Changing Inequalities? The Influence of Environmental Zoning Policies on the Unequal Distribution of Air Pollution

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Abstract

Minority and economically deprived households are exposed to higher levels of air pollution. Previous research has hypothesized that Congestions Charge or Low Emission Zones can reduce the exposure of disadvantaged households living around the city centre, thereby lowering the extent of environmental inequality. However, zoning policies can also lead to processes of environmental gentrification, thus displacing vulnerable households from the areas profiting most in terms of environmental quality. We investigate how tightening Congestion Charge rules and emission regulations in inner London – connected to significant improvement in environmental quality – affected the unequal distribution of air pollution. The study merges aggregate level census data to annual pollution estimates across London from 2003 to 2019 to test if the pollution disadvantage of immigrant minorities in London has changed over the past years. Moreover, we use individual level data to investigate if minority households have indeed been displaced from central city areas.

Keywords: Air pollution; Environmental Inequality; Zoning Policies; Congestion Charge.

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1. Theoretical background

A vast amount of empirical studies documents the existence of environmental inequality – the disproportionate exposure of minority households to environmental pollution [1, 2, 3]. Also in London, recent studies show a significant connection between economic deprivation or the share of ethnic minorities and air pollution, with most deprived and minority households being exposed to higher levels of pollution [4, 5]. This is particularly concerning as research documents the negative and long-lasting consequences or air pollution at the place of residence for later life outcomes [6, 7]. It is thus crucial to investigate policies aiming at reducing the pollution burden in general but also the unequal distribution therein.

Low Emission Zones or Congestion Charge Zones are policies which restrict the access of cars to inner city districts by either imposing a general price or by imposing emission rules for entering vehicles. These policies have been shown to be effective in reducing pollution in general [8]. However, recent studies [9] also hypothesize that such policies might be effective in reducing pollution inequalities. This argument is based on the relative centrality of minority households and air pollution within cities. Research [10, 11] has shown that the positive correlation between air pollution and the share of minority residents is partly driven by the relative centrality of minority households: minorities tend to live closer to the city center where air pollution is worst in most cities. A similar tendency can be observe in London: several immigrant clusters can be observe around the inner city center, whereas more rural suburbs are characterized by a low share of immigrant minorities (see Figure 1).

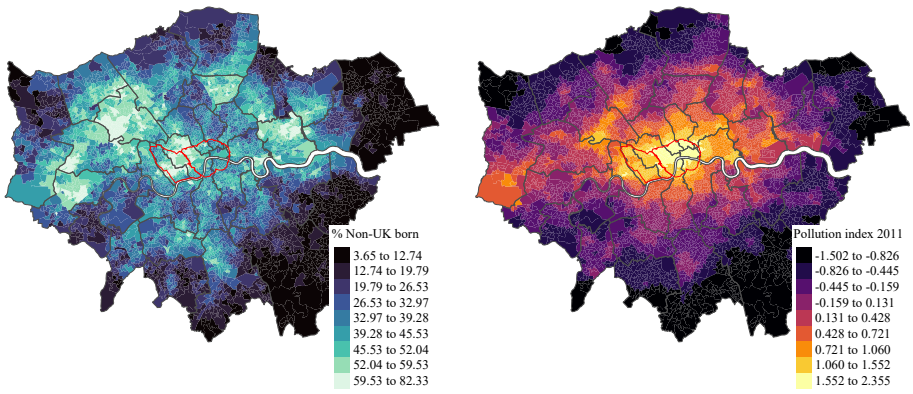

Figure 1: Share of immigrant minorities (left) and composite air pollution index (right) in London. Red polygon marks the Congestion Charge Zone. Data based on Zensus 2011 and Defra's Background pollution estimates.

Given that the Congestion Charge Zone aims at reducing air pollution within and around the central districts (where the Zone is usually implemented), the policy has the potential to reduce the disproportionate exposure of centrally located minority households – thereby

reducing overall environmental inequality. As recent studies [12, 8] demonstrate, air pollution has significantly improved within the inner-city Zone of London from 2015 onwards, with significant spill-over effects within 2km distance to the Zone. *We thus expect that the pollution disadvantage of immigrant minorities in London declines from 2015 onwards.*

However, a potential concern are processes of environmental gentrification [13, 1, 14, 15]. It is likely that improvements in environmental quality increase attractiveness of affected neighbourhoods, thus also increasing house prices and leading to tighter renting markets [16]. The improvements in air quality may thus lead to selective sorting and the displacement of less affluent and minority households into more polluted regions [14, 15]. These residential sorting processes may then offset the benefits of the Zoning policy. We will thus also investigate the likelihood of minority households to live within or in close proximity to the Congestion Charge Zone.

2. Data and Methods

In this study, we employ two different data sources: aggregate-level census data on LSOA level [17], and individual-level panel data with residential LSOA identifiers [18]. We merge both data to pollution estimates of Defra's air pollution estimates [19]. Pollution estimates are provided on a 1×1km grid over the UK, which we re-project on the level of Lower Layer Super Output Areas (LSOA, on average 1,400 individuals 600 households) for merging purposed. Air pollution is then calculated by an average index of standardized estimates for Benzene, NO2, PM2.5 – equally weighting all pollutants.

We use different strategies to estimate the effect of the Zoning policy on environmental inequality. For all analyses, we use 2015 as the treatment year, as the tighter congestion charge and emission regulations were the most successful changes in terms of pollution reduction [12]. First, we estimate the change in the disadvantage of non-UK born residents based on aggregate level census data. Note that the residential characteristics are constant at their 2011 value [NOTE: this might change once 2021 data is available]. Second, we estimate the contribution of each single region to the change over time. Therefore, we employ a jackknife strategy – a) omit each LSOA over all years, b) re-estimate the initial model, and c) compare the individual estimates to the estimated coefficients of the overall model. This strategy is similar to the well-known DFBETAS, with the only difference that we omit observations group-wise (all years for each LSOA).

In the second part, we test selective sorting processes. Therefore, we use the annual individual-level panel data based on Understanding Society. Again, we use interacted Linear Probability models to estimate the annual likelihood that non-UK born participants live in or within 2km to the CCZ. [NOTE: we might perform other tests here if 2021 census data becomes available]

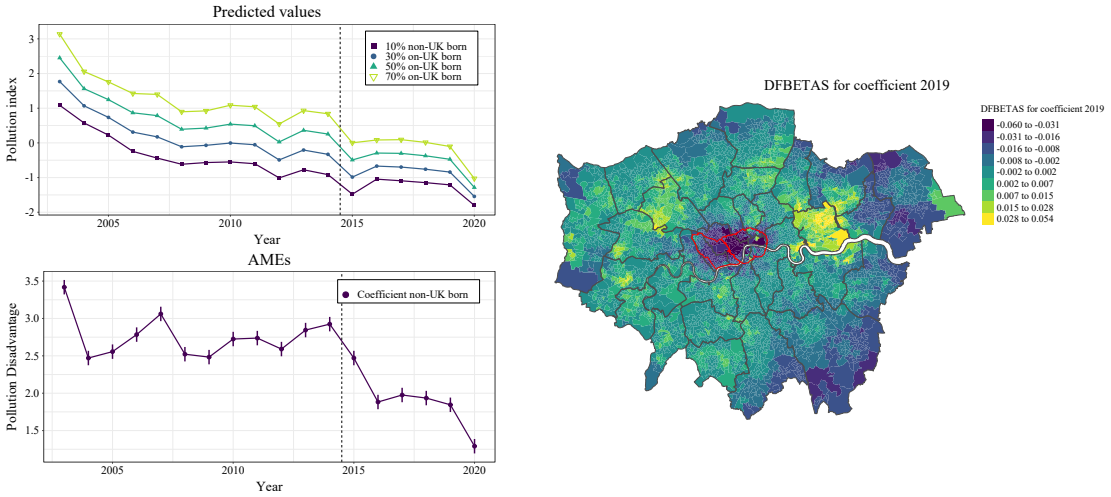

Figure 2: LEFT: Average predicted air pollution of neighbourhoods with different shares of non-UK born residents (top), and the pollution disadvantage associated with a 100 percentage-point increase in non-UK born residents (bottom). Estimates are based on interacted OLS models with 95% CIs. RIGHT: The influence of individual regions on the overall decline in environmental inequality from 2003 to 2019 based on DFBETAS.

3. Results

Figure 1 (left) provides estimates of environmental inequality for immigrant minorities in London from 2003 to 2020. Across all years, immigrant minorities face a substantial and significant pollution disadvantage as compare to UK-born residents in London. Still, Figure 1 also indicates substantial fluctuations in this disadvantage. In 2003, a neighbourhood with 100% immigrants is predicted to have a pollution index of nearly 3.5-times the value we would estimate for a hypothetical neighbourhood with 0% immigrant residents. This is a huge disadvantage. In 2019, this disadvantage is still significant, but substantially smaller with a 1.5-fold pollution index for an immigrant neighbourhood. Most interestingly, the strongest improvements happened in 2015 and 2016 when CCZ rules were substantially tightened – leading to a large improvement in air quality. This supports the idea that the 2015 CCZ policy significantly reduced environmental inequality.

However, it is hard to attribute this change to the CCZ alone, as many other processes might contribute as well. We thus calculated DFBETAS values for the change coefficients (Figure 2, right). The values indicate in which direction single geographical units contribute to the overall reduction in environmental inequality from 2003 to 2019. Note that the model does not a-priori have any information about the spatial structure of the data, nor about the outline of the CCZ. Still, Figure 2 (right) shows a distinct spatial pattern. Especially regions around the CCZ have contributed negatively to the overall trend: these regions had the strongest contribution to reductions in environmental inequality. Other regions, like East Ham (mid-

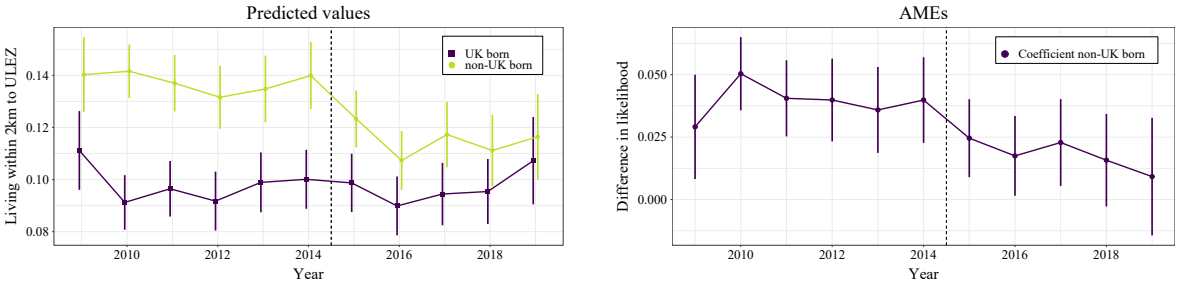

Figure 3: Average predicted likelihood of living inside or within 2km to the CCZ (left) and the difference between non-UK born and UK-born individuals (right). Estimates are based on interacted Linear Probability models.

east, north of Themes) in contrast, would have contributed into the other direction, meaning these regions contributed to an increase in environmental inequality. Again, this provides support for the idea that pollution reductions in central city districts significantly reduce environmental inequality.

Nevertheless, the previous analyses ignore potential relocations by keeping the demographics constant. However, minorities might be displaced by improvements in air quality and raising housing cots. Figure 3 thus uses individual-level panel data to test the likelihood of minorities living close to the CCZ. Across all years, minority resident have a higher likelihood of living within 2km to the CZZ (see also Figure 1). This difference between non-UK born and UK born residents remains relatively constant. Still, we see a very small change since 2015, with non-UK and UK born residents becoming more similar. This is driven by reductions of the likelihood of non-UK born residents to live close to CCZ. One might interpret this as evidence for minority displacements, but changes are within the insecurity bounds of the 95% confidence intervals, thus complicating robust conclusions.

The results indicate that the tightened Congestion Charge rules and the improvements in air quality in central London significantly contributed to a reduction in environmental inequality by lowering the relative disadvantage of immigrant minorities in the city center. However, there are signs of minority misplacement from central city areas after the improvements. Statistical insecurity regarding the displacement processes is however large which may result from the short time period since the policy.

Future plans

If available, the study will also include 2021 (and 2011) census data to investigate minority displacement. Moreover, I plan to implement a synthetic control design to compare the temporal development in London to other cities in the UK. This should provide a more causal estimate of the policy impact.

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