

## Article

# Combining Tradable Credit Schemes with a New Form of Road Pricing: Producing Liveable Cities and Meeting Decarbonisation Goals

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**Abstract:** This paper considers how the implementation of a tradable credit scheme (TCS) may be used to reduce road traffic and to contribute to the formation of liveable cities and global climate change commitments. The concept of applying TCS to individual road transport is familiar to transport researchers as a measure to regulate congestion and reduce transport-related emissions. Yet, it is not a strategy currently being considered by policy makers in the UK, despite the electrification of the road vehicle fleet and the associated loss of tax revenue presenting a rare opportunity to alter the economic instruments, which apply to road traffic. We consider how transport researchers can capitalise on this unique moment in transport history to shape transport policy. Our study uses qualitative methods, including a thematic analysis of semi-structured interviews with transport stakeholders and experts, in addition to a literature review and document analysis. Data analysis is inductive, permitting the formation of new ideas about the potential benefits of TCS and the barriers to the application of TCS to real-world policy. Building upon the results of TCS experiments and the results of our analysis, we propose a novel potential form of TCS combined with road pricing to maintain government revenue, which incentivises road users to decrease road vehicle kilometres travelled and reduce pollution and congestion. The proposal contributes to the discussion on the governance of road transport and taxation.

**Keywords:** road pricing; tradable transport credit; road user charge; decarbonisation; congestion; transport permit; climate change



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## 1. Introduction

Liveable cities require sustainable and reliable transport systems, including congestion-free road transport with low air pollution. The desirability for good air quality is underscored by the climate crisis. The world's need to reduce greenhouse gas emissions, as recognised in the Paris Agreement, has seen the UK pledge international decarbonisation commitments to become Net Zero by 2050. The reduction in road traffic is essential for both liveable cities and to meet international and domestic obligations to reduce CO<sub>2</sub> emissions [1,2]. In the UK, the current transport decarbonisation plan [3] sets out transport demand management policies [4], which promote a modal shift away from private road vehicle use; yet, efforts over the years to reduce road vehicle use have been unsuccessful [3]. This may be further disrupted by the push for electric vehicles [5] or the introduction of automated driving in the longer term [6], as well as the lingering effects of COVID-19 travel behaviour change. At the same time, the electrification focus has also caused the UK government to consider how to replace the revenue from diminishing fuel and vehicle duty caused by the uptake of electric vehicles. This may come from a new type of user-pays road pricing—a scheme, which has traditionally been met with resistance from the public [7]. Swapping fuel duty for road pricing does not automatically mitigate the congestion and pollution caused by high road traffic or address existing transport inequities. Transport

researchers can, however, provide quantitative experimental evidence that schemes such as tradable credit schemes (TCS) have the potential to reduce road user demand and ease congestion in a cost-neutral manner, which may be more acceptable to the public [8]. TCS refer to an allocation of transferable free credits or permits to all road users to undertake trips or to travel miles. The basic features of the system include users who require more trips than has been allocated in free credits having to then purchase unused credits from other users in order to undertake journeys. Users who have unused credits are free to trade these for a financial benefit [9]. The issue of transport inequity in the distribution and cost of credits is also considered. The scheme is revenue neutral, in that there is no financial flow between users and government. Research projects investigating the potential uses for TCS (which are described below) utilised mobile technology and app-based platforms, whereby users were able to observe their balance and trade credits. We use the term “tradable credit scheme”; however, the purpose of this work is to explore the utility of any type of scheme involving incentives to change travel behaviour or travel mode based on the availability of a credit for road use, with the facility to trade unused credits or to purchase additional credits where more are necessary and the overall policy goal of limiting the overall number of vehicles on the road. Drawing on the literature review, document analysis and expert interviews, this paper argues that TCS offers a unique potential for achieving the objectives in transport governance around emissions and congestion. Furthermore, we identify a critical need for transport researchers and professionals to engage with policy makers to include TCS in the transport governance agenda. No form of TCS is currently being considered by the UK government as part of its inquiry into road pricing. This paper draws upon the insights of transport professionals as to how the principles of TCS may be expanded and barriers overcome to integrate TCS into transport governance and achieve real-world policy goals dependent upon a reduction in road traffic. In the next section, we present a literature review outlining the current state of transport governance and policy drivers of background for emissions, congestion, tax revenue and transport equity, as well as introducing the reader to the concepts of and existing research on road pricing and TCS. We then set out our methodology before reporting on the findings. We finish with a general discussion and conclusions, highlighting steps we believe could be taken in order to include TCS in the transport governance agenda. This paper argues that strategies for reducing road vehicle kilometres must be implemented in order to achieve the goals of decarbonising transport and producing sustainable and liveable cities. Research into TCS is more relevant than ever before.

## 2. Background

### 2.1. Electrification of Road Transport

Globally, road transport accounts for nearly three-quarters of transport CO<sub>2</sub> emissions [2]. For the UK (and many other countries), electric vehicles form the centrepiece of the transport decarbonisation strategy. The UK government’s transport decarbonisation plan (TDP) [3] confirms an agenda to electrify the road vehicle fleet and that no new petrol or diesel vehicles will be sold from 2030. However, it is widely acknowledged that the impact of electrification on its own will be too slow to make meaningful progress towards decarbonisation [1] necessary to limit the global average temperature increase to 1.5 °C, as established in the Paris Agreement [10]. Legacy combustion engine vehicles (ICEV) will continue to drive on the roads and contribute to emissions. Electrification does not solve congestion or reduce air pollution to the levels stipulated in the 2033–2037 Carbon Budget [11]. In some cases, it may increase road kilometres and exacerbate congestion, such as where new road users are created by the implementation of mobility-as-a-service (MaaS) platforms, which incorporate electric car sharing as an option [5]. If MaaS platforms are developed alongside public transportation, this provides the potential for an integrated mobility system to cater for individual transportation requirements, while reducing private vehicle usage [12,13].

## 2.2. Tax Revenue

A large contribution to the UK tax budget consists of revenue arising from taxes related to ICEV. As well as the annual vehicle excise duty of up to GBP 2245 (based on certified vehicle gCO<sub>2</sub>/km emissions since 2017), vehicle owners pay a fuel duty on petrol and diesel. Including VAT, the proportion of tax paid at the pump for petrol and diesel is 62% and 61%, respectively [14]. The revenues from fuel duty and vehicle excise duty (VED) amounted to GBP 37 billion in 2019–2020.

HM Treasury has projected that if the current taxes on fuel and VED remain unchanged, tax receipts will progress to zero over the next 20 years, representing 1.5% of GDP [15]. Although taxation related to vehicle ownership and use varies between countries, it all broadly relates to vehicle emissions, meaning the UK is not alone in facing this deficit. Thus, the demise of tax revenue associated with electrification has opened up the possibility for fundamental change in how we tax road users and how roads are used in the UK and beyond. We have a unique opportunity to integrate our domestic and international legal obligations related to the global climate crisis with other policy priorities, such as improving urban liveability, reducing transport inequalities and maintaining road transportation revenue.

## 2.3. Emissions and Congestion

The UK has pledged international commitments to reduce greenhouse gas emissions and enshrined those commitments into domestic law in the form of the Climate Change Act 2008. The Climate Change Act sets out a legal duty to ensure that the UK's carbon account by 2050 is at least 100% below the levels in 1990 ("Net Zero"). The Climate Change Act compels the government to set carbon budgets and for the government to enact policies, which facilitate those carbon budgets to be met. The Sixth Carbon Budget sets out a plan to limit the budget for production of carbon dioxide in the UK to 965 million tonnes in total for the years 2033–2037 [11]. In 2019 alone, the UK produced 454.7 million tonnes of CO<sub>2</sub>, with 27% of this being produced by the transport sector. Currently, transport is the highest emitting sector, with 91% of CO<sub>2</sub> coming from road vehicles [16]. Reducing emissions from road transport is crucial if the UK is to meet its carbon budget set for 2033–2037.

Meanwhile, a sustainable and congestion-free road system facilitating efficient journey times is integral to the overall liveability of our cities, communities and urban environments [17]. A road system, which works to effectively deliver people, services and goods contributes to the safety and well-being of residents, workers and visitors [18]. Congestion and pollution contribute to losses in economic performance in cities and negatively impact the quality of life of residents. Problematic and slow road transport causes harmful emissions, stress and lost time for those using road vehicles [19]. Furthermore, road transportation that produces less local atmospheric pollution contributes to better public health [20].

## 2.4. Road Pricing

The term "road pricing" refers to a charge paid on a "per use" basis by those utilising the road network. The charge can be used to generate revenue, maintain transport infrastructure, and where the charge results in a reduction in vehicle kilometres travelled, it can reduce congestion and address environmental concerns [21]. Butcher [22] sets out what road charging schemes are and how they can be implemented in the UK. She sets out that a road charge is based on "The idea is that motorists should pay for the additional congestion they create when entering a congested road", but such a charge is generally seen as politically unacceptable due to perceived mobility rights by motorists.

The implementation of road pricing across the UK was first proposed in the Smeed report of 1964 [23]. It has been resisted for decades due to a low level of public support [7] and lack of political engagement [24]. Yet, the concept of road pricing has been extensively covered in the academic literature, from economic appraisals [25] and environmental impacts [26] to understanding attitudes [27] and lack on political engagement [28].

It is beyond the scope of this paper to suggest how the government will eventually decide to replace fuel duty, except to say that it must be replaced by some type of payment, such as a time- and/or distance-based pricing scheme or another type of tax. This is reflected in the recently published Transport Select Committee report on road pricing (“the Road Pricing Report”) [29]. The types of strategies that were suggested to the Transport Committee during the 2021 Road Pricing Inquiry included a flat tax or charge, which costs no more to the motorist currently driving a combustion engine vehicle paying fuel duty.

### 2.5. Governance of Road Pricing

In the UK, road transport is regulated through numerous statutory instruments. Devolution, which is the transfer of power to regions of the UK, contemplates that decisions relating to road pricing be made by individual nations and implemented by central or regional governments, although there is no connected road network between Great Britain and Northern Ireland. In the UK, the central government could implement road pricing on some roads, such as trunk roads that are carried by a bridge or pass through a tunnel, via the Transport Act 2000 [30]. Alternatively, a local authority can request a charging scheme on a trunk road, or, under section 164 of the Transport Act 2000, a charge may be made by local authority on roads for which they are the traffic authority.

Road pricing can also be implemented by local government statutes. In London, this is facilitated by The Greater London Authority Act 1999 [31], which establishes the Greater London Authority, defining powers and establishing Transport for London. Outside of London, charging orders can be established by local authorities under the Local Transport Act 2008 [32], where a charge may be created to address congestion and local transport issues if it is included within a local transport plan. There are a number of local road pricing schemes in operation in the UK, most notably the London congestion charge (since 2003) and low emission zones (since 2008). The London Congestion Charge Zone has been in operation since 2003. This is (at the time of writing) a daily charge (GBP 15) charged using ANPR to any vehicle entering the designated area (within London’s inner ring road) at certain times (7 a.m.–10 p.m.), though discounts and exemptions are given to individuals with certain needs (e.g., residents, disabilities), certain vehicle classes (e.g., emergency, registered taxis, roadside recovery) and ultra-low-emission vehicles. The same area has, since 2019, also been designated an Ultra Low Emission Zone (ULEZ) at all times, where vehicles not meeting the emission standards [33] are charged an additional GBP 12.50 a day (GBP 100 for buses/lorries). Individuals currently exempted as per the congestion charge have been granted a grace period to meet the standard. Penalty charges of up to GBP 160 (GBP 1000 for lorries/buses) for the ULEZ and GBP 240 for the Congestion Zone are applied if they are not paid on time. Both of these are managed by Transport for London on behalf of the Mayor of London, and any income is invested in the city’s road network and improving air quality. Local charging authorities may also create Clean Air Zones under the Transport Act (2000), as set out in the Clean Air Zone Framework [34]. “Clean Air Zones” have been proposed in a number of other UK cities, though with charges generally aimed at commercial rather than private vehicles [35].

The subject of road pricing governance is inextricably linked to issues of transport equity [36,37]. Some people on low incomes are dependent on their car to access everyday social and economic activities, while other people rely on access to a car because of disability. Therefore, increases in costs of motoring can create further hardship or social exclusion unless mitigated by a subsidy or provision of affordable and adequate alternatives to the car (see Refs [38–41]). TCS can potentially alleviate rather than exacerbate inequities caused by road pricing alone, based on the potential to allocate additional credit based on a policy designed to address transport inequities.

### 2.6. Transport Tradable Credit Schemes

TCS are already being used by governments in an attempt to regulate greenhouse gas emissions, such as the EU Emissions Trading Directive 2003 and the Greenhouse Gas

Emissions Trading Scheme Regulations 2009. However, currently, there is no application of this strategy to manage individual road vehicle use, to reduce congestion and emissions, and there is limited consideration of it by policy makers [24].

TCS used in the context of road vehicles envisages a constraint on the number of vehicles on the road or the number of trips taken. Such a scheme involves an allocation of trip credits to car users, which are redeemed for trips. Those that do not use their credits are able to trade unused credits for money, and those that require more can purchase credits from other users at the market rate [19].

Transport researchers have considered the potential for TCS to be applied to road vehicle use and have carried out experiments that incorporate the principles of a transport credit trading scheme to change travel behaviour. These experiments have differed in methodology, pricing design and objectives. However, what the studies have in common is that individuals' behaviour (or intended behaviour) has been successfully modified as a result of a tradable scheme, with fewer trips or car kilometres travelled. Further, these studies found that after taking part, the study participants indicated a greater understanding of the TCS concept and that they were in favour of such a scheme being used in the personal transport setting.

### 2.7. TCS Studies

The following sets out previous TSC studies (Figure 1):

Author	Country and date of experiment	Methods	Results
Dogterom, Ettema, and Dijst	Netherlands 2015	<b>Online stated adaptation experiment</b> Participants provided with the ability to organise their activity/trip pattern to include transport and active travel, rescheduling and reorganising trip locations in accordance with driving credit availability	a reduction of 20-24% in car kilometres travelled
Brands et al	Netherlands 2017	<b>Lab in the Field</b> During the experiment, participants could open an (app-based) web application and see the prevailing price, the remainder of their personal budget, and the number of credits in possession	93% of the choices made were the cheapest available it took little time and effort to participate determining the best trading strategy was not difficult. The majority agreed that tradable parking credits would be a good alternative for paid parking.
Brands, Verhoef, Knockart	Netherlands 2019/2020	<b>Real-World parking experiment</b> In this experiment participants were provided with a combination of a parking budget, free parking credits and an application within which credits could be traded.	<ul style="list-style-type: none"> <li>active traders of parking credits reduce the number of parking movements (thus, trips made by car) by 15%.</li> <li>participants found it easier to trade than they had anticipated</li> <li>participants regarded that trading parking credits functioned better, and fairer than paid parking, than an allocation based on a number of working days was fair</li> <li>active participants did not perceive that the process was time consuming</li> <li>active trading and engagement with the credit system had the effect of decreasing the price, whereas passive users of the system who did not trade or change their behaviour, had the affect of increasing the price</li> </ul>
Geng & Verhoef	China 2021	<b>A Comparative experiment</b> was conducted in Beijing which examined the acceptability and user perception of TCS, a congestion charge and a scheme whereby drivers were provided with health information about driving in peak-hour traffic.	The study found that prior to taking part, approximately half of the participants viewed TCS as difficult or very difficult. However, after taking part, this dropped to 25%, and most participants indicated their view that TCS was fairer and more effective than a congestion charge.

Figure 1. TSC studies.

Apart from these experiments conducted by transport researchers, the concept of introducing an element of free mileage credits as part of an overall economic instrument to provide fair access to roads in a manner that is also beneficial for the environment was conceptualised as "road miles" [42]. King and King [42] advocated a system, whereby drivers could be allocated 3000 "free" road miles per year, with drivers in rural areas receiving a larger allocation, which could be tracked using an on-board diagnostics port. However, this proposal entailed a payment for credits over allocation rather than a trading scheme.

### 3. Methods

Our study drew upon a mixed-methods approach incorporating original fieldwork comprising original semi-structured interviews with experts, supported by the literature

review and documentary research. An inductive analysis of the interview data, literature review and documentary sources formed the basis for discussion and recommendations, including a proposed form of combined road pricing and TCS.

### 3.1. Expert Interviews

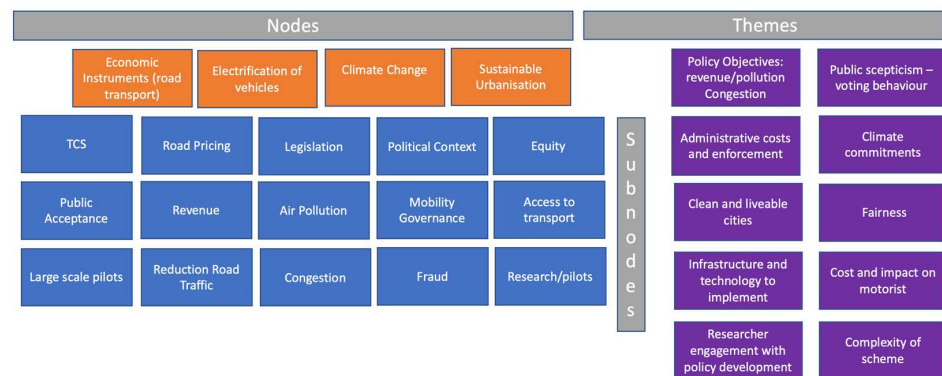
Interview participants were recruited based on their expertise in tradable credit schemes (TCS), economic instruments influencing travel behaviour and/or sustainability transport issues in urban areas. The interviews were conducted with transport academics and professionals as a means of theory generating [43], providing the basis for exploring alternative perspectives [44]. Two of the nine experts interviewed (Table 1) contributed to the U-PASS project (U-PASS (Urban Public Administration and Services innovation for Innovative Urban Mobility Management and Policy, (Grant No 71961137005) <https://jpi-urbaneurope.eu/wp-content/uploads/2019/04/UPASS.pdf> (accessed on 3 July 2022))), a collaborative project between institutions in the UK, the Netherlands and China, investigating sustainable transport systems. From these interviews, further experts were identified and recruited in the UK and the Netherlands. TCS is not currently used in a transport setting, and the number of experts in this field is limited. However, our methodology focused upon obtaining meaningful, professional insights from a small pool of interviewees, where depth rather than scale was key [45]. Interviews were semi-structured and sought to elicit from the experts their experience or qualifications to comment upon tradable credit schemes and sustainable urban transportation, with a view to addressing the main research objective of this paper, that being to consider whether the implementation of TCS may be used to reduce road traffic and contribute to the formation of liveable cities and global climate change commitments. Interview participants were provided with an information sheet about the purpose of the research and consent form samples, which are included in Appendix A.

**Table 1.** Experts interviewed.

Identifier	Description
E1	Professor of Transport Policy
E2	Officer (Government) of the National Railway
E3	Officer (Government) at the Ministry of Infrastructure
E4	Officer (Government) at the Department for Transport
E5	Associate Professor of Transport
E6	Professor of Spatial Economics
E7	Researcher at the Department of Economics
E8	Officer (Government) Transport Economist
E9	Officer (Government) of the Local Government

An interview guide was developed around the following themes: the current political and legal status of tradable credit schemes within the expert's jurisdiction, the potential for a future role of tradable credit schemes in urban mobility, the challenges or problems associated with the introduction of tradable credit schemes, whether those challenges could be addressed and how tradable credit schemes compared with other economic instruments designed to impact congestion (such as road pricing), road use and air pollution, and issues relating to the public acceptance and fairness of TCS and road pricing schemes. The interview guide is available in Appendix B. The open-ended questions contained in the interview guide provided a prompt to begin discussion, the aim of which was to explore avenues that the researcher may not have previously contemplated [46].

The interviews were audio recorded with the interviewee's permission and transcribed anonymously. Relevant excerpts from the interviews were manually coded into primary nodes and sub-nodes. Interview coding was inductive to allow new theory to emerge about the potential role for TCS. The themes developed as a result of the interviews are set out below in Figure 2 and include: competing policy objectives, public scepticism, fairness and complexity of TCS, clean air and liveable cities and the importance of researcher engagement in the policy-making process.



**Figure 2.** Thematic analysis.

### 3.2. Document Analysis

Document analysis was used as a means of providing insights, context and background into the research problem and assisted in generating expert interview questions [47].

Document analysis consisted of the literature (academic and grey) in the form of academic articles on sustainable transport planning, TCS, road pricing and other economic interventions designed to improve problems in road transport. We referred to government publications, statistics and reports, information supplied pursuant to a Freedom of Information Act (2000) request to Highways England, climate change and transport legislation, and oral evidence presented before the Transport Committee as part of the Inquiry into Road Pricing in October 2021 [29]. The transcripts of the oral evidence were reviewed for stakeholder evidence provided to the Committee relevant to the interview themes identified above. Document analysis was conducted in conjunction with the expert data as a means of triangulation.

## 4. Results

The views of experts, and the analysis of the documents and the literature, were analysed to determine the viability of the real-world application of TCS and to consider whether such a scheme may be useful in realising the aims of liveable cities and global climate change commitments.

### 4.1. Political Context

Road pricing is being considered by the UK government as an alternative to the current forms of motoring taxes: fuel duty and vehicle excise duty. The UK Transport Select Committee has recently recognised the inevitability of a new form of motoring taxation and has recommended that a new method could be formulated in a way, which may make concessions in the interest of societal fairness, support vulnerable groups, reduce congestion and support decarbonisation [29].

The government is bound by domestic and international commitments (Climate Change Act 2008) to consider strategies relating to decarbonisation. When planning a new method of road taxation, economic strategy should be considered in light of the Net Zero objectives, as set out by the Climate Change Committee in their July 2021 progress report [48]:

*“We recommend implementation of a ‘Net Zero Test’ to ensure that all Government policy decisions are compatible with the legislated emissions targets.”*

This was echoed by the National Audit Office who recommended that all decisions, policy and funding measures should be underpinned by Net Zero targets [49].

### 4.2. Liveable Cities

Sustainable urbanisation prioritises the minimal use of non-renewable resources and a flourishing environment, while addressing community and individual needs and well-

being [50]. This has highlighted the importance of policies, which encourage modal shift to reduce road vehicle kilometres and their related emissions as soon as possible. The goal of achieving liveable cities and the goal of decarbonisation to slow down climate change are both supported by a reduction in car use.

Compared to traditional pricing and taxing, the major advantages of TCS are that they provide regulators direct control on overall total consumption [19]. TCS can produce more efficient results compared to traditional pricing and taxation approaches, which produce unpredictable numbers of vehicles on the roads:

*“you have the success that you need, because you don’t allocate more credits than you think is acceptable” (E1)*

With a congestion charge, the price is controlled instead of the car use. A tradable credit scheme is effective in reducing car use, since the cap guarantees the predefined reduction in car use [51].

While the UK government has committed to a ban on the sale of conventional petrol and diesel vehicles from 2030, the reduction in emissions flowing from this policy shift will take time, with many internal combustion engine vehicles (ICEV) travelling on the roads for years to come.

As described by one of our interviewees:

*“... not just about getting rid of the cars, it’s about making the city centre more attractive for those that walk, and those that cycle” (E2)*

Increasing the liveability of cities by reducing congestion and air pollution caused by road vehicles can be attained by a range of non-economic incentives, such as providing alternative modes of transport, traffic light management and enforcement of traffic law violations [52]. However, economic reform and incentives are important tools for behaviour change that work to enhance other policy measures.

*“You don’t have to solve all problems using economic incentives, but solving problems without it, is a lot harder” (E6)*

During the UK government’s Road Pricing Inquiry, Professor Goodwin of the Foundation for Integrated Transport was asked about how to manage congestion and issues related to climate change:

*“Mr Bradshaw: How do you do congestion and climate and keep it simple?”*

*Professor Goodwin: “The starting point is a mileage charge, which is the best way of dealing with both.” [29]*

#### 4.3. Policy Objectives

The UK transport decarbonisation plan (2021) commits to an increase in active travel and zero-emission vehicles, alongside the introduction of shared mobility services. However, this commitment was made in the context of unprecedented loss of revenue projected as a result of electrification. In October 2021, the Transport Committee heard evidence from Mike Williams, Director of Business and International Tax, HM Treasury, who referred to the revenue currently generated by roads, that being GBP 28 billion from fuel duty and GBP 7 billion from vehicle excise duty.

Mike Williams stated before the Transport Committee that in considering new economic policy on road taxation:

*“Ministers will need to consider both the ability to fund public services, and also the secondary impacts that currently result from fuel duty, in particular, reducing road congestion, while also promoting the uptake of electric vehicles” [29]*

Here, Mr Williams is referring to what may be competing policy objectives. The government is aiming to replace revenue essential for public services, encourage the uptake of electric vehicles (for the purpose of decarbonisation) and manage congestion. It would



seem that a new type of road pricing or a combination of economic instruments will be necessary to facilitate these policy objectives.

Professor Goodwin from the Foundation for Integrated Transport acknowledged this when he said of a new road pricing scheme:

*“Even the simple stage has to accommodate at least two objectives, and those are congestion and climate. If we do anything on pricing that makes either of those worse, the system is going to be politically unacceptable” [29]*

As one of the political advantages of the TCS model is that the government is precluded from receiving financial rewards, it follows that it is one of the main reasons TCS has not featured as a solution to diminishing fuel duty receipts. TCS will not raise revenue:

*“And so how does a tradable permit help replace fuel duty? It doesn’t” (E5)*

*“It doesn’t raise the revenue; it doesn’t solve the problem of the electric vehicles not paying taxes. So, the original framing of tradable credits is less in line with the current debates on why to introduce road pricing” (E1)*

#### 4.4. Public Acceptance

Road pricing has been on and off the agenda in the UK for many years, perceived as being an unpopular strategy, which may undermine political power (Butcher and Davies, 2020).

*“The real reason road pricing has not happened, (is) because the politicians do not want to lose votes” (E1)*

The reluctance to implement road pricing by national governments has been evident in other countries, such as the Netherlands and China, for decades:

*“In the Netherlands, road pricing has been on the agenda for 33 years, and we did not do anything” (E1)*

*“The Government in China has been discussing the potential for congestion charges in Beijing for many years, but the citizens do not like this policy... They do not want to upset the car users.” (E7)*

Historically, the implementation of road user charging, such as congestion charging, has met with strong public opposition. Charging for driving during rush hour in a particular zone or on a particular road or motorway has the disadvantage, in that there is often little social or political support for it [8].

In the past, the public has been resistant to new road pricing measures, and when it comes to the concept of a tradable credit scheme, the public are completely unfamiliar with the idea. New forms of economic policy, such as a TCS, which impacts road use, are unlikely to receive a strong level of support in the first instance. This applies to any type of road pricing strategy:

*“Road pricing policies have a low level of support before implementation anyway, and this applies to tradable credits. We should not be relying upon surveys of a concept that has not been implemented yet, because people are more negative than after implementation” (E1)*

However, attitudes to a new system of road pricing may be changing. Only 26% of respondents to a recent survey in the UK indicated they were opposed to road pricing to replace fuel duty, with 36% neither supporting nor opposing, and 38% supporting [53]. Variables, which increased the support for road pricing included tax hypothecation to improve roads and transport and a “free allowance” of miles. This support for a free allowance of miles also suggests that there may be public support role for TCS. In addition, the concept of TCS may circumvent the traditional objections to road pricing:

*“If I ask you, are you willing to have another tax, then probably your answer is, you would rather not. It’s a universal objection. One of the solutions that the environmental economics discipline has produced to deal with it, is tradable credits” (E6)*

TCS may play a role in minimising the scepticism towards road pricing. As explained by a transport economics expert interviewee:

*“you start off with traditional road pricing, but you have exemptions. And then it is only a small step to make the exemptions tradable. They are tradable exemptions. you make price instruments more acceptable by taking away what is perceived as pain”* (E6)

#### 4.5. Fairness and Transport Equity

Although undergoing a period of change [53], road pricing has historically been resisted by the public due to perceptions of unfairness:

*“there is a lot of resistance to pricing policies, because people think they are unfair”*. (E1)

During the Road Pricing Inquiry, evidence was provided by Duncan Buchanan of the Road Haulage Association, who was concerned about the objectives of road pricing and that it would be used to:

*“price people off the road”* [29]

In addition, that truck drivers in particular:

*“do not have a choice about when we drive a truck, we drive a truck on the demand of the customer”*. [29]

However, the problem of unaddressed congestion also impacts road users and professional drivers, an issue that was highlighted by John Siraut, Director of Economics at Jacobs. While lobby groups represented in the Road Pricing Inquiry, such as the Road Haulage Association, may resist additional taxation, congestion impacted their business:

*“We heard from the Road Haulage Association about their vehicles being tied up in congestion. If you do not have a system that addresses that, I think you are missing a huge opportunity.”* [29]

Mr Buchanan advocated a cost-neutral transition to road pricing to cause less impact on members of their association. During the inquiry, one of the suggestions for the type of road pricing, which could be implemented, was a flat, distance-based charge. The experts interviewed agreed that this is one of the more likely strategies, albeit not a perfect one:

*“they will probably go for a flat distance based rate, which is not a perfect solution”* (E8)

As highlighted by the comments made before the Transport Committee by Duncan Buchanan of the Road Haulage Association, congestion charges disadvantage those who have no choice but to drive when and where they do. TCS is an alternative to a congestion charge, whereby credits can be allocated, and allocated more liberally to certain groups, depending on government policy.

*“and people argue (on congestion taxes) that you should not charge working people. So it is one thing to be supportive of road pricing, it is another to be supportive of congestion pricing”* (E6)

*“if you could use or design a system of tradable credits as a budget neutral incentive to avoid a peak, so you are not paying a tax, then you take away part of that opposition against the idea of having a price instrument against the working class, so there is an opportunity there”* (E6)

The provision of free credits enhances the public acceptability of the scheme, and the tradability of the credits allows other traders besides the government to benefit from the scheme. As recognised by our interviewee:

*“what if I told you that on one day a week you cannot travel, but on the other 4 days you can travel without congestion? People say, well yes I would be willing to adjust. Then if I say, suppose I add something, what about on the weekend you can buy the option to travel by car, and if it turns out you do not need it, you can sell it? They think that is attractive, because that is an additional feature”*. (E1)

TCS has the potential to benefit groups who already have lower energy consumption and lower car use, and these groups tend to correlate with lower income groups. It also provides the opportunity for authorities to pursue distributional outcomes by means of credit allocation and so could be used to support car-dependent low-income households [19]. The actual distribution of costs and benefits can be manipulated by credit allocation, offering an easy and natural way of providing a subsidy to specific groups of road users [8]. However, it is acknowledged that it will be the policy behind the allocation of credits, which will determine the impact on access to transport for particular groups. Credit allocation could potentially remove transport inequities or it could create or exacerbate them. This highlights the importance of further research into the impact of credit allocation, combined with equity impact assessments [41].

#### 4.6. Complexity for Consumers

Introducing a TCS alongside road pricing is likely to cause some hesitancy and initial confusion for the public. Transport researchers investigating the attitudes on TCS found that, although users were initially reluctant to use TCS and initially found the concept confusing, after participating in experiments, their level of acceptability rose:

*“In our experiment we compared the acceptability of tradable credits, congestion charges and a scheme providing health information to drivers. Drivers were more in favour of tradable credits” (E7)*

This highlights how introducing the concept of TCS to the public requires careful consultation and education:

*“When I explain it (as above) people are much more positive, and so communication is extremely important for this concept” (E1)*

While the experiments outlined above indicated that participants quickly understood how the scheme operated and were able to use it rationally to their advantage, there may be a perception that some people may manipulate the scheme in their favour, while others will struggle to gain the same advantage:

*“A lot of people think it’s quite complicated and you need to be an expert at trading, if not you will lose and others will win” (E1)*

*“People take time to understand tradable credits.” (E7)*

Further, the way that credits are allocated may be perceived to be unfair—for example, if people who do not own vehicles were able to sell and make money from credits [54].

The systems of allocating credits in the experiments to date have varied depending on the objectives of the study, and this has impacted the implied fairness of TCS:

*“where the allocation is based on historical behaviour, people may perceive this as unfair. If someone is allocated one permit per week and someone else is allocated three” (E7)*

The complexity of the scheme may impact its perceived fairness, and the policy for allocating credits will be crucial in a scheme’s success. It is important that TCS is seen as addressing the perceived unfairness of the other mechanisms, such as a congestion charge:

*“if there are discussions on having a congestion pricing element as part of a national road pricing scheme, TCS can perhaps a way to manage the resistance that people will have against congestion pricing” (E6)*

#### 4.7. Administrative Costs/Technology

Early studies of TCS criticised the high administrative and transaction costs associated with the scheme, which affected its viability [54]. However, the improvements in mobile and smart/connected technology may have addressed some of these concerns:

*“When the idea was first developed in the 1960s the main problem was how to get thousands of people trading credits? Now that is simple, we have the internet and the mobile phone” (E6)*

As noted by Professor Goodwin at the Transport Committee on road pricing:

*“we are in the rather odd situation that the technologies that are or can very easily be made available are so far in excess of the degree of complexity of a system you would actually want, that it is simply not a constraint. Anything that, politically, is realistic to design in a road pricing system, the technology can deliver already” [29]*

The advancements in technology may have, to some extent, mitigated the transaction and information costs previously associated with TCS [55]. However, the administrative and enforcement costs of this type of scheme, potentially involving millions of users, are likely to remain significant.

*“You cannot under-estimate the cost of setting up and administering and running this type of scheme . . . Fraud, I think is another big problem” (E9)*

These costs are usually borne by the government [56]. As one of the most desirable aspects of tradable permits is the facility for users to gain some advantage, this also potentially incentivises misuse of the scheme, where some users engage in illegal (or speculative) trading for profit. Without sufficient monitoring of the number of credits being used, the environmental and social benefits provided by TCS are eroded [57].

#### 4.8. Summary of Advantages and Disadvantages of TCS

Advantages	Disadvantages
Credits can be allocated according to government policy to provide additional assistance to particular groups, such as those with disabilities or those on a lower income	TCS could benefit the wealthy depending on the policy surrounding the purchase of credits and the market price of credits compared to road pricing
Revenue from credits does not directly flow to the government, and members of the public can receive a financial benefit from selling credits; consequently, this system of trading among citizens may be more acceptable to the public than a direct tax on roads	As revenue does not flow directly to the government from TCS, it does not address the requirement to create a new means of taxation to replace fuel duty; hence, it must be combined with road pricing
Modern technology provides the means to make TCS a reality through mobile applications. It is feasible that most drivers will have the technology and the ability to access a TCS via their mobile phone or other mobile technology	The scheme may be costly and complicated to introduce, administer and enforce. This will depend on the level of complexity of the scheme devised for allocating and renewing credits, and how a method of policing fair and legal use of the credits can be achieved. The scheme may be a target for fraudsters
The scheme and the allocation of credits can be used to influence modal shift away from road transport, which will reduce road congestion and reduce greenhouse gas emissions if we are able to encourage more trips via active travel and public transport	If the allocation of credits is not performed correctly, it may encourage the use of road transport
	Transport inequities. Some groups may be disadvantaged as a result of the scheme depending on the allocation of credits—for example, people with disabilities relying on road transport, people on low incomes who need to use their credits to access work, education or healthcare
	Public perception of unfairness. Some people receive credits, which they do not need (for example, people working from home), and are able to sell them for profit, while others use their credits to access work, education and healthcare. Professional drivers may not view the scheme as fair if they are not allocated sufficient credits

#### 4.9. Researcher Engagement in the Policy Process

As recognised by Lindsey and Santos [24], policy makers have had limited consideration of TCS for transport. In including strategies such as TCS on the agenda, researchers must engage with real-world issues and apply the findings of their research in a way that addresses government objectives [58]. This includes the question of how to reduce congestion and decarbonise transport while replacing revenue for fuel and vehicle excise duty.

Engaging with policy makers can be a complex process, with many influencers and implementers involved in the process, as well as the many levels of governmental decision makers. Following the standard ROAMEF policy cycle of decision making [59], the rationale

and objectives can be seen to have been addressed through the transport decarbonisation plan and the Road Pricing Report, and we are entering the appraisal stage. This is an opportunity to target the evaluators selected by the DfT/Treasury to assess road pricing strategies and in direct reference to the requirements, as set out in the previous section. Kingdon (1995) advocates that in an agenda-setting a policy, a “window of opportunity” appears when three streams of policy, problem and political are combined. What we derive from the analysis in this work is that the policy stream for TCS (the discussion between academics and experts) is well established, but it is only with the recently positive consideration of road pricing by the government that the political stream is now active. These are instigated by the problem stream, which would appear to be the climate crisis highlighting the need for urgent decarbonisation (and following this fleet electrification, loss of revenue), as well as a raised awareness of local pollution impacts on health and environment of transport emissions (e.g., this recent coroner ruling [60]), the reluctant acceptance of congestion issues and the wider agenda for liveable cities.

There is significant research still to be conducted into the most useful design and implementation of TCS alongside road user pricing, which may be incorporated into a wider mobility-as-a-service (MaaS) transport system. MaaS demonstrations and pilots, which include TCS, are necessary for garnering the financial and political support for such a transition [61].

*“If we were to ever become successful, we need a few small-scale experiments, so that people can see the benefits, one participants have done it, they like it. Once we have done it, it becomes easier to implement alternatives, updates and on a larger scale” (E1)*

Pilots are required to investigate how credits may be distributed and how the scheme could be administered. Further, pilots help to familiarise the public with the concept.

*“Its important to have these demonstration projects so that people can see that it is not as complicated as they thought” (E6)*

To date, there has been no UK-government-funded pilot investigating the viability of TCS in a national road transport setting.

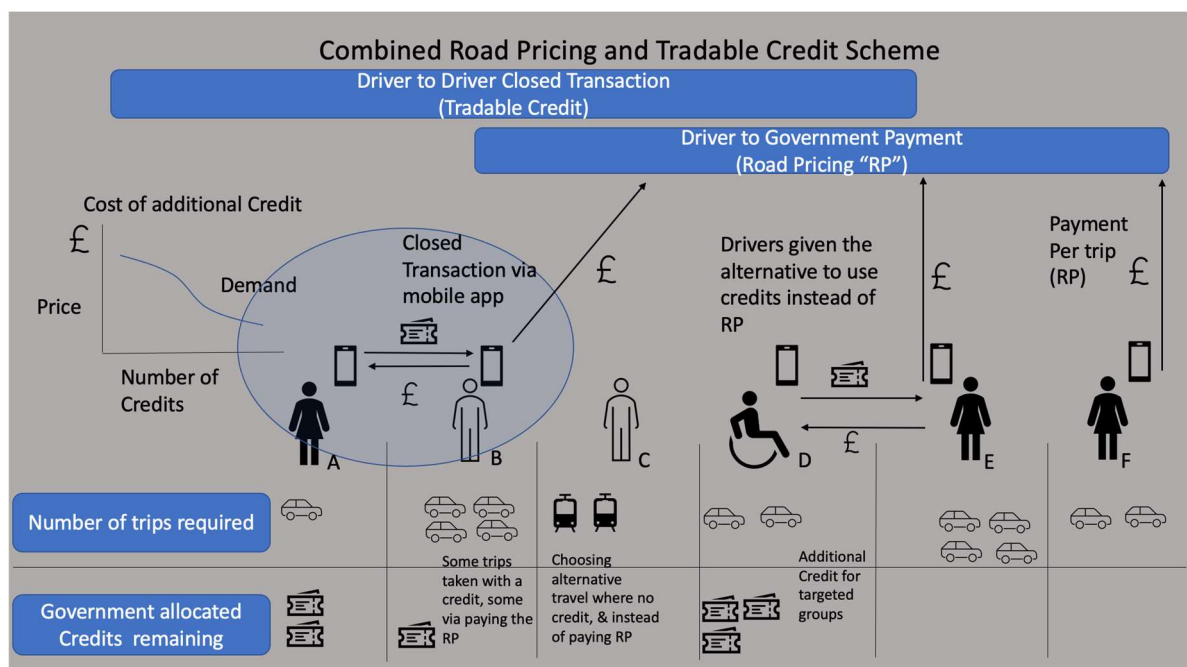
## 5. Proposal for TCS Combined with Road Pricing

With regard to the TCS studies outlined above and the results of the interviews, literature review and document analysis, here, we propose a potential type of a TCS scheme, which could be combined with a new form of road pricing:

- Where government policy is to reduce overall road km travelled in order to minimise congestion and air pollution;
- To run a road pricing scheme alongside, charging a price per trip via mobile app or web-based platform;
- A TCS to be available to drivers, also administered via a mobile app or web-based platform;
- Features of the TCS to include:
  - Drivers issued an allocation of free credits within a period (for example, per month or quarter);
  - Number of credits are distributed according to government policy;
  - Some drivers may receive more or fewer credits depending on government policy (such as more credits may be given to vulnerable people relying on private transport);
  - Trips may be taken using credits instead of paying the road pricing charge;
  - Drivers are able to view their “balance” of credits in the mobile app or web-based platform;
  - Drivers are able to trade their credits. That is, they can sell excess credits or buy credits via the mobile app or web-based platform;
  - The price of the credits is dependent upon demand. Demand can be manipulated by the allocation of credits.

Figure 3 depicts the concept of combining road pricing with a TSC, where road users are allocated two credits per renewal period, unless more are allocated to groups or individuals as per government policy:

- Road User A: Has two credits remaining and only requires one trip. They are able to sell their remaining credit to User B.
- Road User B: Requires four trips and has only one credit remaining. They purchase one credit from User A and pay the road price for the remaining three trips.
- Road User C: Requires two trips and has no remaining credits. They choose alternative travel.
- Road User D: Is a wheelchair user relying on road transport. They have been allocated one extra credit in alignment with government policy and have a total of three credits. As User D only requires two trips, they are able to sell their remaining credit to User E.
- Road User E: Has no credits available. They have purchased one credit from user D and paid the road price for the remaining trips.
- Road User F: Has no remaining credits and has chosen to pay the road price.



**Figure 3.** Proposed combined road pricing and TSC: impact on different road users.

#### Limitations of Proposal

Our proposal is currently limited by aspects, which must be explored via additional research, focus groups and pilots, including:

- how to effectively integrate the TCS and road user charging, such as what type of trips or routes would be suited to both schemes;
- what constitutes a “trip” (i.e., distance, time, whether trips are limited to a geographical area, whether a trip may include multiple stops);
- the method for allocating credits in accordance with government policy priorities, the impact of credit distribution, such as the number of credits allocated to each credit holder;
- the impact of various credit allocations to different groups or individuals and renewal periods, to be considered via a transport equity impact assessment [41];
- investigation should also be conducted into how such a scheme could be integrated into car-sharing models for electric vehicles, as opposed to trips taken in privately owned vehicles [62].

## 6. Discussion

The document and interview analysis provided a useful juxtaposition of TCS to road pricing. Evidence before the Transport Committee on road pricing revealed the complex problems presented when formulating a road pricing scheme while considering the differing policy goals of revenue raising, equitable accessibility, reduction in congestion, minimisation of air pollution and long-term climate change objectives. The analysis revealed challenges related to formulating a scheme that would be accepted by the public while still raising revenue.

The expert interviews revealed overall support or interest in the concept of a TCS from eight of the nine experts, with one expert indicating they were sceptical of the contribution TCS could make due to its potential high administrative cost and complexity. The remaining experts interviewed supported TCS due to its potential to reduce road vehicle kilometres, congestion and air pollution. There was consensus among all experts that the electrification of the vehicle fleet would require a new form of road pricing or economic instrument for taxing road use and that for the purposes of achieving liveable cities and climate change goals, a reduction in road traffic was necessary. However, the document analysis revealed resistance to policy goals, which focused on a reduction in road traffic, as stakeholders representing road users advocated potential hardship if a new form of road pricing made motoring more expensive or roads more difficult to access. One of the most criticised aspects of road pricing is its potential financial impact on particular groups of road users, including low-income earners and professional drivers. Experts recognised the potential of TCS as a mechanism to circumvent this negative impact and potentially help ease the resistance to a new form of road taxation. The enthusiasm from the experts for the use of TCS as a widespread policy idea was caveated by: the requirement for large pilot schemes to test the concept and to examine different methodologies for applying the scheme, concerns about complexity and the administrative cost, the possibility of fraud and how such a scheme would be enforced and concerns that the government would not consider a road use policy that did not (in itself) generate tax revenue.

Electrification, a policy chosen to meet the decarbonisation goals for international climate commitments, will result in major disruption to the governance of the transport system and to wider institutional structures dependent upon the revenue generated by the road network. National governments are being forced to re-examine how road users are taxed due to the demise of fuel and vehicle excise duty. Electrification of the vehicle fleet is not enough to meet the decarbonisation goals, as set out in the Sixth Carbon Budget, and electrification of the vehicle fleet alone also does not necessarily align with the hallmarks of liveable cities, those being cities with low congestion and low air pollution.

Historically, there has been a discrepancy between environmental objectives and the ineffective economic instruments used to pursue them. Carbon budgets and the domestic and individual trading of credits offer substantial scope to achieve policy goals (OECD 2001). We argue that we must utilise economic instruments to meet our environmental objectives and natural resource management goals.

While examples of road pricing exist in the UK, new laws will be required for an integrated national road pricing scheme. In the face of the inevitable overhaul of how road use is taxed on a national basis, now is the time to also consider alternative mechanisms, such as TCS. Transport researchers have a rare opportunity to engage in a redesign of the taxation of road transport, so that it may better meet these policy goals, while dealing with some of the political and public acceptance issues traditionally faced by road pricing. The rationale for using economic instruments to meet revenue, congestion and air pollution policy objectives has never been stronger, and transport researchers are best placed to support evidence-based policy making in this area.

However, further research incorporating TCS with vehicle use is required, in particular, large-scale pilots, to enable experimentation with scheme design and to consider the impact of TCS. In addition, alternative technical methods of delivering the scheme, its cost and methods of enforcement must also be examined. There will only be an opportunity for

TCS to be part of mobility governance if TCS researchers are able to engage successfully in the formation of a new road pricing policy. TCS is not being considered by the Transport Select Committee on road pricing; however, there is an opportunity for consideration of TCS as part of the redesign of road taxation. Road pricing itself has been off the transport governance agenda for decades due to the perceived complexity and lack of public acceptability, so the opportunity for the inclusion of TCS in these discussions as they gain momentum is a unique one that both transport researchers and policy makers must maximise. The Road Pricing Report recommended that any devised scheme should be applied nationally rather than locally. Consequently, researchers must engage with policy makers to implement a scheme on a national basis rather than via individual devolved administrations and local authorities. The Road Pricing Report identified that any scheme would also need to be revenue neutral for motorists (compared to existing taxation) to “promote fairness”. Potentially, a new road pricing scheme could cost drivers the same or less. If a new scheme led to lower costs for average drivers, then this would not incentivise mileage reduction and would not meet the obligations regarding decarbonisation, shared mobility and modal shift identified in the Transport Decarbonisation Report. A combination with TCS may be the only viable option to realise those targets. Furthermore, if TCS could be proved effective within vehicle road pricing, its contribution to non-car-related equitable accessibility may be strengthened within the transport governance discussions.

We are in a unique point at a time where we are simultaneously faced with international and domestic pressure to reduce carbon emissions, while facing the demise of our traditional road transport revenue base. The UK government must replace fuel duty revenue, which cannot be provided by TCS. However, we argue that TCS is a strategy that is compatible with road pricing. The combined strategies have the potential to deal with policy objectives of environment and liveability, while also providing an opportunity for the government to remove the burden of road pricing from disadvantaged groups by providing additional credits.

## 7. Conclusions

The UK government is currently deciding how to replace the fuel duty while also being faced with international and national obligations to attain Net Zero by 2050. Strategies, which mainly rely on the electrification of road vehicles to address climate change goals are unlikely to have the desired impact within the necessary timescales. Policies that encourage a modal shift and the reduction in road use will play an important part in achieving Net Zero. The reduction in road traffic is associated with both climate change goals and improving the liveability of cities, in particular, reducing congestion and improving air quality. However, a new form of road taxation is required to replace the revenue from fuel duty. Road pricing (whereby payment is made for each trip) is a strategy traditionally met with strong opposition from the public. We argued that the implementation of TCS alongside a new form of road pricing may be able to alleviate some of the impact of road pricing on the chosen groups and encourage a modal shift. We proposed a combined TCS and road pricing scheme, whereby road users would have the option of trading a limited number of credits for road trips, paying the road price or taking alternative means of transport. However, for policy makers to engage with TCS, researchers must be able to seize this window of opportunity and demonstrate how these schemes can help address the objectives of generating revenue, decarbonisation, accessibility, reducing congestion and air pollution, which are unlikely to be solved by road pricing alone. Further research is required to run pilot schemes to demonstrate the viability of TCS in a road transport setting to determine how TCS may be used in conjunction with a new method of road user taxation.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Data are available upon request to the corresponding author.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A. Information Sheet

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**UNIVERSITY OF LEEDS**

U-PASS Urban Public Administration and ServiceS innovation for Innovative Urban Mobility Management and Policy: information for participants

We would like to invite you to take part in an academic research project on governance and public administration of new mobility services (including automation, shared mobility, tradeable credits and electric driving). The project is a collaboration between Vrije Universiteit Amsterdam, Beijing Jiaotong University, Leeds University, Beijing Transport Institute and Zhejiang University.

We are inviting you to take part given your expertise in relation to tradable transport permits. We will ask you questions about:

- What is your role in and understanding of tradable transport permit schemes?
- What do you see as the future role in a sustainable transport system and who are the key stakeholders of tradable transport permit schemes?
- What are the challenges to implementing such schemes and how could they be overcome?

Taking part will involve an interview in English lasting around one hour. With your consent, we will take an audio recording of the interview. If you prefer not to be recorded, we can take notes. By taking part, you will make a valuable contribution to the project.

If you agree to take part, we can either interview you without anonymity (where we can identify you as a participant and attribute your responses to you) or we can pseudo-anonymise the data (in which case we will not use your name or precise job title). If you prefer pseudo-anonymisation, please note that, since we are interviewing you in your professional capacity, there can sometimes be a possibility that you might be identifiable because of the detail of your insights and knowledge. If you have concerns about this at any point, we are happy to discuss this and to find ways to further mitigate risks of identification (e.g., by removing quotes or by further generalisations).

With your consent, we will share your responses (along with your name, if you agree to that) among the research team at Universities in Britain, Netherlands and China, so that it can make the most effective contribution to the research. Additionally, with your consent, we would like to keep the transcript or notes of the interview (along with your name, if you agree to that) for future academic research projects.

We will endeavour to store and transfer the data securely; however, we understand that we cannot guarantee the security of electronic information, and this is why we are taking care to ensure you are happy with arrangements for pseudo-anonymisation or non-anonymisation.

It is completely up to you to decide whether or not to take part in this research. If you agree to take part now, you can change your mind at any point before or during the interview. You can ask for the data we collect from you to be removed from the project at

any point up until we begin the analysis. If you do change your mind about taking part, you do not have to give any reason.

If you would like any further information or have any questions now or later, please do get in touch with Dr Caroline Mullen using the contact details at the beginning of this sheet.

## Appendix B. Interview Schedule

### Tradable Transport Permit Interviews

The questions below have been designed to be open in order to allow the participant to offer uninfluenced initial viewpoints before being prompted for more detail. The purpose of each question is described to allow the interviewer to understand what they are aiming to draw out of the question, and they may prompt the participant in whatever way they feel would be appropriate to gather this information. The suggested follow-up questions and prompts are provided for use with the interviewer's discretion. It may be that some questions (and suggested follow-ups) are addressed in previous answers.

1. What is your professional role and/or interest/involvement in tradable transport permit schemes?

This is for background and context.

- What is their own role (i.e., job title/responsibilities)?
- What is their organisation (i.e., general purpose/responsibilities/motivations)?
- What is their own general interest/ motivation regarding sustainability and urban mobility?
- What is their own specific role/interest/motivation in tradable transport permit schemes?
- What are their own desires regarding the growth/integration of tradable transport permit schemes?
- What is their organisation's role/interest/motivation in tradable transport permit schemes?

2. What is your understanding of the term tradable transport permit scheme, and what existing schemes or policies might they be analogous to?

To assess common understanding of what is involved in such schemes, the key characteristics that distinguish them from other transport schemes and what should be considered in the design and implementation.

- In what situations do they apply?
- What are the basic requirements?
- What is being traded?
- Who should be included?
- How should permits/credits be allocated?
- What is the difference between permit and credits?

3. What is your understanding of the current status of tradable transport permit experiments/schemes?

To assess common understanding of the maturity and success of existing experiments/schemes and their interaction with wider mobility systems within the urban environment. Try to distinguish between specific schemes and more generally.

- Who engages in tradable transport permit experiment/schemes?
- Where are they being developed?
- What regulations govern them?
- What are their objectives and how successful are they?
- ?

4. What do you understand to be the future role of tradable transport permit schemes within urban mobility?

Building on the previous question, this focuses on the potential and opportunities of the schemes.

- What sort of growth in the services (if any) could be expected?
- How could it impact on wider existing urban mobility (e.g., modal shift)?
- How can it interact with other new mobility services (e.g., on-demand, car-sharing, scooters, automation)?
- Where will it be used and by whom?
- What needs to happen/change to realise it (e.g., regulation, business models, collaboration/trust and information availability)?
- What is the transferability to other regions?
- How can it contribute to:
  - personal mobility/accessibility,
  - social equality,
  - traffic efficiency (e.g., network connections, congestion, etc.),
  - energy use and environmental impact,
  - public health,
  - land use?

5. Who are the key players in the successful introduction of tradable transport permit schemes into urban mobility?

Try to identify who else they think is relevant to the success. Building on Q1, they should also consider themselves and their organisations. These can be generic stakeholders and/or specific organisations.

- What are their roles in tradable transport permit schemes?
- What are their motivations for being involved in tradable transport permit schemes?
- What are their current relationships between each other (e.g., are they separate organisations, how closely do they work, levels of trust, how do they perceive each other)?
- How do they need to co-operate for success?
- How likely are they to co-operate?
- What business models (existing and innovative) may be needed for success?
- Where do their responsibilities align and where do they differ?
- What are the power dynamics between actors?
- Which of these does the participant currently work with regarding tradable transport permit schemes or wider urban mobility and how do they perceive them?
- Prompts: regulators (local/national), local businesses/employers, service providers (inc. cloud services), technology developer/providers, infrastructure owner/operators, users, public, investors.

6. Where do you see challenges in the introduction of tradable transport permit schemes?

If this has not been discussed already, this should draw out thoughts on what specifically could prevent a successful introduction of tradable transport permit schemes.

- What is currently already preventing (directly/indirectly) the introduction?
- What might lead to market failure should it be introduced?
- Where might conflicts arise between the actors identified in Q4 that could prevent introduction/lead to failure?
- What regulations or policy (both local and national) could prevent introduction/lead to failure?
- What could be the consequences of failure?
- Who would be responsible for market failure?
- How likely are the challenges to happen?

Prompts: political acceptability, public acceptability, practical issues, investment, fairness, trust, co-operation.

7. How do you think these challenges to the introduction of tradable transport permit schemes can be overcome?

Referring to the challenges to growth from Q5, encourage the participant to consider what can be done to mitigate:

- What action needs to be taken (by whom and when)?
- What information will be needed (by whom and by when)?
- How likely are they to be successful in overcoming the challenges?

8. Where do you see challenges for society associated with tradable transport permit schemes?

If this has not been discussed already, this should draw out thoughts on how tradable transport permit schemes could interact with and impact the general public.

- What are the potential issues?
- Who in society will be impacted by the issues and to what extent?
- What might prevent the realisation of the opportunities identified in Q3?
- Who would be responsible for these challenges arising?
- What could be the consequences of these challenges for society?
- How likely are the challenges to happen?
- How big will the impact be?

Prompts: regulatory (local/national), political acceptability, public acceptability, practical issues, investment, fairness, trust, co-operation.

9. How do you think these challenges for society can be overcome?

Referring to the challenges for society from Q7, encourage the participant to consider what can be done to mitigate:

- What action needs to be taken (by whom and when)?
- What information will be needed (by whom and by when)?
- How likely are they to be successful in overcoming the challenges?

10. Are there any other impacts on sustainability from tradable transport permit schemes that you think should be considered?

This is to capture any other comments that may not have been covered in previous questions. Emphasise impacts can be positive or negative, long or short term, local or national (or international). All aspects of sustainability should be considered (environment, economic, social).

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