Paying for Road Use

Professor David Begg, July 2018

Synopsis

The dilemma and the challenge we face in paying for roads is how do we achieve the economic and environmental objective of ensuring that road users cover their external (social costs) while at the same time winning public and political acceptance.

Economists believe that many road users are paying too little road tax as they don't in aggregate cover their external costs (mainly congestion and pollution). However, the public feel they are paying too much in road taxation.

The contention in this essay is that the central problem we face is inefficient use of road capacity. It is difficult to think of any other sector where we are making as inefficient use of a scarce resource. Car occupancy rates languish at around 1.2 per vehicle; roads are sparsely used for large parts of a 24-hour cycle; freight and parcels are too often delivered when the road network is busy rather than quiet; taxi's and private hire vehicles (PHV's) are more expensive to hire when the roads are least busy.

The way forward is to incentivise road users to opt in to a new way of paying not just for roads but for mobility. Mobility as a Service (MaaS) driven by internet apps is revolutionising travel. It would be myopic to propose changes to how we pay for road use that doesn't take cognisance of the rapid change in GPS app based technology which are providing a mobility service. Too many motorists reach for their car keys without checking other options. MaaS provides these options in real time. How long will it take to go from A to B: by car, car sharing, Uber, rail, bus, bike, walking? How much will it cost? What is the trade-off between time and price?

There would be little appetite at Whitehall for a "Big Bang" approach to changing the way we pay for roads. The risks are too high both in term of public acceptance and the precariousness of introducing new technology. The recommendation here is for an incremental approach which in the first phase would entice road users to opt in to a new way of paying for roads, which in return would exempt them from paying fuel duty and VED. The fuel duty element would be deducted at the pump.

The new opt in charges would be set at a level such that road users would pay a similar amount in road taxation to what they are paying now in fuel duty and VED if there is no change in their travel behaviour. The new way paying for roads would combine a distance charge which would pay for road infrastructure and a time charge which would cover congestion and pollution. I have set the charges so the total amount raised covers all current local and national expenditure on roads plus 30% to make sure that funding is adequate. The distance charge is set at 2p per km for cars, and an average of 3p per km for vans and 6p per km for lorries. The charge for lorries and vans would increase in line with weight per axle and wear and tear to the road surface. For cars it would be a flat rate charge of 2p per km as, unlike lorries, the weight of a car is immaterial to the damage inflicted on road surfaces.

There would also be a time charge which would cover external costs of road use. Time is a much better way to internalise the cost of congestion and pollution, compared to a distance charge, as the charge would rise in busy urban conurbations. If it takes twice as long to travel 10 km then the time charge would twice as high. The hourly charge for cars would average £1 per hour. The time charges have been set in phase one to ensure that the new charges (distance plus time) are equal to current

road tax (VED plus fuel duty). In phase one the time charge would not cover the external cost of motoring for most road users. To do so would make opt in financially unattractive. Phase one is all about encouraging and incentivising opt in, monitoring road users' reactions to the new charges, testing the technology needed to administer the scheme, and ensuring that the government only pay for reductions in external cost. Government would pay for car drivers to reduce their external costs. In effect this is what the Treasury have done with VED to incentivise take up of cleaner vehicles.

The scheme would be administered by Mobility Account Providers and regulated by the Office of Road and Rail. Mobility Account Providers would work with road users to encourage opt in and persuade them to reduce their external costs with the promise of a reduced road tax bill. Mobility Account Providers would be incentivised to assist their customers through transparency around external costs, better information to influence choice and marketing to encourage behavioural change.

Phase two would move from discretionary opt in to a mandatory change to the new way of paying for roads to cover autonomous vehicles (A.V.'s). When vehicles are ready to be driven in full automated mode this would be the ideal political opportunity to make it mandatory to pay the new distance and time charges, with the latter covering the full external cost of motoring. This would ensure that the price mechanism prevents the advent of A.V.'s leading to a proliferation in vehicle miles and congestion.

This new way of paying for road use would also provide Government with opportunities to ensure that innovations and disruptive technologies work in the interests of society and do not exacerbate congestion.

Above all the investment case would be persuasive. Apart from the obvious Treasury burning deck of diminishing tax from fuel as vehicles become greener - and ultimately the disappearance of this sizeable revenue stream when the vehicles fleet becomes electric - the investment case would be attractive compared with building new roads or even investing more in public transport.

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Executive Summary

The dilemma and the challenge we face in paying for roads is how do we achieve the economic objective of ensuring that road users cover their external (social costs) while at the same time winning public and political acceptance.

Economists believe that many road users are paying too little road tax as they don't cover their external costs. However, the public feel they are paying too much in road taxation.

Government should strive to do what's in society's interest. If road users do not cover their external costs then they fail in this objective: road space is over consumed with the congestion and pollution problems which we are all too familiar with and the resulting economic, social and health costs that accompany this.

There is a widespread assumption that this is primarily a supply side problem with too little of the tax paid by road users being used to pay for more and better maintained road capacity. However, while there is a strong case for more capacity where the investment case is justified, 80% of the U.K.'s congestion is in urban conurbations and 40% is in Greater London alone[1]. Increasing road capacity in urban areas is challenging to say the least.

There is little appetite for demolishing residential dwellings or to tarmac over what little green space there is. The pressure now, and in the future, is how to make our cities more people friendly by reallocating road space from the movement of people and goods to exchange/people space[2]. This has already happened in London, which is one of the reasons why congestion in the capital has become so acute in recent years. Even where we can increase road capacity, without a fair and efficient charging system it will fill up too quickly.

The contention in this essay is that the central problem we face is inefficient use of road capacity. It is difficult to think of any other sectors where we are making as inefficient use of a scarce resource as we do with road space. Car occupancy rates languish at around 1.2 per vehicle; roads are sparsely used for large parts of a 24-hour cycle; freight and parcels are too often delivered when the road network is busy rather than quiet; taxi's and private hire vehicles (PHV's) are more expensive to hire when the roads are least busy.

Should it not be a priority for any business or organisation to tackle inefficiency and not just reach for the capacity lever?

It is very unlikely that there would be the political appetite, either now or in the foreseeable future, to impose a mandatory change in the way we pay for roads which would entail even a minority of users paying more then they currently do. Since the fuel duty protests in 2000, followed by the referendums on congestion charging in Edinburgh and Manchester, levying additional charges on road users has become politically toxic. This explains why we have had seven consecutive budgets where fuel duty has been frozen - despite the price of oil hitting historically low levels and public finances under severe strain.

The way forward is to incentivise road users to opt in to a new way of paying not just for roads but for mobility. Mobility as a Service (MaaS) driven by internet apps is revolutionising travel. It would be myopic to propose changes to how we pay for road use that doesn't take cognisance of the rapid change in GPS app based technology which are providing a mobility service. Too many motorists

[1] Commission for Integrated Transport, Paying for Road use, 2002
[2] Mayor of London's Roads Task Force 2015

reach for their car keys without checking other options. MaaS provides these options in real time. How long will it take to go from A to B: by car, car sharing, Uber, rail, bus, bike, walking? How much will it cost? What is the trade-off between time and price?

There would be little appetite at Whitehall for a "Big Bang" approach to changing the way we pay for roads. The risks are too high both in term of public acceptance and the precariousness of introducing new technology. The recommendation here is for an incremental approach which in the first phase would entice road users to opt in to a new way of paying for roads, which in return would exempt them from paying fuel duty and VED.

The new opt in charges would be set at a level such that road users would pay a similar amount in road taxation to what they are paying now in fuel duty and VED if there is no change in their travel patterns or vehicle. The new way of paying for roads would combine a distance charge, which would pay for road infrastructure and a time charge which would pay for congestions and emissions. I have set the distance charges so the total amount raised covers all current local and national expenditure on roads, plus 30% to make sure that funding is adequate. The distance charge is set at 2p per km for cars, and an average of 3p per km for vans and 6p per km for lorries. The charge for lorries and vans would increase in line with weight per axle and wear and tear to the road surface. For cars it would be a flat rate charge of 2p per km as, unlike lorries, the weight of a car is immaterial to the damage inflicted on road surfaces.

There would also be a time charge which would cover external costs of road use. Time is a much better way to internalise the cost of congestion and pollution, compared to a distance charge, as the charge would rise in busy urban conurbations. If it takes twice as long to travel 10km then the time charge would be twice as high. The hourly charge for cars would average £1 per hour. It would vary from £0.23 per km for the least polluting cars (VED band A) rising to £1 per hour (VED band D) and rising to £4.59 per hour for the most fuel inefficient cars in VED band M.

The time charges have been set in phase one to ensure that the new charges (distance plus time) are equal to current road tax (VED plus fuel duty) for each VED band. In phase one the time charge would not cover the external cost of motoring for urban road users in particular. To do so would make opt in financially unattractive. Phase one is all about encouraging and incentivising opt in, monitoring road users' reactions to the new charges, testing the technology needed to administer the scheme, and ensuring that the government only pay for reductions in external cost.

Government would pay for road users to reduce their contribution to congestion and pollution. In effect this is what the Treasury have done with VED to incentivise take up of cleaner vehicles. They have taken a hit to tax revenue to reduce the external cost of pollution. This proposal would also cover reduced congestion. Moreover, the time-based charge is a better proxy for pollution than VED changes as the latter does not vary with mileage and congestion

The scheme would be administered by Mobility Account Providers and regulated by the Office of Road and Rail. Mobility Account Providers would work with road users to encourage opt in and persuade them to reduce their external costs with the promise of a reduced road tax bill. Mobility Account Providers would be incentivised to assist their customers through transparency around external costs, better information to influence choice and marketing to encourage behavioural change.

Mobility Account Providers are companies who will hold their customers' bank details in the way that Uber or Amazon do. They would provide efficient mobile payment for all modes of transport, providing seamless door to door journeys.

Phase two would move from discretionary opt in to a mandatory change to the new way of paying for roads to cover autonomous vehicles (A.V.'s). There have been recent suggestions from Californian entrepreneurs such as Elon Musk (Tesla) and Bill Gates (Microsoft) that robots should be taxed to ensure that there is a fiscal level playing field with labour. When vehicles are ready to be driven in full automated mode this would be the ideal opportunity to make it mandatory to pay the new distance and time charges with the latter covering the full external cost of motoring. This would ensure that the price mechanism prevents the advent of A.V.'s leading to a proliferation in vehicle miles and congestion.

A.V.s provide the opportunity for government to implement a mandatory change in how we pay for roads at a politically acceptable time. It could be vindicated as a way of allowing people who drive vehicles for a living a more level playing field with automated vehicles. The cost savings that private hire, taxi's and delivery companies would make from A.V.'s are so considerable that this is golden opportunity to price more efficiently for roads. For motorists, the attraction of owning a vehicle and not being attentive at the wheel, will be significant enough for many to accept the quid pro quo that they must change how they pay for road use.

This new way of paying for road use would also provide Government with opportunities to ensure that innovations and disruptive technologies work in the interests of society and do not exacerbate congestion:

- The exponential growth in online shopping has led to a proliferation in the number of delivery vehicles on the road. We need to make much more use of the road network for the movement of freight and parcels when it is less busy. This includes evenings and through the night.
- Uber and other private hire vehicle apps bring benefits to the consumer in terms of cheaper rides and easier access. However, there is a tipping point when the sheer numbers of new PHV registrations adds significantly to congestion levels. This needs to be managed.
- DfT have forecast that the vehicle fleet will be all electric by 2050. Unless a way is found to ensure that electric vehicles pay for road infrastructure then these costs will be borne by the taxpayer. This will expose serious equity and fairness issues.
- Autonomous vehicles will make it more appealing for passengers to spend longer travelling as they can be more productive if they don't have to be attentive at the wheel of the vehicle. Average journey length could increase significantly with A.V.'s. Congestion consequences will be drastic if Government does not take action. One way they could do this is to make it mandatory for A.V.s to pay for road use based on time and distance. This will ensure that the longer someone is in a vehicle the more they will pay.

Above all the investment case would be persuasive. Apart from the obvious Treasury burning deck of diminishing tax from fuel as vehicles become greener - and ultimately the disappearance of this sizeable revenue stream when the vehicles fleet becomes electric - the investment case would be attractive compared with building new roads or even investing more in public transport.

TIMELINE

2019	• Option of new way of paying for roads by distance and time charge is announced in Chancellors budget as well as intention to give powers to ORR to set charges for distance and time. • Government to set targets and objectives for ORR in similar way that it does for the Monetary Policy Committee of the Bank of England • Cross party political support for ORR role in setting charges
2020	• ORR sets out initial charges for distance and time with the main aim of incentivising road users to opt in and making savings in their annual road tax payments if they cut their external costs
2021	• Mobility Account Providers vetted and authorised to collect the new charges and to work with petrol stations to remove fuel duty from the payment at the pump. • Mobility Account Providers would be financially incentivised to encourage their customers to make savings in their annual road charges by reducing their external costs.
2025	• Owners of Autonomous Vehicles (A.V.s) permitted to operate them in autonomous mode – without being attentive at the wheel – on condition that they pay for roads through the new distance and time charges.
2030	• Majority of vehicle fleet is paying for road use by distance and time.
2040	• Mandatory for all road users to pay for road use by distance and time

1. The Challenge

Economic analysis conclusively demonstrates that many road users do not cover their external costs. However, the challenge we face in changing how we pay for road use is that the public already feel that they are paying too much. Increasing costs on road users is politically difficult.

In an optimum scenario all external costs are internalized, but for public acceptance and political viability this will only be achieved in incremental steps.

1.1 External costs

Economists believe that many road users are paying too little road tax as they don't in aggregate cover their external costs. External costs include congestion, accidents, local air pollution, noise, greenhouse gas emissions, harm to landscape and biodiversity. Department for Transport research in 2010 showed that road users failed by a considerable margin to cover their external costs:

Marginal external costs and taxes paid by road users (pence per km)

Year	Congestion	Environment /Safety	Fuel Duty + VAT	Uncovered Costs
2000	7.3	2.2	5.2	4.3
2010	12.3	1.6	3.9	10.1

A few things to note from this research. There is a shortfall of 10 pence per km on what road users should be paying if they were to cover their external costs. Note how the shortfall more than doubled over the decade. We can expect this trend to accentuate as the vehicle fleet becomes increasingly more fuel efficient. Whilst fuel efficient vehicles reduce both environmental cost and fuel duty paid they do nothing to tackle congestion.

Most estimates would indicate that congestion accounts for more than 80% of externalities. As we move towards a vehicle fleet that is electric, with dramatic reductions in emissions and considerably less noise from quieter electric vehicles, we can expect the proportion of externalities accounted for by congestion to grow even further. Add to this the advent of autonomous vehicles which, by removing human error, are predicted to reduce road accidents by up to 80%, plus the relentless and accelerating rise in traffic, and it is clear that congestion is the overwhelming externality.

1.2 Political constraints

The challenge we face in factoring external costs into the price of motoring, is that the public feel they are already paying too much in road taxation. It is difficult for politicians not to have affinity with public opinion.

There is unlikely to be the political appetite for the foreseeable future to impose a mandatory change in the way we pay for roads which would entail even a minority of users paying more then they currently do. Since the fuel duty protests in 2000, followed by the referendums on congestion

charging in Edinburgh and Manchester, levying additional charges on road users has become politically toxic. This explains why we have had seven consecutive budgets where fuel duty has been frozen - despite the price of oil hitting historically low levels and public finances under severe strain.

The public believe they are paying too much in road tax as it dwarfs the amount spent on road investment and maintenance. The public do not recognize external cost, especially that their journey imposes a congestion cost on other road users.

The result of the failure of road taxation to cover externalities is that we over-consume roads and make incredibly inefficient use of them with very low car occupancy rates. If the external cost of individual road journeys was covered in the tax paid, then road capacity should rise to accommodate rising traffic and an efficient allocation of resources would occur. Because they don't there will also be the criticism that building roads is wasteful because without a fair and efficient charging system they fill up too quickly. We over consume the space because marginal benefit is less than the marginal social cost.

1.3 Guiding principles

In an optimum scenario, all external costs are internalized, but public acceptance and political viability will only be achieved in incremental steps. In recommending changes to how we pay for roads I have adopted some clear principles:

1. In phase one no vehicle owner is forced to make any change in how they pay for road use. They would choose to opt in. This de-risks it politically. It is only in Phase two (2025?) that it would be compulsory to pay by distance and time if vehicles are to be operated in fully autonomous mode.

2. That the government's role is as an enabler rather than an implementer. It will be up to the private sector to offer and run the mobility accounts. Government are not good at delivering projects which involve I.T.

3. The new way of paying for roads is equitable. Past road pricing recommendations suffered from the accusation that we were pricing low income motorists off the road and that our roads would be left to the rich who could afford to pay the charge. The mobility account opt in solution would give low income road users who are price sensitive the opportunity to earn money on their mobility account by sharing their journey with another passenger. This would also give cheaper mobility for those who don't own a car.

4. Improving the efficiency of the road network by increasing car occupancy rates. If this is not one of the outcomes from this change then the policy would have failed.

5. Safe driving is incentivised with an annual bonus paid for sticking to the speed limit.

2. A new way of paying for road use

The central proposition is that the way to better, safer and more reliable roads is to make more efficient use of existing capacity, and that one of the ways we will achieve this is by changing how we pay for road use.

Road users would be given the opportunity to opt in to a new way of paying for roads based on distance and time, and in return would be exempt from paying fuel duty and VED. The new way of paying for road use would be administered by Mobility Account Providers, and the scheme would be regulated by the Office of Road and Rail.

The new opt in charges would be set at a level such that road users would pay a similar amount in road taxation to what they are paying now in fuel duty and VED, if there is no change in their travel behaviour. Mobility account providers would work with road users to encourage opt in and persuade them to reduce their external costs of road use with the promise of a reduced road tax bill.

2.1 Paying by distance and time

The new way of opting in to pay for roads would be based on distance and time. The time element would cover congestion and emissions and the distance element would pay for road infrastructure.

Time is a good proxy for congestion as it enables a higher charge per km in congested urban areas than it does in lightly trafficked rural areas. The impact of emissions is also higher in more densely populated urban conurbations which a time charge picks up while a distance charge doesn't. The charge per hour would vary depending on the vehicles emissions. The time element would be set at the start of the journey based on estimated arrival time and the charge would not be levied on the time the journey actually takes. This is imperative to prevent dangerous driving as road users react to a ticking meter. They should also not have to pay more for unanticipated delays, because of an unforeseen disruption.

The distance element would cover the cost of building and maintaining the road infrastructure. The charges would be based on the wear and tear and damage to the road surface based on different vehicle weights. For car, this would be a flat rate, but for lorries this would be based on weight per axel. I was tempted to vary the charge for a car based on its weight but I was persuaded by the evidence that this makes little difference to road wear and tear[3]. A Hummer weights 2.6 times more than a Prius C hybrid but each contributes about the same wear and tear to roads and bridges. However, the heaviest truck fully loaded causes the same amount of road damage as 9,600 cars[4]

However, road maintenance is only one component that the road infrastructure fund would have to cover. There is also investment in road capacity, information systems, accident prevention measures etc. Therefore, cars would also need to contribute to the road infrastructure fund.

A criticism of previous proposals to switch from fuel duty to congestion charging is that it would only encourage rural vehicle users to switch and would do nothing to influence urban users who are

[3] "when discussing road wear and tear the weight of a car doesn't matter, road damage is effectively caused by trucks" faceweb; Ohio- state edu.
[4] PlanetiZen

travelling on the most congested roads. The difference in this proposal is that if we add in both a time-based charge and a distance charge then there is little variation in how much a rural and urban motorist would pay per annum with the new opt in charges compared with what they would be paying in fuel duty. This is because fuel duty itself is a good proxy - albeit a crude and less transparent one - for congestion in that in urban driving conditions mph is lower and fuel consumption per mile is higher ditto fuel duty. The key is adding in a distance charge to pay for road infrastructure.

We need an emissions charge based on time - hours travelled. Currently we vary VED to reflect emissions. This is no substitute for a time base charge as a car that hardly moves from the driveway pays just as much in VED as the same vehicle in terms of emissions, even if the latter does 100,000 miles per annum. Fuel duty is a better proxy as at least it is linked to mpg which will be lower on urban roads and therefor fuel duty paid per mile would be higher. This is fair as the impact of emissions is much higher in an urban environment than it is in a rural one.

I prefer a time-based charge to cover emissions than a distance based one as the latter does not reflect the higher cost imposed from vehicle emissions in urban environments.

In Oregon, a distance based charge has been introduced to replace the state gas tax but this has opened the accusation that the new charge is encouraging less fuel-efficient vehicles by reducing their tax contribution. The more fuel inefficient the car the less tax is paid per mile traveled with a distance charge compared with fuel duty. A solely distance based charge would become even more of a problem in the U.K. with our higher fuel duty.

Oregon has been addressing a narrower question: what is the best way to pay for road infrastructure. It makes sense to go for a distance charge to cover this especially as fuel duty is dwindling as cars become more fuel efficient. We are addressing a much wider question in this essay - how do we pay for roads in a fair way which covers not just infrastructure costs but wider social costs such as congestion and emissions.

2.2 Mobility Account Providers

Mobility Account Providers are companies who will hold their customers' bank details in the way that Uber or Amazon do. They would provide efficient mobile payment for all modes of transport, providing seamless door to door journeys.

The proposal in this essay is that Mobility Account Providers encourage road users to opt in to paying for roads with a per km infrastructure charge and a per hour charge - which will vary based on the emissions from a vehicle (g/co2/km) - to cover the external costs of road use.

Mobility Account Provider would ensure that the fuel duty element is automatically deducted from the price of filling up a vehicle at the pump. There would be no hassle of retaining and submitting fuel receipts to claim back the fuel duty component.

The new opt in charges would be set at a level such that road users would pay a similar amount in road charges to what they are paying now in fuel duty and VED: assuming there is no change in their behaviour. The role of the mobility account provider would be to work with road users - motorists, delivery and logistics companies, taxi and PHV providers - to encourage opt in and persuade them to reduce their external costs of road use with the promise of a reduced road tax bill.

Mobility Account Providers would compete to sign up customers. They would offer competitive deals and would be commercially incentivised based on a small percentage of the savings that their customers make on their annual payments.

Effectively government would pay for behavioural change and the Mobility Account Providers would be incentivised to assist their customers through transparency around external costs, better information to influence choice and marketing to encourage behavioural change. They will be much better at doing this than government.

2.3 Role of the Office of Road and Rail (ORR)

The ORR needs to be become a strong regulator for roads in the same way we have regulators for other utilities to protect the consumer and ensure that there is sufficient investment in the road network and that it is properly maintained. For this to happen we need a revenue stream and charges for using the road network, in the same way that we are charged for consuming water, gas, electricity and other utilities.

The proposal in this essay is that the per km infrastructure charge would provide this revenue stream. It is fairer to make this a distance based charge as wear and tear on the road network is directly linked to distance. The charge would also vary with vehicle weight with the heavier lorries which cause more damage to the road surface paying proportionately.

Aside from lessons we can learn from regulation of other utilities we can also learn from the establishment of the Monetary Policy Committee (MPC) of the Bank of England. When it comes to setting interest rates, the decision has been taken out of the hands of politicians and delegated to an expert committee to set rates at levels which are right for the economy. Government sets inflation targets and the parameters which the MPC operates within.

In the same way, Government would set parameters and objectives for the ORR:

- To set and annually review the per mile infrastructure charge.
- To set and annually review the time-based charge to reflect the wider congestion and emission costs.
- To ensure charges are set initially with the aim of encouraging opt in to this new way of paying for road use.
- To annually review the charges and apply them to electric vehicles in an incremental way which does not discourage the take up of electric vehicles.
- To work with Transport Focus in monitoring road user satisfaction.
- To ensure that road investment levels are sufficient to deliver an acceptable service level.

3. Setting the new charges

In phase one, the new charges have been set at a level to match what road users are currently paying.

The recommendation to move away from VED shifts the burden of taxation away from fixed annual costs towards variable costs. This allows a closer linkage between road tax and infrastructure costs, congestion and emissions.

A driver who travels 60,000 km per annum imposes a much higher cost than a driver who only travels 6,000 km per annum. VED charges do not reflect this.

3.1 New charges for distance and time

In this proposal, the new charges for a combination of distance and time have been set as far as possible to match how much road users are paying currently in fuel duty and VED. The distance charge would be ring fenced to cover investment in roads and road maintenance.

To cover infrastructure costs, it is recommended that all cars pay a flat rate distance charge of 2p a km, vans an average of 3p a km and lorries an average £6 per km.

I have judged that it is fairer and more accurate to cover external costs by time rather than distance. If pollution and congestion were allocated to the distance charge along with the infrastructure costs this would be unfair on rural road users compared to urban road users. The impact of pollution on people's health is significantly greater in densely populated residential areas. Also, miles per gallon is lower in urban areas when speeds are low. At its most extreme, stop start traffic produces four times as much emissions than free flow traffic[5]. However, a distance charge would not reflect this.

Oregon's new road usage charge to replace fuel duty highlights why it would not be advisable to go for a distance charge. The flat rate charge per car means that fuel inefficient vehicles pay less compared with fuel duty. This creates the wrong incentives. It is perverse that a large SUV emitting 10 times as much pollution per km that a smart hybrid pays the same charge.

The challenge faced in replacing fuel duty is that in many ways it is a fair and efficient tax which produces the right price signals. The more fuel efficient the vehicle the less tax per km it pays and the less congested the road the higher the km per hour and the less is paid in fuel duty per km travelled. So, fuel duty paid per km travelled rises with both emissions and congestion.

It's important that we capture the positives from fuel duty when replacing it. A time charge does this, especially if it rises with the fuel inefficiency of the vehicle. The time charge also allows congestion to be properly priced in a way that fuel duty doesn't.

The VED bands a car falls within reflects its fuel efficiency measured in g/km of CO2. While this is appropriate in phase one when opt in is the objective, it would need to be better targeted in alter phases to reflect air quality and particularly the growing concerns around diesel.

[5]Professor Margret Bell M.C. Environmental Factors in Intelligent Transport Systems, IEE Proceedings 2006

In calculating the hourly charge for vehicles in the 13 different VED bands I have tried to ensure that the new combined charge for infrastructure and externalities is as close as possible to what the road user would pay in fuel duty and VED under the current tax regime. This is important for two reasons:

1. Firstly, it's important to encourage road users to opt in and for the mobility account provider to incentivise their customers to reduce their annual road user tax in a plethora of different ways: car sharing, driving more efficiently, driving safely and within the speed limit, changing the time of journeys, walking or cycling for shorter journeys, switching to public transport, replacing their vehicle with a more fuel efficient one. To ensure maximum take up of the opt in, it's important that the bar is not set too high.
2. Conversely, it's important the government are only paying for reductions in externalities rather than reducing road taxation with no change in externalities. This would represent a dead tax loss for the Treasury.

3.2 Charges for cars

VED Band	VED (£)	g/CO2/km	Litres pa	Fuel duty pa	Fuel duty + VED	Infrastructure Charge (2p/km)	Hourly Charge (£)
A	0	100	546	316	316	£254	0.23
B	20	110	600	348	368	£254	0.43
C	30	120	655	380	410	£254	0.59
D	110	130	709	411	521	£254	1
E	130	140	764	443	573	£254	1.2
F	145	150	819	475	620	£254	1.39
G	185	165	901	522	707	£254	1.72
H	210	175	955	554	764	£254	1.93
I	230	185	1010	586	816	£254	2.12
J	270	200	1092	633	903	£254	2.46
K	295	225	1228	712	1007	£254	2.85
L	500	255	1393	808	1308	£254	3.99
M	515	300	1638	950	1465	£254	4.59

For illustrative purposes I have made assumptions in calculating the above hourly charges:

1. Vehicle km traveled is the UK average: 12,714km. This gives an average annual infrastructure charge of £254.
2. Vehicles travel at U.K. average speed: 48km per hour.

As the level of the new charges are based on what road users are currently paying I have had to calculate annual fuel duty payments.

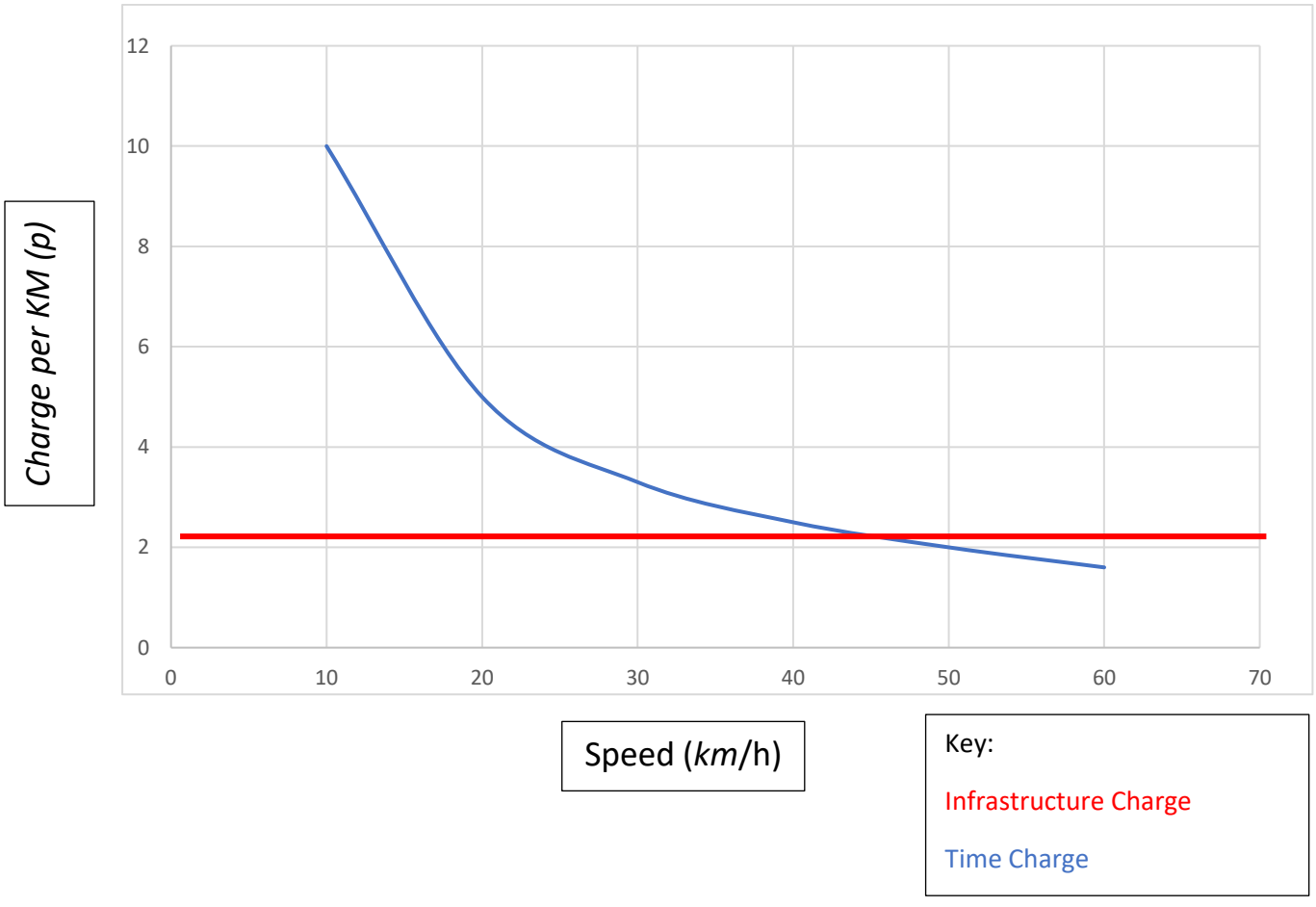
I have taken the high point in each VED band to illustrate how the charge is calculated. So, for a vehicle at the top of band D- g/CO2 per km = 130. This has been multiplied by 0.043 to give litres of fuel per 100km=5.59. Multiply by 127 (12,714 - average km travelled divided by 100) and this gives 709 litres of fuel consumed p.a. Multiply this by the fuel duty per km: 58p x 709 = £411 spent on fuel duty p.a. Add the £130 VED and we get total road taxation at £541. With infrastructure charge (I.C) at £254 (2p x. 12,714 km) this leaves £287- the difference between current road taxation and I.C. We divide this by 264 hours (12,714km divided by 48km per hour) and we get a charge of £1.08 per hour to cover congestion and pollution costs.

The infrastructure charge is set at 2p per km for all cars. I looked at varying it based on vehicle weight but was persuaded by the evidence that this has little impact on road wear and tear as far as cars are concerned. You could argue that an SUV takes up more road space than a Mini and should therefore contribute more to the infrastructure charge. I could still be persuaded by this argument. However, my preference was to vary the time charge to reflect the higher emissions from more polluting vehicles.

It's important to note that the figures above are not based on the charge required to cover externalities. They have been calculated based on the UK average car speed (48km per hour) which gives an average 264 hours travelled per annum. The hourly charge is based on the difference between current annual road tax (VED +Fuel Duty) minus the annual infrastructure charge.

So, the hourly charge ensures that the new charges are the same as the current amount paid in road tax if road users make no change to their travel patterns or vehicle type. It would be up to Mobility Account providers to work with their customers to reduce their external costs by: changing time of day at which they travel, lift sharing, public transport, walking, cycling etc.

Example: VW Golf paying time charge of £1 per hour



The time charge is good way to charge for congestion and it's simpler to communicate to road users than more complex road pricing proposals. The example below is for a car that falls within VED band D, such as a VW Golf SV 1.4, paying approximately £1 per hour. Driving on congested roads where the speed is only 10km per hour would result in a payment of 10p per km, while on free-flowing roads where the speed is 60km per hour the charge would only be 1.66p per km. As the congestion and pollution cost per km rises at low speeds, such as in congested urban conurbations, it is fair that the charge should be higher.

Case study

Bob drives a BMW series 2. It's in VED band H. His infrastructure charge is 2p per km and his hourly charge is £1.93.

He drives to work every week day from Sevenoaks in Kent to Canary Wharf in London. This is a distance of 29 miles and the journey time can vary from 45 minutes to 1 hour 20 minutes depending on traffic conditions. The journey time is particularly susceptible to the length of queues approaching the Blackwell Tunnel. He leaves his home at approximately 7.30 am and leaves his office around 6pm. Hi inward journey time averages out at 1 hour 10 minutes and his homeward journey averages out at 1 hour 5 minutes. The daily charge for the return journey works out at £1.16 infrastructure charge (2p x 58) plus £4.15 time charge giving a daily average of £5.31. Over the course of the year (assuming he travels to work for 230 days of the year) he would pay £1,221 (£267 infrastructure charge and £954 time charge)

He has chosen to opt in and his Mobility Account Provider will quickly work out his price and time sensitivities and would email him the following advice:

Bob- here are a few options you might want to explore to save you time and money:

Option 1. If you leave your house 30 minutes earlier in the morning and leave your office 30 minutes later in the evening you would save 15 minutes per day - £0.48 per day. Over the course of the year you would reduce your time spent driving to work by 57 hours, saving £111.

Option 2. There are several commuters who would car share with you with little trip diversion for you. If you were to share your journey with one passenger you would earn £6 per day for the return trip equating to £1,380 per annum. This would more than pay for your annual charges netting you a small surplus of £159. Click on your app and you will be able to hook up with passengers who want to car share with you. Based on your preferences we would recommend the following people etc.

3.3 Charges for lorries

With lorries, it is the weight per axle which is the crucial metric in deciding how much damage a lorry does to the road surface. Therefore, the km charge for lorries in this proposal increases with the weight per axle. I have used the VED bands for lorries (they are based primarily on weight per axle) to determine the per km charge.

VED Band	VED Charge (£)	Infrastructure charge (pence/km)
A	165	3
B	200	3
C	450	3.5
D	650	4
E	1200	5
F	1500	6
G	1850	7

The infrastructure charge is based on how much lorries would have to pay to cover the amount they are currently paying in VED. However, this is not the case for VED bands A and B, as the VED charge is so low it would produce an infrastructure charge per km even lower than cars. I have therefore assumed a minimum charge per km of 3p for vans and light lorries. VED rates for lighter commercial vehicles have been based on emissions whereas the VED rates for heavier lorries are calculated on weight per axle and road costs. The infrastructure charge is a fairer way for lorries to pay for roads than VED as it is directly linked to mileage and weight per axle.

Current road tax for lorries:

Weight (T)	VED (£)	Fuel Duty PA (£)	Fuel Duty VED (£)
7.5 (van)	165	6,412	6,577
12-14	200	8,092	8,092
16-18	650	12,824	13,474
26	650	15,389	16,039
33	1200	21,374	22,574
40	1850	23,624	25,474
44	1200	26,588	27,788

New charges for lorries:

Weight (T)	Charge per KM	Annual IC Charge (£)	FD + VED - I.C (£)	Average Annual Hours	Charge per Hour (£)
7.5 (van)	3p	1,920	4,657	1,066	2.15
12-14	3p	1,920	6,172	1,066	5.79
16-18	4p	3,840	9,634	1,600	6.02
26	4p	3,840	12,199	1,600	7.62
33	5p	6,000	16,574	2,000	8.28
40	7p	7,840	17,635	1,866	9.45
44	5p	6,800	20,988	2,266	9.26

The above table illustrates how lorries would be charged per hour for different weights. As with cars, the objective in phase one is to make the new distance (F) and time charge (I) as close as possible in aggregate to what each category of lorry would be paying in VED and fuel duty (D). To calculate fuel duty per annum(C) I have sourced the average mileage and the average fuel costs for each category of lorry from the Freight Transport Association's fuel cost calculator. Fuel duty works out at 64% of the total fuel bill.

The average distance varies with each category of vehicle as does fuel consumption.

To calculate hours travelled per annum (H) I have assumed average speed of 60 km per hour.

Note how the infrastructure charge is lower for 44 tonne than 40 tonne. This is because the VED rate is lower for 44 tonne as it has an extra axle, thus reducing the weight per axle.

Note how the charge per km is less for 44 tonne (£9.26) than 40 tonne (£9.45) despite the above. This is because the average distance travelled for 44 tonne is greater than 40 tonne thus increasing the average annual hours (H).

4. Implementation

To be politically deliverable the new way of paying for road use would be implemented in stages. The first phase will be optional. Autonomous vehicles provide the opportunity for Government to introduce a mandatory change in how we pay for roads.

It is also important that there is cross party political support for the role of the ORR in setting charges, so that the process is depoliticised as much as possible.

Government will need to get ahead of the curve of new disruptive technologies such as autonomous vehicles, Uber and online shopping to ensure that they work in the interests of society. Changing how we pay for road use is central if this objective is to be achieved.

4.1 Timeline

2019	• Option of new way of paying for roads by distance and time charge is announced in Chancellors budget as well as intention to give powers to ORR to set charges for distance and time. • Government to set targets and objectives for ORR in similar way that it does for the Monetary Policy Committee of the Bank of England • Cross party political support for ORR role in setting charges
2020	• ORR sets out initial charges for distance and time with the main aim of incentivising road users to opt in and making savings in their annual road tax payments if they cut their external costs
2021	• Mobility Account Providers vetted and authorised to collect the new charges and to work with petrol stations to remove fuel duty from the payment at the pump. • Mobility Account Providers would be financially incentivised to encourage their customers to make savings in their annual road charges by reducing their external costs.
2025	• Owners of Autonomous Vehicles (A.V.s) permitted to operate them in autonomous mode – without being attentive at the wheel – on condition that they pay for roads through the new distance and time charges.
2030	• Majority of vehicle fleet is paying for road use by distance and time.
2040	• Mandatory for all road users to pay for road use by distance and time

4.2 Disruptive technologies and trends

4.2.1 Vans and light vehicles

The exponential growth in online shopping has led to a proliferation in the number of delivery vehicles on the road.

It is ironic that few deliveries are made to households in the evening when the roads are quieter and the customer is more likely to be at home. You would think that congestion itself would encourage fewer deliveries during day- and the daily peaks in particular - as the logistic costs are higher. Congestion itself is not producing the right price signals to incentivise this.

We need to make much more use of the road network for the movement of freight and parcels when it is less busy. This includes evenings and through the night.

The advent of electric lorries and vans will enable quieter deliveries which removes one of the main objections in residential areas. We will also see the provision of more safe deposit boxes for household parcel deliveries which encourage night time drop offs. For new residential developments, this will become an essential feature.

An opt in which allows the logistics industry to cut costs by paying by the hour and by distance, instead of paying fuel duty, will incentivise and encourage 24-hour distribution.

4.2.2 Uber and other Private Hire Vehicle's (PHV)

There is no doubt about the benefits they bring to the consumer in terms of cheaper rides and easier access. However, there is a tipping point when the sheer numbers of new PHV registrations adds significantly to congestion levels. London is a case in point. There are now 20,000 Uber vehicles operating daily inside the congestion charge zone. It seems perverse that they are exempt from paying the congestion charge.

When first introduced in 2003 congestion charging reduced vehicle numbers within the zone by 60,000 a day. One third of the reduction in vehicle numbers has evaporated with the increased supply of Uber vehicles. Without action this trend will become more pronounced.

Market pricing for PHV's and taxi's pushes up the fare when demand is high and public transport alternatives more limited - late evening and early hours of the morning. This is also the time when there is much less congestion on the road network and when emissions are less as traffic moves closer to free flow speeds. The opposite is true for trips made during more congested times of the day. However, because we don't price in externalities such as congestion and pollution they are not reflected in the fare charged.

PHV's would be able to opt in to a new way of paying for road use. The shift from fuel duty to time and distance charging would reduce costs when the roads are less congested and increase costs when they are busier. It should also encourage more vehicle sharing and higher occupancy levels during the more congested times when we need it most.

It is anticipated that A.V.'s will become more prevalent in the taxi/PHV market before other areas. The financial savings from eliminating the cost of paying a driver are a game changer. This is the ideal political opportunity to make it mandatory that road taxation switches to distance and time, with full external costs covered, if vehicles are to be operated in full autonomous mode.

4.2.3 Electric vehicles

DfT have forecast that the vehicle fleet will be all electric by 2050. The cost of purchasing electric vehicles will become incrementally more competitive as battery technology evolves. Unless a new way is found to ensure that electric vehicles pay for road infrastructure then cost will be borne by the taxpayer. This will expose serious equity and fairness issues.

The ORR should be given an objective of incentivising electric vehicles but setting out a longer-term strategy to ensure that eventually they pay for electric charging, road infrastructure and congestion costs. The first two would be distance based and the latter time based.

We need to pass a tipping point when electric vehicles are price competitive and take up would not be discouraged by charging for infrastructure and congestion.

We need to avoid the criticism government has faced on diesel where it was encouraged and incentivised and the public purchased diesel vehicles on good faith. The ORR would need to set out a longer-term pricing strategy, in the same way that the Bank of England gives warnings that interest rates will not always be low, to prevent the public from taking on affordable debt when interest rates rise.

4.2.4 Autonomous Vehicles (A.V.'s)

A.V.s will make it more appealing for passengers to spend longer travelling as they can be more productive if they don't have to attentive at the wheel of the vehicle. Effectively they could become extensions of people's homes and offices. The journey will be more productive as it will allow people to work in transit rather than concentrate on driving and will lead to a proliferation in vehicles that provide personal services such as hairdressing etc. To this you would have to add the prospect of users catching up on sleep on their journey and you can see how the average journey length could increase significantly with A.V.'s.

When you combine the prospect of electric vehicles which don't pay for road use and A.V.'s - which make it more attractive to travel more prodigious distances in them with more spatial sprawl - then the congestion consequences will be drastic if Government does not take action to prevent this.

One way they could do this is to make it mandatory for A.V.s to change the way we pay for road use to time and distance. This will ensure that the longer someone is in a vehicle the more they will pay. The politics of making a new time and distance charging system compulsory is very challenging. However, this is a hurdle which could be negotiated with the introduction of A.V.'s. If they are rented - and this is much more likely with A.V.'s as opposed to ownership - then there will be even less public resistance. If A.V.'s are owned and privately used, then this would be a golden opportunity for government to permit them to be used, without the driver having to be attentive at the wheel, only on condition that the time and distance system of paying or roads is adopted.

The desire to operate vehicles in autonomous mode will be strong enough for many to accept the condition that they pay differently for road use. This is a one-off opportunity to get the public to adopt change.

4.3 Technological delivery

Technology is moving at such a rapid rate that its best to look at current ways in which the new way of paying for road use can be implemented and possible ways it could be implemented in the future. GPS based apps and vehicle tracking devices could be utilised. In the future algorithm driven blockchains could provide a safe, relatable ledger tracking movements which users, mobility providers and the treasury could all have confidence in.

4.3.1 technology

In Oregon, a vehicle miles travelled (VMT) tax has been successfully trialled since 2007. The objective is to replace fuel duty which is dwindling every year as vehicle become more fuel efficient. An on-

board vehicle device captures the distance travelled through GPS. They have also managed to protect privacy.

Last year the California Department of Transport selected four account managers: Azura, IMS, Arvato and Eroad for a road charging pilot. It is possible to use an in-vehicle unit with a pre-paid stored value card which would protect a user's privacy.

Tantalum, a vehicle tracking company, fit vehicles with a telematics device linked to the on-board computer that measures emissions using engine speed, temperature, acceleration and deceleration. The device can detect location and time, enabling drivers to be charged more in congested and polluted areas.

4.3.2 Blockchain.

We are in the infancy of working out the impact Blockchain will have on transport. It has the potential to influence behaviour immediately. Forget about carrots and sticks. It's all about universal and transparent information. And you wouldn't have to have officials manipulating the pricing and making good intentioned but suboptimal manipulations but machine driven algorithms automatically price adjusting all options. The algorithms would learn as choices are made over time and that would then be fed back into the ledger.

A Blockchain is an open ledger that is updated in real-time on the internet and its integrity is validated by all its users in real-time thereby eliminating the need for clearing houses and other third-party validating entities that hold information, limit transparency and delay settlements. The Blockchain structure is most famous (or infamous) for being the means of distributing and accounting for bitcoins, but that is now understood to be a specialised use.

If there were a Blockchain of transport usage, recording and charging in real-time, the costs of choice would be immediate, transparent, and capable of influencing behaviour in real-time. Imagine different charges for different modes, different parts of modes (route/ time) and those charges were assessed in real-time and visible on your smartphone, Apple Watch, or other device, it could change behaviour in the same way that your traffic data from Waze affects you. It would also educate the public in real time about transport choices and keep their education current in real-time.

5. Conclusion

In giving road users the option to change how they pay for road use, government would effectively be paying for a reduction in external costs.

The new way of paying for road use also addresses the prospect of declining fuel duty receipts as the vehicle fleet becomes greener. Moreover, there would be significant wider social, economic and environmental benefits.

We would achieve a significant improvement in road space efficiency by increasing car occupancy and spreading traffic flows for the movement of people and goods.

5.1 Reducing external costs

The proposal in this essay is that government would be paying for road users to reduce their contribution to congestion and pollution as opposed to policies proposed in the past - which have proven to be politically undeliverable - where road users were asked to pay more to cover their external costs.

In effect this is what has been done to reduce emissions with vehicles which emit less than 100g of CO2 per km exempt from VED, with government taking a big hit in tax revenue. One quarter of new cars registered fall within band A and pay no VED.

The difference between the VED exemptions and the proposal in this essay is that it would produce a long term and fair way of paying for roads. The VED changes, while effective in incentivising the take up of lower emission vehicles, have led to the longer-term prospect of vanishing tax revenues.

The proposition here is that we extend this principle to cover congestion and pollution and that we incentivise road users to cut their externalities by reducing road taxation when running a vehicle. Changes to marginal cost (running costs) has a much bigger impact on behavioural choice than changing the fixed cost of owning a car and is much fairer way to pay for roads. The more we can link payment with use rather than ownership the fairer and more efficient the tax becomes.

There is an attraction in reducing the fixed cost of motoring for those who opt in and replacing it with higher running costs. This would give greater incentive for behavioural change. Too often public transport finds it difficult to compete on price with the car as the motorist only takes into account running costs - usually only petrol and parking.

The same principle applies to vehicle insurance. This has been a risk cost for vehicles owners but it tends to be a fixed cost paid up front. The Mobility Account Providers will be incentivised to strike deals with insurance companies to switch to a distance based charge for insurance. The technology on the mobility accounts will enable mileage to be monitored and accurately calculate for insurance purposes. Reduced insurance charges for every mile travelled could be available for safe driving within the speed limit.

5.2 The investment case

Why should government pay for road users to opt in to this new way of paying for roads? Apart from the obvious Treasury burning deck of diminishing tax from fuel as vehicles become greener - and ultimately the disappearance of this sizeable revenue stream when the vehicles fleet becomes

electric - the investment case would be attractive compared with building new roads or even investing more in public transport.

If an increase in car occupancy rates from 1.2 per car to 1.3 could be achieved this would lead to a substantial reduction in congestion. Marginal changes to the time of a journey would also be extremely effective in cutting congestion. By shifting the peak by only 1% in a handful of select suburbs, you can reduce the commuting times across the entire city network by 14-18% [6]

5.3 Wider benefits

There would be compelling economic, environmental, equity and accessibility cases to justify government paying for road users to opt in to this new way of paying for roads.

We would achieve a significant improvement in road space efficiency by increasing car occupancy and spread traffic flows for the movement of people and goods more evenly through the daily, weekly and yearly cycles. There would be more freight and parcel deliveries in the evening and through the night as the logistics industry is financially incentivised to make more use of the road network when it is quieter. This becomes more acceptable with the advent of quiet electric vehicles and with the provision of secure residential and business drop off points.

Taxi and Uber's fares would more accurately reflect the higher external cost of congestion and emissions which would reduce the numbers on the road during the busiest times and increase the number when the roads are quieter and public transport alternatives are more limited. This new way of opting in to pay for roads would provide a credible strategy for dealing with the two categories of vehicle which are increasing exponentially: delivery vans and PHV's.

Opting in to this new way of paying for roads would:

- give better access to car capacity for those who can't afford to buy and run a car,
- reduce costs for low income motorists
- encourage fuel efficiency and reduce emissions.
- be fair for rural and urban road users
- encourage public transport use, walking and cycling by stopping motorists from automatically reaching for their car keys without looking at the alternatives
- encourage a change in behaviour by reducing the fixed costs of owning a car (VED and insurance) and shift more onto running cost.
- provide more transparency to road users on the external costs they occur and pave the way for a change in how everyone pays for roads in the future
- give road users more confidence in the setting of the new charges with the Office of Road and Rail setting the charges and road investment levels.
- minimise political risk both in terms of public reaction and in implementation: Government would be the enabler and the private sector would deliver the new mobility accounts with the opt in for paying for roads in a more efficient way.

[6] Xing.et.al “Mitigation of expressway traffic congestion through transport demand management with toll discount”