How Does Emissions-Charging Influence House Prices? Evidence From London's ULEZ

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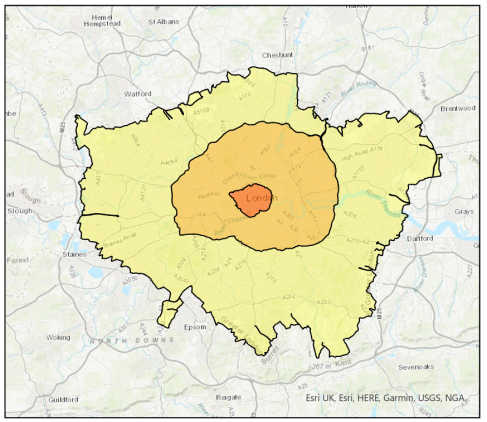
Policy Context

In 2018, the costs from London's air pollution were almost 2x as high as those in any other European city (CE Delft, 2020)

Solution: London's Ultra-Low Emissions Zone (ULEZ)

- £12.50 daily charge on non-compliant cars driven in the zone
- Established in 2019, then expanded (with a difference) in 2021 and 2023



This may have helped combat pollution, but how can we determine its overall effect on the attractiveness of living in London? Crucial from a policy perspective

- Answer = house prices!

Question and Literature

What was the effect of ULEZ on house prices in London?

The literature on this topic is surprisingly thin!

- Evidence suggests emissions charges generally achieve their main goal of reducing pollution (e.g. Wolff, 2014), but evidence on secondary effects is varied
- In Germany, LEZs have led house prices to increase (Gruhl et al, 2022)
- The initial 2019 ULEZ also increased house prices (Schneebacher et al, 2024), but we can't extrapolate this

Key Findings

- The ULEZ has caused a 3-4% decline in house prices in the 2021 and 2023 expansion zones
- This corresponds to a £25,000 windfall loss for the average homeowner, roughly half the average annual salary in the region
- The results are robust to different estimators and to substantial weakening of identifying assumptions
- The ULEZ also led house prices in nearby unaffected zones to fall by around 2%
- The relative prices show signs of gradual recovery, rationalisable as a product of asymmetric information transmission

Data

Source: Price Paid Data from HM Land Registry

- Sale price, address and characteristics of all houses sold in England and Wales from Jan 2015 to Nov 2024

I then use ArcGIS to geocode each house, and calculate its distance to each of the 2019, 2021 and 2023 ULEZ borders, as well as whether it is in each zone

Keeping all sales within 20km of the outer border gives 1,308,297 observations

VARIABLES	N	mean	sd	min	max	Source
Log(sale price)	1,308,297	13.06	0.586	0	19.95	Contained in the data
Detached?	1,308,297	0.119	0.324	0	1	Contained in the data
Semidetached?	1,308,297	0.190	0.392	0	1	Contained in the data
Terraced?	1,308,297	0.269	0.443	0	1	Contained in the data
Flat?	1,308,297	0.422	0.494	0	1	Contained in the data
New?	1,308,297	0.113	0.317	0	1	Contained in the data
Leasehold?	1,308,297	0.432	0.495	0	1	Contained in the data
In 2019 ULEZ?	1,308,297	0.016	0.123	0	1	Constructed with ArcGIS
Distance from 2019 ULEZ (km)	1,308,297	17.62	12.08	-1.942	46.42	Constructed with ArcGIS
In 2021 ULEZ?	1,308,297	0.255	0.436	0	1	Constructed with ArcGIS
Distance from 2021 ULEZ (km)	1,308,297	9.427	11.64	-9.191	37.82	Constructed with ArcGIS
In 2023 ULEZ?	1,308,297	0.611	0.488	0	1	Constructed with ArcGIS
Distance from 2023 ULEZ (km)	1,308,297	-0.137	9.089	-14.76	20.00	Constructed with ArcGIS

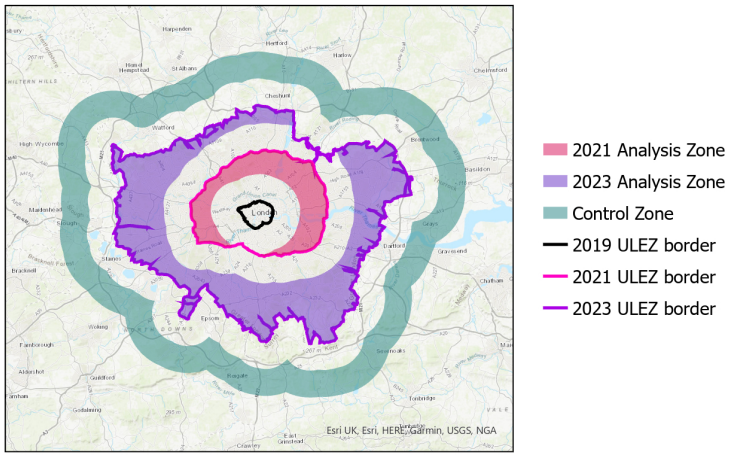
Sample Construction

Important: not all of these can be used!

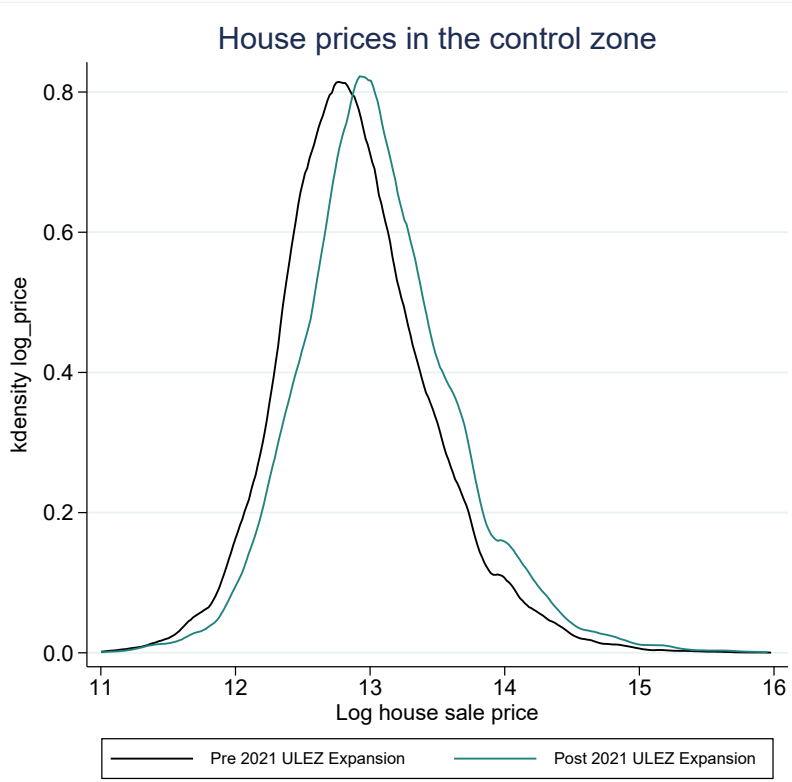
- The original 2019 ULEZ was implemented differently (residents exempt from the charge)
- Considerable spillover effects of ULEZ on nearby regions
- Can't use regions too far from central London as a control

After refinement, we have three 'rings' of observations:

- Houses in the 2021 expansion zone, but at least 5km from the 2019 border
- Houses in the 2023 expansion zone, but at least 5km from the 2021 border
- Houses between 5km and 10km outside of the 2023 border



Exploratory Analysis



Methodology

Hypothesis: house prices fall. How do we confirm this?

- Sequential implementation of homogeneous treatment in similar regions...**staggered DiD!**

To examine the overall average treatment effect on the treated (ATT), and its evolution over time, use a dynamic staggered DiD (i.e. an event study):

$$y_{ipt} = \alpha_p + \delta_t + \sum_{j \neq -1} \beta_j \mathbb{1}(t - G_p = j) + \rho \mathbf{X}_{it} + \varepsilon_{ipt}$$

- y_{ipt} is the log of the sale price of house i in postcode sector p, sold in quarter t
- α_p and δ_t are postcode sector and time fixed effects
- $\mathbf{X}_{it}$ are characteristics of the house
- G_p is the first quarter in which postcode sector p was treated

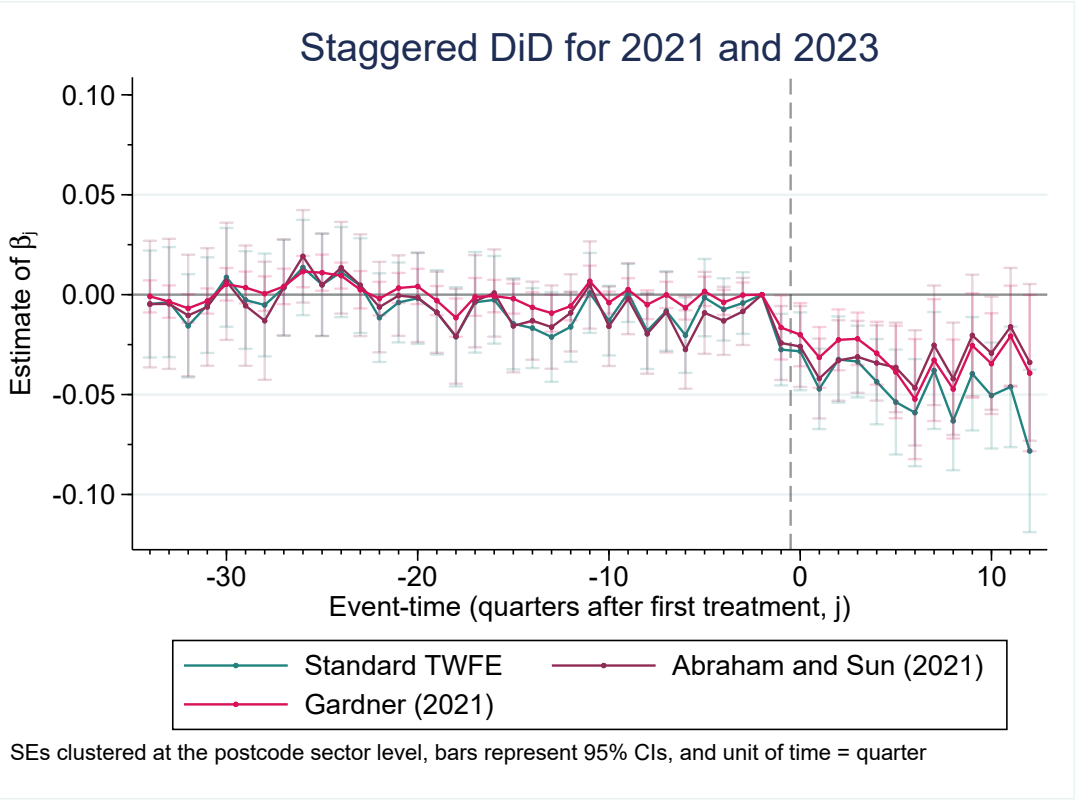
β_j are our coefficients of interest: they represent the effect of ULEZ j quarters after the zone was implemented (assuming parallel trends)

Results

Recent literature: with staggered treatment and a heterogeneous treatment effect between groups, the OLS estimates of β_j are inconsistent in this standard two-way fixed-effects (TWFE) model!

To check for robustness, I reestimate the coefficients with two alternative estimators robust to heterogeneity in this setting

- Abraham and Sun (2021)
- Gardner (2021)



All three look good: insignificant before treatment, and significant and negative after

- ULEZ leads house prices to fall by roughly 3-4%!

Spillovers

Back to the data processing - is there a better way to deal with spillovers than crudely cutting out rings?

- Yes - we can deal with their issues directly within the estimation!

Butts (2024) extends Gardner (2021):

- Gardner: estimate the ATT as a two-stage procedure with fixed effects estimated first on only not-yet-treated observations
- Butts: just omit the regions vulnerable to spillovers in the first stage, not the whole process!
- Further, spillover event-time dummies can be added in the second stage, allowing estimation of the house-price effect of the ULEZ being introduced *nearby*

What does 'nearby' mean? Butts forces the researcher to set a distance by which spillovers end - I set this to 10km

- 'nearby' = houses within 10km from an active ULEZ

I now reinsert the rings, and re-estimate the β_j using this estimator...

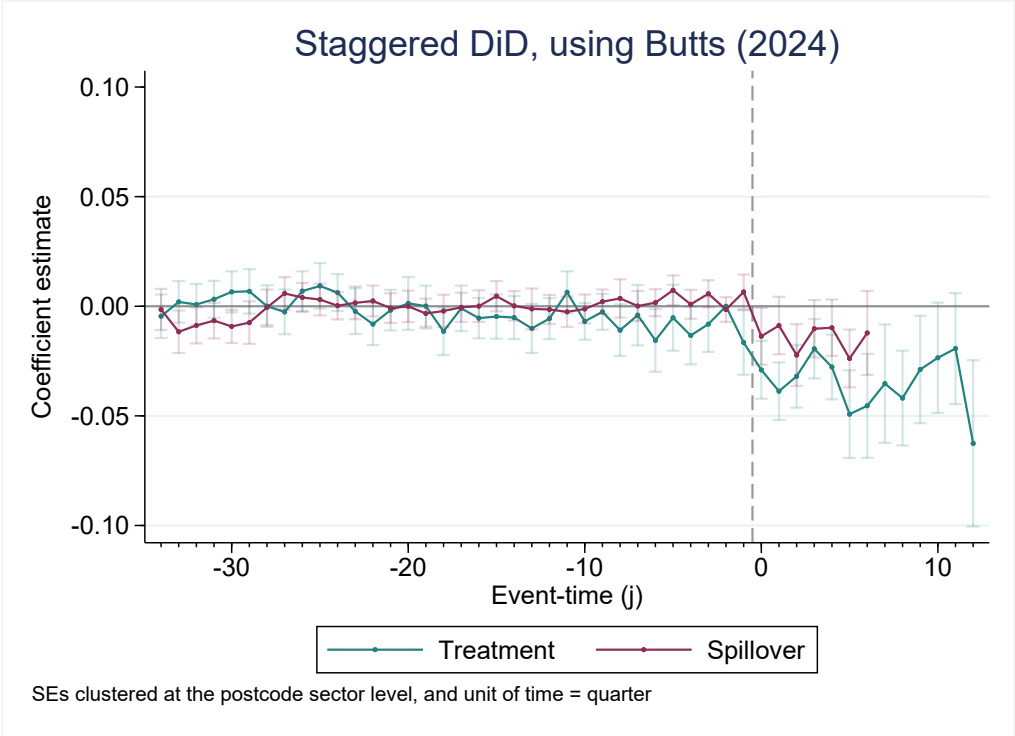
Results

The treatment effects align closely with the previous reliable estimators:

- Near-zero pre-treatment coefficients
- Post-treatment coefficients reaching roughly -0.04, then gradually recovering

We also observe a negative and partially significant spillover effect

- The ULEZ leads house prices in untreated regions within 10km to fall by roughly 2%!



Parallel Trends

Roth (2022): stop doing pre-trend testing! It is low-powered and introduces bias

- I still need to ensure my results are robust to parallel trends - how?

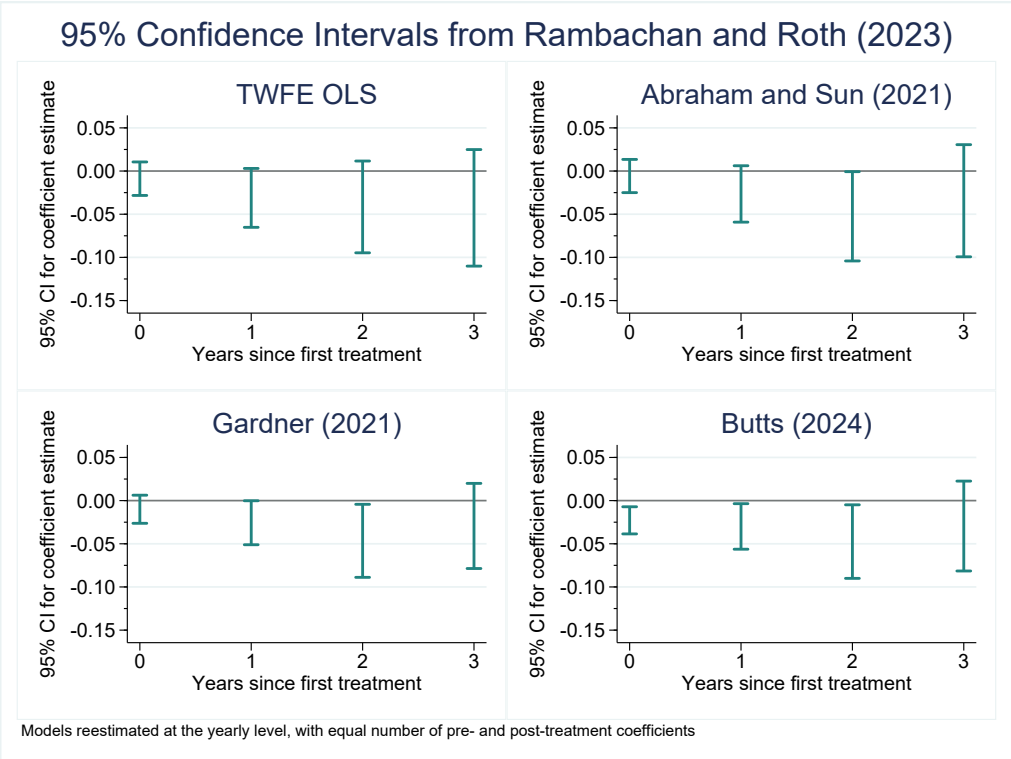
Rambachan and Roth (2023) provide a new approach: show results are robust to *violations* of this assumption

- Idea: make more post-treatment trends 'feasible' under the null of no treatment effect, and show that what we see still isn't one of them

New assumption: if there was no treatment, deviations from parallel trends in consecutive periods after treatment are no worse than the largest such deviation in the pre-period

R+R (2023) formalise a way of calculating confidence intervals for the treatment effect under this more relaxed assumption

Results



Each of the three robust estimators retain their significance at the 5% level!

- i.e. under weak assumptions on how badly parallel trends can fail, I still have significant results
- Note: compounding of the 'bad deviations' makes this look less convincing than it is

Short-term

Results suggest house prices fall by roughly 3-4% as a result of ULEZ

The average house sale price in the expansion zones since 2021 was £690,000: a 3.5% decline corresponds to a £25,000 windfall loss to the average homeowner

- Median salary in London in 2024: £47,455 (ONS, 2024)
- The ULEZ costs the average London resident over half the average annual regional salary!

There are also factors that may provoke further opposition to the policy:

- Heterogeneity analysis suggests cheaper houses lost proportionally more of their value: inequality concerns
- The loss is independent of individual polluting behaviour, which might provoke more local aggravations

Long-term

Recall the dynamics: the relative price falls, then begins to recover

This can be understood via relative speed of information transmission:

- Hedonic pricing models suggest each dimension of the ULEZ effect individually influences house prices (congestion, pollution, transport cost, etc)
- However, this can only occur once the effects have been understood by housing market participants
- **Negative effects** (the charge itself): sharp change, implications easy to notice and completely understand
- **Positive effects** (pollution, congestion): gradual change, may require academic research/media coverage to be noticed, hard to completely understand implications
- Reasonable that relative prices initially fall!

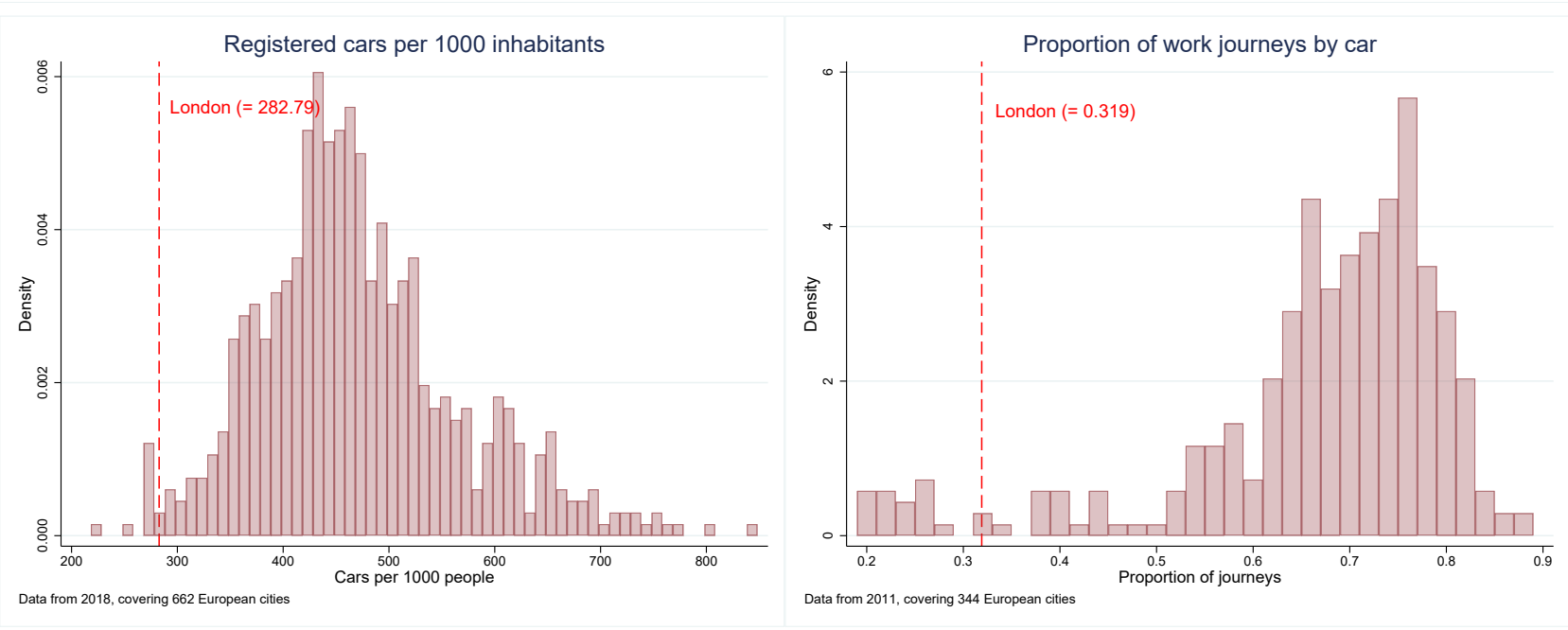
Key policy-relevant question: where will the relative price end up once information has been fully transmitted?

External Validity

The negative effects stem from costly behavioural changes for non-compliant car drivers

- All else equal, the more car-dependent a city is, the worse the expected impact

Compare London's car-dependence to other European cities...



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