fuel duty to GDP had in 2022, a year we chose arbitrarily.

As well as requiring that the ratio of revenues to GDP stay constant throughout the modelling period, we divided the overall revenue goal into sub-goals: one for each combination of vehicle type and trip purpose: car work, car non-work, LGV work, LGV non-work, OGV1 and OGV2. All OGV1 and OGV2 were assumed to make work trips only, and PSV were excluded from the calculation as they will not be expected to pay the distance-based charge because PSV are essential in a sustainable



**Fig. 12.** Relative cost advantage between electric vehicles and petrol vehicles under the different scenarios. Note: Graph A includes fuel price, fuel duty, VAT on pre-tax price of fuel and on fuel duty, electricity price, and VAT on the pre-tax price of electricity, and DbC. Graph B includes all the costs in Graph A plus non-fuel costs (i.e., oil, tyres, maintenance, depreciation).

transport system, even assuming full decarbonisation. The revenues lost from the electrification of PSV were recouped from other vehicle type/trip purpose combinations. The reason for defining revenue sub-goals was to make the distance-based charge payable by each vehicle type/trip purpose combination proportional to the fuel duty revenues the combination would have produced under zero electrification.

We find that, under fast decarbonisation scenarios (MB, VL, and TC), fuel duty revenues, along with VAT on the pre-tax price of fuel and on fuel duty, virtually disappear by 2050, in line with Adam and Stroud (2019), Corfe (2022), Corlett and Marshall (2023), and Santos and Cornford (2024). Not surprisingly, we also find that under slow decarbonisation scenarios (CO, HE, LE, RE, and BC), revenues decrease but do not disappear. The decrease, however, is substantial and is 39.7–49.6% between 2025 and 2050, in the absence of our distance-based charge, and 44.3–58.4% in the presence of our distance-based charge. The reduction in the presence of our distance-based charge is larger because the distance-based charge causes a reduction in average distance travelled by both electric vehicles and fossil fuel vehicles, with the consequent reduction in fuel consumption. The revenue-neutral distance-based charge we estimate varies from 0.4 to 3.8 p/km in 2025 and from 2.2 to 34.7 p/km in 2050, depending on the vehicle type/trip purpose combination, the scenario, and the elasticity assumed.

None of these values is directly comparable with previous results reported in the literature, such as those in Corlett and Marshall (2023), as the methodology and assumptions used are very different, especially regarding the fact that in our study, all vehicles, internal combustion engine and electric, pay the distance-based charge, and each vehicle type/trip purpose combination has a revenue sub-goal. The caveat to our estimates is that the projected revenues from fuel duties, which enter the calculation of our distance-based charge, are underestimated. The magnitude of the error, however, decreases over the modelling period, 2025–2050, and practically disappears under full electrification.

The distance-based charge we model is assumed to apply on top of the fuel duties in place. We conduct a cost comparison between electric vehicles and internal combustion engine vehicles, before and after the implementation of our distance-based charge. The results indicate that whilst the distance-based charge diminishes the comparative advantage of electric vehicles over fossil fuel vehicles, the operating costs per kilometre remain between 33.7% and 46.5% lower, factoring in both fuel and non-fuel costs.

### 6.1. Policy recommendations

The methodology developed in the present study and the results obtained lead to the following policy recommendations:

- The government in Great Britain should introduce a distance-based charge as soon as possible to alleviate the fiscal challenges associated with the electrification of road transport. This is supported by one of our main results, which is that fuel duty revenues will decrease substantially under slow decarbonisation scenarios and virtually disappear under fast decarbonisation ones by 2050. The urgency for this action is also supported by our results: the reduction in revenues increases with time as more drivers switch from internal combustion engines to electric vehicles. Furthermore, electric vehicle drivers, whose number will increase over time, will become used to not paying any charge or tax replacing the fuel duty they used to pay when they owned a fossil fuel vehicle. The more time goes by, the more politically difficult it will be for the government to introduce such a policy.
- The distance-based charge should be levied on all power trains. This is supported by our methodology, which had to be aligned to the problem at hand: applying a charge on the distance driven by electric vehicles only, and not on internal combustion engine vehicles, would require this distance-based charge to be very high to make up for the loss in revenues from fuel duties. This would delay the transition to electric vehicles and would be politically difficult to sell.
- The distance-based charge should be differentiated by vehicle type/trip purpose combination. This is also supported by the methodology we developed. When designing the model, the revenue-neutrality had to be granulated down not just to cars, light good vehicles, and other good vehicles, but also to work and non-work trips to ensure that the distance-based charge payable by each vehicle was proportional to the fuel duty revenues they would have contributed to assuming all vehicles run on petrol or diesel.
- Public service vehicles such as buses should not pay any distance-based charge. This policy recommendation is also rooted in our methodology. When setting up the model, the problem of public service vehicles became evident from the start: they had to be excluded and the revenue loss from this vehicle type had to be recouped via all the other vehicle types. The reason for this is that a distance-based charge levied on public transport would be very likely to be passed on to users, which would act as a deterrent to using public transport.
- The distance-based charge should be applied on top of the fuel duties currently in place. This recommendation is supported both by our methodology and our results. When designing the model, it became clear that scrapping fuel duties, which have been in place since 1928 and still raise substantial revenues, was neither

practical nor logical. For electric vehicles to keep at least some of the operating cost advantage over internal combustion engine vehicles so as not to delay the green transition, maintaining the fuel duty in place is essential. The distance-based charge was then modelled on top of the fuel duties paid by internal combustion engine vehicles, and, indeed, the results show that the operating costs of electric vehicles paying a distance-based charge are still lower than those of petrol and diesel vehicles. This ensures that electric vehicles are still relatively attractive even when they pay a distance-based charge.

6.2. Final remarks

In this paper, we make the following contributions. First, we provide a framework with a possible range of values for a distance-based charge, which varies over time, and with different scenarios and elasticities assumed, thus providing a starting point for policy design. Second, we show that the revenue contribution from each vehicle type/trip purpose combination varies with the assumptions made, including the elasticity. Third, we propose a methodology to calculate the distance-based charge, which, with the formulae and the parameters we present, allows for a straightforward replication to estimate the distance-based charge with updated data for Great Britain, and for other countries, provided equivalent parameters can be sourced. Fourth, and most importantly, we provide specific policy recommendations.

Future lines of research include a dynamic model that will consider

the mode and energy switch that would result from a distance-based charge in Great Britain and the potential distributional impacts, both of which fall outside the remit of the present study. In a different vein, future research should also address the technological challenges of enforcing a distance-based charge.

CRediT authorship contribution statement

Allan Peñafiel-Mera: Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. Georgina Santos: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was supported by the Economic and Social Research Council via Allan Peñafiel-Mera’s PhD studentship.

Appendix 1

As advanced in Section 2.2, we organised the literature search systematically. The literature search from three sources, Web of Science, Scopus, and Google, was conducted on 19 August 2024, and then again on 4 September 2025, but the second time only covering the period 19 August 2024 to 4 September 2025. The search followed the steps detailed in Table A. The keywords were carefully chosen, and we are confident they cover all relevant studies on the topic. The identification, screening and selection of papers and reports followed the steps detailed in Table B.

Web of Science and Scopus are large databases, covering 34,600 and 26,600 peer-reviewed journals, respectively, as well as book series and conference proceedings (Clarivate, 2024; Scopus, 2023). They were, therefore, clear candidates for this exercise. Google and Google Scholar are search engines that rank websites based on the user’s search query, but Google Scholar focuses exclusively on scholarly content. We chose Google over Google Scholar because we wanted to be as comprehensive as possible, and focusing on scholarly articles only ran the risk of omitting important outputs in the grey literature. For each Google query, we arbitrarily set a limit of 45 records in the August 2024 search and 30 records in the September 2025 search, leading to a total of 975 records after the 13 keyword queries. These limits are reasonable as, in most cases, well over half (and in some cases virtually all) of the records from each query were duplicates or not relevant, and these duplicates or irrelevant records appeared in the second half, suggesting that had we collected more records, it would have made no difference.

Table A  
Literature search steps

Sources	Scopus Web of Science Google
Keywords	fuel tax revenues AND electric vehicles fuel duty revenues AND electric vehicles fuel tax revenues AND alternative fuel vehicles fuel duty revenues AND alternative fuel vehicles distance-based charge distance-based charging distance-based tolls vehicle-miles travelled charge vehicle-miles travelled charging vehicle-miles travelled tolls VMT charge VMT charging VMT tolls

**Table B**  
Identification, screening and selection

Identified	Input of keywords		
	Scopus N = 977	Web of Science N = 1044	Google N = 975
	Total N = 2996		
	Duplicates deletion (1661 deleted)		
Screened	Title screening Irrelevant works deletion (815 deleted)		
	Abstract screening, followed by paper screening when necessary Irrelevant works deletion (460 deleted)		
Included	Papers, reports and other articles included in review N = 60		

Source: Authors' own, inspired by [Page et al. \(2021\)](#).

Although the final set of papers, reports and media articles deemed relevant and substantive was 60, there were an additional 23 sources that were also included in the literature review. These were searched and reviewed as they were sources of data or information cited in some of the originally screened and selected sources. In some cases, the media article citing the grey literature report or official statistic was not cited, and the grey literature report or official statistic was cited instead.

## Appendix 2

[Table C](#) shows that the shares of distance travelled in England, Wales and Scotland over the period 1993–2023 have remained virtually constant.

**Table C**  
Shares of distance travelled in England, Wales and Scotland, 1993–2023

Year	England	Wales	Scotland
1993	86.17%	5.36%	8.47%
1994	86.15%	5.37%	8.48%
1995	86.14%	5.37%	8.49%
1996	86.13%	5.36%	8.51%
1997	86.12%	5.37%	8.52%
1998	86.16%	5.34%	8.49%
1999	86.20%	5.33%	8.47%
2000	86.25%	5.31%	8.44%
2001	86.27%	5.29%	8.43%
2002	86.11%	5.34%	8.54%
2003	86.04%	5.37%	8.60%
2004	86.06%	5.43%	8.51%
2005	86.09%	5.40%	8.51%
2006	85.91%	5.44%	8.65%
2007	85.87%	5.45%	8.68%
2008	85.81%	5.48%	8.71%
2009	85.80%	5.45%	8.75%
2010	85.77%	5.44%	8.79%
2011	85.82%	5.44%	8.74%
2012	85.74%	5.46%	8.81%
2013	85.69%	5.49%	8.82%
2014	85.68%	5.55%	8.78%
2015	85.69%	5.57%	8.74%
2016	85.52%	5.66%	8.82%
2017	85.47%	5.61%	8.92%
2018	85.44%	5.66%	8.90%
2019	85.49%	5.64%	8.87%
2020	85.81%	5.48%	8.71%
2021	85.49%	5.54%	8.97%
2022	85.38%	5.61%	9.01%
2023	85.39%	5.59%	9.02%

Source: Percentages calculated on the basis of [Department for Transport \(2024d\)](#).

### Appendix 3

Holding the year used as reference for the revenue goal constant at 2022, varying the year used as reference for the share of distance driven by petrol and diesel vehicles makes virtually no difference to the results, as shown in Table D. The share of the distance driven by petrol and diesel vehicles has not varied much in the period 2015–2022,<sup>28</sup> so the differences in the calculated DbC are very small.

**Table D**

DbC calculated under different assumptions on the share of distance driven by petrol and diesel vehicles

Reference year	2025		2050	
	Lowest estimates (p/km)	Highest estimates (p/km)	Lowest estimates (p/km)	Highest estimates (p/km)
2015	0.376	3.877	2.216	34.681
2016	0.379	3.891	2.218	34.699
2017	0.379	3.894	2.219	34.704
2018	0.378	3.888	2.218	34.695
2019	0.376	3.875	2.216	34.678
2020	0.373	3.862	2.215	34.660
2021	0.370	3.848	2.214	34.638
2022	0.367	3.836	2.213	34.621

Holding the year used as reference for the share of distance driven by petrol and diesel vehicles constant at 2022, varying the year used as reference for the revenue goal, unsurprisingly, changes the results, as shown in Table E. The earlier the year used as the reference, the higher the DbC needed to recoup the revenues, which were higher. The year 2020 is an anomaly – COVID meant that revenues declined drastically, and so that year cannot be used as the reference year.

**Table E**

DbC calculated with revenue goals associated to years 2015–2022

Reference year	2025		2050	
	Lowest estimates (p/km)	Highest estimates (p/km)	Lowest estimates (p/km)	Highest estimates (p/km)
2015	1.86	12.33	3.66	47.23
2016	1.75	11.67	3.55	46.29
2017	1.57	10.64	3.38	44.83
2018	1.40	9.63	3.21	43.37
2019	1.14	8.14	2.96	41.18
2020	0.30	3.49	2.15	34.07
2021	0.48	4.44	2.32	35.57
2022	0.37	3.84	2.21	34.62

### Appendix 4

This is the distance-based charge formula including all indices:

$$\omega_{stuml}^x = \frac{-(2\omega_{stum}M_{stum} - (1 - \varepsilon_l)\widehat{R}_{stum} + (1 + \varepsilon_l)R_{stum}) + \sqrt{(2\omega_{stum}M_{stum} - (1 - \varepsilon_l)\widehat{R}_{stum} + (1 + \varepsilon_l)R_{stum})^2 - 8M_{stum}\omega_{stum}(1 + \varepsilon_l)(R_{stum} - \widehat{R}_{stum})}}{2(1 + \varepsilon_l)M_{stum}}$$

<sup>28</sup> Although the variation between 2015 and 2022 has been small, this has not always been the case. From the beginning of the 2000s, the European Commission actively promoted diesel cars via emission concessions and tax advantages (Cames and Helmers, 2013). It was hoped that the dieselisation of the car fleet would reduce CO2 emissions. Diesel cars were also promoted in the UK. Although since March 1999, the excise duties levied per litre on petrol and diesel in the UK have been harmonised, i.e., the rates applied to each litre of petrol and diesel have been identical (HM Revenue and Customs, 2025), diesel vehicles still have a tax advantage thanks to their higher fuel efficiency. In addition, in 2001, a new system of Vehicle Excise Duty was introduced to boost diesel cars (Allan, 2025). As a result, the share of total distance driven by diesel cars in the UK increased from 27% in 2004 to 50% in 2015. In 2012, diesel was classified as carcinogenic by the World Health Organisation (2012), and in 2015, the US Environmental Protection Agency accused the VW Group of cheating on emissions tests (Allan, 2025), a scandal that became known as Dieseldate, with lawsuits against several car makers still taking place as of October 2025 (Moreau and Leggett, 2025). The share of the distance driven by diesel cars in the UK peaked in 2017 at 51% and has decreased since then.

## Data Availability

The sources of data are clearly indicated throughout the paper. All the data are freely available on the links provided in the list of references.

## References

- Adam, S., Stroud, R., 2019. A road map for motoring taxation. In: Emmerson, C., Farquharson, C., Johnson, P. (Eds.), *The IFS Green Budget: October 2019*. Institute for Fiscal Studies, London, pp. 209–240. ([https://ifs.org.uk/sites/default/files/output\\_url\\_files/The-2019-IFS-Green-Budget-Updated-2.pdf](https://ifs.org.uk/sites/default/files/output_url_files/The-2019-IFS-Green-Budget-Updated-2.pdf)).
- Adam, A., 2024. Electric car owners hit by new charge: how is it paid?, RÚV, Icelandic National Broadcasting Service, 4 January. (<https://www.ruv.is/english/2024-01-04-electric-car-owners-hit-by-new-charge-how-is-it-paid-401187>).
- Al-Deek, H., Moradi, M., 2015. Mileage-based user fee: a financial evaluation case study for the state of Florida. *Int. J. Sustain. Transp.* 9 (3), 176–191. <https://doi.org/10.1080/15568318.2012.753493>.
- Allan, L., 2025. Diesel emissions: are diesel cars bad for the environment? RAC. (<https://www.rac.co.uk/drive/advice/emissions/diesel-emissions-are-diesel-cars-bad-for-the-environment/>).
- Bakirtas, D., Nazlioglu, M., Yazar, H., 2024. Are electric vehicles discharging tax revenues? The Türkiye case. *EGE Acad. Rev.* 517–530. <https://doi.org/10.21121/eab.20240403>.
- Bergeron, Y. (Ed.), 2013. *Mileage Fees and the Highway Trust Fund: An Examination*. NOVA Science Publishers. ISBN 9781626188297.
- Bishop, C., 2025. Next steps on replacing petrol tax with electronic road user charges, Beehive.govt.nz, The official website of the New Zealand Government, 6 August. (<https://www.beehive.govt.nz/release/next-steps-replacing-petrol-tax-electronic-road-user-charges>).
- Bonilla, D., Soberon, H., Ugarteche Galarza, O., 2022. Electric vehicle deployment & fossil fuel tax revenue in Mexico to 2050. *Energy Policy* 171, 113276. <https://doi.org/10.1016/j.enpol.2022.113276>.
- Börjesson, M., Asplund, D., Hamilton, C., 2023. Optimal kilometre tax for electric vehicles. *Transp. Policy* 134, 52–64. <https://doi.org/10.1016/j.tranpol.2023.01.019>.
- Bose, M., Miners, B., Kaard, T., Zhan, M., Alleaume, C., 2021. The future of road pricing: Key considerations for the UK and lessons from the USA experience. *KMPG*. (<http://m.marketing.kpmg.uk/webApp/the-future-of-road-pricing>).
- Buckeye, K., Berrens, C., Baker, R., 2023. Minnesota Distance-Based Fee Project: Charting a Path Forward. *Transp. Res. Rec.* 2677 (3), 609–619. <https://doi.org/10.1177/03611981221116371>.
- Butcher, L., Davies, N., 2020. Road Pricing, House of Commons Briefing Paper Number CBP 3732. (<https://commonslibrary.parliament.uk/research-briefings/sn03732/>).
- Byrne, E., 2023. Victorian electric car owners win High Court challenge against controversial tax, 18 October. (<https://www.abc.net.au/news/2023-10-18/high-court-judgment-on-victorian-ev-drivers-tax/102989942>).
- Cames, M., Helmers, E., 2013. Critical evaluation of the European diesel car boom – global comparison, environmental effects and various national strategies. *Environ. Sci. Eur.* 25 (15). (<http://www.enveurope.com/content/25/1/15>).
- Chang, S.E., Woo, J., 2024. Are electric vehicle users willing to pay tax for charging electric vehicles? A case study of South Korea. *Energy Econ.* 129, 107243. <https://doi.org/10.1016/j.eneco.2023.107243>.
- Cheon, J., 2025. Distributional effects of a vehicle miles traveled tax over the different vehicle efficiency. *Econ. Transp.* 41, 100394. <https://doi.org/10.1016/j.ecotra.2025.100394>.
- Clarivate, 2024. Web of Science Platform. (<https://clarivate.com/products/scientific-and-academic-research/research-discovery-and-workflow-solutions/webofscience-platform/>).
- Collis, D., 2025. Petrol, diesel, hybrid or EV: What new road user charge could mean for you. *news.com.au*, 12 August (<https://www.news.com.au/technology/motoring/petrol-diesel-hybrid-or-ev-what-new-road-user-charge-could-mean-for-you/news-story/f9a07f6b0b0173c2aac16588b765c342>).
- Corfe, S., 2022. Miles Ahead: Road Pricing as a fairer form of motoring taxation. *Social Market Foundation*. (<https://www.smf.co.uk/publications/miles-ahead-road-pricing/>).
- Corlett, A., Marshall, J., 2023. Where the rubber hits the road: Reforming vehicle taxes, Resolution Foundation, June. (<https://economy2030.resolutionfoundation.org/reports/where-the-rubber-hits-the-road/>).
- Davis, L., Sallee, J., 2020. Should electric vehicle drivers pay a mileage tax? *NBER Environ. Energy Policy Econ.* (<https://www.journals.uchicago.edu/doi/pdf/10.1086/706793>).
- Department for Transport, 2004. Feasibility study of road pricing in the UK: a report to the Secretary of State for Transport, London. ([https://www.london.gov.uk/sites/default/files/gla\\_migrate\\_files\\_destination/DfT%20road%20pricing%20feasibility%20study.pdf](https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/DfT%20road%20pricing%20feasibility%20study.pdf)).
- Department for Transport, 2022. National Road Traffic Projections Workbook. (<https://www.gov.uk/government/publications/national-road-traffic-projections>).
- Department for Transport, 2023a. Common Analytical Scenarios Databook. (<https://www.gov.uk/government/publications/common-analytical-scenarios-databook>).
- Department for Transport, 2023b. TAG Uncertainty Toolkit. (<https://www.gov.uk/government/publications/tag-uncertainty-toolkit>).
- Department for Transport, 2024a. Transport Statistics Great Britain, Table TSGB1310. (<https://www.gov.uk/government/statistical-data-sets/transport-expenditure-tsg-b13>).
- Department for Transport, 2024b. Transport Analysis Guidance Databook. (<https://www.gov.uk/transport-analysis-guidance-tag>).
- Department for Transport, 2024c. Table RFS0110: Vehicle kilometres by type and weight of vehicle. (<https://www.gov.uk/government/statistical-data-sets/rfs01-goods-lifted-and-distance-hauled>).
- Department for Transport, 2024d. Road traffic bulk downloads: Table Regional Traffic: by vehicle type. (<https://roadtraffic.dft.gov.uk/downloads>).
- Department for Transport, 2024e. TAG Unit M2.1: Variable Demand Modelling. (<https://www.gov.uk/government/publications/tag-unit-m2-1-variable-demand-modelling>).
- Department for Transport, 2024f. NTS0901b: Annual mileage of cars by ownership and trip purpose (miles): England, 2002 onwards. (<https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy-car-mileage>).
- Department for Transport, 2025. Phasing out sales of new petrol and diesel cars from 2030 and supporting the ZEV transition: summary of responses and joint government response, 7 April. (<https://www.gov.uk/government/consultations/phasing-out-sales-of-new-petrol-and-diesel-cars-from-2030-and-supporting-the-zev-transition/outcome-phasing-out-sales-of-new-petrol-and-diesel-cars-from-2030-and-supporting-the-zev-transition-summary-of-responses-and-joint-government-response>).
- Department for Transport and Driver and Vehicle Licensing Agency, 2024. Vehicle Licensing Statistics: 2023. New registrations of zero emission vehicles. (<https://www.gov.uk/government/statistics/vehicle-licensing-statistics-2023>).
- Eddington, R., 2006. The Eddington transport study: The case for change: Sir Rod Eddington's advice to the government. HM Treasury, London. (<https://webarchive.nationalarchives.gov.uk/ukgwa/20081230093524/http://www.dft.gov.uk/about/strategy/transportstrategy/eddingtontstudy/>).
- European Commission, 2025. European Alternative Fuels Observatory: Iceland. (<https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/iceland/incinent-ives-legislations>).
- Evans, J., Firth, D., 2007. Central London congestion charging distance-based charging trials, Conference Proceedings of the 14th World Congress on Intelligent Transport Systems, Vol. 3, 1664–1666, Beijing, China, 9–13 October.
- Finance Act, 1910. Chapter 8. Acts of Parliament. (<https://www.legislation.gov.uk/ukpga/Edw7and1Geo5/10/8/enacted>).
- Finance Act, 1920. Chapter 18. Acts of Parliament. (<https://www.legislation.gov.uk/ukpga/Geo5/10-11/18/enacted>).
- Financial Statement, 24 April 1928. 216 cc861-3. (<https://api.parliament.uk/historic-hansard/commons/1928/apr/24/motor-vehicle-duties>).
- Forkenbrock, D., 2005. Implementing a mileage-based road user charge. *Public Works Manag. Policy* 10 (2), 87–100. <https://doi.org/10.1177/1087724X05283689>.
- Glaeser, E., Gorbach, C., Poterba, J., 2023. How regressive are mobility-related user fees and gasoline taxes? *Tax. Policy Econ.* 37, 1–56. <https://doi.org/10.1086/724352>.
- Glaister, S., 2018. The Smeed Report at 50: Will road pricing always be 10 years away? In: Walker, J. (Ed.), *Road Pricing: Technologies, economics and acceptability*. The Institution of Engineering and Technology, London, pp. 17–36. ([https://digital-library.theiet.org/content/books/10.1049/pbtr008e\\_ch2](https://digital-library.theiet.org/content/books/10.1049/pbtr008e_ch2)).
- Greene, D., 2011. What is greener than a VMT tax? The case for an indexed energy user fee to finance us surface transportation. *Transp. Res. Part D Transp. Environ.* 16 (6), 451–458. <https://doi.org/10.1016/j.trd.2011.05.003>.
- Hajiamiri, S., Wachs, M., 2010. Hybrid electric vehicles and implications for transportation finance. *Public Works Manag. Policy* 15 (2), 121–135. <https://doi.org/10.1177/1087724X10378173>.
- Hawai'i State Legislature, 2023. SB1534 SD2 HD3 CD1 Relating to Transportation: DOT; Electric Vehicles; Road Usage Charge System; Mileage-Based Road Usage Fees; Reports; Appropriation (\$). ([https://www.capitol.hawaii.gov/session/archives/measure\\_indiv\\_Archives.aspx?billtype=SB&billnumber=1534&year=2023](https://www.capitol.hawaii.gov/session/archives/measure_indiv_Archives.aspx?billtype=SB&billnumber=1534&year=2023)).
- Hensher, D., Mulley, C., 2014. Complementing distance-based charges with discounted registration fees in the reform of road user charges: the impact for motorists and government revenue. *Transportation* 41 (4), 697–715. <https://doi.org/10.1007/s11116-013-9473-6>.
- Hensher, D., Wei, E., Liu, W., 2021. Battery electric vehicles in cities: measurement of some impacts on traffic and government revenue recovery. *J. Transp. Geogr.* 94, 103121. <https://doi.org/10.1016/j.jtrangeo.2021.103121>.
- HM Revenue & Customs, 2024a. Tax receipts and National Insurance contributions for the UK; Table 5: Annual Contribution by Tax. (<https://www.gov.uk/government/statistics/hmrc-tax-and-nics-receipts-for-the-uk>).
- HM Revenue & Customs, 2024b. FOI2024/120647, Request made under the Freedom of Information Act, and reply received from the Information Rights Unit via private communication, 30 August.
- HM Revenue & Customs, 2025. Historical hydrocarbon oils duty rates. (<https://www.gov.uk/government/statistics/hydrocarbon-oils-bulletin/historical-hydrocarbon-oils-duty-rates-2>).
- HM Treasury, 2024a. GDP Deflators at Market Prices and Money GDP – June 2024. (<https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-june-2024-quarterly-national-accounts>).
- HM Treasury, 2024b. Autumn Budget 2024. (<https://www.gov.uk/government/publications/autumn-budget-2024>).
- House of Commons Transport Committee, 2022. Road Pricing, Fourth Report of Session 2021–22. (<https://committees.parliament.uk/publications/8754/documents/88692/default/>).

- Hriday, D.N., Tasnia, R., Pandey, V., Hasnine, M.S., 2025. Towards vehicle miles traveled reduction: Impact of mileage-based user fee on travel mode choices. *Case Stud. Transp. Policy* 20, 101454. <https://doi.org/10.1016/j.cstp.2025.101454>.
- Iceland Government, 2023. Why introduce a per-kilometer charge?, Our Roads to the Future. (<https://vegirokkarallra.is/en#why-introduce-a-per-kilometer-charge>).
- Iceland Government, 2024. Kilometer fee for electric, hydrogen and plug-in hybrid cars. (<https://island.is/en/kilometer-fee>).
- Igleheart, A., 2023. Special Fees on Plug-in Hybrid and Electric Vehicles: Brief, National Conference of State Legislatures, 27 March. (<https://www.ncsl.org/energy/special-fees-on-plug-in-hybrid-and-electric-vehicles>).
- International Energy Agency, 2024. Global EV Outlook 2024: Moving towards increased affordability. (<https://www.iea.org/reports/global-ev-outlook-2024>).
- Jaros, B., Hoffer, A., 2023. How are electric vehicles taxed in your state? Tax Foundation, 20 September. (<https://taxfoundation.org/data/all/state/electric-vehicles-ev-taxes-state/>).
- Jenn, A., Azevedo, I., Fischbeck, P., 2015. How will we fund our roads? A case study of decreasing revenue from electric vehicles. *Transp. Res. Part A Policy Pract.* 74, 136–147. <https://doi.org/10.1016/j.tra.2015.02.004>.
- Ji, J.Y., Chakraborty, D., Jenn, A.T., 2024. The present and future of road financing: Leveraging knowledge from the tolling industry to implement road-usage charge programs in the U.S. *Transp. Res. Interdiscip. Perspect.* 27, 101240. <https://doi.org/10.1016/j.trip.2024.101240>.
- Jia, W., Jiang, Z., Chen, T., Paletti, R., 2019. Evaluating Fuel Tax Revenue Impacts of Electric Vehicle Adoption in Virginia Counties: Application of a Bivariate Linear Mixed Count Model. *Conference Proceedings of the International Conference on Transportation and Development*. American Society of Civil Engineers, Alexandria, Virginia, US, pp. 91–110, 9–12 June. <https://ascelibrary.org/doi/epdf/10.1061/9780784482582.009>.
- Ju, H., Rahman, M., Khan, M., Burris, M., 2024. Distributional Impact of a Vehicle Miles Traveled Fee. *Transp. Res. Rec.* 2678 (7), 405–412. <https://doi.org/10.1177/0361198123120615>.
- Kastrouni, E., Gkritza, K., Hallmark, S., Stephenson, W., 2015. Fuel tax versus vehicle-miles-traveled fee: identifying vulnerable households by three-stage least squares analysis. *Transp. Res. Rec.* 2531 (1), 161–169. <https://doi.org/10.3141/2531-19>.
- Keford, A., 2023. Let's Simplify Vehicle Tax, Loop, April. (<https://loopagency.co.uk/wp-content/uploads/2023/04/lets-simplify-vehicle-tax.pdf>).
- Kim, D., Porter, J., Whitty, J., Svadlenak, J., Larsen, N., Capps, D., Imholt, B., Pearson, J., Hall, D., 2008. Technology evaluation of Oregon's vehicle-miles-traveled revenue collection system: lessons learned. *Transp. Res. Rec.* 2079 (1), 37–44. <https://doi.org/10.3141/2079-06>.
- King, D., King, E., 2017. Road Miles: Miles better, fairer, greener, safer. *Wolfson Economics Prize MMXVII*. (<https://policyexchange.org.uk/wp-content/uploads/2017/04/81221682.pdf>).
- Knittel, C., Metcalf, G., Saraf, S., 2025. From Tank to Odometer: Winners and Losers from a Gas-to-VMT Tax Shift. *NBER Working Paper*. No. w33894. (<https://www.nber.org/papers/w33894>).
- Kolpakov, A., Sipiora, A., 2020. Implications of market penetration of electric and autonomous vehicles for Florida State transportation revenue. *Athens J. Technol. Eng.* 7 (4), 299–318.
- Konstantinou, T., Labi, S., Gkritza, K., 2023. Assessing highway revenue impacts of electric vehicles using a case study. *Res. Transp. Econ.*, 101248 <https://doi.org/10.1016/j.retrec.2022.101248>.
- Langer, A., Maheshri, V., Winston, C., 2017. From gallons to miles: A disaggregate analysis of automobile travel and externality taxes. *J. Public Econ.* 152, 34–46. <https://doi.org/10.1016/j.jpubeco.2017.05.003>.
- Larsen, L., Burris, M., Pearson, D., Ellis, P., 2012. Equity evaluation of fees for vehicle miles traveled in Texas. *Transp. Res. Rec.* 2297 (1), 11–20. <https://doi.org/10.3141/2297-02>.
- Levis, A., Lichten, F., Bernauer, T., 2025. Compensating losses in fossil fuel tax revenues: First evidence of public support for a BEV mileage tax. *Transp. Policy* 171, 359–369. <https://doi.org/10.1016/j.tranpol.2025.05.007>.
- Lindsey, R., 2010. Reforming road user charges: a research challenge for regional science. *J. Reg. Sci.* 50 (1), 471–492. <https://doi.org/10.1111/j.1467-9787.2009.00639.x>.
- Meloche, J.P., Robert-Angers, M., Godbout, L., 2025. Policy forum: On the way to a distance-based tax? *Can. Tax. J.* 73 (1), 57–75. <https://doi.org/10.32721/ctj.2025.73.1.pf.meloche>.
- Metcalf, G., 2023. The Distributional Impacts of a VMT-Gas Tax Swap. In: *Environmental and Energy Policy and the Economy*, 4. National Bureau of Economic Research. <https://doi.org/10.1086/722672>.
- Meurs, H., Haaajfer, R., Geurs, K., 2013. Modeling the effects of environmentally differentiated distance-based car-use charges in the Netherlands. *Transp. Res. Part D Transp. Environ.* 22, 1–9. <https://doi.org/10.1016/j.trd.2013.02.013>.
- Minnesota Department of Transportation, 2024. Electric Vehicle Fee Restructuring, TRS 2403, March. ([https://mdl.mndot.gov/index.php/\\_flysystem/fedora/2024-04/TRS2403.pdf](https://mdl.mndot.gov/index.php/_flysystem/fedora/2024-04/TRS2403.pdf)).
- Moradi, M., Al-Deek, H., 2012. Financial evaluation of the CAFE standards and viability of a mileage-based user fee as a substitute for the current per gallon fuel taxes. *ITE J.* 82 (10), 37–41.
- Moreau, E., Leggett, T., 2025. Carmakers go on trial over emissions cheat claims. *BBC News*. (<https://www.bbc.co.uk/news/articles/cjr5epw8dweo>).
- Munnich, L., Doan, J., Johnson, C., 2013. Minnesota Task Force for Mileage-Based User Fee Policy. *Transp. Res. Rec.* 2345 (1), 48–52. <https://doi.org/10.3141/2345-07>.
- Muresianu, A., Hoffer, A., 2025. EVs and the Highway Trust Fund: Five Things to Know. *Tax Foundation*, 4 March. (<https://taxfoundation.org/blog/ev-highway-trust-fund/>).
- Muresianu, A., Hoffer, A., Macumber-Rosin, J., Durante, A., 2024. Expanding user fees for transportation: Roads and beyond. *Tax Foundation*, August. (<https://taxfoundation.org/wp-content/uploads/2024/08/Expanding-User-Fees-for-Transportation-Roads-and-Beyond.pdf>).
- National Conference of State Legislatures, 2022. Road Usage Charge Fact Sheet: Utah. (<https://www.ncsl.org/transportation/state-road-usage-charge-toolkit/road-usage-charge-fact-sheet-utah>).
- Nelson, C., Rowagould, G., 2024. Data-driven analysis of rural equity and cost concerns for mileage-based user fees in Vermont. *Transp. Res. Rec.* 2678 (7), 327–339. <https://doi.org/10.1177/03611981231206167>.
- New Zealand Transport Agency, 2024a. Electric vehicles and plug-in hybrids to start paying road user charges from 1 April 2024. (<https://www.nzta.govt.nz/media-releases/electric-vehicles-and-plug-in-hybrids-to-start-paying-road-user-charges-from-1-april-2024/>).
- New Zealand Transport Agency, 2024b. RUC for electric vehicles. (<https://www.nzta.govt.nz/vehicles/road-user-charges/ruc-for-electric-vehicles/#:~:text=Plug%2Din%20petrol%20hybrid%20vehicle,rate%20of%20%2438.00%20per%201000km>).
- Newbery, D., Santos, G., 1999. Road taxes, road user charges and earmarking. *Fisc. Stud.* 20 (3), 103–132. <https://doi.org/10.1111/j.1475-5890.1999.tb00006.x>.
- Noll, B., Schmidt, T.S., Egli, F., 2024. Managing trade-offs between electric vehicle taxation and adoption. *Cell Rep. Sustain.* 1, 100130. <https://doi.org/10.1016/j.crsus.2024.100130>.
- Norwegian Tax Administration and Norwegian Public Roads Administration, 2022. KVV Veibrugsavgift og bompenger: Konseptvalgforening Trinn 1 – versjon 1.0, November. (<https://www.skatteetaten.no/contentassets/343a9f921ade437c81482661e96320de/2022-11-kvu-veibrugsavgift-og-bompenger.pdf>).
- NSW Government, 2025. A fair and sustainable road user charge. (<https://www.nsw.gov.au/driving-boating-and-transport/nsw-governments-electric-vehicle-strategy/road-user-charge#:~:text=The%20road%20user%20charge%20rate%20for%20the%202024%2D25%20financial,at%20plug%2Din%20hybrid%20EV>).
- Office for Budget Responsibility, 2022. What does faster take-up of electric cars mean for tax receipts? (<https://obr.uk/box/what-does-faster-take-up-of-electric-cars-mean-for-tax-receipts/>).
- Office for Budget Responsibility, 2023. Fiscal risks and sustainability. ([https://obr.uk/docs/dlm\\_uploads/Fiscal\\_risks\\_and\\_sustainability\\_report\\_July\\_2023.pdf](https://obr.uk/docs/dlm_uploads/Fiscal_risks_and_sustainability_report_July_2023.pdf)).
- Office for Budget Responsibility, 2024. Fuel duties. (<https://obr.uk/forecasts-in-depth/tax-by-tax-spend-by-spend/fuel-duties/>).
- Office for National Statistics, 2004a. Dataset: Environmental taxes. (<https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsenvironmentaltaxes>).
- Office for National Statistics, 2004b. Gross Domestic Product at market prices: Current price: Seasonally adjusted £m. (<https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/ybha/pn2>).
- Office for National Statistics, 2024c. Dataset: Country and regional public sector finances: financial year ending 2023. (<https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/datasets/countryandregionalpublicsectorfinancesrevenueables>).
- Page, M., Moher, D., Bossuyt, P., Boutron, I., Hoffmann, T., Mulrow, C., Shamseer, L., Tetzlaff, J., Akl, E., Brennan, S., Chou, R., Glanville, J., Grimshaw, J., Hróbjartsson, A., Lalu, M., Li, T., Loder, E., Mayo-Wilson, E., McDonald, S., McGuinness, L., Stewart, L., Thomas, J., Tricco, A., Welch, V., Whiting, P., McKenzie, J., 2021. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ* 372, n160. <https://doi.org/10.1136/bmj.n160>.
- Paré, G., Kitsiou, S., 2017. Chapter 9: Methods for Literature Reviews. In: Lau, F., Kuziemyk, C. (Eds.), *Handbook of eHealth Evaluation: An Evidence-based Approach [Internet]*. Victoria (BC): University of Victoria. (<https://www.ncbi.nlm.nih.gov/books/NBK481583/>).
- Quarby, S., Santos, G., Mathias, M., 2019. Air Quality Strategies and Technologies: A Rapid Review of the International Evidence. *Sustainability* 11 (10). <https://doi.org/10.3390/su11102757>.
- RAC Foundation, 2023. RACF responds to calls for per-mile charge for EVs, RAC Foundation, June. (<https://www.racfoundation.org/media-centre/racf-responds-to-calls-for-per-mile-charge-for-evs>).
- Rahman, M., Ju, H., Burris, M., 2025. Income and geographic distribution of a vehicle miles traveled fee: case study of four states. *Transp. Res. Rec.* 2679 (4), 615–629. <https://doi.org/10.1177/03611981241295714>.
- Robitaille, A., Methipara, J., Zhang, L., 2011. Effectiveness and Equity of Vehicle Mileage Fee at Federal and State Levels. *Transp. Res. Rec.* 2221 (1), 27–38. <https://doi.org/10.3141/2221-04>.
- Rodriguez, A., Pulugurtha, S., 2021. Vehicle miles traveled fee to complement the gas tax and mitigate the local transportation finance deficit. *Urban Plan. Transp. Res.* 9 (1), 18–35. <https://doi.org/10.1080/21650020.2020.1850334>.
- Sallnow, R., Plowden, B., 2022. Road-user charging – the answer to everything or nothing? PA Consulting. (<https://www.paconsulting.com/insights/road-user-charging-the-answer-to-everything-or-nothing>).
- Santos, G., 2005. Road User Charges and Infrastructure, 135 Round Table of the European Conference of Ministers of Transport on Transport Infrastructure Charges and Capacity Choice, Paris. ([https://www.oecd.org/content/dam/oecd/en/publications/reports/2007/03/transport-infrastructure-charges-and-capacity-choice\\_g1gh7c f8/9789282101094-en.pdf](https://www.oecd.org/content/dam/oecd/en/publications/reports/2007/03/transport-infrastructure-charges-and-capacity-choice_g1gh7c f8/9789282101094-en.pdf)).
- Santos, G., Behrendt, H., Teytelboym, A., 2010. Policy Instruments for Sustainable Road Transport. *Res. Transp. Econ.* 28 (1), 46–91. <https://doi.org/10.1016/j.retrec.2010.03.002>.

- Santos, G., Catchsides, T., 2005. Distributional Consequences of Gasoline Taxation in the United Kingdom. *Transp. Res. Rec.* 1924, 103–111. <https://doi.org/10.3141/1924-13>.
- Santos, G., Cornford, C., 2024. Road transport electrification and motoring taxation in the UK. *Energy Rep.* 11, 4326–4337. <https://doi.org/10.1016/j.egy.2023.12.017>.
- Scopus, 2023. (<https://www.elsevier.com/products/scopus/content>).
- Sin, R., Donnelly, S., Acharya, P., Matthews, H., 2021. Mileage-based user fees to fund transportation infrastructure: Looking beyond revenue neutrality. *Conference Proceedings of the 25th International Conference of Hong Kong Society for Transportation Studies*, 9–10 December.
- Sjöström, T., Larsson, P., 2010. Swedish distance-based charging – Field trials results. *Conference Proceedings of the 17th World Congress on Intelligent Transport Systems*, Busan, South Korea, 25–29 October.
- Smith, D., Clougherty, T., 2023. *The Future of Driving*, Centre for Policy Studies, May. (<https://cps.org.uk/research/the-future-of-driving/>).
- Smyth, J., Chu, A., 2024. Governments slap taxes on EVs as \$110bn fuel duty shortfall looms, *Financial Times*, *FT.com*, 7 May. (<https://www.ft.com/content/9e4e38af-acb6-426b-9cd5-5f7e938d4443>) and (<https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:6BYW-TYJ1-F039-6017-00000-00&context=1519360>).
- Todts, W., 2024. As transport electrifies, governments can still make up for lost fuel duty revenues. *Energy, Environment and Transport*, Euractiv, 22 May. (<https://www.euractiv.com/section/electric-cars/opinion/as-transport-electrifies-governments-can-still-make-up-for-lost-fuel-duty-revenues/>).
- UK Government, 2025. Vehicle tax for electric, zero and low emission vehicles. 1 April. (<https://www.gov.uk/guidance/vehicle-tax-for-electric-and-low-emissions-vehicles>).
- Utah Department of Transportation, 2022, Utah's Road Usage Charge. (<https://www.utahroadusagecharge.com/EN/>).
- Wang, Y., Miao, Q., 2018. Implication of Replacing the Federal and State Fuel Taxes with a National Vehicle Miles Traveled Tax. *Transp. Res. Rec.* 2672 (4), 32–42. <https://doi.org/10.1177/0361198118796737>.
- Weatherford, B., 2011. Distributional Implications of Replacing the Federal Fuel Tax with per Mile User Charges. *Transp. Res. Rec.* 2221 (1), 19–26. <https://doi.org/10.3141/2221-03>.
- Wei, D., Giuliano, G., Moffa, K.A., Mallett, Z., 2025. Analysis of alternative commercial vehicle road user charges. *Transp. Res. Interdiscip. Perspect.* 32, 101519. <https://doi.org/10.1016/j.trip.2025.101519>.
- Welch, T., Mishra, S., 2014. A framework for determining road pricing revenue use and its welfare effects. *Res. Transp. Econ.* 44, 61–70. <https://doi.org/10.1016/j.retrec.2014.04.006>.
- Wood, J., 2024. Finances of the nation: The past, present, and future of fuel taxation in Canada. *Can. Tax. J.* 72 (2), 375–400. <https://doi.org/10.32721/cj.2024.72.2.fn>.
- World Health Organisation, 2012. Diesel engine exhaust carcinogenic. Press release N°213, 12 June. ([http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213\\_E.pdf](http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf)).
- Zhang, L., Lu, Y., 2012. Marginal-cost vehicle mileage fee. *Transp. Res. Rec.* 2297 (1), 1–10. <https://doi.org/10.3141/2297-01>.
- Zhang, L., Lu, Y., 2013. Implementing marginal-cost vehicle mileage fees on the Maryland statewide road network. *Transp. Res. Rec.* 2345 (1), 53–62. <https://doi.org/10.3141/2345-08>.