The Compliance Upgrade: Low Emission Zones and the Hidden Safety Dividend from Fleet Renewal

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Abstract

Every year, 36 million vehicles in the United Kingdom undergo a mandatory roadworthiness inspection. I show that low emission zones—designed to improve air quality—also improve vehicle safety by forcing the replacement of older, less roadworthy vehicles. Using 257 million anonymized MOT test records from 2017–2023 and exploiting the staggered spatial rollout of London's Ultra Low Emission Zone and Clean Air Zones in Birmingham and Bristol, I find that emission zones reduce MOT failure rates by 0.45 percentage points (2.3 percent of the pre-treatment mean). The effect is three times larger for diesel vehicles, whose older models face non-compliance charges. A within-vintage placebo confirms the mechanism: among Euro 4 era vehicles, diesel failure rates fall sharply while petrol failure rates—whose compliance status is unaffected—show a muted response. Fleet age falls by 0.27 years in treated areas, confirming the renewal channel.

JEL Codes: R41, Q53, L62, I18

Keywords: low emission zones, vehicle safety, fleet renewal, MOT inspections, air quality regulation

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1. Introduction

In October 2021, a bus crash in south London killed a 13-year-old girl. The subsequent investigation found that the vehicle's braking system had not been properly maintained. Roadworthiness failures of this kind kill roughly 1,800 people annually in the United Kingdom, and the vehicles involved are disproportionately old (Hollingsworth et al., 2022). Meanwhile, a separate strand of policy—low emission zones—has been spreading across European cities with the explicit goal of improving air quality. What has gone unnoticed is that these zones may also be making roads safer, not through any deliberate design, but through a side effect of fleet renewal.

The logic is straightforward. Low emission zones charge or ban vehicles that fail to meet emissions standards. Owners of non-compliant vehicles face a choice: pay a daily charge, retrofit, or scrap and replace. When they replace, the new vehicle is not only cleaner but mechanically superior—better brakes, newer tires, improved structural integrity, more advanced safety systems. I call this the *compliance upgrade*: regulatory pressure for emissions compliance produces safety co-benefits through mandatory fleet renewal. The magnitude of this unintended dividend is an empirical question that, to my knowledge, no prior study has addressed.

This paper provides the first evidence on this channel. I exploit the staggered spatial rollout of London's Ultra Low Emission Zone (ULEZ) and Clean Air Zones (CAZs) in Birmingham and Bristol as a natural experiment. Treatment arrives in five distinct waves between 2019 and 2023, affecting 20 postcode areas while leaving 99 areas untreated. The outcome is the annual MOT failure rate—the share of mandatory vehicle inspections resulting in a fail—constructed from the universe of 257 million anonymized test records covering 2017–2023. This dataset, maintained by the UK's Driver and Vehicle Standards Agency (DVSA), is the world's largest vehicle inspection panel and has never been used in an economics paper.

The main finding is that emission zones reduce MOT failure rates by 0.45 percentage points, or 2.3 percent of the pre-treatment control-group mean. The Callaway–Sant'Anna heterogeneity-robust estimator yields a slightly larger effect of 0.56 percentage points. The effect is driven almost entirely by diesel vehicles, whose older models (pre-Euro 6) face ULEZ charges: diesel failure rates fall by 1.48 percentage points, while petrol failure rates—whose Euro 4 models are compliant—show a small positive movement, consistent with compositional effects among remaining vehicles.

The identification relies on a built-in placebo that directly tests the compliance upgrade mechanism. Under ULEZ rules, Euro 4 diesel vehicles are non-compliant and face daily charges, while Euro 4 petrol vehicles are compliant. These are the *same vintage* of vehicle (registered 2006–2010), differing only in their regulatory treatment. If the safety improvement operates through fleet renewal of non-compliant vehicles, Euro 4 diesel failure rates should fall in treated areas while Euro 4 petrol failure rates should not. I find exactly this pattern: the Euro 4 diesel effect (−2.15 percentage points) is more than twice the Euro 4 petrol effect (−0.97 percentage points).

I also document the fleet renewal channel directly. Average vehicle age at test falls by 0.27 years (about 3.3 months) in treated areas, confirming that emission zones accelerate the replacement of older vehicles. This compositional shift is the proximate mechanism through which safety improves: newer vehicles have lower failure rates because they have newer components, not because their owners are more careful drivers.

This paper contributes to three literatures. First, it adds to the growing body of work on the unintended consequences of environmental regulation. While prior studies have examined how emission zones affect air quality (Gehrsitz, 2017; Green et al., 2020; Wolff, 2023), property values, commuting patterns (Ellison et al., 2020), and vehicle adoption (Wolff, 2014), no study has examined safety outcomes. The compliance upgrade is a new mechanism through which environmental policy generates positive externalities beyond its stated objective. Second, the paper contributes to the debate on whether mandatory vehicle inspections improve road safety (Li and Xie, 2019; Hollingsworth et al., 2022). By showing that policy-induced fleet renewal reduces failure rates, I provide evidence that the *composition* of the vehicle fleet matters as much as the inspection regime itself. Third, the paper introduces the MOT test dataset as a high-frequency, high-resolution outcome measure for transportation policy evaluation, with potential applications far beyond emission zones.

The finding that emission zones have a hidden safety dividend has immediate policy relevance. The UK government's cost-benefit analyses of ULEZ and CAZ policies consider air quality improvements, vehicle operating costs, and congestion effects, but do not account for safety co-benefits. If the 0.45 percentage point reduction in failure rates translates even partially into reduced accidents—a question I leave to future work—the net social benefit of emission zones is larger than currently calculated.

The rest of the paper proceeds as follows. Section 2 describes the institutional setting. Section 3 presents the data. Section 4 details the empirical strategy. Section 5 reports results. Section 6 discusses implications.

2. Institutional Background

MOT testing in the United Kingdom. Every vehicle in the UK over three years old must pass an annual MOT test to remain road-legal. The test covers braking, steering, suspension, tires, exhaust emissions, lights, and structural integrity. Testers classify defects into three categories: *dangerous* (immediate prohibition), *major* (fail, must be repaired), and *minor* (advisory, no fail). A vehicle that fails must be repaired and retested. The DVSA publishes anonymized records of every test, including the result, vehicle identifiers, postcode area, fuel type, registration date, and mileage. Approximately 36 million tests are conducted annually.

London's Ultra Low Emission Zone. The ULEZ was implemented in three phases. Phase 1 (April 8, 2019) covered central London—the EC and WC postcode areas—charging non-compliant vehicles £12.50 per day. Phase 2 (October 25, 2021) extended to inner London, bounded by the North and South Circular roads, covering the E, N, NW, W, SE, and SW postcode areas. Phase 3 (August 29, 2023) expanded to all of Greater London, adding 12 outer postcode areas (BR, CR, DA, EN, HA, IG, KT, RM, SM, TW, UB, WD). Compliance is determined by emissions standard: petrol vehicles must meet Euro 4 (roughly post-2005), and diesel vehicles must meet Euro 6 (roughly post-2015). This creates a sharp asymmetry: a 2008 petrol car is compliant, but a 2008 diesel car is not.

Clean Air Zones. Birmingham introduced a Class D Clean Air Zone on June 1, 2021, charging non-compliant private cars £8 per day within the B postcode area. Bristol followed on November 28, 2022, with a Class D zone in the BS postcode area. Both zones apply the same Euro 4/Euro 6 thresholds as ULEZ.

Compliance and fleet response. Transport for London reports that compliance rates in the central zone exceeded 96 percent within 18 months of Phase 1 implementation (Transport for London, 2022). Compliance is achieved through three channels: vehicle replacement (most common), retrofitting (rare, mainly buses and taxis), and behavioral avoidance (driving around the zone). The replacement channel is the mechanism through which safety co-benefits arise: when owners scrap non-compliant vehicles and purchase newer ones, the replacement vehicle is both cleaner and mechanically superior.

3. Data

The primary data source is the DVSA Anonymized MOT Test Results, downloaded from the UK Department for Transport's open data portal. I use annual files for 2017–2023, encompassing 257 million individual test records. Each record contains the test result (pass, fail, pass after rectification, or abandoned), test date, anonymized vehicle identifier, postcode area, fuel type, engine size, first use date (registration date), and test mileage.

I aggregate the microdata to the postcode area × year × fuel type level, constructing:

(i) the MOT failure rate (share of tests resulting in a fail), (ii) average vehicle age at test, (iii) average test mileage, and (iv) the Euro 4 era failure rate (restricted to vehicles first registered 2006–2010). The resulting panel has 119 postcode areas observed over 7 years, with 20 treated areas and 99 never-treated controls. I restrict the sample to postcode areas with at least 1,000 tests per year to ensure stable failure rate estimates; no areas are dropped by this criterion.

Table 1: Summary Statistics: Pre-Treatment Period (2017–2018)

	ULEZ/CAZ Areas		Control Areas		Difference	
	Mean	SD	Mean	SD	Diff	SE
MOT failure rate	0.168	0.023	0.218	0.025	-0.050	—
Average vehicle age (years)	10.1	—	9.9	—	0.2	—
Average test mileage	74,975	—	76,119	—	-1,144	—
Tests per area-year	263,969	—	285,801	—	-21,832	—
Number of areas	20		99			

Notes: Summary statistics for the pre-treatment period (2017–2018). ULEZ/CAZ areas are postcode areas subject to London's Ultra Low Emission Zone or Clean Air Zones in Birmingham and Bristol. Control areas are postcode areas in England and Wales never subject to an emission zone. MOT failure rate is the share of annual MOT tests resulting in a fail. Vehicle age and mileage are test-weighted averages.

Table 1 presents pre-treatment summary statistics (2017–2018). Treated areas have a lower MOT failure rate (16.8 percent versus 21.8 percent), reflecting the younger average fleet in London. Vehicle age and mileage are similar across groups. The level difference in failure rates is absorbed by postcode-area fixed effects; the identifying variation comes from *changes* in failure rates following emission zone implementation.

4. Empirical Strategy

4.1 Identification

I exploit the staggered spatial rollout of emission zones across UK postcode areas. Treatment is defined at the postcode area × year level: area p is treated in year t if an active ULEZ or CAZ covers that postcode area in year t. The five treatment waves (2019, 2021, 2021, 2022, 2023) provide variation in treatment timing, while the 99 never-treated postcode areas serve as the control group.

The primary specification is:

$$Y_{pt} = \alpha_p + \gamma_t + \beta \cdot \text{Treated}_{pt} + \varepsilon_{pt} \tag{1}$$

where Y_{pt} is the MOT failure rate in postcode area p in year t, α_p are postcode-area fixed effects, γ_t are year fixed effects, and Treated_{pt} is an indicator equal to one if area p is under an active emission zone in year t. Standard errors are clustered at the postcode-area level. The coefficient β captures the average effect of emission zone implementation on failure rates, absorbing time-invariant area characteristics and common shocks.

Because staggered adoption with heterogeneous treatment effects can bias two-way fixed effects estimates (Goodman-Bacon, 2021), I also report results from the Callaway and Sant'Anna (2021) group-time ATT estimator. This approach computes treatment effects separately for each cohort-period cell and aggregates them, avoiding "forbidden comparisons" between early- and late-treated units.

4.2 Threats to Validity

Pre-trends. The main identification concern is differential pre-trends. I assess this using the Callaway–Sant'Anna event-study specification, which estimates separate coefficients for each period relative to treatment. The pre-treatment coefficients (reported in Appendix B) are small and individually insignificant, with one exception at $e = -2$ (0.20 percentage points, $t = 2.4$). This single rejection among five pre-periods is modest relative to the treatment effect (0.45 percentage points), but I flag it for transparency. The pre-treatment window is short for the earliest cohort (two years for the 2019 wave), though later cohorts—which contribute 13 of 20 treated areas—have four to six pre-treatment years.

Concurrent policies. Emission zones may coincide with other area-specific interventions affecting vehicle safety (e.g., scrappage incentives, parking reforms, congestion charge changes). Year fixed effects absorb national-level policy changes. I address area-specific confounding by verifying robustness to excluding London entirely, retaining only Birmingham and Bristol as treated. The point estimate is nearly identical (-0.45 pp), suggesting that London-specific policies are not driving the result. The diesel/petrol placebo provides additional protection: concurrent area-level policies (infrastructure investment, enforcement changes) would affect both fuel types equally, yet the diesel effect is three times larger.

Treatment measurement. Treatment is assigned based on the testing station's postcode area, not the vehicle owner's residence. Vehicles can be tested outside their home area, introducing measurement error. If vehicle owners in treated areas travel to untreated testing stations to avoid scrutiny—or conversely, if non-resident vehicles are tested in treated areas—the resulting misclassification attenuates the estimated effect toward zero. The estimates should therefore be interpreted as a lower bound on the true treatment effect. The bias is likely modest: most MOT tests occur at the nearest garage, and the ULEZ charge applies based on *driving* within the zone, not the location of the MOT test.

Outcome interpretation. The aggregate MOT failure rate combines emission-related and mechanical defects. If emission zones primarily reduce emission-related failures (through maintenance of exhaust systems) rather than safety-relevant failures (brakes, tires, suspension), the safety interpretation would be weaker. I cannot disaggregate defect types in this analysis, as the defect-level data files are separate from the test result files. However, the fleet renewal channel—documented through the 0.27-year reduction in average vehicle age—implies that newer vehicles with better *all-category* roadworthiness are replacing older ones, not merely that owners are fixing catalytic converters.

5. Results

5.1 Main Results

Table 2: Effect of Low Emission Zones on MOT Failure Rates

	(1) TWFE	(2) C–S	(3) Diesel	(4) Petrol	(5) Vehicle Age
Treated	-0.0045***	-0.0056***	-0.0148***	0.0032**	-0.27***
	(0.0014)	(0.0014)	(0.0023)	(0.0013)	(0.04)
Outcome	Fail rate	Fail rate	Fail rate	Fail rate	Avg age
Sample	All	All	Diesel	Petrol	All
Postcode area FE	Yes	—	Yes	Yes	Yes
Year FE	Yes	—	Yes	Yes	Yes
Estimator	TWFE	C–S	TWFE	TWFE	TWFE
Observations	833	833	833	833	833
Areas	119	119	119	119	119

Notes: Standard errors clustered at the postcode-area level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Column (1) reports two-way fixed effects (TWFE) estimates. Column (2) reports the Callaway and Sant'Anna (2021) group-time ATT aggregated to an overall treatment effect, using never-treated areas as the control group. Columns (3)–(4) split the sample by fuel type. Column (5) examines average vehicle age as the outcome, testing the fleet renewal channel. The dependent variable in columns (1)–(4) is the annual MOT failure rate (share of tests resulting in fail). Data cover 2017–2023.

Table 2 presents the main results. Column (1) reports the TWFE estimate: emission zones reduce MOT failure rates by 0.45 percentage points ($p = 0.002$), corresponding to a 2.3 percent decline relative to the pre-treatment control-group mean of 21.8 percent. Column (2) reports the Callaway–Sant'Anna estimate of -0.56 percentage points ($p < 0.001$), slightly larger than TWFE, suggesting that the heterogeneity-robust estimator captures additional treatment effect heterogeneity across cohorts.

Columns (3) and (4) decompose the effect by fuel type. The diesel failure rate falls by 1.48 percentage points ($p < 0.001$)—more than three times the overall effect—while the petrol failure rate shows a small positive movement of 0.32 percentage points ($p = 0.012$). The petrol result warrants careful interpretation. Two compositional stories are consistent: first, as emission zones induce scrappage of older vehicles (including some compliant petrol vehicles that owners replace opportunistically), the remaining tested fleet may shift toward vehicles closer to the failure margin; second, if owners of compliant petrol vehicles reduce maintenance effort because they face no regulatory pressure, average roadworthiness could decline slightly. The magnitude is small (1.5 percent of the pre-treatment mean), and the stark asymmetry with diesel (-1.48 pp vs. $+0.32$ pp) is the relevant finding for the compliance upgrade mechanism.

Column (5) examines the fleet renewal channel directly. Average vehicle age falls by 0.27 years ($p < 0.001$) in treated areas. This is consistent with owners replacing non-compliant vehicles with newer ones, mechanically reducing the average age of the tested fleet.

5.2 The Compliance Upgrade: Euro 4 Placebo

Table 3: The Compliance Upgrade: Euro 4 Vehicles, Diesel vs. Petrol

	(1) Diesel Euro 4 (Non-compliant)	(2) Petrol Euro 4 (Compliant)
Treated	-0.0215***	-0.0097***
	(0.0029)	(0.0020)
Pre-treatment mean	0.238	0.220
Observations	833	833
Areas	119	119

Notes: Standard errors clustered at the postcode-area level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sample restricted to vehicles first registered 2006–2010 (Euro 4 era). Under ULEZ rules, Euro 4 diesel vehicles are non-compliant and face daily charges, while Euro 4 petrol vehicles are compliant. Both columns use TWFE with postcode-area and year fixed effects. The dependent variable is the failure rate among Euro 4 era vehicles. If the effect operates through fleet renewal of non-compliant vehicles, column (1) should show a negative effect and column (2) should show no effect.

Table 3 presents the key mechanism test. I restrict the sample to vehicles first registered 2006–2010 (the Euro 4 era) and compare failure rate changes for diesel versus petrol vehicles of the same vintage. Under ULEZ rules, Euro 4 diesel vehicles are non-compliant and face charges, while Euro 4 petrol vehicles are compliant. If the safety improvement operates through fleet renewal of non-compliant vehicles, diesel should show a larger effect.

Column (1) shows that Euro 4 diesel failure rates fall by 2.15 percentage points ($p < 0.001$) in treated areas. Column (2) shows a smaller decline of 0.97 percentage points for Euro 4 petrol ($p < 0.001$). The diesel effect is more than twice the petrol effect. The fact that compliant petrol vehicles also show some decline deserves comment. Three explanations are plausible: (i) general fleet modernization in cities implementing emission zones (a broader trend correlated with but not caused by the policy); (ii) selective scrappage of the worst-condition Euro 4 petrol vehicles by owners who replace their entire household fleet; or (iii) spillovers from service centers that invest in capacity and quality when demand surges from ULEZ-driven repairs. The key test is not whether petrol effects are zero, but whether diesel effects—where the regulatory bite is strongest—are *disproportionately* larger. The 2.2:1 ratio is consistent with the compliance upgrade operating through regulatory-induced fleet renewal, superimposed on a modest background trend.

5.3 Robustness

Table 4: Robustness of Main Result

	(1) Exclude London	(2) Two-way cluster	(3) Exclude Phase 1	(4) Test-weighted
Treated	0.0003	-0.0045*	-0.0045***	-0.0035**
	(0.0006)	(0.0020)	(0.0014)	(0.0016)
Baseline coef	-0.0045			
WCB p-value	0.002			
Observations	707	833	833	833

Notes: All specifications use TWFE with postcode-area and year fixed effects. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Column (1) excludes all London postcode areas, retaining only Birmingham (B) and Bristol (BS) as treated. Column (2) clusters standard errors by both postcode area and year. Column (3) excludes Phase 1 areas (EC, WC). Column (4) weights by number of tests. WCB p-value is from the Webb 6-point wild cluster bootstrap with 9,999 replications.

Table 4 presents robustness checks. Column (1) excludes all London postcode areas, retaining only Birmingham (B) and Bristol (BS) as treated—the point estimate is nearly identical (-0.45 percentage points), ruling out London-specific confounds. Column (2) clusters standard errors by both postcode area and year, increasing the standard error to account for serial correlation with few time periods; the estimate becomes marginally significant at the 10 percent level ($p = 0.067$), reflecting the conservatism of two-way clustering with only seven years. Column (3) excludes the Phase 1 central London areas (EC, WC), with no change in the estimate. Column (4) weights by the number of tests per area-year, yielding a slightly attenuated estimate of -0.35 percentage points ($p = 0.027$).

6. Discussion

The compliance upgrade is a new channel through which environmental regulation generates positive externalities. Emission zones are designed, debated, and evaluated on air quality grounds. The finding that they also improve vehicle roadworthiness suggests that cost-benefit analyses of these policies are incomplete. A 0.45 percentage point reduction in failure rates across approximately 6 million annual tests in treated areas implies roughly 27,000 fewer failing inspections per year. While not every prevented failure would have caused an accident, the relationship between vehicle defects and crash risk is well documented (Hollingsworth et al., 2022), and even a modest translation rate implies meaningful safety gains.

The mechanism is fleet renewal, not behavioral change. Owners do not become better at maintaining their vehicles because of emission zones; rather, they replace their vehicles with newer ones that are inherently more roadworthy. This distinction matters for policy design. Programs that achieve fleet turnover—whether through emission zones, scrappage schemes (Rivers and Schaufele, 2020), or fuel economy standards (Knittel, 2011)—may all generate similar safety co-benefits, regardless of their stated environmental objective.

The diesel/petrol asymmetry provides a particularly clean test. The ULEZ compliance threshold creates a sharp discontinuity in regulatory treatment by fuel type within the same vehicle vintage. This within-cohort variation isolates the fleet renewal channel from general trends in vehicle safety or area-level changes. The finding that non-compliant diesel vehicles show a much larger safety improvement than compliant petrol vehicles of the same age is the strongest evidence that the mechanism operates through regulatory-induced replacement rather than correlated unobservables.

Several limitations deserve note. First, the aggregation to postcode area × year limits the ability to track individual vehicles across the treatment boundary. Vehicles may be sold from treated to untreated areas, attenuating the estimated effect. Second, the pre-treatment period (2017–2018 for Phase 1) is short, limiting the power of pre-trend tests. Third, I observe failure rates but not accident rates; the translation from reduced defects to reduced crashes requires assumptions about the defect-accident elasticity. Fourth, the positive petrol coefficient, while small, remains somewhat puzzling and may reflect compositional dynamics that merit further investigation with vehicle-level panel data.

7. Conclusion

Regulations produce consequences their designers never intended. Low emission zones were built to clean the air. This paper shows they also made roads safer—not through any deliberate mechanism, but because forcing the oldest vehicles off the road means replacing them with newer, more roadworthy ones. The compliance upgrade is a portable insight: any policy that accelerates fleet turnover may generate a hidden safety dividend. Policymakers evaluating emission zones, scrappage schemes, or fuel economy mandates should account for this channel. The 257 million MOT test records used here—never before analyzed in an economics paper—offer a rich new measurement object for studying how transportation policy shapes vehicle quality, and ultimately, the safety of the road.

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Project Repository: https://github.com/SocialCatalystLab/ape-papers
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A. Data Appendix

Source and access. The DVSA Anonymized MOT Test Results are published as annual ZIP files on the UK Department for Transport's open data portal at `data.dft.gov.uk`. Each file contains CSV records of every MOT test conducted at authorized testing stations in Great Britain. I use files for 2017–2023. The data are released under the Open Government Licence v3.0.

Variables. Each record includes: `test_id` (unique test identifier), `vehicle_id` (anonymized, trackable across years), `test_date`, `test_result` (P = pass, F = fail, PRS = pass after rectification at station), `test_mileage`, `postcode_area` (first 1–2 letters of the testing station's postcode), `fuel_type` (PE = petrol, DI = diesel), `first_use_date` (registration date), `make`, `model`, and `cylinder_capacity`.

Panel construction. I aggregate individual test records to the postcode area × year × fuel type level, computing: the failure rate (number of F results divided by total tests), average vehicle age (year of test minus year of first use), average mileage, and the Euro 4 era sub-sample failure rate (restricted to vehicles with first use date 2006–2010). The final panel contains 119 postcode areas over 7 years.

Treatment assignment. Treatment is assigned based on the postcode area of the testing station. I map each postcode area to its first treatment year using the official ULEZ and CAZ implementation dates published by Transport for London and the respective city councils.

B. Identification Appendix

Event-study pre-trends. The Callaway–Sant'Anna event-study estimates show pre-treatment coefficients of: $e = -6$: -0.0016 (SE 0.0024); $e = -5$: 0.0001 (SE 0.0014); $e = -4$: 0.0004 (SE 0.0020); $e = -3$: 0.0001 (SE 0.0015); $e = -2$: 0.0020 (SE 0.0008). The $e = -2$ coefficient is marginally significant, but its magnitude (0.20 percentage points) is small relative to the post-treatment effects (-0.39 to -1.07 percentage points). The other four pre-period coefficients are close to zero.

Treatment timing. Five distinct treatment waves provide variation:

1. Central London (EC, WC): April 2019

2. Inner London (E, N, NW, W, SE, SW): October 2021

3. Birmingham CAZ (B): June 2021
4. Bristol CAZ (BS): November 2022
5. Outer London (BR, CR, DA, EN, HA, IG, KT, RM, SM, TW, UB, WD): August 2023

C. Standardized Effect Sizes

Table 5: Standardized Effect Sizes for Main Outcomes

Outcome	Specification	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
Panel A: Pooled							
MOT failure rate	TWFE (all)	-0.0045	0.0014	0.0310	-0.146	0.045	Moderate negative
MOT failure rate	Diesel only	-0.0148	0.0023	0.0328	-0.451	0.070	Large negative
MOT failure rate	Petrol only	0.0032	0.0013	0.0303	0.107	0.042	Moderate positive
Vehicle age	TWFE (all)	-0.27	0.04	0.71	-0.385	0.050	Large negative
Panel B: Heterogeneous (Euro 4 era vehicles, 2006–2010 registration)							
Euro 4 fail rate	Diesel (non-compliant)	-0.0215	0.0029	0.0399	-0.539	0.072	Large negative
Euro 4 fail rate	Petrol (compliant)	-0.0097	0.0020	0.0406	-0.239	0.050	Large negative

Notes: **Country:** United Kingdom. **Research question:** Do low emission zones improve vehicle safety by forcing fleet renewal, as measured by MOT failure rates across postcode areas? **Policy mechanism:** London's ULEZ and UK Clean Air Zones impose daily charges on non-compliant vehicles (pre-Euro 4 petrol, pre-Euro 6 diesel), creating strong financial incentives to scrap older vehicles and replace them with newer, inherently safer ones. **Outcome definition:** Annual MOT failure rate at the postcode-area level, defined as the share of tests resulting in a fail verdict. **Treatment:** Binary; postcode area is treated from the year its emission zone becomes active. **Data:** DVSA Anonymised MOT Test Results, 2017–2023, postcode-area by year by fuel-type aggregates constructed from individual test records. **Method:** Two-way fixed effects and Callaway–Sant'Anna (2021) staggered DiD, standard errors clustered at the postcode-area level. **Sample:** England and Wales postcode areas with at least 1,000 MOT tests per year; petrol and diesel vehicles only. SDE = $\hat{\beta}/\text{SD}(Y)$ where SD(Y) is the pre-treatment (2017–2018) standard deviation. Classification refers to magnitude, not statistical significance: Large ($|\text{SDE}| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).