Next Stop, Better Rail: Technical report

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Produced for Green Alliance, funded by the Foundation for Integrated Transport & Trainline

January 2025

Contents

1. Introduction

This report falls within the wider context of other reports completed by Green Alliance, including *Not going the extra mile: driving less to tackle climate change* (Bennett and Brandmayr, 2021) and *Moving on: greener travel for the UK* (Allen et al., 2023). The first of these identified a need to reduce UK car miles, in addition to the government strategy of promoting electric cars, to meet climate change targets. Reductions to car miles can be achieved either by reducing travel altogether or by shifting to greener modes. The current report focuses on opportunities for modal shift offered by the rail system.

2. Management of induced demand

It is important to consider, in any policy that moves trips from cars to rail, the importance of managing induced demand. Current congestion levels on the road network represent an equilibrium state: individual drivers will naturally make fewer trips if deterred by congestion, and hence, conversely, make more trips if congestion is reduced. If the goal is to reduce greenhouse gas emissions from car use, then this effect can potentially undo any efforts to shift car trips to rail through increasing the attractiveness of rail.

In the long run, the UK aims for all cars to be electric, with sales of new purely internal combustion engine (ICE) cars set to be banned from 2030/2035. Once the vehicle fleet is fully electric, then the return of congestion to previous levels is not necessarily a problem. Each trip is providing a benefit to somebody which can be quantified as economic activity.

In the short term however, the manufacture and sale of electric cars in the UK is not happening fast enough for us to meet agreed emissions targets (Bennett and Brandmayr, 2021). Any modal shift policy must therefore be complemented by additional measures such as road use, congestion or air quality charges to ensure that further demand for car travel is not induced. Although in the decongested scenario the cost of car use would rise, people who continue to make car trips would benefit from faster travel times.

3. Reducing the cost to the consumer

3.1 Quantifying costs

In this section I derive figures for financial, environmental and health costs to be discussed in later sections.

According to the Office of Rail and Road (2023) total expenditure on the UK rail system during the 2022-3 reporting year was £25.4bn. Total income from passenger ticket sales was £8.6bn, and income from government subsidy £11.9bn, and other sources £1.5bn. (Total income appears to differ from expenditure as the reporting dates for each are different). Fare income is also stated as being £0.16 per passenger km. From this I deduce the number of passenger km is 57.5bn and hence the government subsidy per passenger km as £0.22.

Rail operational emissions are currently 31 grams of CO2 equivalent per passenger km (gCO2e/pkm) (Office of Rail and Road, 2024b). This includes fleet operating emissions, but not lifecycle costs of manufacturing rolling stock or maintaining tracks. The International Union of Railways estimates manufacture and maintenance CO2 emissions of 50 tonnes per km of rail route (UIC-International Union of Railways, 2015). Based on 15,874 km of rail routes in the UK (Office of Rail and Road, 2022) this would total 793,700 tonnes, or 15g per passenger km.

Together, these figures suggest a lifecycle carbon cost for rail of around 45gCO2e/pkm. Using 2024 prices, this can be valued at £0.013/pkm (TAG data book table 3.4).

Car operating costs per vehicle km vary substantially depending on vehicle choice and usage patterns, from ‘bangernomics’ figures under £0.10/vkm to luxury cars exceeding £1.00/vkm. Costs such as vehicle excise duty and MOT tests are fixed per annum, while fuel costs directly increase with the distance driven (although will still vary depending on type of car and driving). Maintenance, insurance and depreciation costs are largely fixed but will still show some increases due to distance driven. In general, vehicles which travel further will have a lower total cost of ownership per mile, as the fixed costs are spread over a greater number of miles. One recent estimate (NimbleFins, 2024) give an average cost per vehicle km of £0.33. The RAC Foundation (RAC Foundation, 2023) arrives at a similar figure (£0.39) by inflation adjustment of historic vehicle reimbursement rates set by HMRC. Adjusting the former for average vehicle occupancy of 1.6 (Department for Transport, 2024a) gives average costs per passenger km of £0.21. This rate is currently similar for both electric and internal combustion engine (ICE) cars: electric cars have higher up-front costs of purchase and insurance but require lower energy costs to run, provided electricity can be obtained for charging at low cost, a consideration which also varies depending on the usage pattern (home versus public charging).

If a traveller already owns a car, then they are likely to base the mode choice of an individual trip on the variable rather than fixed costs of car use. Principal among these is the cost of energy (whether electric or ICE), however in some urban cases costs such as parking, tolls or congestion charges can dominate. For ICE the fuel cost ranges between £0.08-£0.11/vkm (Office for Zero Emissions Vehicles, 2024) of which around 55%, or £0.05/vkm is currently reclaimed by the government in the form of VAT and fuel duty (RAC Foundation, 2024). Charging of electric vehicles costs £0.02-0.05/vkm (Office for Zero Emissions Vehicles, 2024) of which 5% is reclaimed by the government as VAT. Adjusting for vehicle occupancy gives fuel costs of £0.05-£0.07/pkm, fuel duty £0.03/pkm and electric charging at £0.009-£0.03/pkm.

To compare these figures against rail, the cost of road maintenance should also be considered. This was £11.8bn in 2023 (Department for Transport, 2024e). Considering the 330.8bn vehicle miles travelled in the UK (Department for Transport, 2024c) equates to 846.8bn passenger miles, this gives a road maintenance cost of £0.01/pkm, although the Department for Transport (DfT) estimate of car external costs is lower at £0.001/pkm (TAG data book table 5.4.2 adjusted for occupancy). However, using the upper estimate, after deducting maintenance costs from fuel tax and VAT, the government still generates revenue from ICE vehicle use equivalent to around £0.02/pkm.

Lifecycle CO2 emissions from car use are estimated at 45gCO2e/vkm for electric cars, versus 167gCO2e/vkm for ICE cars (Gifford, 2021). Road maintenance adds a small quantity to this. National Highways estimated 734 kilotons of CO2e during 2020 (National Highways, 2024), which works out at around 1.4gCO2e/vkm based on all vehicle kilometres travelled in the UK. This figure does not include local highways, however based on relative size of the national and local highway maintenance budgets a similar ballpark figure could be assumed, giving around 3gCO2e/vkm in total for highway maintenance. Adding this to the lifecycle emissions above and adjusting for occupancy gives 30 and 106gCO2e/pkm for electric and ICE cars respectively. Taking 2024 carbon valuation prices (TAG data book table 3.4) these can be valued at £0.01/pkm and £0.03/pkm respectively.

The Department for Environment, Food and Rural Affairs (DEFRA, 2010) estimated that air pollution cost the UK £9-20bn per year (2010 prices; £10-23bn in 2024 prices (Department for Transport, 2024d)). The exact proportion of this cost attributable to car use is unclear, however, 14% of PM2.5 emissions come from urban traffic while 30% of NOx emissions come from road transport (DEFRA, 2024). As an upper bound estimate, 30% of the higher cost given above is £6.9bn, or around £0.01/pkm. The DfT estimate is lower at £0.002/pkm (TAG data book table 5.4.2 adjusted for occupancy).

The Department for Transport's (2012) economic valuation of road casualties in the UK put the cost at £34.3bn, equivalent to £39bn in 2024 prices (Department for Transport, 2024d), or around £0.05/pkm, although the DfT estimate for marginal external costs of car travel gives a lower figure of £0.016/pkm (TAG data book table 5.4.2 adjusted for occupancy). Rail has considerably fewer fatal injuries, which makes the true rate harder to estimate for a single year; usually a more reliable estimate would be derived by combining data from multiple recent years but this would be affected by periods of low usage during the global COVID19 pandemic. For 2022-3 the rate was 0.5 fatal accidents per billion pkm (including trespassers) (Office of Rail and Road, 2024c) as compared to 1.9 per billion pkm for road (Department for Transport, 2024b). Some historic years exhibit higher rail accident rates.

WPI (2024) estimate a total contribution of the rail network to the UK economy of £26bn/year. However, much of this headline figure is not relevant in consideration of modal shift. Direct user benefits are considered in isolation (Oxera, 2014), rather than compared to the benefits of other transport modes which will also have large benefits. WPI's estimates for contributions to local economies are not additional on a national scale, but measure clustering around the rail system of economic activity that would have taken place elsewhere.

WPI's estimate for the cost of road congestion saved by rail is £8bn/year, which is substantial and relevant, equivalent to around £0.15 per rail passenger km. This is however an average cost, not a marginal cost which will better reflect changes from the status quo. Aftabuzzaman (2010) values average congestion relief impacts as $0.45 (Aus$ 2008, £0.30 in GBP2024) per marginal car (not rail) vehicle km (vkm). Department for Transport figures (TAG data book table 5.4.4) value this similarly at £0.28/vkm on average, rising to £1.13/vkm in London. The equivalent on a rail passenger kilometre basis is determined by diversion factors which average 0.27 (TAG data book table 5.4.5), hence the valuation of congestion relief per additional rail passenger kilometre is, based on the DfT average, around £0.08. Goodwin (2004) estimated the total cost of all UK road congestion (not just that relieved by rail) in 2010 as £30bn (2010 prices).

3.2 Discussing costs and subsidies

Table 1 summarises the costs derived in Section 1.1.

	Rail (current)	Car
Lifecycle greenhouse gas emissions	45 gCO2e (£0.013/pkm)	ICE: 106 gCO2e (£0.03/pkm) Electric: 30 gCO2e (£0.009/pkm)
Total cost including infrastructure	£0.38	Total cost of ownership and infrastructure £0.21 This is an average which varies widely depending on car choice and usage pattern (£0.08 to over £1.00)
Consumer pays	£0.16	For ICE cars, the consumer pays £0.02 more than the total cost due to the difference between fuel duty (~3p/km) and road spending (~1p/km) Consumers will in many cases base their decisions on fuel costs alone: £0.05-£0.07 (ICE) or £0.01-£0.03 (electric)
Safety	0.5 fatal injuries per billion pkm	1.9 fatal injuries per billion pkm (valued at £0.016-0.05/pkm)
Other impacts	Reduces urban congestion (valued at £0.08 per rail passenger km average, exceeding £0.30 in some cases)	Air pollution (valued £0.002- £0.01/pkm) Urban congestion

Table 1 Comparison of financial and environmental costs of car and rail. All figures per passenger km 2022/3 for current occupancy levels.

Considering the infrastructure and running costs paid by both consumer and government, and current occupancy rates, rail is considerably more expensive than car travel. This point should be emphasized as it strongly shapes the current political discussion around rail spending in a time of budgetary constraints.

However, once external costs - in particular of carbon emissions and congestion - are factored in, the picture changes. Exact figures will depend on the sources used and assumptions of analysis and it is beyond the scope of this report to determine a ‘winner’ in terms of the total cost to society. Considering ICE cars in particular, and using the lower (Department for Transport) estimates for pollution/safety costs, suggests total social ICE cost per passenger mile which is 14% lower than that of rail. This is not such a dramatic cost difference.

Considering only the costs faced by the consumer, the average cost of owning a car, per km of travel, is in total greater than rail. This is true even before including a financial valuation of the costs of road congestion experienced by the car user. However, this average hides considerable variance, and for many people the reverse will be true due to their choice of car and usage patterns. Furthermore, when a traveller already owns a car, then they are likely to base the mode choice of an individual trip on the variable rather than fixed costs of car ownership. Considering fuel costs alone, car use is substantially less expensive, other than for short trips in large cities where congestion/low emission/parking charges are likely to apply. This is reflected in the public perception of rail tickets as expensive (YouGov, 2024). This difference in variable costs persists, in spite of the fact that the rail system already receives large subsidies from government, while the road system generates revenue.

The most obvious route to encouraging greater rail use is therefore to increase the existing subsidy and further reduce the cost of rail to the consumer. If reduced fares are targeted at routes without capacity constraints – filling currently empty seats – then the increase to operating costs would be minimal. However, the ticket price subsidy still requires investment. Based on our own previous TrafRed model (Haggar and Cooper, 2023b; 2023a; Allen et al., 2023) a 10% reduction in consumer rail ticket prices could increase rail use by 10%. Applying a diversion factor of 0.27 (TAG data book table 5.4.5) suggests this would remove approximately 1.5bn vehicle kilometres from the roads annually. If filling only empty seats, this subsidy would still cost in the region of £1 billion (according to TrafRed; although taking 10% of the current annual subsidy budget also gives a similar figure in the region of £0.9bn).

The benefits of such subsidy, quantified in financial terms, would mainly be attributable to reduced carbon emissions and road congestion.

In the case of carbon emissions, it should be noted that on the basis of the figures estimated in Table 1, complete electrification of the vehicle fleet would appear to result in lower carbon emissions per pkm than rail. However, the estimation of carbon emissions is based on international studies and given the inherent uncertainties of the estimation methods, further study would be needed to establish more accurately which of electric car, and rail transport, has the lower carbon emission in the UK context. We can, however assume that both have substantially lower emissions than ICE cars. The lower emissions of electric cars notwithstanding, a key benefit of the rail system is that it is available for immediate use, allowing us to reduce emissions with immediate effect, while at present the manufacture and sale of electric cars in the UK is not growing fast enough for us to meet agreed emissions targets in the short term (Bennett and Brandmayr, 2021).

The above 10% subsidy would equate to a reduction of 267,000 tonnes CO2 from vehicle emissions (assuming ICE), and if filling only empty seats on rail would not substantially increase the carbon emissions from the rail system. Under central appraisal values from the current year (£292/tCO2e) this reduction is valued at £78 million. However, it is crucial to note that there is considerable uncertainty surrounding carbon appraisal, with upper estimates in 2024 at £445/tCO2e, and all values rising a further 46% by 2050 (TAG data book table 3.4). A scenario of increasing carbon costs could therefore strengthen the business case for rail.

In the case of road congestion, the reduction in vehicle km could have congestion relief impacts valued at £410 million. This could be further improved with local plans targeted at congested cities, the economic benefits of reduced congestion are potentially four times greater – and may therefore exceed the subsidy based on congestion relief alone, depending on details of the local transport system. However, a simple ticket price subsidy may be inappropriate if the rail system in these locations is already at capacity, so further modelling is recommended to evaluate costs of increasing rail capacity (e.g. frequency of services and carriages per service) as well as ticket price subsidy on services which are not crowded; also an increase in rail capacity will lead to greater carbon emissions in the rail sector, negating the carbon reduction outlined above in the short term – though improving in the long term as the rail sector continues to reduce emissions.

3.3 Concluding remarks on costs and subsidies

Summarizing Section 3.2, further subsidy of ticket price is not currently likely to be financially justified on a national scale, but may pay for itself in some local cases where the shift to rail transport would further reduce congestion on roads.

It is worth making a few points on the limitations of cost analyses both here and in general.

The efficacy of current approaches to carbon pricing is still subject to ongoing debate (Santos, 2022). Although the government's current appraisal values are based on abatement costs and IPCC models aimed at meeting agreed international targets (Department for Business, Energy & Industrial Strategy, 2021), if we are missing agreed emissions targets nonetheless, then it shows a need to take actions beyond those justified by valuation of carbon emissions - whether in the rail sector or elsewhere. Also, although it is the approach most widely used by policymakers, people are in general uncomfortable with quantifying the value of life in financial terms (Ugazio et al., 2021). While proposing a replacement for either framework is beyond the remit of this report, the relevant context is that marginal cost benefit analysis is not the final arbiter of government decisions.

Public opinion (YouGov, 2024) shows public support for improving rail infrastructure provided ticket prices do not increase, highlighting what is ultimately the political nature of rail spending.

Our own steering group was divided on the question of whether further subsidy of rail ticket prices was politically realistic in the current financial climate. The majority thought not. However, to offer an opposing view, the Campaign for Better Transport (CBT 2023) points out that fuel duty has remained frozen since 2011, until a further reduction in 2023/4, while rail prices have increased with inflation. According to CBT, continuing the freeze to fuel duty will cost the government £92bn over the next five years (an average of £18.4bn/year), an amount which, if repurposed, would more than cover the annual ticket revenue on the rail system and could therefore be used to substantially reduce the rail price experienced by consumers. Even reversing the recent 5p cuts to fuel duty would raise around £2bn per annum, which in the TrafRed model allows ticket price reductions of 20%, reducing car miles travelled by around 1-2%.

Either way, costs are the proverbial “elephant in the room” which must be faced. If the UK is to shift substantial demand from car to rail then we likely need to invest heavily in reducing the cost of rail to the consumer.

The political nature of this problem places it outside the scope of a technical report. The remainder of this report therefore focuses on alternative opportunities for increasing rail use - while noting that cost considerations currently are, and are likely to remain, the primary determinant of consumer behaviour.

4. Spatial differences in rail costs and usage

4.1 Method

Although on average rail travel does not compare favourably to car travel, there are times when it does, and these situations should be leveraged for increasing rail use. In particular, this includes routes where rail has a time advantage, for trips with high values of time.

Trainline's *Reasonable by Rail* database is derived from anonymised ticket sales data to determine the median price paid by customers on each rail route. It also includes journey times and comparable prices and times for each route taken by car.

I have combined this with data released from the Office of Road and Rail (ORR, 2024a). The ORR counts each half of return trips separately but gives identical passenger counts for each direction on a route. To convert this into a producer/attractor (PA) matrix, so I have estimated the proportion of trips originating from each end of each route based on Trainline's split of return ticket sales from each end.

In this section, I map train route times and fares compared to car travel. A 'route' in this context means an origin destination pair, so a single train line can comprise many routes between all pairs of stations on the line. Costs for car are defined as fuel costs only as this is likely to influence consumer decisions for individual trips. As such, and bearing in mind the variance in individual car costs, the maps are not intended to show in absolute terms where a rail ticket costs more or less than a car journey, but to show in relative terms where rail offers greater or lesser value.

I also bring cost and time together using a value of time approach. The value of time is a quantity used in the Department for Transport's recommended modelling methods, as part of the choice modelling process used to predict individual mode choice for a given trip. Values of time vary according to both the individual (e.g. varying with individual income), and also the purpose of the trip (e.g. travel on employer's time, commuting, or leisure). As such, the recommended modelling values vary within a range of approximately £7/hour to £30/hour (Department for Transport, 2024d). To keep the number of maps manageable I use only a single figure from the (log-)midpoint of this range, of £15/hour.

Two sets of maps are provided

- Large PKM: the largest 0.6% of routes (exceeding 1,484,378 pkm per year). Together these are responsible for 70% of the total annual pkm for all routes. The width of each route shown is proportional to its total passenger km.
- Most Journeys: the largest 0.7% of routes (exceeding 19,043 journeys per year). Together these are responsible for 70% of all journeys. The width of each route shown is proportional to its total journey count.
- Principal Routes: routes between the largest 10 urban areas in the UK only. Width is constant so as not to obscure routes with low flow.

The maps are provided as separate documents at https://users.cs.cf.ac.uk/CooperCH/NextStopBetterRailMaps .

4.2 Discussion

Looking at the relative cost of rail compared to car, we see in most cases that rail is more expensive. The relative cost difference is less for some of the longest distance routes e.g. to/from Glasgow.

Rail is substantially quicker than the car for high speed routes to/from London, but not for remaining routes e.g. on lines between the Southwest and North, though there are some exceptions e.g. Manchester-Glasgow and Bristol-Sheffield. It should be noted that rail times given here do not include time to access the stations at each end of the journey, so to remain competitive overall on time, the rail system needs to maintain a considerable time advantage on the rail journey itself.

Looking at the perceived generalized cost of rail, the pattern is more complex. Again, routes from London to the North are computed to have better value due to their high speed, but London to Bristol/Cardiff is not so cost effective due to the high ticket price. Routes from the South West to the North are shown as lower value due to the combination of high price with lower speeds.

Rail usage shows a clear London-centric pattern, with far more passenger kilometres travelled to/from London than between regional hubs – even in cases where the regional hubs are relatively close together e.g. Leeds, Manchester. This is not just because the longer routes account for more pkm per journey; the number of journeys is also greater, e.g. for routes between Leeds/Manchester to London, than between these northern cities themselves.

The reasons for this pattern are beyond the scope of this report, but will likely relate to numerous factors including London's role as a centrepiece of the UK economy, and the demographics of rail users. The lower value (in generalized cost terms) of non-London routes may however play a partial role.

5. Means tested railcards

As noted in Section 2, encouraging greater rail use by reducing ticket prices would require further subsidy. Reducing the price of all tickets will cost money which will not be recouped through the additional sales, even in cases where there is empty capacity on current services.

The situation is different, however, if reduced prices can be targeted only at trips which would not otherwise have taken place on the rail system. If this could be achieved exclusively to fill existing unused capacity, the extra trips would, in theory, represent a financial gain. In practice, such precise targeting of discounts is unlikely to be achievable, however partial targeting is likely to offer better value per money (in terms of extra rail km travelled per pound) than general reduction in ticket prices.

A means tested railcard offers one such opportunity for targeting. Various approaches to means testing are possible; here, I consider the approach used by the Wales ECO4 heating grants scheme, for which anyone already in receipt of a means tested benefit is eligible. Based on ONS figures for England & Wales, this would include 34% of the population, or approximately 11% if we discount those already eligible for discount railcards (over-60s and under-25s[1]) (Department for Work & Pensions, 2023). People in the lowest two income bands

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[1] Benefits data is grouped into age bands which do not exactly match railcard eligibility; the 11% figure therefore includes people aged 25 who are still eligible for the 16-25 railcard.

are underrepresented in UK rail miles, and the majority of even the lowest income band still have access to a car, showing an opportunity for modal shift within these income bands. Conversely, for those without access to a car, there exists an opportunity to increase transport equity.

Income band	Access to car (NTS0703)	Proportion of UK rail miles (NTS0705)
Lowest 20% of earners	56%	12%
20-40%	74%	11%
40-60%	85%	18%
60-80%	87%	23%
Highest 20% of earners	85%	36%

Table 2 Access to car and representation among rail passengers by income band

The question remains as to whether subsidising a means tested railcard, by this definition, would represent better value for reduced car miles than a general subsidy of ticket price. This would be the case if the price elasticity of demand is higher than average for these groups. One might expect this to be the case given that modelled values of time are lower for these groups (Department for Transport, 2024d M2.1, M2.2) meaning that price is a proportionately greater deterrent to rail use. However, households with no access to a car have fewer alternatives to rail use, which will offset this price sensitivity to some extent. Nonetheless, comparable work on UK bus usage has shown lower income groups to have higher price elasticity (Molnar and Nesheim, 2011, described in Miller and Savage, 2017). I recommend further modelling be undertaken to provide a similar analysis for rail, and to provide a range of more refined options for the targeting of a means tested railcard.

A final note on the topic of railcards is that, although leisure use of the rail network has increased in recent years, existing family railcards may not offer sufficient discount to represent a viable option for leisure use. Family railcards typically give 33% discount for adults and 60% discounts for children. For a combination of 1 adult + 1 child this is less expensive than the adult travelling alone, but a family of 2+2 will still pay considerably more than this. The same families travelling by car will see fairly constant costs regardless of the number of occupants. Although in environmental terms, a car with 4 occupants is efficient use of resources, the lesser cost of car in this situation means some families will choose to own a vehicle (which may then be used for other trips with a single occupant) rather than live car free.

6. Spatial inequalities in rail frequency

Spatial inequalities in rail frequency have previously been mapped in 2019:

https://projectmapping.co.uk/Reviews/greatbritaintrai.html

As with price and time, a London-centric pattern of provision is visible.

It should be noted that increases in rail frequency will require extra funding. From the TrafRed model, a 10% frequency increase leads to a 2% increase in rail uptake, whereas a 10% decrease in fares leads to a 10% increase in rail uptake.

7. Spatial inequalities in first/last mile public transport

7.1 Method

There are large inequalities in the accessibility of rail stations by public transport. To map these, I made use of public travel time matrices from the Urban Big Data Centre (UBDC) (2024) and population data (National Records of Scotland, 2022; Office for National Statistics, 2021). The smallest spatial unit available in the English/Welsh, and Scottish census is the output area (OA, roughly equivalent to a postcode), of which there are a total of 235,242.

I assigned each OA to the closest rail station (Ordnance Survey (GB), 2024) in terms of public transport time. Public transport times vary depending on time of departure: the representative time taken from the UBDC matrix is the median time taken to access the station over a 3 hour morning peak departure period (7am-10am on 7th March 2023), including any waiting time necessary for the first available service (headway). Where walking is necessary to meet public transport links the speed is assumed to be 4km/h.

To ensure fair comparison between OAs close to, and far from the station, I then computed the average effective speed of the journey from each OA to the station. To take account of indirect public transport routes, the distance used for average speed computation is the distance of the shortest route on the road network, not the actual public transport route used.

I then calculated a population weighted median speed for the journey to each station, over all the OAs within its catchment (i.e. those which were not closer to another station). OAs over 12km from the station were not counted, to remove outliers. This is therefore not strictly a measure of first/last 'mile' but of the journey between rail station and home, up to 12km.

A limitation of the UBDC matrices is that they do not contain precise locations of railway stations, these were therefore assumed to be at the centre of the nearest OA. To remove inaccuracies arising from incorrect station placement I did not count any OAs under 2km from each station (a distance which most people can walk within 30 minutes). A further limitation of the UBDC matrices is that they relate to older (2011) census OAs, necessitating that the most recent (2021-2) OAs must be assigned to the nearest corresponding older (2011) OA in cases where census districts have changed.

7.2 Discussion

Effective speeds of public transport will appear low, as they account for the time required to wait for the first available service. They are therefore a reflection of service frequency as well as route directness, walking stages and interchange times. The median speed nationally is 5.7 km/h – barely faster than walking (4 km/h) and low compared to the mean speed of cars on local streets which we previously estimated at 21km/h (Haggar and Cooper, 2023b). Effective speeds will in some cases be higher for users who are able to plan their times of departure around the available services. However, examination of the faster 25% percentile effective speeds - which represent users with more flexibility - still reveals similar patterns of spatial inequality.

Although it is inevitable that buses cannot depart from every home, every few minutes, and must stop for other passengers, the comparison of effective speed with cars emphasizes the importance of improving public transport links to rail stations where possible. The use of cars to access stations should also not be discouraged, as combined car/rail trips are likely to have substantially lower environmental impact than the equivalent full journeys taken by car.

Feasible measures include increased bus frequencies, bus priority lanes and further integration of both ticketing systems and timetables between bus and rail. Our previous review (ibid.) suggested that integrated transport measures might increase use of both bus and rail by around 14%. It is likely that bus networks surrounding stations with currently worse effective public transport speeds should be prioritized, especially where such stations have a large surrounding population. However, taking an integrated approach to timetabling means that effective speeds should be considered through the entire multimodal (bus + rail) trip which means that priorities may shift depending on the details of timetable integration.

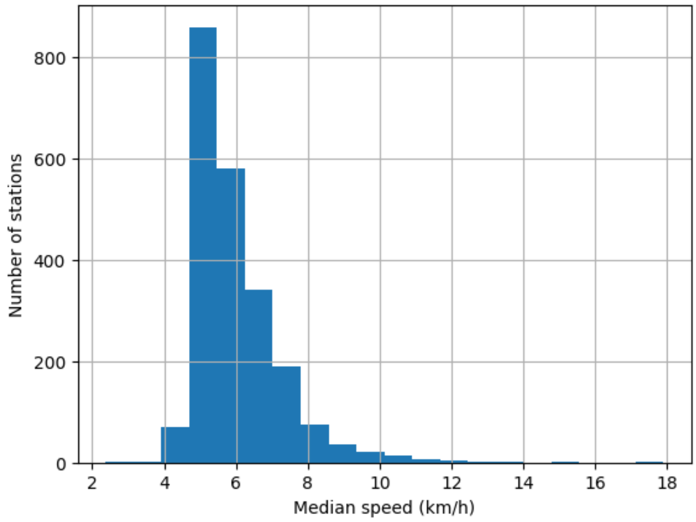

Figure 1 Median effective speed of access to stations by public transport (walking where necessary)

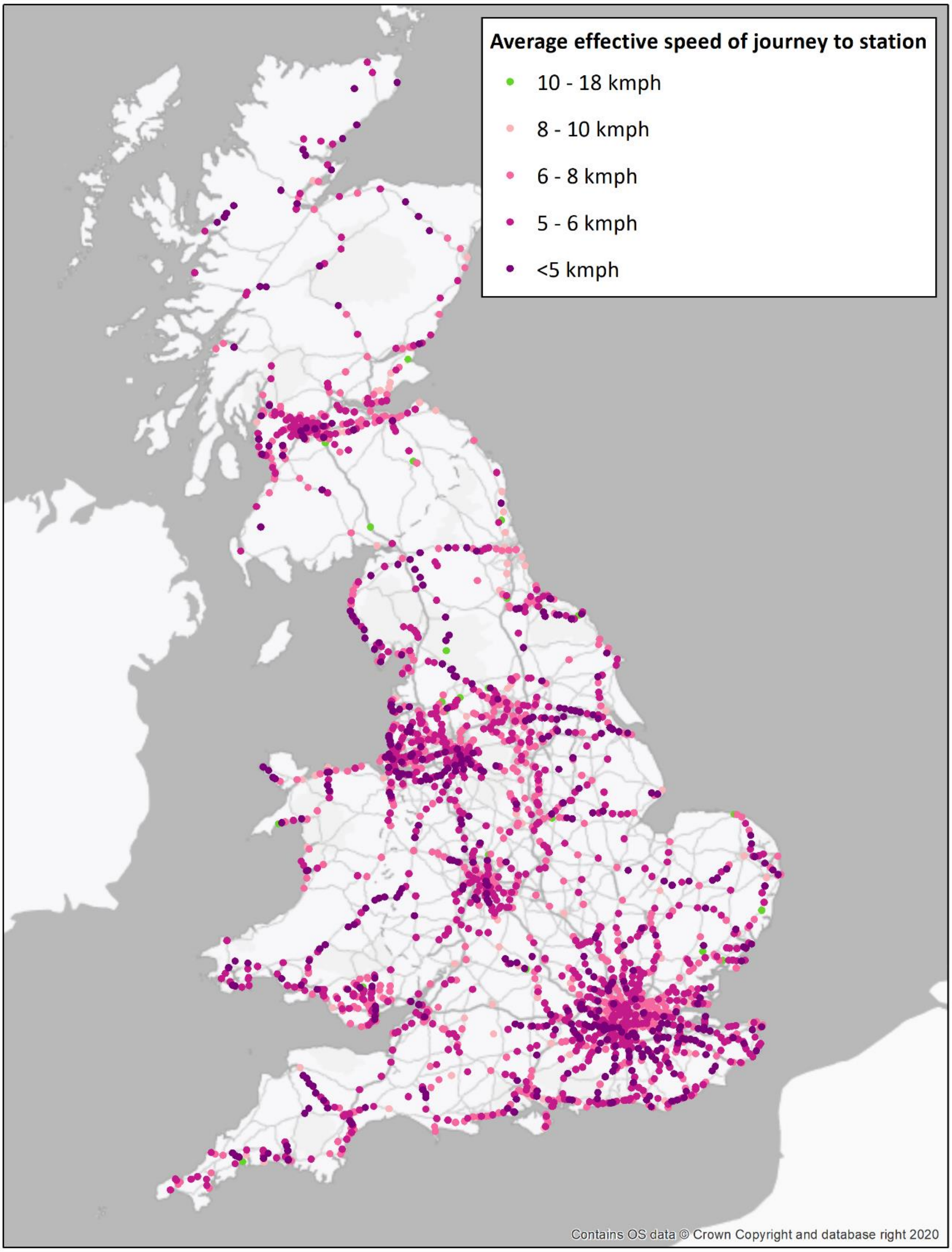

Figure 2 Mapping the median effective speed of public transport journey to each station

8. Car free living in cities

I can’t prove a causal relationship between urban living and car free living, as both are likely the result of underlying lifestyle choices. The statistics given here also relate to areas, not households, so it is worth noting that less deprived areas can still contain deprived households. However the pattern is still clear, that regardless of area deprivation level, car ownership levels are lower in urban areas. This suggests that the accessibility offered by urban living – in which access to rail links already plays a part - is associated with more households living car-free. In many cases this is likely to be a free choice by households who could, if they chose to, afford a car.

	Proportion of households without a car	
Area deprivation	**Rural areas**	**Urban areas**
1 (most deprived)	36%	46%
2	22%	35%
3	15%	26%
4	12%	18%
5 (least deprived)	10%	12%

Table 3 Proportion of households without a car. ONS and UK Data Service (2011)

9. Reliability impacts

The most recent APM average, for the past year in Great Britain is 3.3 minutes (Office of Rail and Road, 2024d).

Recent meta-analysis (Wardman and Batley, 2022) measures the impact of lateness on rail demand. Elasticities are measures with respect to Average Performance Minutes (APM), a measure of average late time which includes cancellations at 1.5x the service interval. We use the 'LR2' summary of the meta-analysis given in their Table 8, which gives elasticities from 0.027 to 0.088. Excluding trips within London and to/from airports which are more time-sensitive, mean elasticities are 0.03 for season tickets and 0.05 for non-season tickets.

These latter two elasticities imply that halving the APM lateness could lead to increases in rail demand of 2% (for season tickets) and 4% (non season tickets), with further increase in demand possible for further reductions in lateness.

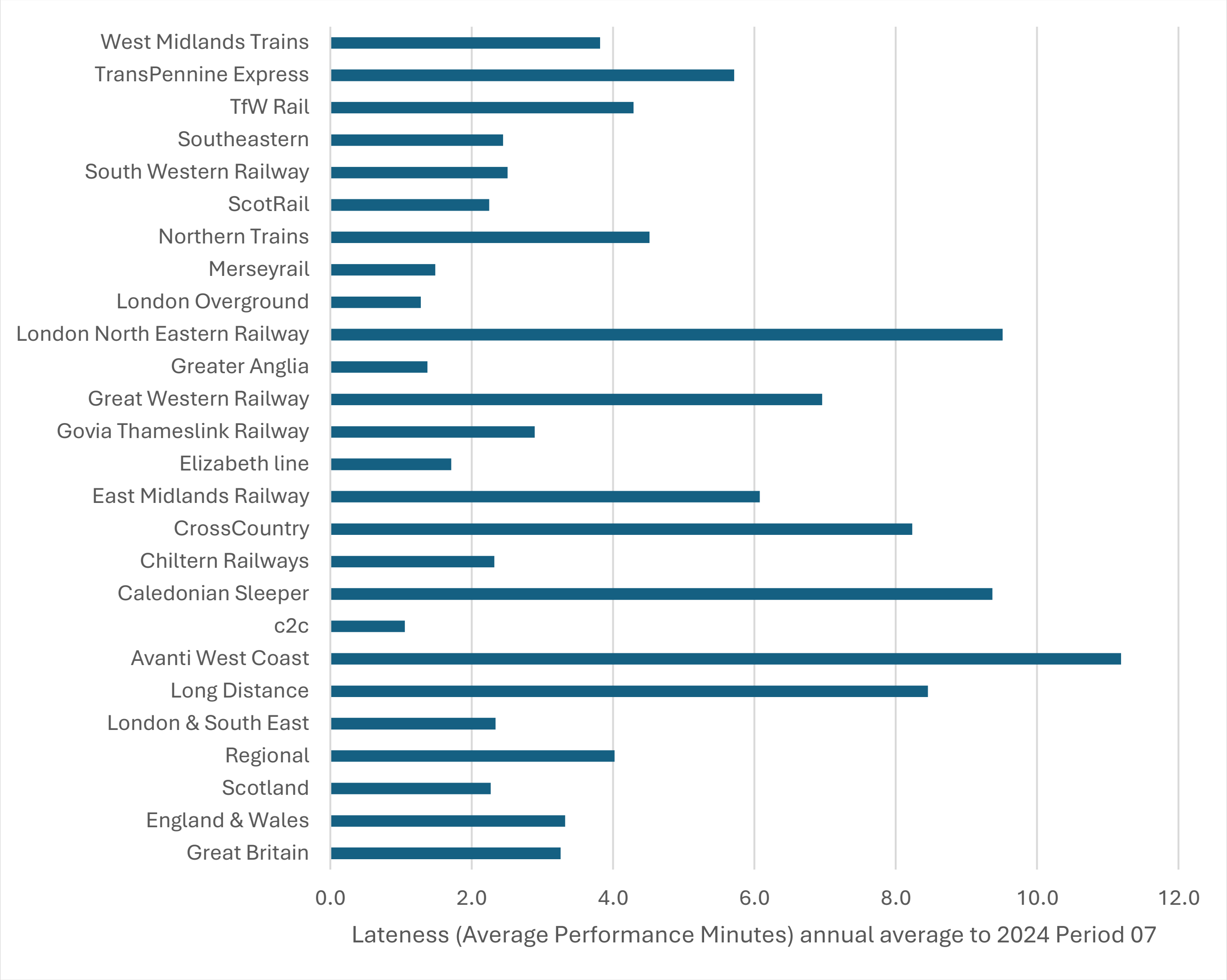

Figure 3 Current lateness by national, sector and train operating company level (Office of Rail and Road, 2024d)

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Acknowledgements

This report was funded by the Foundation for Integrated Transport, and Trainline. The project was managed by Green Alliance.

Part of this research made use of the supercomputing facilities at Cardiff University operated by Advanced Research Computing at Cardiff (ARCCA) on behalf of the Cardiff Supercomputing Facility and the HPC Wales and Supercomputing Wales (SCW) projects. The author would like to thank Jose Criollo for supercomputing advice and support.

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