Appendix A. Model, data and methods

This appendix documents the model behind the revenue and fiscal estimates in the paper. Section A1 sets out the structure and notation. Sections A2 to A5 describe the charge, the behavioural responses, the adoption path and the revenue accounting. Sections A6 to A10 report the fiscal-window calculation, the journey examples, the sensitivity analysis, the congestion-feedback variant and the scope of the estimate. All monetary values are in 2025-26 prices unless stated. Distances are in miles; where a source publishes per kilometre, the kilometre value is given alongside.

A1 Structure and notation

The model has four linked components. A rate card sets a congestion charge for each of six zones defined by place and time of day (A2). A set of behavioural responses determines what share of self-driving miles pays the charge, how total mileage changes, and how robotaxi demand responds to the charge as a fare increase (A3). An adoption model produces the self-driving miles in each calendar year from 2027 to 2050, separately for private cars and robotaxis (A4). A revenue account applies the rate card to the charged miles, subtracts the electric vehicle excise duty (eVED) those miles would otherwise have paid, and reports the result by year alongside the motoring taxes the charge replaces (A5).

Throughout, z indexes the six zones, t indexes calendar years, and p_z is the charge in zone z, quoted per mile in A2 and per minute in A3. The charge applies only to miles driven in self-driving mode: private cars with a driver at the wheel pay fuel duty or eVED as now. This scope is fixed across every result in the paper.

Two closed loops make the calculation iterative. The charge is an input to the mode choice that determines how many miles are charged, and it enters robotaxi fares and so the size of the robotaxi market. Under the congestion-feedback variant in A9, the charge also changes the traffic volume that determines the congestion cost the charge is set at.

A2 The charge

Zone rates

The charge in each zone is set at the marginal external cost of congestion (MEC): the delay one additional vehicle-kilometre imposes on other road users. The Department for Transport (DfT) publishes this cost in pence per vehicle-kilometre by area type, road type, and time of day in the Transport Analysis Guidance (TAG) Data Book, tables A5.4.2 and A5.4.4 (v2.03, May 2026, 2023 prices). Table A2.1 gives the mapping from the published cells to the six zones.

Table A2.1. Zone definitions

Zone	TAG cells	Sheet
London / mega-urban peak	Mean of London AM peak and PM peak	A5.4.4
Regional urban peak	Urban-km-weighted mean of AM and PM peak, all regions except London	A5.4.4
Urban off-peak	Urban-km-weighted inter-peak, all regions	A5.4.4
Urban overnight	Urban-km-weighted 1900-0600, all regions	A5.4.4
Rural (A and minor)	Mileage-weighted rural A and rural minor (weights 0.67 and 0.33 from DfT TRA0104)	A5.4.2
Motorways / overnight	Rural motorway, 1900-0600	A5.4.2

The charge is a zone rate. Every self-driving mile driven in a zone pays that zone's MEC, and the policy mark-up over marginal cost is zero by construction. Table A2.2 quotes the rate per mile and per minute. The per-mile column converts the published per-kilometre cost at 1.609 km per mile. The per-minute column is the same cost expressed for a vehicle moving at the zone's measured average speed,

$$p_z^{\text{min}} = \text{MEC}_z \times \frac{v_z}{60},$$

where MEC_z is in pence per kilometre and v_z is the average speed in kilometres per hour, from DfT congestion statistics CGN0404 and CGN0503. The model holds one speed per zone, so a mile charged per minute at the zone speed pays the same as a mile charged at the per-mile rate, and every result in the paper is computed on the per-mile basis. The mode choice in A3 works in the per-minute form because the value of freed time is measured per minute.

The paper also reports a per-minute design, which is a different charge. It is one national rate per minute, the same in every zone, set in each year so that on the baseline distribution of all car miles across zones it raises the same as the zone per-mile charge. On 2025 costs that rate is 13.6p per minute in the price base of Table A2.2. A mile then pays the flat rate for the minutes it takes at the zone's speed, so the charge per mile varies with speed alone: 49.3p per km in the London peak against a congestion cost of 162.6p, and 17.1p per km on rural roads against 6.6p. The flat rate under-charges urban roads and over-charges rural roads and motorways relative to congestion cost. Its revenue is reported in A5. The last two columns give each zone's share of car vehicle-miles (DfT TRA0104 by road class, distributed over time of day by National Travel Survey table NTS0501) and its share of the charge that a fleet driving the measured distribution would pay.

Table A2.2. The rate card

Zone	MEC, p per km	MEC, p per mile	Speed, km/h	Speed, mph	Charge, p per minute	Share of car miles	Share of charge base
London / mega-urban peak	162.6	261.7	16.5	10.3	44.7	2.3%	18.1%
Regional urban peak	39.6	63.8	25.4	15.8	16.8	14.7%	28.3%
Urban off-peak	41.7	67.1	26.8	16.7	18.6	14.1%	28.5%
Urban overnight	22.9	36.9	33.4	20.8	12.7	5.0%	5.5%
Rural (A and minor)	6.6	10.6	47.6	29.6	5.2	44.5%	14.2%
Motorways / overnight	5.7	9.2	95.2	59.2	9.0	19.4%	5.4%

TAG publishes congestion costs for modelled years from 2025 to 2060. The full-take-up result in A5 uses the 2025 values. The year-by-year results use each year's own published value, interpolated between modelled years. TAG's 2023 prices are converted to 2025-26 prices with the HM Treasury GDP deflator, a factor of 1.0765.

Comparators

The eVED the charge displaces is 3p per mile on battery-electric and hydrogen cars from April 2028 (HMRC policy paper, 13 July 2026). Fuel duty, vehicle excise duty (VED) and eVED receipts in the absence of the charge are computed in A5 from miles, fuel consumption at the speed driven, and the duty rate, and checked against the Office for Budget Responsibility (OBR) receipts path.

A3 Behavioural responses

Mode choice for dual-mode private cars

A private car capable of self-driving can avoid the charge by being driven manually. The model prices that alternative. In each zone, the share of a dual-mode car's miles that stays in self-driving mode is

$$s_z = q_z + (1 - q_z)\left[\lambda_z \,\mathsf{Pr}(v + w_z^L > p_z) + (1 - \lambda_z)\,\mathsf{Pr}(v + w_z^T > \bar{p}_z)\right].$$

q_z is the captive share: miles with no manual alternative. It combines escort trips where the car returns without its passenger (NTS0409b, NTS0403c), miles by adults without a full licence (NTS9901, converted to a mileage share by the take-up parameter in Table A3.2), and overnight leisure trips where drink rules out driving (NTS0502a). Captive users' fallback is a taxi at roughly twice the highest rate on the card, so they stay in self-driving mode at every rate on the card. v is the value of the time freed by not driving, in pence per minute, distributed across drivers and trips. w_z is the manual-cost wedge: the per-minute cost of driving manually that self-driving mode avoids. It has three parts: insurance, since liability in self-driving mode rests with the manufacturer under the Automated Vehicles Act 2024; parking, since a self-driving car can drop off and relocate to free kerbside rather than pay at the destination; and the energy saved by smoother machine driving. The wedge is evaluated separately for local trips under 10 miles (w^L) and through trips (w^T), because a parking fee is avoided once per trip and its per-minute equivalent depends on trip duration. λ_z is the local share of the zone's miles. Through trips are compared against a trip-average charge $\bar{p}_z = \beta p_z + (1-\beta)p_{\mathsf{corridor}}$, where p_{corridor} is the mileage-weighted rate over rural roads and motorways.

The value of freed time is the difference between the value of time as a driver in traffic and the value of time as a passenger, drawn from the TAG value of travel time (VTT) by purpose (table A1.3.1):

$$v_{j,z} = (m_{z,j} - r)\,\mathsf{VTT}_j \times u_z,$$

where j indexes purpose (business, commuting, other). $m_{z,j}$ is the in-vehicle time multiplier for the zone's traffic conditions from the 2014/15 UK value of time study (Arup, ITS Leeds and Accent, 2015): 1.56 for commuting and 1.46 for other purposes in heavy traffic, 1.40 and 1.36 in light traffic, and 1.0 in free flow. r is the ratio of the value of time as a passenger to the value as a driver in free flow, 0.760 in the central case (Wardman, Chintakayala and de Jong, 2016). u_z is a London earnings uplift of 1.291 on commuting and business trips, from Annual Survey of Hours and Earnings (ASHE) place-of-work earnings. v is lognormal across drivers with a log standard deviation of 0.80, derived from the same UK study, and mixed over purposes by each zone's distance-weighted purpose shares (NTS0502). The implied fraction of a driver's own time value recovered by riding, $1 - r/m$, is 0.24 in free-flow zones and about 0.5 in heavy traffic, which brackets the 30% to 41% reductions in the value of travel time found in the stated-preference literature on automated vehicles (Steck et al., 2018; Kolarova et al., 2019; Kolarova, 2021).

Induced demand

The same distribution gives the change in the generalised cost of a self-driving mile and, through an elasticity, the change in miles. For a voluntary user who stays in self-driving mode, the per-minute generalised cost falls by $v + w_z - p_z$. For a captive user it changes by $E[v] - p_z$, which is negative where the charge exceeds the mean freed-time value. Averaging over the zone's users gives Δ_z, and the induced multiplier on self-driving miles is

$$I_z = \left(1 - \frac{\Delta_z}{\mathsf{GC}_z^0}\right)^{\varepsilon},$$

where GC_z^0 is the baseline generalised cost per kilometre (time at the TAG value of time per vehicle, table A1.3.5, plus electric vehicle operating cost from tables A1.3.13 and A1.3.14) and $\varepsilon = -0.5$ is the elasticity of car kilometres to generalised cost, with a range of -0.3 to -0.9 from SACTRA (1994), Goodwin, Dargay and Hanly (2004) and the Stockholm congestion charge evaluations (Börjesson et al., 2012; Börjesson and Kristoffersson, 2018). The same elasticity governs the fall in generalised cost from freed driver time and the rise from the charge.

Table A3.1 reports the zone-level outputs at the central parameters. At a zero charge, the mileage-weighted induced multiplier is 1.445, against 1.273 measured in Harb et al.'s (2018) chauffeur experiment. The Harb figure is a validation comparison and enters no parameter. At the levied rates it is 1.049: the charge removes most of the freed-time saving that would otherwise induce travel.

Table A3.1. Mode choice and induced demand by zone, central parameters

Zone	Charge, p per minute	Median v, p per minute	Captive share q_z	Local wedge w_z^L, p per minute	Self-driving share s_z	Induced multiplier I_z
London / mega-urban peak	44.7	15.8	27.4%	5.1	48.2%	0.932
Regional urban peak	16.8	13.5	20.4%	9.0	80.6%	1.168
Urban off-peak	18.6	9.4	20.9%	9.6	68.7%	1.029
Urban overnight	12.7	4.3	26.7%	2.7	48.0%	0.981
Rural (A and minor)	5.2	4.0	16.7%	2.9	65.2%	1.049
Motorways / overnight	9.0	4.0	22.4%	3.5	65.2%	1.007

Weighted by the distribution of self-driving miles, 66.7% of dual-mode miles stay in self-driving mode at the central rates.

Retiming

The three urban zones are the same roads at different times of day, and their rates differ by a factor of four. A share of peak miles moves to the adjacent off-peak zone with an elasticity of 0.10 to the peak-to-off-peak ratio of generalised cost (range 0.09 to 0.17), drawn from the departure-time responses observed in the Transport for London congestion charge monitoring reports. At the central rates 0.9% of peak miles retime.

Robotaxi demand

Robotaxis have no manual mode, so the charge reaches their demand only as a fare increase. The per-trip charge is the rate card applied to the robotaxi trip profile (6.29 miles per trip gross of empty running, on the urban-concentrated zone distribution), which gives £3.65 in London and £2.14 elsewhere against metered fares of £18.60 and £10.70 for the same passenger distance (TfL Tariff 1; the median of the local authority tariffs in the rest of the UK). The charge is 19.9% of the fare. The addressable trip market is multiplied by

$$m = \left(1 + \pi \frac{c}{F}\right)^{-\eta},$$

with pass-through $\pi = 0.89$ (0.69 to 0.95) and fare elasticity $\eta = -0.5$ (-0.34 to -0.84), from Tarduno (2025), Cohen et al. (2016) and He et al. (2021). The central multiplier is 0.922.

Parameters

Table A3.2 collects the behavioural parameters with their central values, ranges and sources. Ranges come from the source evidence, and the slow and fast columns of the scenario tables are the two ends of each range.

Table A3.2. Behavioural parameters

Parameter	Central	Range	Source
Elasticity of car km to generalised cost, ε	–0.5	–0.3 to –0.9	SACTRA (1994); Goodwin, Dargay and Hanly (2004); Börjesson et al. (2012, 2018)
Passenger-to-driver value of time ratio, r	0.760	0.714 to 0.847	Wardman, Chintakayala and de Jong (2016)
Log standard deviation of v, σ	0.80	0.75 to 0.85	Arup, ITS Leeds and Accent (2015), Table 4.10
London earnings uplift, u	1.291	1.111 to 1.429	ONS ASHE, place of work
Self-driving use by adults without a licence, relative to licence holders	0.44	0.1 to 1.0	NTS9901; analyst range
Share of motor premium repriced onto manual minutes	0.41	0.243 to 0.53	ABI Q1 2026 premium (£560); Automated Vehicles Act 2024
Energy saving from machine driving	10%	5% to 20%	Wadud, MacKenzie and Leiby (2016)
Retiming elasticity	0.10	0.09 to 0.17	TfL congestion charge monitoring, 2003-2008
Robotaxi fare pass-through, π	0.89	0.69 to 0.95	Tarduno (2025)
Robotaxi fare elasticity, η	–0.5	–0.34 to –0.84	Cohen et al. (2016); Tarduno (2025); He et al. (2021)

Empty running is a model output with no parameter of its own. For private cars it follows from the park-or-relocate decision at each zone's charge and from relay trips between household members. For robotaxis it follows from the three mileage channels the California Public Utilities Commission (CPUC) reports for Waymo (collection, idle and passenger-onboard), each estimated against operating scale over 32 months of data (Abdelhalim, 2026): at the mature scale, 44.0% of robotaxi miles run empty and total mileage is 6.29 miles per trip against 3.52 passenger-onboard miles.

A4 Adoption

Private cars

Self-driving capability enters the fleet through new sales and reaches the stock through turnover. The share of new sales that is self-driving capable follows a logistic curve anchored to the UK commercial launch in the second half of 2027 (DfT, 10 June 2025), with growth rate and launch-to-midpoint lag fitted to Tesla's global deliveries from 2013 to 2023 (growth 0.58 per year, lag 9.1 years, midpoint 2036.6). Tesla supplies the diffusion shape only. The capable stock share is the sales curve run through fleet turnover with a mean car life of 14 years (Society of Motor Manufacturers and Traders, SMMT), so stock lags sales.

The share of a capable car's miles driven in self-driving mode depends on the roads on which hands-off operation is certified, which the model widens in a stated order: urban minor roads first, then urban A roads and motorways, then rural minor, then rural A roads. This order is an analyst input; authorisations under the Automated Vehicles Act 2024 attach to vehicles on roads, and DfT has published no domain sequence. The certified share of car miles rises along the same fitted logistic from 21.2% (the urban minor share of car miles, DfT TRA0104) to a ceiling of 70.2%. Multiplied by the zero-charge engagement rate, the mileage-weighted s_z at $p = 0$ from A3 (0.866), the self-driving share of a capable car's miles reaches 60.8% by 2050. The private self-driving pool in year t is

$$M_t^P = \text{car miles}_t \times \text{capable stock share}_t \times \text{self-driving usage}_t,$$

with car miles grown from 256.8 billion in 2025 on the DfT National Road Traffic Projections 2022 core scenario to 301.9 billion in 2050.

This pool is measured before the charge. The mode choice in A3 is applied downstream in the revenue account, so that only the share s_z of the pool is charged. The two are kept separate because the engagement rate is measured at a zero charge, and feeding the charged share back into the usage curve would count the same response twice.

Robotaxis

Robotaxi trips grow along a logistic in each of two tracks, London and the rest of the UK:

$$\text{trips}_t = \sum_r \frac{L_r}{1 + \exp(-k(t - t_{0,r}))}.$$

The growth rate $k = 2.06$ per year is fitted to Waymo's monthly paid trips in California from the August 2023 launch, from the CPUC's quarterly disclosures. Only k transfers; the ceiling and inflection of the Californian series reflect fleet and permit constraints rather than demand. The UK ceiling L_r is the for-hire trip market (678.9 million trips a year, from NTS trips per person and DfT TAXI0101 vehicles, 31.0% of them in London) multiplied by a pool expansion b that represents the growth of the for-hire market when the driver's cost is removed. The expansion is built from three components, a price effect (elasticity times fare fall), a new-user effect (non-drivers, older people and people with mobility-limiting conditions) and a coverage effect (off-peak, overnight and rural availability), and is then multiplied by the fare-response multiplier m from A3. The central value is 1.65 (1.09 slow, 2.37 fast).

The inflection $t_{0,r}$ is solved from a launch anchor of 1.15 million trips in the first year, Waymo's Californian first year. The London track launches at the UK commercial launch date (18 months later in the slow case and a year earlier in the fast case); the rest of the UK follows 2.85 years later (3.71 in the slow case), the lag Waymo took between its first and later cities.

Trips convert to vehicles at Waymo's December 2025 utilisation of 450,000 paid rides a week over a 3,067-vehicle fleet (about 21 trips per vehicle per day), and to miles at the scale-dependent miles per trip from A3.

Scenarios

Table A4.1 reports the adoption path. The three scenarios move the launch timing, the diffusion rate (the 95% interval of the Tesla fit), the pool expansion and the certified-domain ceiling together. The self-driving share of miles is the pool before mode choice.

Table A4.1. Adoption by year and scenario

	2030	2035	2040	2045	2050
Central: capable share of car stock	0.2%	3.7%	19.9%	39.2%	54.4%

	2030	2035	2040	2045	2050
Central: self-driving share of a capable car's miles	19.3%	30.3%	55.6%	60.5%	60.8%
Central: robotaxi fleet	13,817	142,893	152,577	154,494	156,435
Central: robotaxi miles, billion	0.66	6.88	7.34	7.43	7.53
Central: private self-driving pool, billion miles	0.14	3.70	37.36	81.75	115.34
Central: self-driving share of all car miles	0.3%	3.7%	15.3%	29.9%	40.7%
Slow: self-driving share of all car miles	0.1%	2.3%	9.4%	19.4%	27.6%
Fast: self-driving share of all car miles	0.9%	5.8%	26.8%	50.0%	65.8%
Total car miles, billion	271.9	283.9	292.7	298.4	301.9

A5 Revenue accounting

Full take-up

The static calculation holds traffic and congestion costs at 2025 values and reports what the charge raises if every car mile is self-driving. The base is 36.2 million cars (SMMT Motorparc, 2024) driving 7,093 miles each (NTS0901a, 2024). Each zone's miles are multiplied by s_z, by I_z, and by one plus the empty-running share, moved between zones by retiming, and charged at the zone's per-mile rate. The eVED those miles would have paid is subtracted.

Table A5.1. Revenue at a given share of self-driving miles, 2025 traffic and congestion costs

Share of car miles self-driving	Charged miles, billion	Gross charge, £ billion	Net of displaced eVED, £ billion
10%	26.8	8.9	8.2
50%	134.0	44.4	40.8
100%	267.9	88.8	81.6

At full take-up the average charge is 33p per charged mile, and the £88.8 billion gross is 2.9 times the £30.6 billion that fuel duty, VED and eVED together raise in 2030 in the absence of the charge.

The year path

The year-by-year account charges the two fleet segments separately. Private self-driving miles from A4 are distributed over zones on the mix of roads certified in that year, so the launch years are priced on urban minor roads, and carry the mode choice, induced demand and empty running from A3. Robotaxi miles are distributed on the urban-concentrated pattern and charged flat, since their miles per trip already include empty running and their market size already carries the fare response. Each year uses its own TAG congestion cost. Displaced eVED is netted on private replacement miles in full and on robotaxi miles at the passenger-onboard share of the pre-expansion trip volume, since empty and induced robotaxi miles displace no existing car mile.

Motoring-tax receipts without the charge are built from the same miles: fuel consumption at the speed driven (TAG A1.3.11) times the duty rate, on the TAG A1.3.9 fuel-mix path, plus eVED on electric car miles from April 2028. VED is taken from the OBR's July 2026 Fiscal risks and sustainability report.

Table A5.2. Motoring-tax revenue by stream, central adoption, £ billion a year

Year	Fuel duty	VED	eVED on human-driven miles	Self-driving charge	Total with the charge	Total without it
2030	17.9	10.3	2.3	0.4	31.0	30.6
2035	13.2	10.9	4.3	5.7	34.1	28.6
2040	10.4	11.4	5.3	18.8	45.8	27.7
2045	8.9	12.0	5.7	34.2	60.8	27.8
2050	8.5	12.3	5.8	46.6	73.1	28.0

Mileage-linked lines are Great Britain; VED is UK. The table excludes VAT on fuel, the HGV levy and local charging schemes.

The fuel duty that would be raised at today's fuel mix rises from £26.1 billion in 2030 to £34.9 billion in 2050 with traffic growth. The charge covers 1.6% of it in 2030, 62.2% in 2040 and 133.5% in 2050. Cumulative net receipts from launch to 2050 are £414 billion on the central path, £307 billion on the slow path and £562 billion on the fast path.

Under the flat per-minute design of A2, the same self-driving miles raise £0.4 billion in 2030, £4.9 billion in 2035, £16.5 billion in 2040, £30.6 billion in 2045 and £42.3 billion in 2050 gross, or £41.0 billion net in 2050. The flat rate is set to match the per-mile charge on the distribution of all car miles, and self-driving miles concentrate on the urban roads it under-charges, since those roads are certified first and robotaxi miles are urban-concentrated.

The same account reports three further volumes. In 2050 on the central path, 47.5 billion miles are charged, 74.9 billion miles of the private pool are driven manually to avoid the charge, and those reverted miles would have paid £63.0 billion. Empty miles carry £4.4 billion of the £46.6 billion charge, or 9.4%. Total car traffic with the charge is 309.5 billion miles in 2050, against a no-automation baseline of 301.9 billion and 442.8 billion if the same fleet were self-driving and uncharged.

A6 The fiscal window

Two effects fall inside the OBR's five-year forecast window and are kept separate because they differ in kind.

The first is scored receipts. Self-driving miles in 2030-31 are charged at the mileage-weighted rate for that year's certified roads, 87.6p per mile in 2025-26 prices, net of eVED. The rate is higher than the fleet average of 36p per mile because the roads certified first are urban. Private miles are scaled by the mileage-weighted s_z of 0.69; robotaxi miles are unscaled. The OBR would score these receipts against the current-budget rule in the same way as eVED.

The second is a gilt-yield response. A legislated long-run revenue stream may lower the yield on government debt. The OBR's March 2026 ready reckoner puts debt interest in the 2029-30 rule year at £8.4 billion per percentage point on gilt rates. The assumed yield fall is measured from the one-day move in the Bank of

England's fitted 25-year nominal spot yield on the day of each of nine UK fiscal events that announced a consolidation between 2009 and 2025. The yield fell at four of the nine and rose at five.

The cautious case therefore assumes no fall, the central case takes the median of the falls that occurred (3 basis points), and the ambitious case takes the largest (10 basis points, the Budget of 26 November 2025). The OBR does not score market responses of this kind. In Table A6.1 the cautious, central and ambitious columns pair these yield cases with the slow, central and fast adoption paths of Table A4.1.

Table A6.1. In-window fiscal effect, 2030-31, £ billion

	Cautious	Central	Ambitious
Robotaxi fleet, 2030	1,034	13,817	46,300
Self-driving share of car miles	0.08%	0.30%	0.87%
Gross charge receipts	0.14	0.67	2.01
Net scored receipts (current-budget rule)	0.14	0.66	1.99
Scored net-debt reduction by 2029-30	0.23	0.85	2.79
Assumed gilt-yield fall	0bp	3bp	10bp
Lower debt interest, 2029-30	0.00	0.29	0.84
Combined headroom, 2029-30	0.14	0.95	2.83
Combined net-debt reduction by 2029-30	0.23	1.71	5.31

The debt row and the headroom row measure the same money against the two fiscal rules and do not add.

A7 Journey examples

Table A7.1 prices five journeys on the rate card. Each segment pays its zone's per-mile rate for the distance travelled; the time column is the distance at the zone's measured speed, and the per-minute rate applied to it gives the same charge. The eVED comparator is 3p per mile.

Table A7.1. The charge on five journeys

Journey	Distance, miles	Time, minutes	Charge	eVED it replaces	Charge, p per mile
Village to market town, Saturday	8.0	16	£0.85	£0.24	11
Rural commute to nearest town, 8am	12.0	24	£1.27	£0.36	11
Leeds to Sheffield, Sunday	33.0	33	£3.03	£0.99	9
Birmingham suburb to Manchester Airport, 5am weekday	86.0	108	£10.93	£2.58	13
Paddington to a central London office, 8:30am weekday	3.4	20	£8.90	£0.10	262

The Birmingham journey splits into 75 miles of motorway (£6.88) and 11 miles of urban overnight roads (£4.05). The first three journeys fall in the rural and motorway zones, at 9p to 11p per mile.

A8 Sensitivity

Each parameter in Table A3.2 was moved alone to each end of its range with everything else at the central value, and the year path re-run. The swing is read at 2040, when both fleet segments carry material mileage. Table A8.1 reports the five parameters with the largest swings in gross charge revenue. The swings do not add, because several of the parameters multiply one another.

Table A8.1. The five largest single-parameter swings, gross charge revenue in 2040, £ billion

Parameter	Low end	High end	Revenue at low end	Revenue at high end	Swing
Self-driving use by adults without a licence	0.1	1.0	18.29	22.15	3.87
Passenger-to-driver value of time ratio	0.847	0.714	18.31	20.95	2.64
Zone distribution of robotaxi miles	as human taxis	urban-concentrated	19.05	21.06	2.01
Share of premium repriced onto manual minutes	0.243	0.53	19.44	20.55	1.10
Generalised-cost pass-through for captive miles	1.0	0.0	20.06	21.05	0.99

A9 Congestion feedback

The results above hold each zone's congestion cost at the TAG value for the year, which is measured on baseline traffic before the self-driving fleet adds its own miles. Because the MEC is convex in volume, pricing at the pre-entry level understates the charge, and the understatement grows with adoption. Automation also changes road capacity, and the published simulations disagree on the direction.

The congestion-feedback variant lets the cost respond to volume through TAG's own congestion bands. TAG Unit A5.4 Appendix A.3 defines five bands by the ratio of volume to capacity ($v/c < 0.25$, 0.25 to 0.5, 0.5 to 0.75, 0.75 to 1, and above 1) and publishes the MEC in each band and the share of each zone's traffic in each. Given a volume ratio R relative to baseline, every link's v/c scales by R divided by effective capacity, traffic re-bins across the bands, and the band-weighted MEC changes. Effective capacity is $1 + a_t(\kappa - 1)$, where a_t is the self-driving penetration in year t and κ is the capacity factor at full penetration. The charge set from the new MEC changes the traffic that determines it, so each year is solved to a fixed point.

The capacity factor is taken from the one UK-specific source, Atkins' microsimulation for DfT (2016) of the M25 and an urban network, which reports single-lane capacity at 100% penetration from 38.5% lower (cautious headways of 2.1 seconds) through 5.2% higher (headways equal to the legacy fleet) to 58.5% higher (assertive headways of 0.5 seconds). The DfT National Road Traffic Projections do not model the effect. Two steps in the method are assumptions: v/c is taken as uniformly distributed within each band, and the open-ended top band is closed at $v/c = 1.2$ following TAG Unit M3.1. TAG itself cautions against using band 5 values without consulting the Department; band 5 supplies 55% of the band-weighted cost in London peak and 45% in the regional urban zones at baseline.

Table A9.1. Cumulative net receipts to 2050 under the two bases, £ billion

Basis	Slow	Central	Fast
Flat congestion cost (headline)	307	414	562
Feedback, capacity factor 0.615 (cautious headways)	374	532	779
Feedback, capacity factor 1.052 (legacy-equivalent headways)	345	461	584
Feedback, capacity factor 1.585 (assertive headways)	328	435	564

On every capacity assumption the feedback total exceeds the flat one, by 5% at the assertive end and 28% at the cautious end on the central path. The paper reports the flat basis.

A10 Scope

The estimate is a revenue account and includes no welfare account. The charge is set at the marginal external congestion cost, so receipts and the congestion externality are the same object measured once. The following are outside the estimate.

Non-congestion externalities (accidents, local air quality, noise, greenhouse gases and infrastructure wear) are measured per zone from TAG A5.4 but not priced under the congestion basis. The time saved by other drivers when the charge suppresses or reverts miles is tracked as a volume and not valued. The value to travellers of the induced trips that are made, and of the 133.3 billion miles in 2050 that the charge prices off, is not counted. The cost to drivers of reverting to manual driving is priced inside the mode choice and not reported as a cost.

Administration and enforcement costs are not estimated; receipts are gross of collection. The model has no household dimension, so incidence by income is not represented; zones are places. The model covers cars only. Vans, lorries and buses are outside it.

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