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

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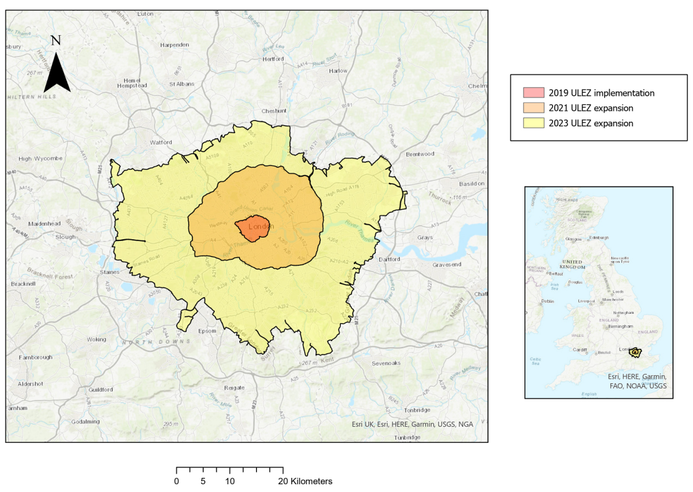
Policy Context

London's Ultra-Low Emissions Zone (ULEZ) was introduced in 2019. This policy comprises of a £12.50 daily charge on all environmentally non-compliant cars driven in the zone. As shown below, it was expanded in 2021, and again in 2023.



Research Question

The ULEZ may be dealing effectively with the air pollution problem, but at what cost? A policy-relevant question: how does it affect the overall attractiveness of living in London? House prices are a useful proxy, hence...

Key question: What was the effect of ULEZ on London house prices?

It is also interesting to investigate the presence of spillover effects on a house nearby (but not in) the ULEZ, as well as the direct effect on a house being in the ULEZ itself.

Literature

The literature on this topic is sparse:

- 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 the 2019 implementation made residents exempt, which was not the case in the expansions, so we can't extrapolate this

Data

Source: Price Paid Data from HM Land Registry

- I take the sale price, address and characteristics of all houses sold in England and Wales from Jan 2015 to Nov 2024

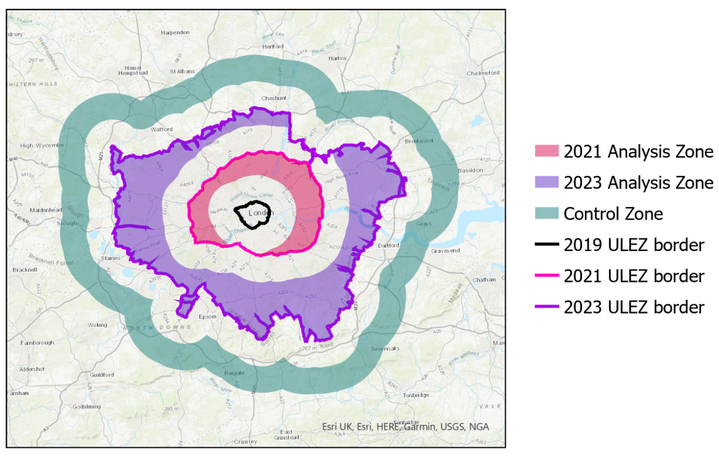
I then use ArcGIS to geocode each house, and calculate its Euclidean distance to each of the 2019, 2021 and 2023 ULEZ borders, as well as whether it is in each zone

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

Importantly though, not all of these houses can be used!

- As noted above, the original 2019 ULEZ was implemented differently: residents were exempt from the charge, so I focus on the 2021 and 2023 expansion regions
- There are considerable spillover effects of the ULEZ on nearby regions, so I cut out all houses within 5km of the closest inner border
- I can't use regions too far from central London as a control, because they become too rural and unrepresentative of the treated regions, so I cut out all houses further than 10km of the outer 2023 border

After this refinement, I have three 'rings' of observations, as shown below.



Methodology I

I have a sequential implementation of a fixed treatment in otherwise similar regions...this lends itself perfectly to identification of the ATT via staggered difference-in-differences (i.e. an event-study).

The baseline two-way fixed-effects (TWFE) regression to do this is as follows:

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

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

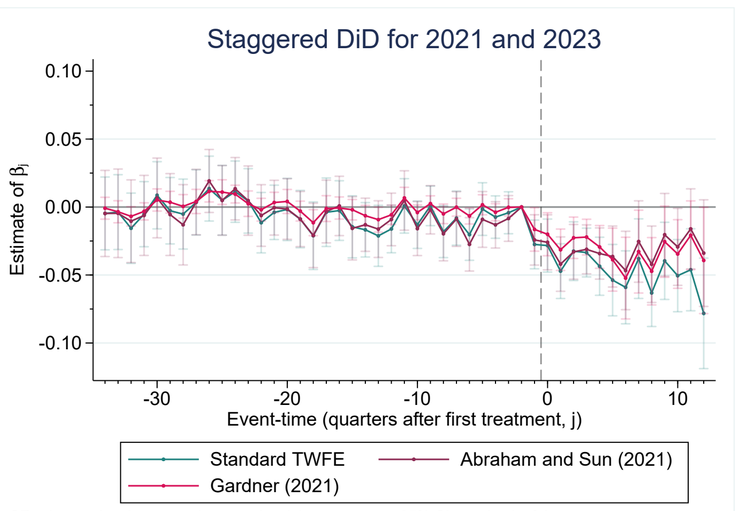
However, recent developments in the event-study literature have found that with staggered treatment and a heterogeneous treatment effect between cohorts, the OLS estimates of β_j are inconsistent in the TWFE model! (see e.g. Goodman-Bacon (2021))

Alongside this literature has come the development of new estimators for the ATT robust to the heterogeneity issue in this setting. To check for robustness, I reestimate the β_j coefficients with two such estimators:

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

Results I

The below figure plots the estimates of the β_j coefficients using each of the three estimators above, alongside 95% confidence intervals for each.



There are two main things to note:

- Pre-treatment coefficients are mainly insignificant and have no obvious trend, suggesting parallel trends may hold (more on this later)
- Post-treatment coefficients are insignificant and negative, suggesting the ULEZ causes house prices to fall in treated regions

The magnitude of the post-treatment coefficients suggest the ULEZ leads house prices to fall by roughly 3-4%.

Methodology II

Back to the data processing - is there a better way to deal with spillovers than crudely cutting out rings? Yes: I use the estimator outlined in Butts (2024), which extends Gardner (2021)

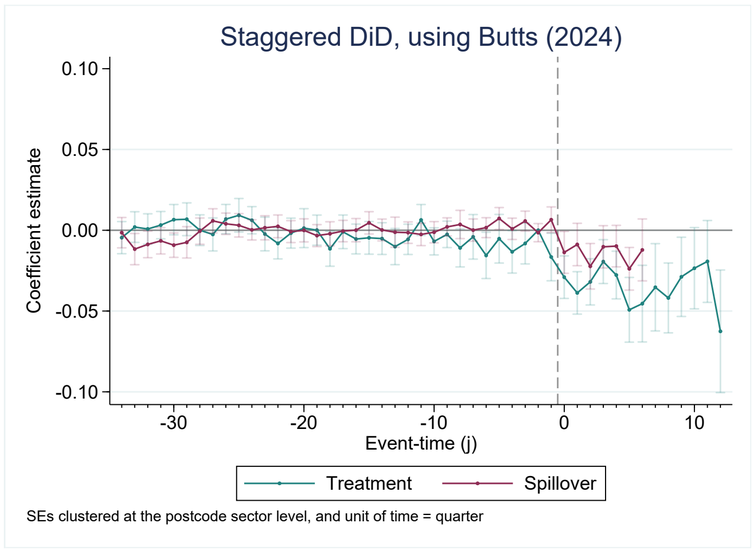
- Gardner: estimate the ATT as a two-stage procedure with fixed effects estimated first on only not-yet-treated observations
- Butts: just omit the regions vulnerable to spillovers in the first stage, not the whole process!
- Further, spillover event-time dummies can be added in the second stage, allowing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



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

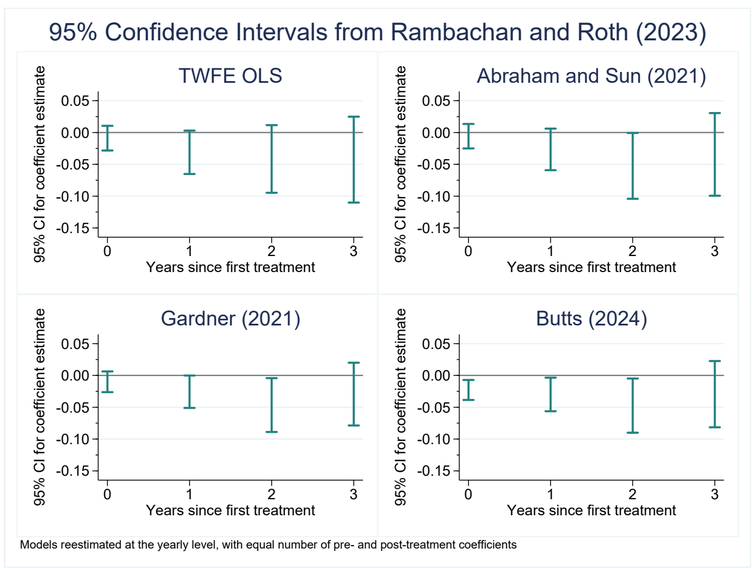
We also observe a negative and partially significant spillover effect: the ULEZ leads house prices in untreated regions within 10km to fall by roughly 2%!

Parallel Trends

I haven't formally addressed the parallel trends assumption. Most papers test the joint significance of the pre-treatment coefficients in the hope they are insignificant, but recent work suggests this is a poor approach (e.g. Roth (2022)).

Rambachan and Roth (2023) provide a new method: show results are robust to *violations* of the parallel trends assumption

- I make an alternative, weaker 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 (i.e. we permit deviations, but bound their size)
- R+R (2023) formalise a way of calculating confidence intervals for the treatment effect under this more relaxed assumption



The above figure shows the three robust estimators retain their significance at the 5% level! Under mild assumptions on how badly parallel trends can fail, the results are still significant, so we can be confident the true effect is strictly negative.

Implications

Short term: results suggest house prices fall by roughly 3-4% as a result of the 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, which is over half the average annual regional salary!

Long term: the observed effect can be understood via differing speeds of information transmission:

- Hedonic pricing models suggest each dimension of the ULEZ effect individually influences house prices (congestion, pollution, transport cost, etc), but rely on the public fully understanding its implications
- The negative effects (i.e. the charge itself) are sharp and easy to notice, but the positive effects (i.e. pollution, congestion) change more gradually and are harder to identify and incorporate into decisions
- Reasonable that relative prices initially fall, as we observe! The key policy-relevant question is this: where will the relative price end up once information has been fully transmitted?

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