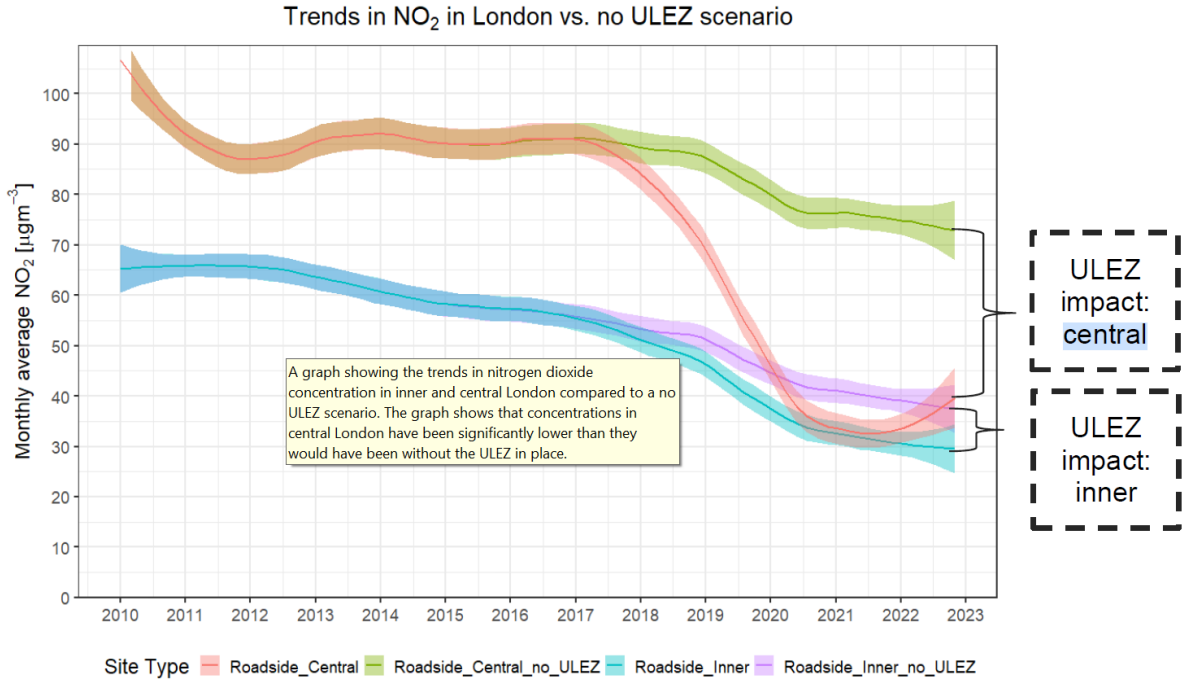
Evaluation of the Inner London ULEZ 'One Year Report'

In February 2023, The Mayor of London published *Inner London Ultra Low Emission Zone – One Year Report*. The report claims to demonstrate the success of the mayor's policies, including the ULEZ, and its expansion. This was vividly demonstrated by the following chart, produced by the report's analysis.



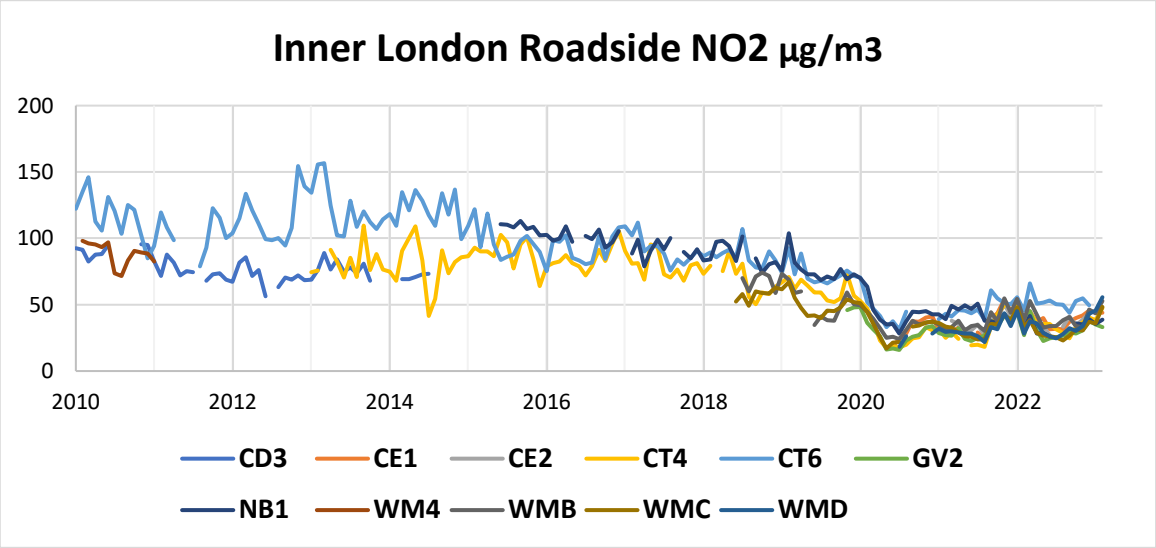
The success of ULEZ is depicted by the red curve, which, compared with a hypothetical continuation of a business-as-usual scenario (green), shows a radical decline of NO_2 concentrations, as recorded by air pollution monitoring stations in Central London. However, investigation of the data used by the report reveals that the red curve, and thus the estimate of positive 'impact', is unreliable.

Summary

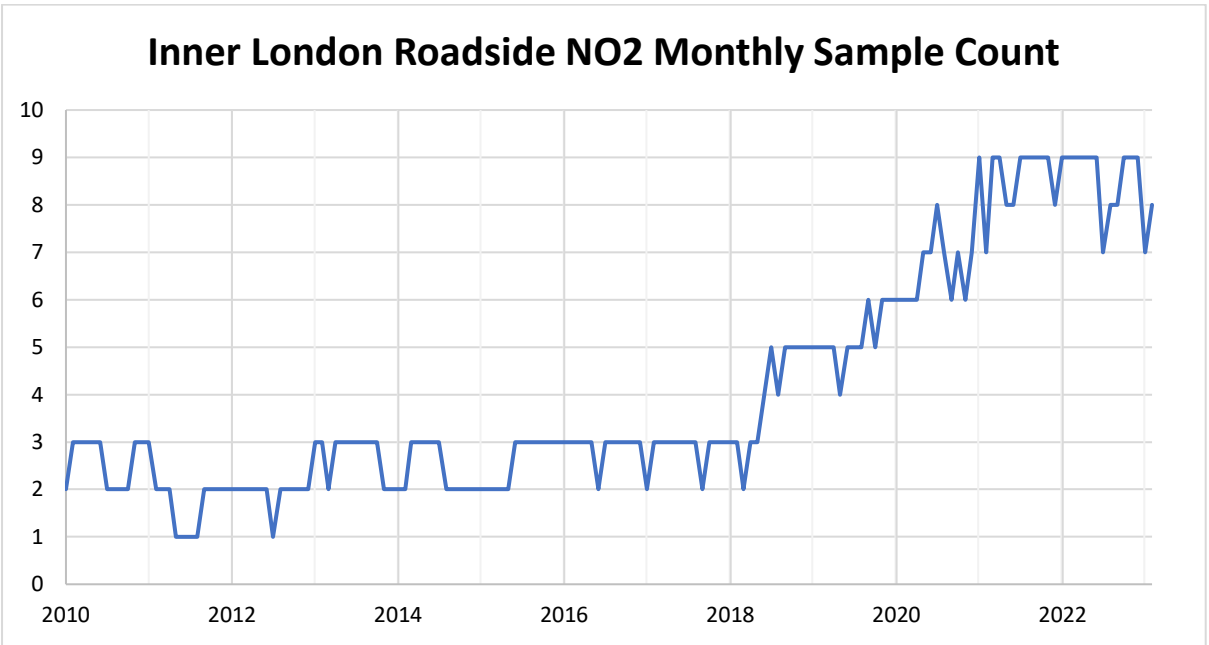
- The data relating to pre-ULEZ roadside air pollution is not of sufficient quality to be used to produce a 'roadside increment' calculation.
    - Central London roadside air pollution data is extremely sparse and extremely biased towards very heavy traffic areas.
    - Post-ULEZ data has more representative coverage but is influenced by lockdowns.
    - The appearance of reduced air pollution levels may have been caused by lasting economic damage caused by lockdowns.
- The techniques used by the Mayor's report produce a misleading evaluation of ULEZ's impact.
    - The Mayor's report uses a statistical technique (LOESS) to eliminate noise and produce trends, but this conceals the low quality of the underlying data.
    - The Mayor's report makes no serious attempt to normalise air pollution at the level of station data against traffic volumes, geographic situation, or economic context.
    - The 2018-2020 period does show significant falls in air pollution at station-level data. But this may be due to traffic-reduction policies on a small number of roads, not the ULEZ region in general.

Central London Roadside air pollution data

We attempted to reproduce the Roadside_Central curve in the above chart. We obtained the data using the same method – using the OpenAir addon package for the statistical analysis application, R. Monthly air quality data for Central London monitoring stations were downloaded for 'roadside' stations (site codes CD3, CE1, CE2, CT4, CT6, GV2, NB1, WM4, WMB, WMC, WMD), and for 'urban background' stations (CD4, CD5, CT1, CT3, SK6, BL0, WM0, WM5). Months with less than 75% data were excluded, in accordance with the method described by the Mayor's report. Data from these sites are shown in the following chart.



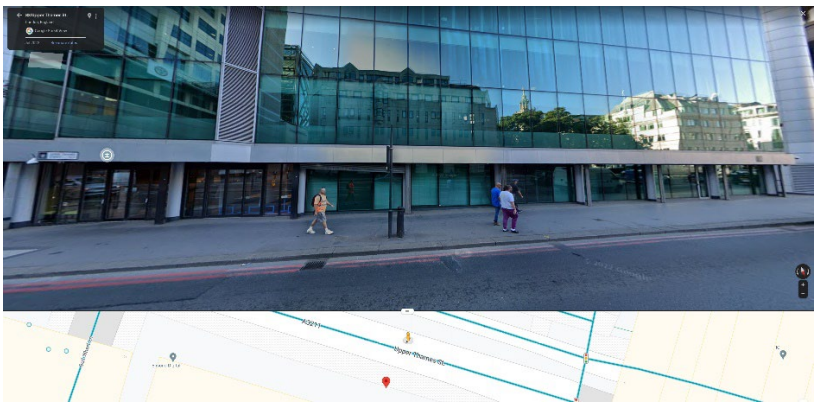
As can be seen in the chart, data at the start of the beginning of the series is sparse and is not continuous – large gaps exist. The sample counts for each month in the period is shown below. At no point in the 96 months between the start of 2010 and the end of 2017, were there more than 3 active roadside air pollution monitoring stations for the entire Central London area. For 41 months, there were just 2 stations recording, and for 5 months, only one station was producing data. This raises serious questions about the quality of the data the Mayor and TFL are using in their analysis.



Central London air pollution monitoring stations active before 2018 (pre-ULEZ)

The longest and most continuous series of data was produced by site "CT6". This site provided two of the monthly readings in which no other monitoring station produced data. The data obtained from KCL using the OpenAir R package states that the long name of this monitoring station is "City of London - Walbrook Wharf", and is located at 51°30'37.8"N, 0°05'29.9"W, between 83 Upper Thames Street and the kerbside, approximately 3 meters from the road.

Data provided by the City of London Corporation Air Quality Annual Status Report for 2021 places the monitoring station at 532528, 180784 (a different coordinate system, resolving to 51.510450, -0.091658), which is a location inside the Walbrook Wharf building, though the same report states that the station is 1m to the nearest kerb and placed at 3m height. Inspection of the location using Google Maps Street View suggests that there is no station air quality monitoring station at this location.



The City of London Corporation was contacted by email, to ask for clarity on the precise location of CT6. It was explained that CT9 is housed inside the Walbrook Wharf building, and air is brought in through an intake pipe from Upper Thames Street, above the building's main entrance.

This view may help to explain why CT6 records such high levels of NO_2. Until April 2016, Upper Thames Street carried four lanes of mixed traffic, when one of these lanes was converted to a cycle path. This would have likely contributed to the reduction in NO_2 seen since that time. Both ends of Walbrook Warf adjoin tunnels – one underneath Cannon Bridge, the other Bell Wharf Lane, which is home to many service vehicles – leading to likely concentrations of pollutants in the immediate area. Furthermore, tall buildings are situated on both sides of the road, further adding to the possibility of pollutants building up in a structure which is in form equivalent to a canyon.

Data from CT6 provided monthly air quality samples for 93 of the 96 months between and including 2010 and 2017. Four other stations provided 144 samples. This means that CT6 provided 39 per cent of the data to the estimate of pre-ULEZ air pollution. This very busy road, with characteristics that are likely to lead to concentrations of pollutants, and which are not representative of the wider Inner London area, may have produced data that is also unrepresentative, misleading analyses on which they are based.

The next most significant contributor of data to the series prior to ULEZ came from air quality monitoring station CT4, "City of London - Beech Street", which seems to have been installed in 2013. Inspection of this location on Google Street View reveals it to adjacent to a tunnel, much of the length of which is enclosed. This site, given the sparse data available relating to Central London, is also arguably of extremely little use to informing an estimate of air quality in the broader Central London area, and is potentially misleading.

The Third most significant contributor to the pre-ULEZ data was CD3 – "Camden - Shaftesbury Avenue". This location was identified, and the air quality monitoring station discovered to have been located between traffic lights and a bus stop. Though data from this station may be seen as more representative of roadside air quality than data obtained by a monitor located in a tunnel, again given the sparseness of the data, it is arguably not representative of the Central London roadside in general, since most lengths of road are not precisely midway between a controlled traffic junction and a bus stop.

The fourth and fifth stations that contributed data during this period are NB1 – "Westminster - Strand (Northbank BID)" – and WM4 – "Westminster - Charing Cross Library". Inspection of Streeview shows these locations to be (respectively) outside the main KCL building, and outside Charing Cross Library, but no evidence of roadside air quality monitoring stations could be found, and so therefore are assumed also to be housed within buildings.

NB1 is adjacent to a busy bus stop, and tall buildings.

Likewise, WM4 is on a major route to the West End and tourist attractions such as the nearby Trafalgar Square.

Central London air pollution monitoring stations active after 2017

The Air pollution monitoring stations active before 2018 are sited in qualitatively different locations to those installed after this date. Whereas the above situations are on major arterial routes, in or near tunnels, under bridges and between tall buildings, next to bus stops and traffic lights the following images of the post-2018 sites have significantly less traffic. One is a one-way, single-lane road and another is one-way road, from which through traffic is prohibited (though it is adjacent to a coach station entrance). There is significant separation from the traffic and the buildings.

CE1, Regent Street facade (The Crown Estate)

CE2, Waterloo Place (The Crown Estate)

GV2, Westminster - Duke Street (Grosvenor)

WMB, Westminster - Oxford Street East

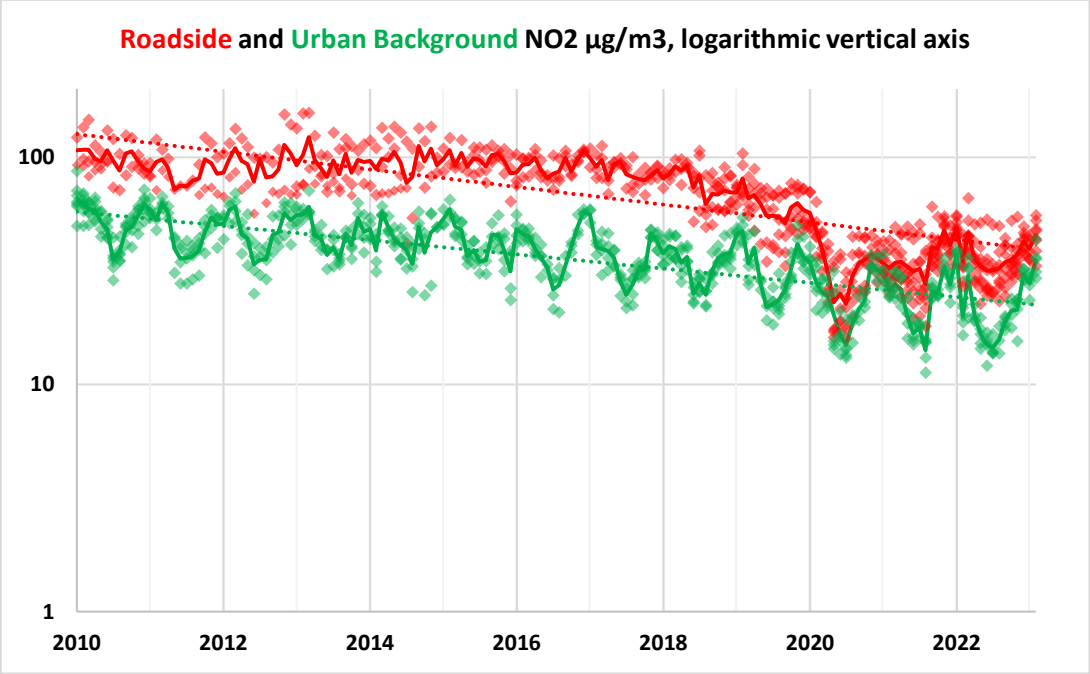
WMC, Westminster - Cavendish Square

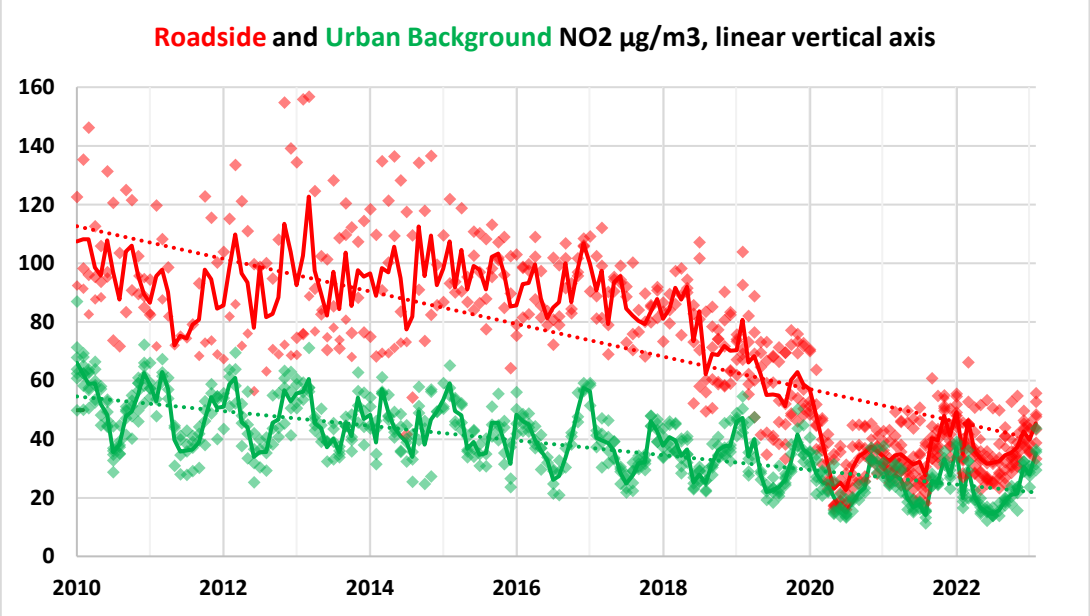
WMD, Westminster - Elizabeth Bridge

Finding trends in the data

The difference between the sites that were installed, broadly speaking, pre- and post-ULEZ, casts more doubt on the quality of the data used by the Mayor's report. The report uses relatively complex statistical techniques to smooth out noise and seasonal variation, to produce a trendline. However, this method (LOESS) gives a misleading picture of the underlying data, as discussed above, to produce trendlines that show ULEZ favourably. Below, the data for both central London roadside and urban background concentration of NO_2 are shown (dots). This data was averaged (solid line) and linear trends (dashed) obtained.

These charts suggest that NO_2 concentrations were already falling, and that ULEZ has not significantly influenced this rate of progress.





Estimating ULEZ 'impact'

The Mayor's report argues that the impact of ULEZ policies can be determined by comparing Central London roadside pollution levels to a projection of a 'No-ULEZ' scenario – a prediction of what those levels would have been without policies. That projection is shown in the chart at the top of this document, in the green line.

In order to produce this counterfactual statistic, the report assumes that, had no ULEZ policies been implemented, roadside levels of pollution in Central London would have shown the same responses to other factors that have reduced pollution (such as improved engine designs coming onto the market and older models being scrapped) in the Outer London area. The report explains:

> *The no ULEZ scenario was calculated by subtracting the reduction in R_{inc} in outer London compared to January 2017 from the R_{inc} in central/ inner London in January 2017.*

$$R_{inc}^{cenral\ no\ ulez}{}_{i} = R_{inc}^{central}{}_{Jan17} - \left(R_{inc}^{outer}{}_{Jan17} - R_{inc}^{outer}{}_{i} \right)$$

The term 'R_{inc}' (and 'inc') refers to the roadside increment – a figure produced by subtracting measurements of air pollution recorded at roadside monitoring stations, from measurements taken from the urban background. The above equation takes this measure and aligns it to the Central London Roadside Increment recorded on January 1 2017 to produce the 'No-ULEZ' data series. This transformation is shown in the following graphic.

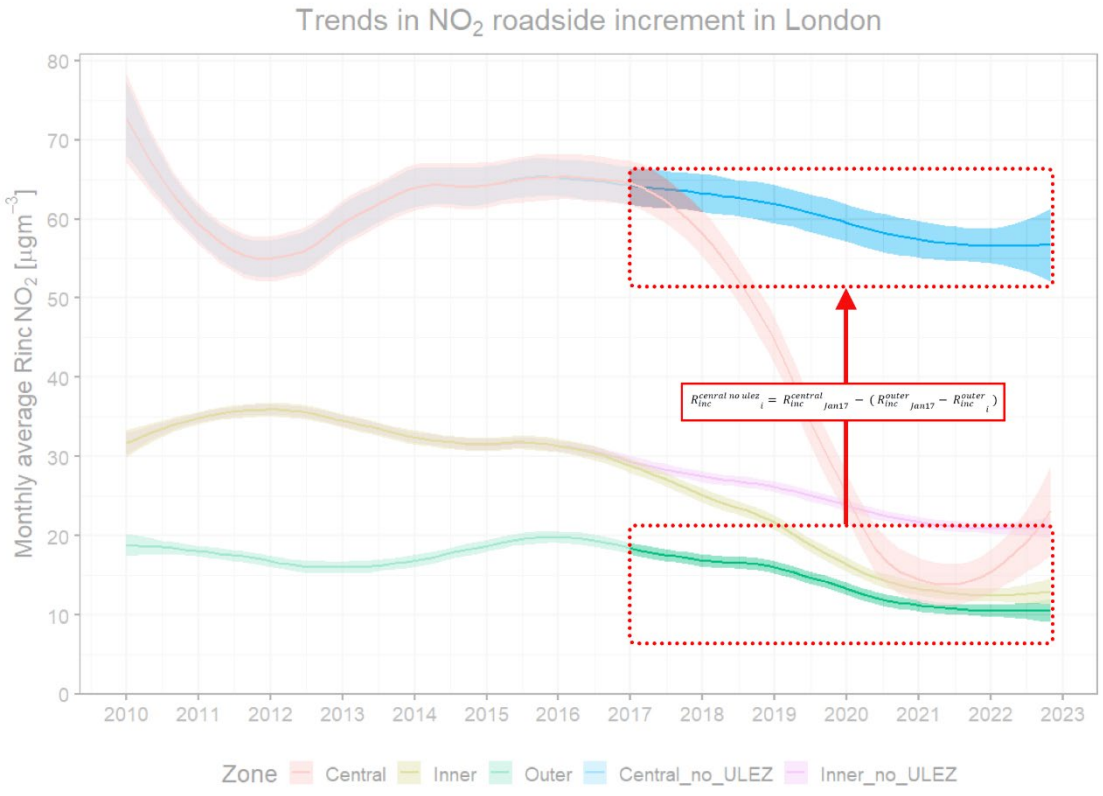


Figure 21: Trends in monthly average NO_2 roadside increment

But the report's assumption and its method are unsound, and the data on which they are based are unreliable. First, as has been shown above, pre-2018 data on Central London roadside air pollution levels are extremely biased towards heavy traffic areas and are sparse. Second, there is no reasonable basis for the assumption that air pollution from a region (Outer London), which is in very many places radically different to Central London, can provide a reliable 'no-ULEZ' scenario projection. Third, the selection of January 2017 as the point at which to constrain this projection is at best arbitrary. Fourth, given the low quality of pre-2018 data, this starting point is unduly high.

Despite the further confounding factor of covid lockdowns, which Central London arguably has not yet recovered from, the mayor's report claims on the basis of this analysis that ULEZ has produced a 50 per cent reduction in roadside air pollution levels. A simple visual inspection of the charts shows that inner London Roadside air pollutions are now, post-covid in a steep upward trend. To claim success for ULEZ or any other policies on this basis is thus at best premature.

However, it may be much worse than this. Given the extremely low quality of the data that existed prior to the introduction of these policies, it may never be possible to produce an objective estimate of the levels of air pollution in Central London by which to compare against post-ULEZ levels and an assessment of ULEZ's success. Hastily using 'smoothing' techniques to fill substantial gaps in data – i.e. to create data where none exists – and inventing counterfactuals is bad statistics and can only lead to bad policy making.