Distributional Analysis Methodology Report (E3)

Report for Derby City Council

ED 10107 | Issue Number 5 | Date 06/02/2019

Customer:

Derby City Council

Customer reference:

Derby Roadside NO_2 Project

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Date:

06 February 2019

Ricardo Energy & Environment reference:

Ref: ED10107- Issue Number 5

Table of contents

Appendices

1 Introduction

Derby has been named as one of many cities in the UK that will not be compliant with nitrogen dioxide regulations by 2020 (which have been set in line with EU air quality targets). As a result, DEFRA's air quality action plan named Derby as having to carry out a Feasibility Study to achieve compliance as soon as possible.

Each city must develop a Business Case which explores viable options to tackle air quality and present the case to support the preferred policy option. The Business Cases are being developed in line with guidance issued by the Joint Air Quality Unit (JAQU), which in turn is based upon HMT's five case model[1].

JAQU have shared with the cities detailed guidance around the economic methodologies and assumptions to adopt when appraising the policy options[2]. This guidance stipulates that deliverables to be provided by the Local Authority are:

1. Economic Appraisal Methodology Report (E1) – a write-up of the economic appraisal and results
2. The Economic Model (E2) and any linked documents (linked spreadsheets or user guide)
3. Distributional Analysis Methodology Report (E3) – covering the approach to distributional analysis and the results.

This report sets out the draft methodology and quantitative analysis of the distributional impacts of the policy options considered by Derby following the requirements of the deliverable E3. The aim of the distributional analysis is to explore how the impacts of the policy options are distributed amongst the different socio-economic groups (such as children, different income groups, and disabled). It also sheds light onto whether any key amenities such as schools, hospitals etc. are adversely affected through changes in access or surrounding air quality. This can inform measures to mitigate the impact of the policy on those groups or amendment of the policy itself.

The distributional analysis relies on other areas of the modelling undertaken to support the assessment of policy options, specifically the transport modelling undertaken by Systra and air quality modelling undertaken by the Ricardo team. This paper clearly references where the distributional analysis has used the outputs of other modelling and describes how these outputs are used. However, it does not set out a detailed account of how this supporting modelling has been undertaken, which has been provided elsewhere (e.g. through the Air Quality Modelling Methodology Report (AQ2)).

The JAQU Guidance stipulates that distributional analysis is necessary for local feasibility studies in two respects:

1. to investigate the distributional impacts of measures proposed to achieve compliance with air quality limits, thereby fulfilling the public-sector equality duty;
2. to show how mitigation measures alleviate those impacts.

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/469317/green_book_guidance_public_sector_business_cases_2015_update.pdf

[2] Latest version issued 27/11/17

2 Methodology

2.1 Overview

JAQU have provided detailed guidance regarding the appraisal of policy options. This provides a steer for many of the key data inputs and assumptions that have framed the analysis undertaken.

The key guidance documents include:

- Options Appraisal – Guidance (2017)[3] (and preceding versions of this guidance)
- National data inputs for Local Economic Models (2017)[4].

With respect to distributional analysis, the JAQU Guidance strongly leans on supporting WebTAG guidance issued by Department for Transport, DfT[5]. The methodology used to undertake the distributional analysis is based on this guidance. In some cases, we have sought alternative methods, or elaborated additional steps and assumptions where the study team felt that such approaches were warranted to facilitate or improve the analysis. In particular, this is the case where additional output metrics were deemed useful to convey the distributional impacts of the policy options. We have mapped the results where appropriate but in many cases the scale of the map made it difficult to clearly identify the geographic variation in the topic of interest. In these cases we have presented the data in tabular or graphical form.

Our approach is broadly defined by WebTAG covering the following three steps: Screening, assessment and appraisal.

2.2 Selecting options for assessment

The economics methodology report undertaken by the Ricardo team included a cost-benefit analysis (CBA) for two shortlisted policy options, these also are the options considered in this distributional analysis:

- *Stafford Street traffic management scheme:* this is a targeted set of traffic management measures designed to limit traffic flows along Stafford Street in order to achieve compliance with the NO_2 limit value in this location.

- *A benchmark Class D charging access restriction (Charging Scheme)*: this scheme would apply to all vehicles entering the area within the outer ring-road and is a benchmark charging access restriction scheme against which to test the traffic management option in terms compliance with the NO_2 limit values as soon as possible. The bus retrofit measures have not been included to avoid double counting of the compliance assumptions associated with the benchmark charging option. The traffic management option on Stafford Street has also not been included to ensure that the re-routing effects of the benchmark charging option were fully understood and that this test was not undermined by any potentially conflicting management schemes.

These scenarios will be compared to the Do Minimum option. This is the baseline business as usual scenario plus the key measure which could be modelled that has already received funding from Government. This is the Clean Bus Technology Fund (CBTF) bus retrofit programme that will bring the core bus fleet (some 152 vehicles) up to a Euro VI compliant standard.

[3] Unpublished – provided directly by JAQU to cities
[4] Unpublished – provided directly by JAQU to cities
[5] DfT (2015): 'WebTAG: TAG unit A4-2 distributional impact appraisal, December 2015'; https://www.gov.uk/government/publications/webtag-tag-unit-a4-2-distributional-impact-appraisal-december-2015

2.3 Screening of impacts

We have undertaken the screening process on the basis of the list of impacts listed in WebTAG A4.2 taking into account the likely local issues of the proposed policy options. A summary of the screening is included Table 1 below.

On the basis of the screening, the following effects have been 'scoped-in':

1. Air quality - changes in concentrations of NO_2
2. Affordability – including user benefits, considering both residents and local businesses
3. Traffic impacts – considered as changes in traffic as a proxy for noise and safety/accidents

Table 1 – Screening of WebTAG impacts

Impact	Description of impact	Screening assessment	
		Traffic management scheme	Charging scheme class D
Air quality	Change in NO_2 concentration	There will be changes in concentrations across the city and for different user groups in these locations.	There will be changes in concentrations across the city and for different user groups in these locations.
Affordability and user benefits			
User benefits	Changes in vehicle operating costs met by the user	Rerouting of traffic might have an impact on access to key amenities with public transport, both positive and negative.	Vehicle changes will be generated by this option and so there will be changes in operating costs (both positives and negative)
Affordability	Changes in user charges, including fares, tariffs and tolls;	There will be no changes in fares or tolls.	Charging CAZ will have significant impact on costs which will vary by vehicle ownership
Traffic and transport*			
Travel times	Changes in travel time	Redirecting the traffic will have both positive and negative impacts on bus journey times and car congestion.	Possible distributional impacts where diversion affects generate changes in traffic and journey times on individual links
Noise	Changes in noise levels – move in line with traffic on roads	Redirecting the traffic will have both positive and negative impacts on noise levels from traffic.	Possible distributional impacts where diversion affects generate changes in traffic on individual links
Accidents	Changes in accident rates – move in line with traffic / speed on roads	Small changes in traffic flows related to environmental corridors and demand management may influence accident levels.	Possible distributional impacts where diversion affects generate changes in traffic on individual links
Security	Any change in public transport waiting/interchange facilities including pedestrian access expected to affect user perceptions of personal security.	No changes are expected that would influence perception of security.	Charging CAZ will not impact on security. Could be indirect impact on public transport provision
Severance	Introduction or removal of barriers to pedestrian movement, either through changes to road crossing provision, or through introduction of new public transport or road corridors.	Bus priority measures are included but these are not expected to contribute to severance.	CAZ will not impact on physical road crossings
Accessibility	Changes in routings or timings of current public transport services, any changes to public transport provision, including routing, frequencies, waiting facilities (bus stops / rail stations) and rolling stock, or any indirect impacts on accessibility to services (e.g. demolition & re-location of a school).	The traffic management scheme is not expected to change public transport services or impact on physical access to services.	The charging scheme is not expected to change public transport services or impact on physical access to services. Although the consultation suggested some bus operators might considered changes to services.

Key Impacts screened in

Impacts screened out

2.4 Approach to assessing impacts

The approach to appraising each of the impacts closely follows the methodology set out in the JAQU and supporting WebTAG guidance. Namely, the 'impact variables' (describing how the impacts vary or are distributed across a geographic area) are overlaid with the 'grouping variables' (describing how different societal groups are distributed across the same area).

In most cases the appraisal is then made on the basis of splitting both the grouping and impact variables into quintiles, and then judging whether the impact on a given population group is proportionate to the representation of that group in the wider population (this type of analysis is referred to as 'quintile analysis' throughout this document). Not all of the impacts need to be appraised for each grouping variable. Table 2 indicates the impacts that should be appraised for each group.[6]

The overlay of impacts and groups was then undertaken on a LSOA basis, as defined in the guidance. The geospatial boundaries of each LSOA are available to download as a shapefile from the Office for National Statistics.[7] The datasets collected describing the social characteristics were joined to the spatial representation of the LSOAs to allow geospatial analysis of the social characteristics using a Geographical Information System (GIS).

Table 2: Impact categories in scope

Group	Air quality	Affordability	Traffic impacts
Deprivation / income	✓	✓	✓
Children	✓		✓
Old people			✓
Disability			✓
Sex			✓
Ethnicity			✓
Businesses		✓	

In order to assess the impacts of the policy option on the population, a number of datasets were obtained to identify the social characteristics of the population within the study area. These datasets provided information on several characteristics at the LSOA level. A description of the characteristics obtained and their data source is provided Table 3 below:

Table 3: Key data sources

Dataset	Description
Index of Multiple Deprivation (IMD)	The IMD gives an indication of the overall levels of deprivation in each LSOA and takes into consideration several factors including crime and employment deprivation. Lower IMD values correspond to areas with higher deprivation. This data is available from the Department for Communities and Local Government: English Indices of Deprivation 2015.

[6] We present some summary results also for air quality impacts for old, disability, sex, ethnicity and old people but these are not as detailed as for the children and income groups.

[7] http://geoportal.statistics.gov.uk/datasets/lower-layer-super-output-areas-december-2011-full-extent-boundaries-in-england-and-wales

Number of businesses	The number of businesses located in each LSOA is available, where a larger number represents a greater number of businesses located within the LSOA in question. This data is available from the Office for National Statistics nomis website, from the 2011 census data (UK Business Counts – local units by industry and employment band size).
Number of children, elderly and data on gender	The number of individuals of each individual age, split by gender, is available for each LSOA. The larger values for this characteristic represent a larger number of individuals of this characteristic in the total population. This data was available from the Office of National Statistics (Table SAPE19DT1: Mid-2016 Population Estimates for Lower Layer Super Output Areas in England and Wales by Single Year of Age and Sex). The data for 2016 was the most recent population data set available at the time of writing. The number of children was identified as the sum of those aged 16 or below, while the number of elderly was identified as the sum of those aged 65 or over. The proportion of females was identified by dividing the number of females in the population by the total population in each LSOA.
Disability	The comparative illness and disability ratio indicates the numbers of individuals in the LSOA that receive benefits due to the inability to work. This information is gathered from the UK Department for Work and Pensions and a higher value indicates a higher level of deprivation. The data is available from the Department for Communities and Local Government: English Indices of Deprivation 2015.
Ethnicity	The ratio of the number of non-white to white individuals in each LSOA was calculated to obtain an estimate of ethnicity in the area. The larger the ratio the greater the number of non-white individuals in the population. The data on the number of individuals classifying themselves in each ethnic class was available from the Office for National Statistics nomis website (Table LC2101EW – Ethnic group by sex by age).
Sensitive receptor data	Shapefiles showing the location of education establishments, hospitals and parks was obtained from OS Open Data. The location of community centres was obtained from OS Address Base Plus as this was not available through Open Data.
Operator license	The location (post codes) of businesses with HGV operator licences was obtained from data.gov.uk (Traffic Commissioners: goods and public service vehicle operator license records). Last updated Sept 2014.

In some cases, we have also produced alternative output metrics to help further explore and present the distributional nature of some of the impacts. For example, alongside the 'quintile analysis' for air quality, we also produce average changes in concentration by grouping variable quintile, and present the average changes in concentration at sensitive receptors. Table 4 sets out the appraisal approach for each of the impacts screened-in.

Businesses located in the various domains will be affected to some extent by the policy options. That extent will be determined by a number of parameters, including both the location of the business but

also the type of business (which in turn determines the likelihood of it operating vehicles, its reliance on deliveries, and potential impact on its supply chain). The spatial distribution of costs is not modelled as part of the economic analysis, hence impacts on businesses must be assessed 'indirectly' using proxies to illustrate where costs could fall.

Drawing on the JAQU guidance, we will undertake the following analysis which will help give a sense of how many businesses (in particular local businesses) may be affected by the CAZ:

1. Overlaying spatial data on business location/LGV ownership with CAZ areas. From this a count of potentially affected businesses can be derived.
2. Overlaying spatial data on non-compliant trips for LGVs/ HGVs within and destined for the CAZ area. Areas with the highest number of HGV or LGV trips the greater the assumed business impacts.

Table 4: Appraisal approach for each impact

Impact	Proposed Method	Notes	Outputs
Air quality	• Overlay NO_2 concentrations with population data to calculate change in population-weighted concentrations[8] • Concentrations will be produced as an average for each LSOA • Overlay mapping of concentrations with mapping of different groups at LSOA level • Groups covered: deprivation/income and children • Calculate average change in concentration by IMD / average children per household quintile • Calculate change in concentrations at sensitive receptors: Schools, Playgrounds, Parks, Hospitals, Care homes, Community centres	• Population weighted concentration results are used only as a single metric for each scheme for the whole modelling domain. • Average concentrations are used at the LSOA level as this is easier to understand and little is added by adding weighting by population as each LSOA is based on a similar population.	• Change in population weighted concentrations at the domain level for each scheme. • Average change in concentration by income decile / quintile of households with children • Average change in concentration at sensitive receptors • Quintile analysis (as described in WebTAG)
Affordability for businesses	• Mapping likely business impacted by or benefiting by each scheme • Explore key business data sets covering business numbers and type • Overlaying spatial data on business location/LGV ownership for each assessment area	• There will be a large level of uncertainty around any inferences drawn from mapping. Just because a business is located in/around the relevant areas, does not necessarily mean it will be impacted. • Nor can we tell how a business will be impacted, or whether the impacts will be 'affordable' • Cost / user benefit data is available through TUBA modelling	• Key risks and opportunities faced by each policy option. • Narrative of what type of businesses will be affected and pathways of impacts • Costs / user benefit at LSOA level
Affordability for households	• Mapping of non-compliant vehicle ownership data for the core travel to Derby assessment area. • IMD is the only characteristic to be explored and will be overplayed with ownership data	• Cost / user benefit data is available through TUBA modelling	• Key risks and opportunities faced by non-charging measures • Count of non-compliant vehicles by LSOA • Overlay with travel to Derby and IMD

[8] Air quality modelling will be drawn from wider modelling around the CAZ options. Hence domain of distributional analysis will match that of wider AQ modelling. This will cover intervention area and surrounding area to capture potential diversionary routes

Impact	Proposed Method	Notes	Outputs
	• Cost / user benefit analysis		quintiles • Costs / user benefit at LSOA level
Traffic impacts – Traffic flows (Noise / safety)	• Map changes in AADT by road link and average for each LSOA • Overlay with impact groups	• Specific noise / accident modelling is not available. Use traffic patterns as a proxy	• Proportion of links/LSOA experience increases in traffic flows • Count of links experiencing significant change in traffic for each income decile / other characteristics • Quintile analysis as per JAQU guidance
Traffic impacts- Journey times (Accessibility)	• Calculate change in total journey time across network for each scheme. • Calculate change in journey time between each LSOA and the city centre. • Ovelay with impact variables	• Journey time is used as a proxy for accessibility	• Change in total travel time for each scheme. • Count of LSOAs where travel time increases / decreases split by characteristic • Quintile analysis

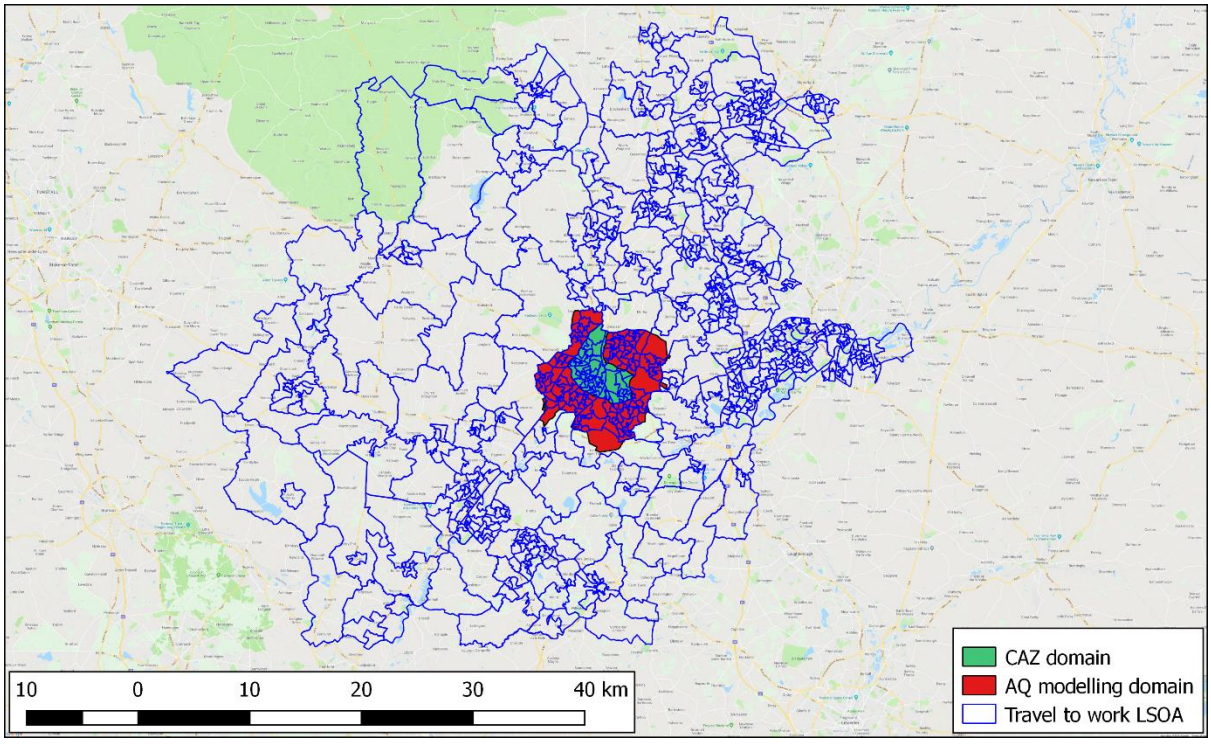
2.5 Defining the assessment domains

The full assessment domain for the distributional analysis needs to consider all those who would likely be affected by the scheme. Such an assessment domain has already been considered through the Derby Clean Air Incentive Scheme (CAIS) feasibility study and this domain will be used here. In additional to the full domain the assessment of the air quality impacts can only be carried out over the area for which the air quality modelling has been done, which is essential the city boundary.

The study domain developed for the CAIS feasibility study was designed to capture the majority of those who would be impacted by the introduction of the CAIS based on estimating a Derby Travel to Work (TTW) area. This analysis was conducted using 2011 Office for National Statistics (ONS) census data at Middle Layer Super Output Area (MSOA). The Derby travel to work (TTW) area was assessed using data of residents in each MSOA who drive a car or van to work in Derby.[9] A practical definition of the extent of the travel to work area was then based on the top 10% of all MSOA within the East and West Midlands, where residents drive a car or van to work in Derby.

As discussed in Section 2.4 the social characteristics were available at the LSOA level, which is more spatially detailed. Therefore, the boundary of the distributional analysis domain identified from the MSOA commuters was used to identify the LSOA within the same domain. Figure 1 shows the LSOAs contained within the TTW area. Figure 1 also shows the location of the TTW area in relation to air quality modelling domain, over which the air quality impact assessment is carried out, and the proposed Derby charging access restriction boundary for considering effects inside and outside this boundary.

Figure 1: Location of LSOA included in geographical scope of distributional analysis. Also shown is the location of the air quality modelling domain, and the area within Derby covered by the Charging Scheme.



[9] Location of usual residence and place of work by method of travel to work (MSOA level), Available from: https://www.nomisweb.co.uk/census/2011/wu03ew

2.6 Distribution of impact categories across the assessment domains

Six socioeconomic impact groups, as defined by the JAQU guidance, have been analysed in this distributional analysis and ranked as quintiles, with the first quintile meaning the lowest 20% and the fifth quintile the highest 20% of the population. The quintile ranking was based on the whole of England and Wales. In addition, IMD category, used as reference for the income, has also been evaluated in relation to our study area only (the Derby TWW). All the socioeconomic impact groups are summarised as follows:

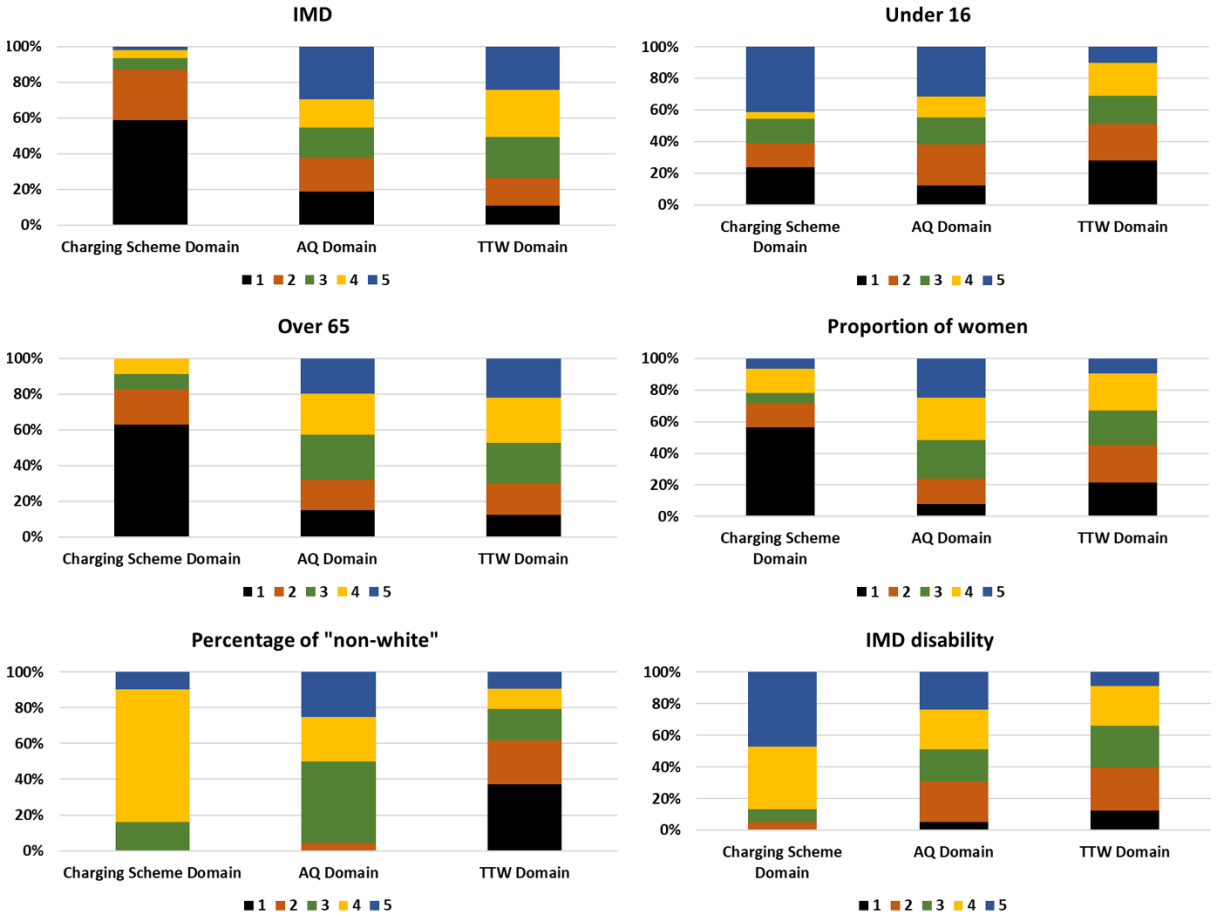
Table 5: Socioeconomic impact groups

Socioeconomic group	Domain of study for quintile calculations	Quintile 1 reference	Quintile 5 reference
Income (referred to as IMD)	TTW domain England	Most deprived population	Least deprived population
Under 16 (referred to as Children)	England and Wales	Lowest proportion of under 16 in the population	Highest proportion of under 16 in the population
Over 65 (referred to as Elderly)	England and Wales	Lowest proportion of over 65 in the population (at LSOA level)	Highest proportion of under 65 in the population (at LSOA level)
Proportion of women (referred to as women)	England and Wales	Lowest proportion of women in the population (at LSOA level)	Highest proportion of women in the population (at LSOA level)
Percentage of "non-white" (referred to as Ethnicity)	England and Wales	Lowest proportion of "non-white" in the population (at LSOA level)	Highest proportion of "non-white" in the population (at LSOA level)
IMD disability (referred to as disability)	England	Lowest ratio of population with disability in the population (at LSOA level)	Highest ratio of population with disability in the population (at LSOA level)

The quintile distribution for each impact group living within each of the assessment domains (Derby TWW, AQ modelling domain and charging scheme areas) is summarised in Figure 2. Some of the key points from these charts can be summarised as follows:

- The city centre area (within the Charging Scheme boundary) has the highest proportion of low income families, children under 16 and disabled compared to the other areas. As such improvements in air quality in this area will have greater benefits for these potentially disadvantaged groups.
- Conversely the wider TTW area has the lowest proportion of low income households, children and disabled people.
- The city centre also seems to have the lowest proportion of over 65s and 'non-white' households, but high proportions of females.
- More generally the distribution of these socioeconomic groups is more even outside the city centre.

Figure 2: Relative percentage of quintiles for each geographical zones and demographic groups.



Note: The total number of LSOAs within the different zones are as follows: 46 (Charing scheme area); 112 (AQ Domain excluding the charging scheme area); 544 (Remaining LSOAs inside the Travel to Work domain).

More detailed maps illustrating the quintile distribution for income (for the travel to work domain) and children under 16 are shown in Figure 3 and Figure 4. These maps highlight again that the city centre is dominated by the lowest quintile for IMD and a larger proportion of children living within and close to the city centre. Mapped results for the other socioeconomic groups are presented in Appendix 1.

Figure 3: Quintile plots of Income (Travel-to-work domain).

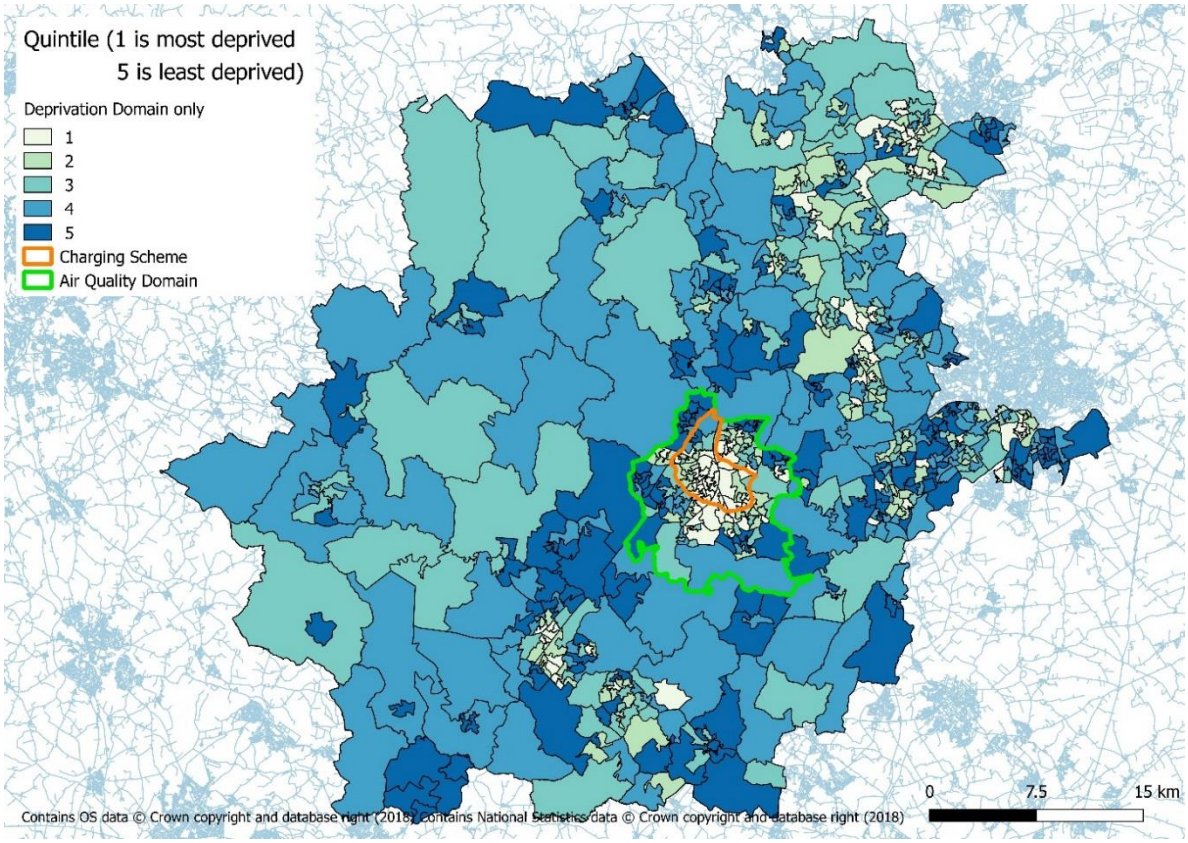
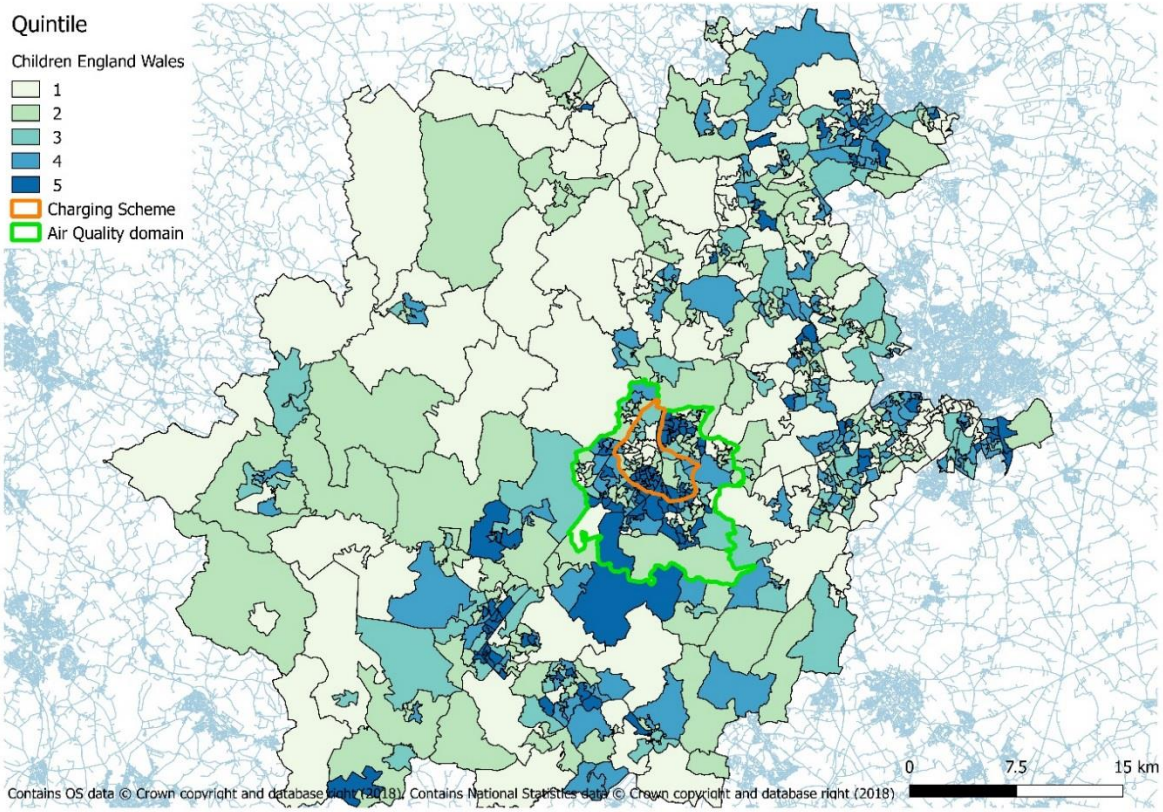


Figure 4: Quintile plots of Children (England and Wales)



3 Air quality appraisal

3.1 Overview of air quality results

The air quality modelling carried out to evaluate the policy option scenarios modelled NO_2 concentrations across Derby at a 1 m resolution. The resultant concentration contour map for the Do Minimum baseline and each of the options is shown below in Figure 5 to Figure 7.

These figures show that there is only a small difference between the do minimum situation and the traffic management scheme. Principally concentrations are significantly reduced on Stafford Street on the inner ring road, which is the compliance issue, with some small changes on other roads, such as Uttoxeter Old Road, as traffic is diverted. However, overall when considered at the LSOA area, as will be seen from the following analysis, the changes are essentially insignificant.

In contrast the charging scheme (CAZ D) shows significant improvements in air quality within the charged area. Again, this is borne out in the analysis at the LSOA level with concentrations being reduced within the charging area.

Figure 5 NO_2 modelled concentrations for baseline

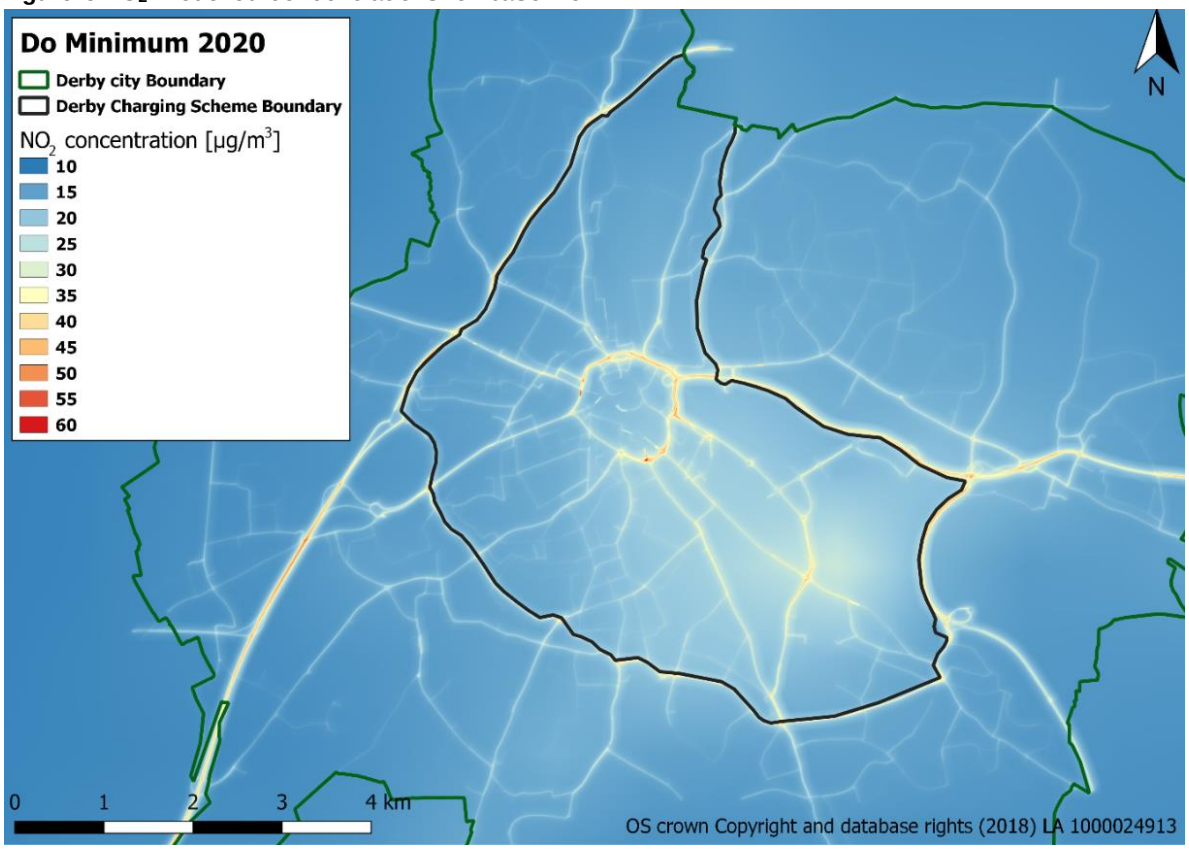


Figure 6 NO_2 modelled concentrations for Stafford Street traffic management scheme

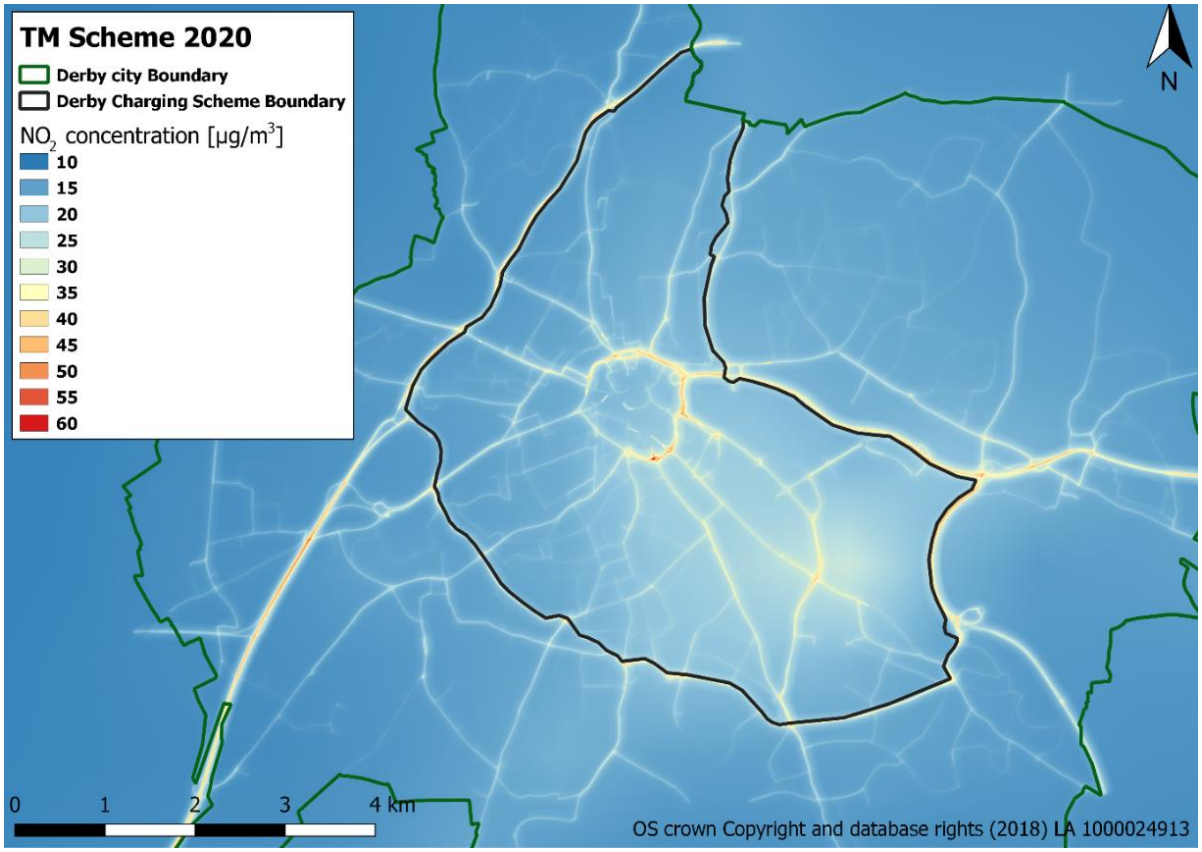
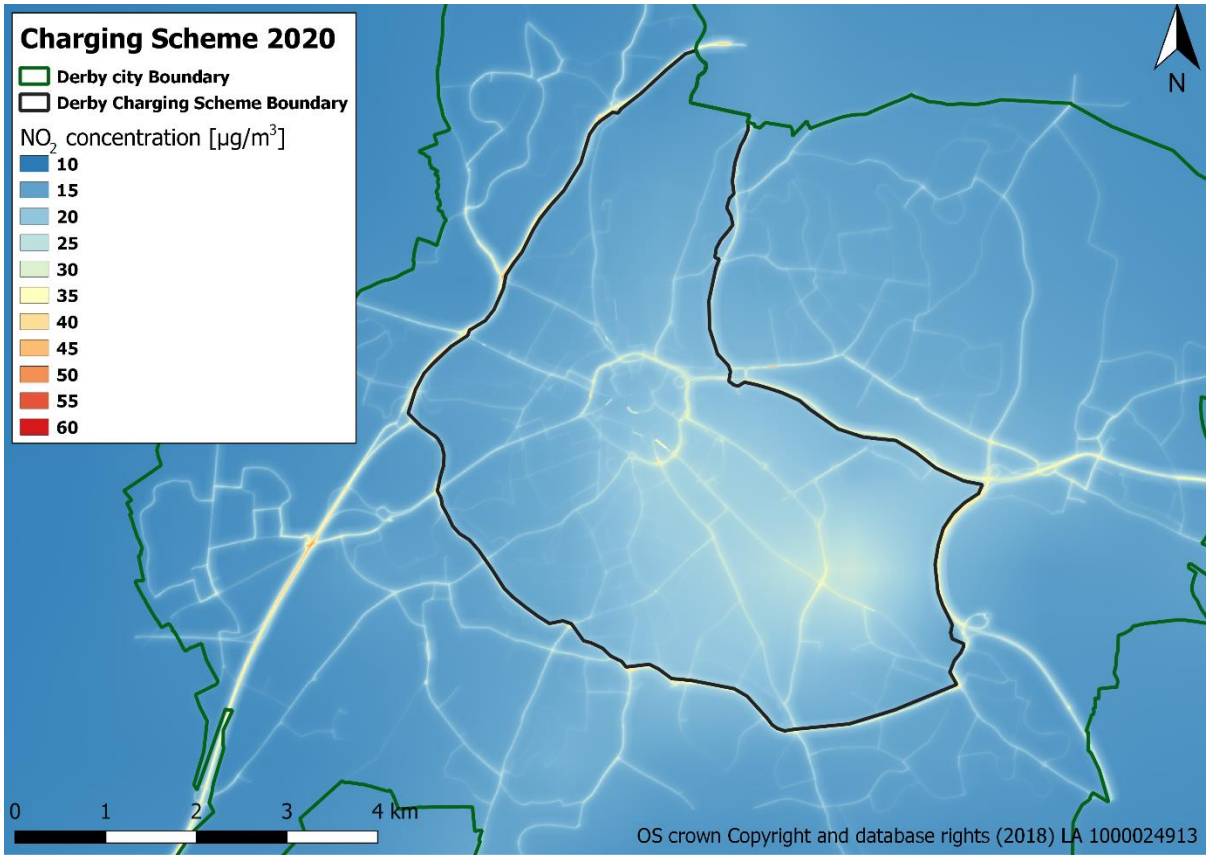


Figure 7 NO_2 modelled concentrations for charging scheme



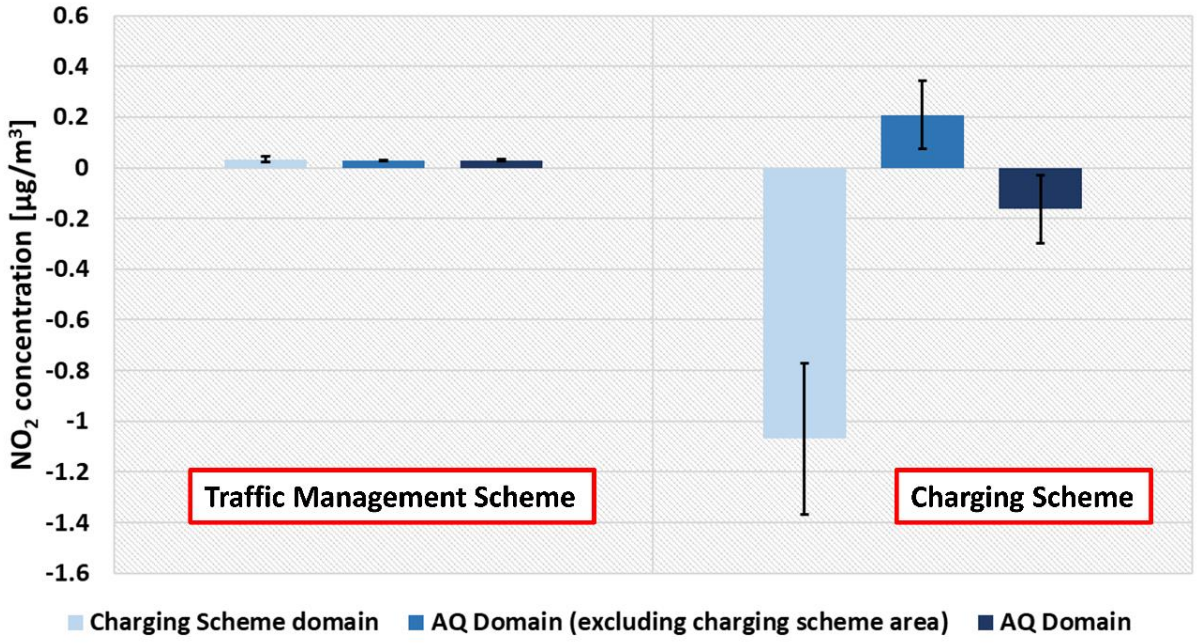
To assess the average NO_2 concentration for each LSOA falling within the air quality modelling domain in 2020 for the baseline and each of the modelled options, the calculation was carried out using the zonal statistics function in GIS. The number of LSOAs within the air quality modelling domain for which average concentrations could be calculated was 158 (only those LSOA with greater than half of their area in the modelling domain were included).

To evaluate the impact of the options on each LSOA, the change in the average NO_2 concentrations for each LSOA was calculated by subtracting the 2020 Do Minimum scenario (i.e. Baseline plus CBTF scheme) from the policy option. If the resulting change is *negative* this means there is an *improvement* in air quality as a result of the introduction of the policy option.

The results of this analysis are summarised in Figure 8 below for each of our three analysis zones. This shows that the traffic management scheme very small absolute change in modelled NO_2 concentrations and can be considered as neutral on average across the three assessment areas. In comparison this basic analysis shows the following impacts in each area for the Charging Scheme:

- *Within Charging Scheme area*: The Charging Scheme shows a significant reduction in NO_2 concentration in that area, as expected.
- *Outside the Charging Scheme:* The charging scheme shows an increase, related to the diversion of traffic around the charging area which increases emissions.
- *Across the whole modelling domain: T*he Charging Scheme reduces average concentrations, due to a very strong decrease within the charging scheme area.

Figure 8: Difference in average NO_2 concentration (in µg/m^3) between the modelled scenarios and the Baseline 2020 for each of the assessment zones



Full maps of average difference in NO_2 concentrations, for each option compared to the baseline, by LSOA are provided in Appendix 3.

3.2 Socioeconomic quintile analysis

3.2.1 General analysis

The following analysis explores the distribution of average NO_2 concentrations for each of our socioeconomic impact groups, with a focus on low income groups (IMD) and children under 16. Table 6 and Table 7 present the average concentration, and average change in concentration under the charging scheme option, split by IMD and proportion of children quintiles, relative to the 2020 Do Minimum.

Table 6: Modelled NO_2 concentration differentiated by IMD quintile (reference whole model domain) for the baseline, the traffic management schema and the Charging scheme.

Option	Income IMD	Most deprived				Least deprived
	Quintile domain	1	2	3	4	5
2020 BASELINE	Average NO_2 concentration ($\mu g/m^3$)	18.79	16.51	15.93	15.25	14.17
2020 Traffic Management Scheme	Average NO_2 concentration ($\mu g/m^3$)	18.83	16.53	15.97	15.29	14.19
	Absolute difference in NO_2 concentration to baseline ($\mu g/m^3$)	0.04	0.02	0.03	0.03	0.03
	Relative difference in NO_2 concentration to baseline (%)	0.19	0.11	0.21	0.22	0.19
2020 Charging Scheme	Average NO_2 concentration ($\mu g/m^3$)	18.13	16.01	16.27	15.27	14.67
	Absolute difference in NO_2 concentration to baseline ($\mu g/m^3$)	-0.67	-0.50	0.34	0.02	0.50
	Relative difference in NO_2 concentration to baseline (%)	-3.54	-3.04	2.13	0.13	3.56

For the baseline situation the analysis shows that concentration of NO_2 are highest for the lowest income groups indicating that these groups tend to live in areas with more traffic and congestion. Therefore, there is a clear existing inequality in the burden of air pollution in Derby when looking through the lens of income distribution.

The picture is somewhat more complicated for children. In the baseline the areas with the highest proportion of children have the highest levels of pollution. However, there is no clear trend between proportion of children and air quality with the second worst NO_2 concentrations occurring in the area with the least children.

The implementation of a traffic management scheme will have a much lower impact in terms of air quality (NO_2 concentrations) than a charging scheme. With a traffic management scheme, there would be a very slight increase of around 0.2% in NO_2 concentrations, evenly distributed among the income (Table 6) and children quintiles (Table 7). Therefore, the traffic management scheme would not have a disproportionate impact on any type of population.

For the charging scheme, however, we can see reductions in pollution for all income groups, and we can see a clear impact trend of the scheme in relation to income group. The overall trend remains the same, with lower income groups still experiencing the highest levels of pollution, but the reductions generated by the charging scheme are greatest for low income groups so this inequality is being reduced. This result is likely to be caused by the charging scheme as it shows increasing levels of NO_2 outside the charging zone where higher income groups live.

The charging scheme shows a similar trend in relation to children, with all groups seeing a reduction but households with the least children showing the greatest reduction. Therefore there is a distributional impact observed for children, with the air pollution deteriorating with increasing quintile, with areas with the highest proportion of children suffering from an increase in air pollution.

Table 7: Modelled NO_2 concentration differentiated by "Under 16s" quintile for the baseline and all the scenarios.

Option	Under 16 (quintile)	Lowest proportion 1	2	3	4	Highest proportion 5
2020 BASELINE	Average NO_2 ($\mu g/m^3$)	16.55	16.00	16.17	15.74	17.15
2020 Traffic Management Scheme	Average NO_2 concentration ($\mu g/m^3$)	16.56	16.04	16.19	15.78	17.19
	Absolute difference in NO_2 concentration to baseline ($\mu g/m^3$)	0.01	0.03	0.03	0.03	0.03
	Relative difference in NO_2 concentration to baseline (%)	0.07	0.21	0.16	0.22	0.20
2020 Charging Scheme	Average NO_2 concentration ($\mu g/m^3$)	16.11	15.69	15.95	15.70	17.20
	Absolute difference in NO_2 concentration to BASELINE ($\mu g/m^3$)	-0.43	-0.32	-0.22	-0.04	0.05
	Relative difference in NO_2 concentration to BASELINE (%)	-2.61	-1.97	-1.33	-0.27	0.28

An alternative view of the data is seen by counting the number of LSOAs experiencing an improvement or a deterioration of air quality in terms of NO_2 and this is shown in Table 8 and Table 9 below. When carrying out this analysis it was clear that the changes in average NO_2 concentration for the traffic management scheme were so small so as not to be significant or reliable in calculating the number of LSOAs with increasing or decreasing concentrations. As such we have not reported this analysis further as it is likely to be misleading. Therefore the analysis in **Table 8** and Table 9 only includes the charging scheme.

The charging scheme improves air quality for the majority of the population within Derby, but a non-negligible part of the population will see its air quality deteriorate. This is due to the diverting traffic increasing concentrations around the charging zone.

In terms of the impact of the charging scheme on income quintiles the picture is similar to when considering average concentrations. The greatest benefit is for low income areas and the smallest benefit is for high income areas. In relation to children under 16 the picture is more complex. Those in the highest quintile have both the greatest number of areas showing an improvement and the equal greatest showing a deterioration. So although there is a general improvement in air quality for the areas with the highest proportion of children, this is balanced by some worsening. This is due to a larger proportion of those areas being in the charging scheme domain compared to the overall air quality domain, as illustrated in Figure 2.

Table 8: Number of LSOAs and population with an improvement or a deterioration of NO_2 concentration (relative to baseline), disaggregated by IMD quintile (reference whole model domain) for the Air Quality domain.*

Option	Income IMD	Most deprived ←				→ Least deprived	
	Quintile domain	1	2	3	4	5	Total
Charging Scheme	Number of LSOAs with improved air quality	39	23	11	8	12	93
	Population with improved air quality	72,871	41,063	19,020	12,886	18,670	164,510
	Number of LSOAs with a worsening of air quality	10	12	9	12	22	65
	Population with a worsening of air quality	16,833	18,712	14,661	18,671	33,942	102,909

* The traffic management scheme is not presented in this table as the absolute differences are too small (less than 0.05 $\mu g.m^{-3}$ in absolute change of NO_2 concentrations) to be presented as an improvement or worsening in air quality.

Table 9: Number of LSOAs and population with an improvement or a deterioration of NO_2 concentration (relative to baseline), disaggregated by Children quintile (reference England and Wales) for the Air Quality domain.

Option	Children	Lowest proportion ←				→ Highest proportion	
	Quintile	1	2	3	4	5	Total Population
Charging Scheme	Number of LSOAs with improved air quality	18	16	17	8	34	93
	Population with improved air quality	32,214	25,195	27,349	13,734	66,018	164,510
	Number of LSOAs with a worsening of air quality	7	20	9	9	20	65
	Population with a worsening of air quality	9,574	30,363	13,710	15,703	33,469	102,909

* The traffic management scheme is not presented in this table as the absolute differences are too small (less than 0.05 $\mu g.m^{-3}$ in absolute change of NO_2 concentrations) to be presented as an improvement or worsening in air quality.

The rest of the demographic groups are summarised in Table 10. All the demographic groups have an air quality improvement within the charging scheme area, and the magnitude of improvement is in correlation with the population living in the zone. As an example, the areas with the lowest proportion of women have the best air quality improvement, as almost half of the lowest quintiles for this group are living within the CAZ domain (Figure 2). For the whole air quality domain, the distribution among quintiles remain similar for the groups but some part of the population will experience a worsening of their air quality, due to the rerouting of the traffic outside the Charging Scheme. No clear distributional impact can be derived except for the elderly group, with a global worsening of air quality with increasing quintiles.

Table 10: Difference in NO_2 concentration (in µg/m^3) between the Charging Scheme and the Do Minimum Scenario as well as the traffic management scheme and the Do Minimum scenario for the four demographic groups.

Charging Scheme	Demographic group	Lowest ratios ← 1	2	3	4	Largest ratios → 5
Charging Scheme Charging Scheme domain	Elderly (over 65s)	-0.96	-1.96	-0.52	-0.42	N/A*
	Proportion of women	-1.56	-0.40	-0.39	-0.42	-0.55
	Proportion of "non-white"	N/A*	N/A*	-0.44	-1.59	-0.58
	Proportion of population with disabilities	N/A	-0.40	-0.52	-1.07	-1.18
Charging Scheme AQ domain	Elderly (over 65s)	-0.23	-0.65	-0.09	0.00	0.26
	Proportion of women	-0.98	-0.02	0.10	0.18	-0.02
	Proportion of "non-white"	N/A*	-0.26	0.21	-0.64	-0.08
	Proportion of population with disabilities	0.11	0.54	0.25	-0.38	-0.69
Traffic management Scheme AQ Domain	Elderly (over 65s)	0.03	0.03	0.03	0.03	0.03
	Proportion of women	0.02	0.04	0.03	0.03	0.03
	Proportion of "non-white"	N/A*	0.04	0.03	0.01	0.04
	Proportion of population with disabilities	0.03	0.03	0.04	0.02	0.03

* N/A refers to quintiles that are not represented in the charging scheme or the AQ domains.

3.2.2 Traffic management scheme – link level analysis

The results above showed small impacts (positive or negative) of the traffic management scheme on air quality throughout the city when averaged across LSOAs. However, as this measure would only be effective near Stafford Street, a more localised assessment is needed.

The main predicted flow impacts of the preferred traffic management scheme are as follows:

- Significant reduction in the use of Stafford Street realising the main objective of the scheme.
- Significant reductions in traffic on the western and northern parts of the Inner Ring Road between Uttoxeter New Road and the A52 at Eastgate.
- Large reduction in traffic on Uttoxeter New Road and Ashbourne Road with significant proportions of this traffic transferring to other radial routes such as Kedleston Road and Duffield Road to access the city centre.
- Significant increase in traffic on Uttoxeter Old Road which is being enhanced to be an alternative route to Stafford Street as part of the scheme.

These changes are then reflected in the 2020 road transport NOx emissions as reported in Figure 9 and 10 (Also in Appendix 3). In this central area NOx emissions will decrease by between 10% to 50% on Uttoxeter Road, Stafford Street and Ford Street. But due to the rerouting of traffic, adjacent currently less trafficked roads like Uttoxeter Old Road would suffer from an increase of NOx emissions by more than 50%. This explains why an average of air quality results at LSOA level was difficult see

for this scenario. However, it does show that at this detailed level of individual roads there is a distributional impact with some residents seeing air quality benefits and others a disbenefit. However, since these roads all lie in areas with a similar demographic, more deprived and older than other areas (see Figures 3 and 4), there is not significant difference between social groups.

Figure 9: Difference in NOx emissions (in g/km/s) between the Traffic Management scheme (TM) and the Baseline (DM)

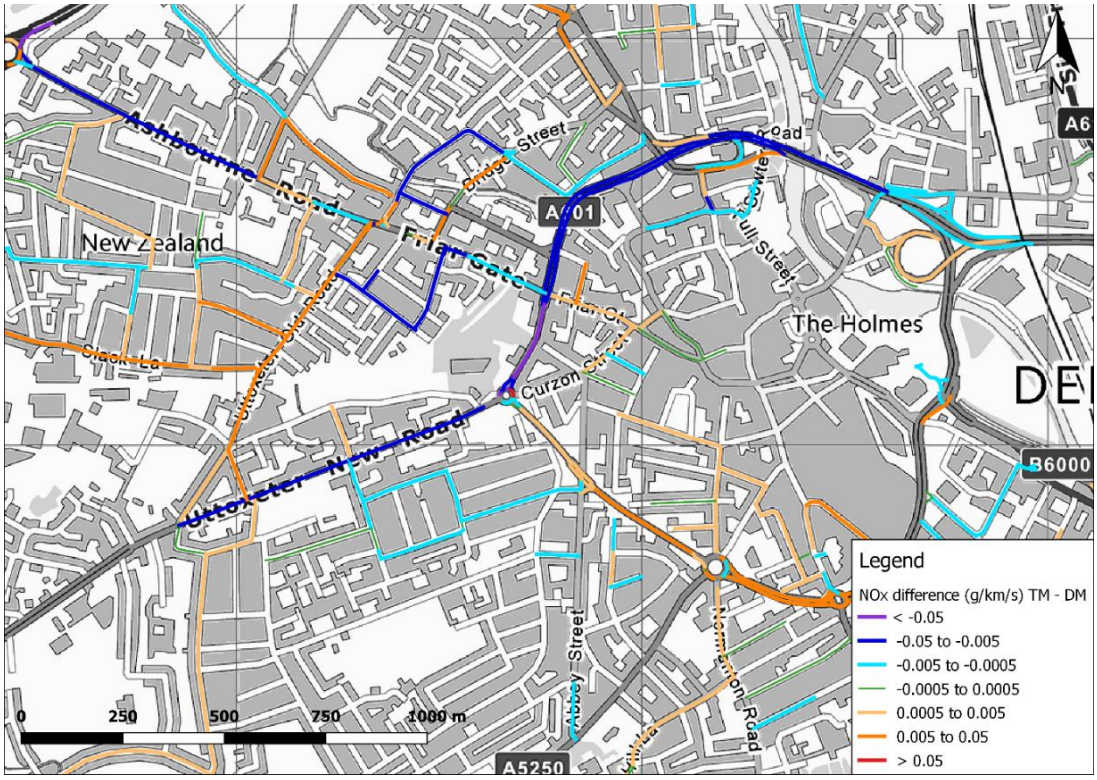
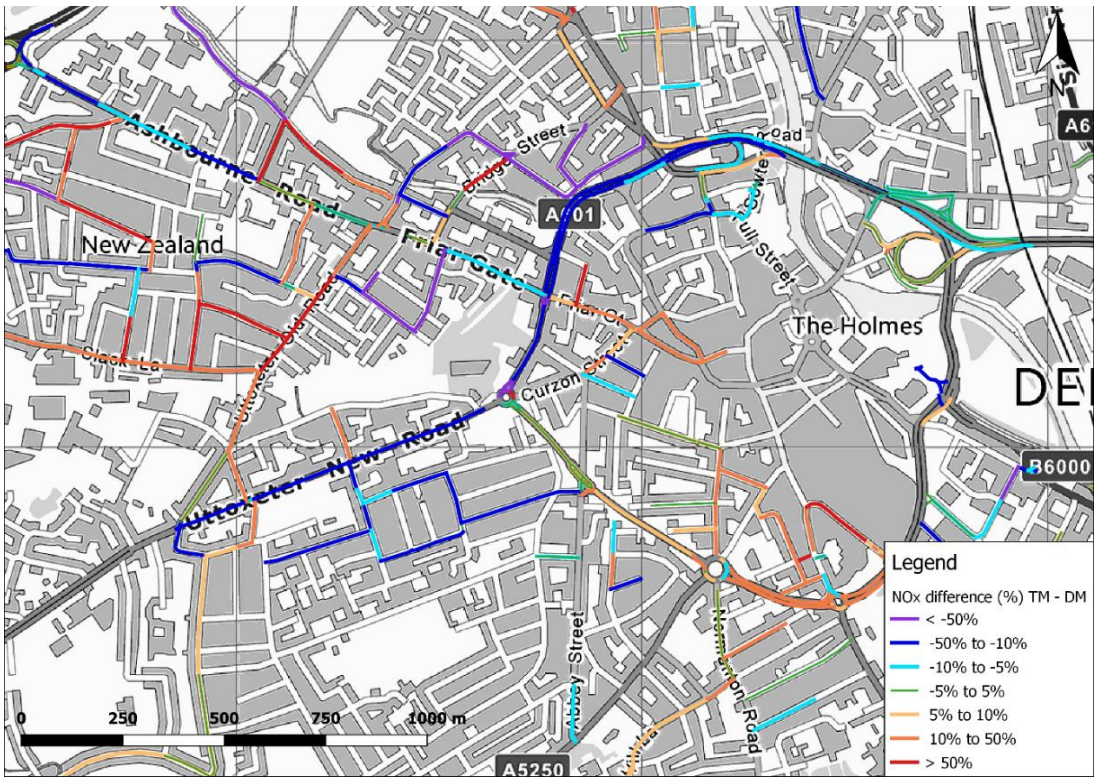


Figure 10: Difference in NOx emissions (in %) between the Traffic Management scheme (TM) and the Baseline (DM)



3.3 Analysis of sensitive receptors

Sensitive receptors in Derby are divided into 11 categories based on the TAG Unit A4.2 Distributional Impact Appraisal as follows:

- CC04: Public and Village Halls
- CE02: Nursery/Creche
- CE03: Primary, Junior, Infants or Middle School
- CE04: Secondary School
- CM03: Medical, Hospitals and Hospices
- LP01: Public Parks and Gardens
- LP02: Public Open Spaces and Nature Reserves
- LP03: Playgrounds
- RI01: Care/Nursing Homes
- RI02: Communal Residences
- RI03: Residential Education

The NO_2 concentration has then been calculated at each these receptors for the Do Minimum and each of the modelled options. From this an average absolute difference in concentrations for each receptor type has been calculated for each scenario. The results of this are illustrated in Figure 11. To provide some locational context Figure 12 shows the proportion of each receptor type within the charging zone boundary.

Implementing a Charging Scheme will lead to a significantly larger decrease in NO_2 concentrations for all receptor types, whilst a very small increase is experienced with a traffic management scheme. With the traffic management scheme only a redirection of traffic in the vicinity of Stafford Street is considered (where the largest decrease in NO_2 concentrations are modelled) and therefore it is not having an significant influence over the wider domain.

On the other hand, all receptors types see an improvement in air pollution with the introduction of a charging scheme. The least impacted receptors are open spaces (LP02) and hospitals (CM03), which have less or no prevalence in the central area where the charging scheme has most impact. In general, those receptors that have a greater prevalence within the charging scheme are showing, with those having the highest concentration within the charging scheme area, nurseries, cares, communal residences and educational residences (CE02, RI01, RI02 and RI03) seeing the greatest benefits.

Figure 11: Absolute Difference in NO_2 concentration between the modelled scenarios and the Do Minimum 2020, disaggregated by the 11 groups of sensitive receptors

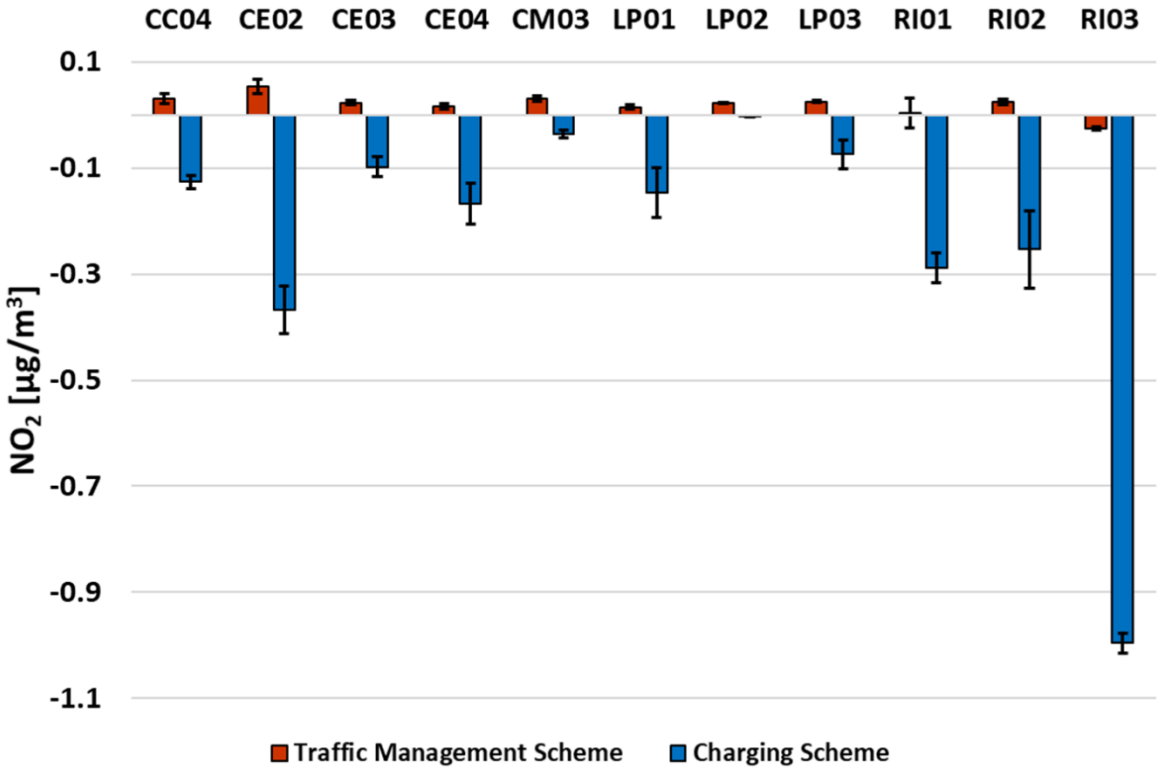
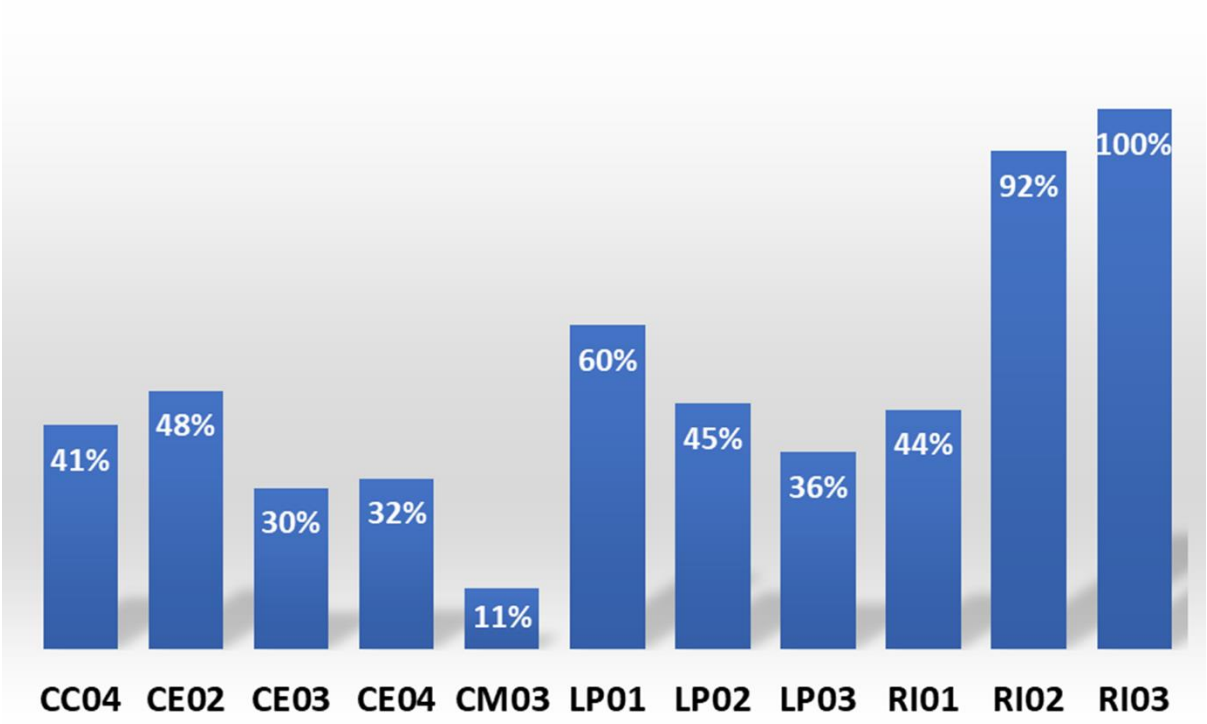


Figure 12: Percentage of groups of receptors located in the Charging Scheme boundary



3.4 Summary

The geographical distribution of changes in NO_2 concentrations does vary between the options. In simple terms the traffic management scheme results in almost no change in air quality compared to the Do Minimum, when considered on the LSOA level. However, it does generate very local differences on a road by road basis as traffic is shifted as a result of the scheme. Near Stafford Street, the air quality is expected to improve for the population living near Uttoxeter Road, Stafford Street and Ford Street. However, adjacent roads such as Uttoxeter Old Road might suffer from an air quality deterioration. The charging scheme on the other hand would lead to a greater improvement within the charging scheme boundary but it will be accompanied by deteriorating air quality outside the zone as a result of diverting traffic.

The analysis in relation to demographic data at the LSOA level reflects this basic picture and allows an assessment of the distribution of impacts for key socioeconomic groups (primarily IMD and children under 16). Again in terms of the traffic management scheme its city-wide impact is so small as to have no distributional impact across different social groups. In contrast the charging scheme shows a benefit for those inside the zone and a dis-benefit for those outside the zone. This results in a disproportional impact on groups with higher prevalence outside the charging zone, principally those in the higher income quintiles and those with a greater proportion of children.

That said, the most deprived population and the population with the lowest proportion of children (representative of the residents inside the CAZ boundary) would have an air quality improvement with the charging scheme, while the least deprived population indicate a worsening which somewhat increases as the IMD quintile increases.

Looking at sensitive receptors, again, the traffic management scheme shows small increases in air pollution which can be considered not significant. The charging scheme however indicates a general improvement for all receptors, with the highest reduction in NO_2 concentrations experienced for residential education.

Overall this suggests that the traffic management scheme has no clear distributional impacts at the population level. However, it will have some very localised impacts that should be considered in terms terms of mitigation measures. In contrast the CAZ D charging scheme has clear distributional impacts. impacts. These results are summarised in

Table 11 and Table 12 below, using the WebTAG analysis guidance.

Table 11: Impact appraisal matrix: Air quality

Grouping variable	Scenario	Distributional impact – quintile					Are impacts distributed evenly?	Key impacts
		1	2	3	4	5		
IMD	Traffic Management Scheme	-	-	-	-	-	Yes	The traffic management scheme has no relevant distributional impact on air quality.
	Charging Scheme	✓✓✓	✓✓	XX	X	X X	No	The large majority of LSOAs observe improvement in air quality, but with the greatest benefit felt by the lowest quintiles so a clear distributional impact.
Children	Traffic Management Scheme	-	-	-	-	-	Yes	The traffic management scheme has no relevant distributional impact on air quality.
	Charging Scheme	✓✓✓	✓✓	✓✓	✓	X	No	The large majority of LSOAs observe improvement in air quality, but with the greatest benefit felt by the lowest quintiles so a clear distributional impact.

Table 12: Summary of air quality distributional impacts

Scenario	Summary assessment
Traffic Management Scheme	- • The changes in NO_2 concentrations at LSOA level are too small to be relevant, therefore the traffic management scheme has no overall distributional impact on the population. However, the population living near Stafford Street and the A601 should benefit from an air quality improvement, whereas the population living in the surrounding roads (e.g. Uttoxeter Old Road) will experience some dis-benefit.
Charging Scheme	✓ • The majority of LSOAs see an improvement in air quality. • This improvement is greatest for the most deprived population and the areas with the lowest proportion of children, representative of those living within the charging scheme area. • The receptors located inside the charging scheme boundary observe strong air quality improvement on average, with the greatest benefit being for educational residences. Receptors outside the charging scheme are on average also beneficial although with a smaller reduction in NO_2 concentrations.

Note:

- no impact

X negative impact

✓ positive impact

4 Affordability for businesses

4.1 Impacts of the policy options

The two options considered will have impacts of different scope and scale on business. Some of these will be direct (where the policy option targets a business directly) and some will be indirect (where the policy option influences a set of factors which will in turn affect a business). How a business will be impacted by the policy option is broadly dependent on their reliance on transport services, the composition of any fleet they may own and the size of their operations.

- Cleaner fleets and vehicles will benefit from policy options seeking to improve air quality. They will be best placed to take advantage of potential changes in demand towards cleaner vehicles and will not be subject to any mandatory charges, although they will not be able to take advantage of any incentives provided to upgrade their fleet.
- Older, dirtier fleets will be negatively impacted by a change in demand and will potentially face upgrade costs to take advantage of a changing market or be subject to mandatory charges.

Table 13: Relevant policy options for business and their direct impacts

	Traffic Management scheme	Charging Scheme
Relevant measures for HGVs	-	£100/day
Direct impacts on HGVs	-	Compliance cost to the operators of non-compliant vehicles depending on behavioural response. (↓ - 5)
Relevant measures for LGVs	-	£12.50/day
Direct impacts on LGVs	-	Compliance cost to the operators of non-compliant vehicles depending on behavioural response. (↓ - 5)
Relevant measures for Buses/ Coaches	-	£100/day
Direct impacts on Buses/Coaches	-	Compliance cost to the operators of non-compliant vehicles depending on behavioural response. (↓ - 5)
Relevant measures Taxis/PH	-	£12.50/day
Direct impacts on Taxis/PH	-	Compliance cost to the operators of non-compliant vehicles depending on behavioural response. (↓ - 5)

Impact - ↑ = minor positive impact, ↑↑ = positive impact, ↓ = minor negative impact, ↓↓ = negative impact ↑/↓ = mixed impact.
Confidence - 1-5 = low confidence – certainty.

Table 14: Relevant policy options for business and their indirect impacts

Impact Categories	Traffic management scheme	Charging Scheme
Workforce	Workforce may take up public transport as an alternative. (↑/↓ - 1)	Employees may be charged for commuting. May have impacts on car sharing and also commuting patterns which leads to increased commuting time. (↑/↓ - 2)
Operations	Redirecting global traffic in the city might influence delivery time to/from the business (↑/↓ - 2)	Deliveries to/from the business may increase in cost, if done so via a non-compliant vehicle. Or delivery time may increase if operator avoids charging area. (↓ - 4)
Customer preference	-	Customer attitudes may shift, which results in preference for businesses operating cleaner vehicle fleet. (↑/↓ - 2)
Customer numbers	Increase in number of people taking public transport. (↑/↓ - 1)	Charging scheme may deter customers from driving to centre of town. (↓ - 3)
Health impacts	Improved productivity and wellbeing of workforce (↑ - 1)	Improved productivity and wellbeing of workforce (↑ - 2)

Impact - ↑ = minor positive impact, ↑↑ = positive impact, ↓ = minor negative impact, ↓↓ = negative impact ↑/↓ = mixed impact.
Confidence - 1-5 = low confidence – certainty.

The policy options will be introduced into a fast-changing landscape. For example: public awareness of AQ issues is rapidly increasing, EV vehicles are being taken up more quickly than initially anticipated and commuting via cycling is increasing in popularity. As a result indirect impacts it will be very difficult to define the additional impact of a policy option compared to the baseline.

An example of difficulty in attribution is a potential change in consumer demand resulting from the policy option. Markets are likely to favour cleaner transport services in the baseline as the fleet upgrades and as the general public and business become more aware of the impacts of poor air quality. This will occur in the absence of any of the policy options considered. But will the policy options change the pace of these shifts in demand? The Charging Scheme sends a strong behavioural signal to all vehicles, not only non-compliant vehicles, entering the Charging Scheme area. Such signalling could have consequences beyond those which traditional economic modelling would suggest. So, yes in theory the policy option could create a change in market conditions, but baseline conditions are likely to dominate.

4.2 Risks

Whether a policy option is affordable or unaffordable determines its effectiveness depending on the policy goals. In general terms, a subsidy should make a desired outcome affordable, while a charge should be sufficiently large to change behaviour.

Affordability considerations are relevant to the policy options considered in the following ways:

- **Stafford Street traffic management scheme:** No affordability risks are predicted with this measure. As it is meant to limit traffic flow along Stafford Street and does not target a specific class of vehicles or users.
- **Charging Scheme –** A business may not be able to pay the CAZ charge or to upgrade to a compliant vehicle. However, it is possible that the charge is set at too low level, which is too affordable, and doesn't change behaviour.

Predicting a company's response to an incentive is difficult because operational data is difficult to come by and the decision-making process of a business is opaque. Therefore, modelling the right level of a charge is a process fraught with uncertainty. The behavioural responses to the incentives used in our analysis to date, which contain assumptions about affordability, are based on best available evidence and guidance. However, these assumptions are in aggregate terms. In this paper we explore the distributional impacts that these high-level figures do not consider.

Where the policy is unaffordable

The policy option of greatest concern is the Charging Scheme. Unlike the traffic management scheme, it is mandatory for non-compliant vehicles entering the relevant area. If the charge is unaffordable, a business may:

- Cancel trip / activity (but carry on other unaffected operations) – with potential subsequent impacts on economic activity in Derby (and potentially jobs)
- Shift locations outside Charging Scheme – potentially with an impact on jobs and 'local' economic activity if the shift is far enough.
- Reduce the size of operations
- Go out of business altogether – impacting on jobs and activity in Derby

As stated, modelling these responses is particularly difficult. There is also scant evidence from existing charging schemes. But we do know the freight sector is highly competitive and has a lower-than-average survival rate for new businesses. In London in 2008, the year the London LEZ was introduced, 3250 new freight companies were created in the UK; however, only 37.7% of these new businesses were still operational 5 years later, compared to an average survival rate of 41.3% for all economic activities.[10] When considering this survival rate, it is important to recognize that it is impossible to isolate the effects of the London LEZ from wider economic contexts, such as an ongoing trend in the freight industry towards consolidation (i.e., towards fewer firms with larger fleets) and the impacts of financial recessions since 2008. Therefore wider market conditions, rather than a specific policy option could be a larger impact than any policy option.

Where the policy is affordable

If businesses choose to 'pay the charge' or upgrade in response, it could be assumed that the business can 'afford' the compliance costs placed on it, at least in the short-run. These responses will still carry additional direct costs for businesses, but they are deemed 'affordable' as either businesses can:

1. Pass through to customers
2. Can internalise the costs with limited risk to the ongoing viability of the business.
3. A combination of the above

The Stafford Street traffic management scheme is not expected to impact specific vehicle types or users in a general sense, unlike a charging scheme that targets certain classes of vehicles. Its main consequence would be to limit traffic flows on Stafford Street which may have an impact on specific businesses accessing this area through changes in travel time, but this would not have a wider impact across the city. As such the remainder of this section focuses on the impacts of the charging scheme.

[10] AEA Technology Environment, "The London Low Emission Zone Feasibility Study: A summary of the phase 2 report to the London Low Emission Zone Steering Group," July 2003, https://tfl.gov.uk/cdn/static/cms/documents/phase-2-feasibility-summary.pdf, accessed 25/04/2018.

4.3 Focus on vehicle types

4.3.1 Impacts on Heavy Goods Vehicles

4.3.1.1 Numbers of vehicles

O-Licence data contains licensing information for goods and public service vehicle (PSV) operators[11]. Table 15 and Figure 13 present the number of businesses and registered vehicles within the two domains of focus. The O-Licence data covers a number of different vehicles. An O-Licence is required for a goods vehicle if its maximum weight is over 3,500 kg tonnes, or if it has an unladen weight of more than 1,525 kg[12]. An O- Licence is *also* required for a PSV when they operate a vehicle for hire or reward which can carry over 9 passengers, or operate a smaller vehicle charging separate fares for the journey[13]. Therefore, the dataset does not represent only HGVs. It can also include coaches or minibuses. For the purposes of this analysis we assume that O-Licence data is considered to be representative of the distribution of HGVs.

Overall there are approximately 1,400 O-Licence operators in the Derby travel to work (TTW) region, with close to 15,500 registered vehicles. Of these, 128 operators are located within the city-wide Charging Scheme area (operating 1,600 vehicles). It is important to note that this only shows where vehicles are registered, not where they travel and many of those registered outside the Charging Zone will frequently travel into it.

The Charging Scheme and TTW domains contain roughly similar profiles of operators. The largest proportion of operators have just one vehicle (37% in the Charging Scheme, 38% in the TTW) and the majority of vehicles (72% Charging Scheme and 80% TTW) are owned by operators with fewer than 10 vehicles. This suggests that smaller operators dominate the landscape in the Derby.

The data shows that there are proportionally more HGVs per business (UK Business Counts[14]) situated in the TTW than in the Charging Area. This is not a surprising finding as it is expected that operators will situate themselves outside the centre of Derby.

Table 15: O Licence Data for Derby (2018) [15]

	Operators	Total vehicles	Average vehicles per operator	Operators / Business	Vehicles / Business
Charging Area	128	1667	13	0.02	0.26
TTW	1358	15526	11	0.03	0.31

[11] DfT, (2014) Traffic Commissioners: goods and public service vehicle operator licence records, Available at: https://data.gov.uk/dataset/2a67d1ee-8f1b-43a3-8bc6-e8772d162a3c/traffic-commissioners-goods-and-public-service-vehicle-operator-licence-records

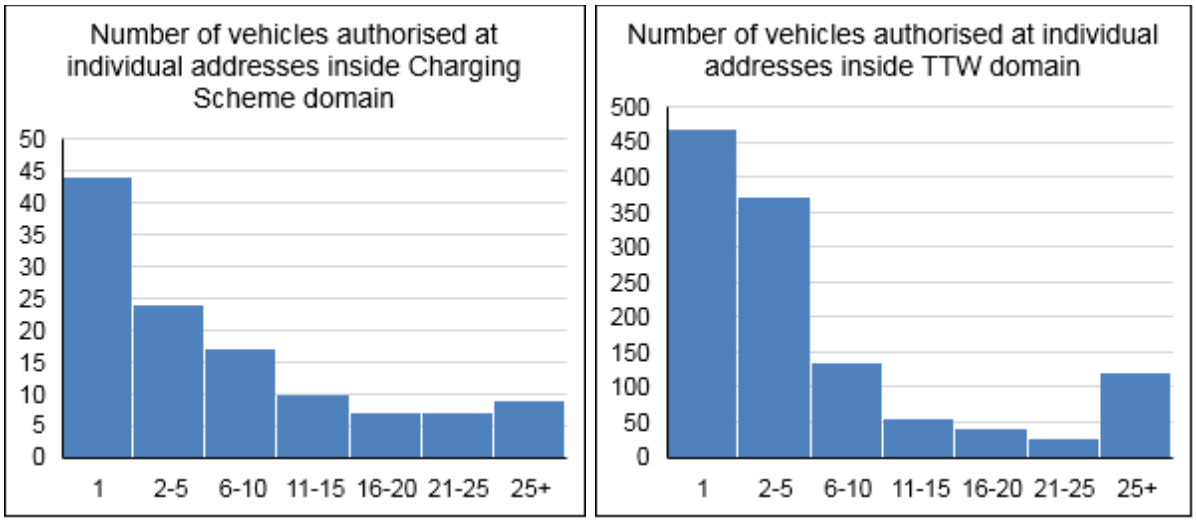
[12] DfT, Being a goods vehicle operator, Available at: https://www.gov.uk/being-a-goods-vehicle-operator

[13] DfT, PSV (Public Service Vehicle) operator licences, Available at: https://www.gov.uk/psv-operator-licences

[14] Nomis (2017), UK Business Counts, Available at: https://www.nomisweb.co.uk/articles/764.aspx

[15] Postcodes within a domain were identified then licence holders were mapped to the domains using their postcodes

Figure 13 – Distribution of O Licence registrations by number of vehicles authorised at individual addresses within Charging Scheme and TTW domains (2018)



It is expected that HGV operators can be characterised in the following ways:

- Large fleet operators operating nationally with 100+ vehicles typically purchase HGVs new, and run intensively on motorways for 3 years. As a result, by 2020 the vast majority of these fleets would be Euro 6 and Charging Scheme-compliant.
- Medium fleet operators – operating with 10-100 vehicles purchase these relatively new 2nd hand vehicles and run for 3-5 years. Currently operating Euro 5 vehicles, the majority of these will be transitioning to Euro 6 in the next 1-3 years.
- Small fleet operators – operating <10 vehicles typically buy 2nd hand at 8 years old typically doing short local/regional journeys. These vehicles can be run for many years. Currently operating Euro 2-4 vehicles.
- Specialist vehicle operators – operating vehicles that are highly specialised and have both a significant lead-in time on production (6-18 months), and additional expense due to specificity e.g., waste vehicles, concrete mixers. Small operators operate Euro 2-4 vehicles. Some of these vehicles such as cement mixers have a relatively low mileage and a longer life span (up to 12 years).

This means that stakeholders of concern are smaller operators that run dirtier vehicles for longer periods. However, a small proportion of HGVs are based within the charging zone.

The implementation of a traffic management scheme will not have direct impacts on HGVs. Only a decrease or increase in travel time could affect delivery services. However, there will be overall balancing out between the roads with increasing traffic levels and the roads with reduced traffic levels.

4.3.1.2 Impact of Charging Scheme

Smaller operators with dirtier fleets are likely to be disproportionally impacted by the introduction of a charging scheme. Smaller firms are more likely to be non-compliant and locally based by their nature: they have small fleets operating in a defined geographic area and are therefore unable to redistribute fleets or shift their customer base away from the Charging Scheme. With respect to HGVs, it is also worth noting the following points which will impact on the affordability risk:

- The Charging Scheme introduction itself may increase the cost of upgrading to compliant vehicles: Lack of availability and increased demand has inflated Euro 6 HGV prices due to simultaneous Charging Scheme implementation across cities. Euro VI vehicles now costing £150,000+. Further, the Charging Scheme may also suppress the value of Euro IV and V vehicles resulting in increased financial challenges to replacing vehicles.

- There may often be long lead-in times to upgrading the fleet, in particular for specialist vehicles, which need to be adapted for a specific requirement. Hence, the speed of Charging Scheme implementation may be a challenge for many. 24 months from proposal to charging implementation is a challenging timescale for HGV operators to purchase compliant vehicles hence the requirement is somewhat out of step with company replacement cycles of 3-12 years, in particular for specialist vehicles.

In response to the introduction of the London LEZ, an impact monitoring report noted that HGV owners with large fleets serving large geographical areas tended to react by conducting an in-depth analysis of how they organized their transport activities. Fleets were then redistributed so that the newest and cleanest vehicles were used in the Greater London region, while older vehicles were operated in zones without charging schemes. HGV owners with smaller fleets and/or serving smaller geographical areas were not able to adapt by redistributing their fleet. These businesses needed to put money aside ahead of time in order to purchase newer vehicles or retrofit existing vehicles. Where these options were not feasible due to financial constraints, these businesses rented newer vehicles, paid the charge, or went out of business[16].

In the impact assessment for the London ULEZ, it was anticipated that fleet redistribution would be a viable option for approximately 95% of fleet operators with more than 10 LGVs registered, whereas this number fell to 75% for fleet operators with smaller fleets.

Opportunities – Large operators may redistribute fleets at minimal cost to avoid paying charges. This will put them at a competitive advantage to those operators paying charges or upgrading.

Risks – Operators with dirtier fleets may be unable to adapt to the introduction of the Charging Scheme.

4.3.2 Impacts on LGVs

4.3.2.1 Numbers of vehicles

LGVs are important elements in many sectors of the economy. In London, LGVs serve sectors ranging from financial and business service companies to independent retailers and food outlets.[17] In an impact assessment for London's proposed ULEZ, it was found that LGV ownership is split roughly half and half between companies and private owners, and LGVs are important to a range of owner run businesses.[17]

As demonstrated in the Table 16 and Table 17 a significant number of LGVs would not be compliant with the introduction of a Charging Scheme or the introduction of a CAIS. LGVs are not covered by O Licence data, but it is anticipated that they will follow the same distribution pattern as seen for HGVs – smaller operators owning a low number of vehicles. It is expected that these small operators will own older LGVs.

The analysis shows there are proportionally more non-compliant LGVs per business situated in the TTW than in the Charging Scheme area. There are more compliant vehicles, on a per business basis, situated within the Charging Scheme area than in the TTW area.

[16] Cecilia Cruz and Antoine Montenon, "Implementation and impacts of low emission zones on freight activities in Europe: Local schemes versus national schemes",

[17] Jacobs, "Proposed changes to the Ultra-Low Emission Zone: Update to the 2014/2015 Integrated Impact Assessment", prepared for Transport for London, April 2017, https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010021/TR010021-001701-8.127%20ULEZ%20Integrated%20Impact%20Assessment.pdf, accessed 24/04/2018.

Table 16: Registered LGVs in the Travel to Work and Charging Scheme domains (based on data provided by DVLA/DfT)

	Total LGVs	Total compliant LGVs	Total non-compliant LGVs
TTW	66,017	9,614	56,403
Charging Scheme	7,784	2,437	5,347
LGVs in Charging Area / Business	1.19	0.37	0.82
LGVs in TTW / Business	1.33	0.19	1.13

Table 17: Diesel LGVs entering the Charging Scheme area in 2020, taken from the economic model

Euro Standard	Compliance	Number
Pre-Euro 1	Non-Compliant	-
Euro 1	Non-Compliant	-
Euro 2	Non-Compliant	167
Euro 3	Non-Compliant	4,160
Euro 4	Non-Compliant	44,879
Euro 5	Non-Compliant	79,470
Euro 6	Compliant	51,007
Total	Non-Compliant	128,676
Total	Total	179,683

As is the case with HGVs, the response adopted by a LGV owner will depend on factors such as the size of their fleet, the geographic area(s) in which they currently do business, the sector it is in, and whether the vehicle is specialized. Many of the factors influencing the response for HGVs, as discussed above, are also applicable to LGVs.

Stakeholders of concern: A significant number of LGVs will be owned by smaller businesses.

4.3.2.2 Impact of Charging Scheme

Where it is possible to minimize the financial impact of a proposed charging zone using LGV fleet redistribution, this is likely to be a preferred response due to the relatively low costs involved. This is more likely to be the response adopted by those with large fleets. In the impact assessment for the London ULEZ, it was anticipated that fleet redistribution would be a viable option for approximately 95% of fleet operators with more than 10 LGVs registered, whereas this number fell to 75% for fleet operators with smaller fleets.[18] Again, as charging schemes become more commonplace in the UK, it is increasingly likely that fleet owners will need to adapt using methods other than fleet redistribution.

The London ULEZ impact assessment suggests that, due to the high proportion of non-compliant vehicles in the LGV fleet, it may be possible for operators to pass some of the additional compliance costs on to customers.[18] An updated impact assessment for the London ULEZ suggested that self-employed tradespeople, independent retailers and market traders, including farmers' market traders, may be disproportionally impacted by the introduction of a charging scheme.[18]

[18] Jacobs, "Proposed changes to the Ultra-Low Emission Zone: Update to the 2014/2015 Integrated Impact Assessment", prepared for Transport for London, April 2017, https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010021/TR010021-001701-8.127%20ULEZ%20Integrated%20Impact%20Assessment.pdf, accessed 24/04/2018.

A strategic review of the London LEZ[19] asserted that LGVs are essential to business for many small operators, such as self-employed tradesmen, and that for many micro businesses, their LGV is both their greatest asset and largest expenditure. As such, any additional cost in relation to owning and operating the LGV would potentially impose a significant strain on the small business' financial operation.

Opportunities – Large operators may redistribute fleets at minimal cost to avoid paying charges. This will put them at a competitive advantage to those operators paying charges or upgrading.

Risks: smaller operators that are unable to redistribute LGV fleets will be disproportionately impacted by the charging scheme.

4.3.3 Impacts on buses and coaches

4.3.3.1 Numbers of vehicles

An upgrade of the main Derby bus fleet to Euro 6 by 2020 is already funded and was therefore assumed to be compliant in the fleet baseline.

There is limited data available on coaches operating in and around Derby, both in terms of quantities of coaches and operators, and the nature of the operators.

Coach operators are likely to serve several different routes and demand, ranging from serving regular routes (e.g. school buses), large national firms serving regular but less frequent inter-city routes (e.g. National Express) or one-off coaches serving visitor attractions or events (such as the football stadium). This could also capture vehicles operated by charities and community groups (e.g. providing transport to and from the hospitals).

An impact assessment for the London ULEZ[20] depicted various sub-categories of buses, coaches and minibuses. Vehicles less than 5 tonnes can be classified as minibus vehicles, and are generally used for small scheduled services, inter-company shuttles, airport-hotel link services, as well as private hire and private uses (for organisations such as schools and clubs). Vehicles over 5 tonnes can be classified as buses and larger coaches. Coaches were identified as typically being used for scheduled long distance and commuter services as well as sightseeing, tourist and leisure trips.

Stakeholders of concern – Smaller operators operating local ad hoc or irregular services

4.3.3.2 Impact of Charging Scheme

As with HGVs, smaller operators are likely to be more at risk as they typically operate ageing vehicles, operate with tighter margins (i.e. with less contingency), and have limited capacity to replace vehicles outside of planned replacement cycles.

The risk for smaller coach operators may also be exaggerated by the nature of the customers they serve. If smaller coach operators are more likely to serve regular routes within the city (e.g. school buses), they will have less ability to pass costs through to their customers. This is because the total cost passed through per customer will be much higher than say a national operator which sees a

[19] Deloitte, "LEZ Strategic Review Report", 2004, http://content.tfl.gov.uk/3-lez-strategic-Review-Report-250205.pdf, accessed 24/05/18.

[20] Office of the Transport Commissioner, "Traffic Commissioners' Annual Reports", 2016-2017, https://www.gov.uk/government/collections/traffic-commissioners-annual-reports, accessed 23/04/2018.

greater variance in its customer base. It is also likely that commuter services run by national operators, especially those on long-distance service lines, may be able to re-route their services to avoid passing through a charging zone.

Opportunities – Large operators may redistribute fleets at minimal cost to avoid paying charges. This will put them at a competitive advantage to those operators paying charges or upgrading.

Risks – Smaller operators operating older vehicles may struggle to pay charges or be able to upgrade.

4.3.4 Taxi drivers and operators

4.3.4.1 Numbers of vehicles

Table 18: Compliant and non-compliant Taxis in 2020 operating in Charging Scheme area captured by ANPR and projected forward

	Compliant	Non-Compliant
Taxis	2735	3819
Private Hire Car	4802	6707

The majority of taxis and private hire vehicles operating in Derby are non-compliant (as defined by a Charging Scheme). In addition, taxis drivers are likely to be paid relatively poorly. A survey by Insuretaxi reported that average weekly income of a taxi driver in the East Midlands is around £300 per week[21], corresponding to an annual income of around £15,600 (assuming 52 weeks worked). The weekly income is one of the lowest reported in the country amongst taxi drivers and is in the lower quarter of total personal income reported by ONS (23rd percentile)[22]. This suggests that taxi drivers will struggle to buy a new vehicle or pay an additional daily charge.

Other specific issues affecting taxis include:

- In some circumstances, taxis are also subject to other operator and consumer demands. E.g. Uber London drivers must use hybrid or electric by 2020. Hence taxi operators may be facing other requirements which impact on their vehicle operation and upgrade behaviour.
- Taxi and Private Hire vehicles are typically run for 6-7 years. As a result a large proportion of drivers would not normally be purchasing a new vehicle until after 2020. Hence the speed of implementation may be a challenge for taxi operators

Stakeholders of concern: taxis drivers generally come from low income groups and therefore how the policy options will impact their income will be of concern.

4.3.4.2 Impact of Charging Scheme

Charging Scheme charges will be faced equally by operators licenced in Derby and elsewhere. However, assuming those licenced in Derby will operate in the city centre more often, there will likely be a greater cost burden placed on those operating (and licenced) in Derby.

Taxis could also be uniquely affected due to their ownership structure: Unlike other modes, taxis tend to be owned/operated by single driver, rather than larger businesses. The cost burden of the Charging Scheme is likely to be faced by an individual, rather than a business. This has two impacts:

[21] https://www.insuretaxi.com/2016/08/taxi-driver-survey-2016/
[22] ONS: Percentile points from 1 to 99 for total income before and after tax, available at: https://www.gov.uk/government/statistics/percentile-points-from-1-to-99-for-total-income-before-and-after-tax

1. An individual inherently has less potential to spread any cost burden across multiple operations or revenue streams
2. The impacts on taxi operators will impact directly on household income, rather than business revenue, and hence will likely be more keenly felt by those affected. Indeed, the London ULEZ impact assessment recognized that virtually all taxi drivers are self-employed and therefore would need to bear the cost of a new vehicle themselves.

As outlined above, Taxi and Private Hire drivers are typically on relatively low-income living in deprived areas. They have limited financial resources to purchase hybrid vehicles which have a cost premium. Drivers who have recently purchased vehicles may be tied into loan repayments beyond 2020.

Opportunities – Owners of cleaner vehicles not facing the charge or the prospect of upgrades will be at a competitive advantage.

Risks - Taxis and private hire will be affected greatly by the introduction of a charging scheme.

4.3.5 Wider business

4.3.5.1 Numbers of vehicles

A breakdown of the businesses (by type) that could be affected by the policy options is available from the AddressBase Plus (Table 19).

Table 19: OS data for categories of business potentially affected by the policy options

Description	TTW	Charging Scheme
Industrial - manufacturing, engineering, maintenance, storage / wholesale	5,951	870
Retail - commercial enterprises open to public visiting	12,333	2,004
Commercial Storage Land	81	12
Transport Handling / Storage	811	117
Utilities - Energy, water, telecommunication supply & refuse disposal	121	4
Forestry un/managed / wooded land, amenity wooded land - not used for other purposes	174	0
Total	19,471	3,007

From this data, the key affected category of businesses with the largest numbers of sites in Derby are:

- Retail sites (including markets, Petrol Filling Stations, Pubs / Bars/ Nightclubs, Restaurants / Cafes, Shops / Showrooms, Garden centres etc.)
- Industrial sites (including workshops garages, warehouses and storage depots).

4.3.5.2 Impact of Charging Scheme

All businesses are dependent on transport services to a certain extent through deliveries of supplies or products and staff commuting. Retail businesses may be greatly impacted by any reduction in number of trips to the Charging Scheme area. It is likely that the Charging Scheme will be served by public transport but many customers will choose to avoid the Charging Area. However, as indicated in the census data, there are many retail businesses outside the Charging Scheme area which will may receive the customers displaced from the town centre.

Conversely, it is possible that the Charging Scheme could make the centre of Derby a lot more hospitable to the public, and will in fact draw visitors to the area. The impact assessment for the London ULEZ anticipates that the ULEZ may be seen as a potential benefit to restaurants and cafes

within the scheme zone, as improvements in air quality may encourage customers to use on-street seating.

Businesses situated in the Charging Scheme area, may face higher charges for delivery services if the delivery service only offers non-compliant delivery services and passes the charge onto customers. Businesses may therefore favour delivery companies with cleaner fleets to avoid paying any passed on charge. However, given the large percentage of non-compliant LGVs and HGVs operating in Derby, it is likely that demand for a relatively small number of cleaner vehicles will result in price increases.

There will also be impacts on businesses that sell vehicles. Following the implementation of a charging zone, there is likely to be a period of higher than average fleet turnover, as was the case for the London LEZ. New vehicle sales, and associated businesses, are very likely to see increased activity. The second-hand vehicle market may also become more active, as used non-compliant vehicles are sold by businesses affected by the charging scheme and potentially purchased by businesses outside of the charging scheme zone. However, as charging schemes become more common, it is increasingly likely that used non-compliant vehicles will become more difficult to sell. As the demand for second-hand non-compliant vehicles decreases in response to a growing number of charging schemes, this will affect the profitability of any businesses which sell second-hand vehicles. Businesses that develop, fit and service emissions abatement equipment onto existing vehicles are also likely to see increased activity.

Opportunities: Cleaner air can make improved areas more attractive places to be.

Risks - Businesses within the Charging Scheme area will see a reduction in number of trips.

4.4 Distribution of businesses benefits from TUBA

The TUBA model provides cost benefit analysis disaggregated by user groups for different variables. For the Distributional Analysis report, Time benefits, user charges benefits, and fuel vehicle operating costs (fuel VOC) have been analysed at the LSOA level. For this analysis only one time period (AM peak) has been used for both scenarios as representative of the impacts. Results are aggregated for all the trips from an LSOA of origin. For businesses the vehicle types chosen are LGV Freight, OGV1 and OGV2 and the trip purposes is business.

Based on total benefits (aggregate of time benefits, user charges benefits and fuel vehicle operating costs) TUBA outputs indicate that the traffic management scheme will show a mixture of benefits and disbenefits driven primarily by changes in journey times. In particular, areas to the North of Stafford Street such as Kedleston Road and Duffield Road will be affected by slower journey times (Figure 14).

The charging scheme shows a greater adverse impact on businesses (Figure 15). The disbenefit is driven largely by charges for non-compliant vehicles from the scheme but also some travel changes from diversions. This is counteracted in some cases within the charging zone by reductions in traffic and consequent better travel times. For a charging scheme, within the 164 LSOAs included in the TUBA outputs, 153 indicate a disbenefit for businesses. And this disbenefit is due to the user charges for 147 LSOAs (4 for time disbenefit and 2 for fuel operating costs) strongly emphasizing the role of the charge as main negative impact for businesses in Derby.

Figure 14: Total benefit or disbenefit (at LSOA level) for businesses with the introduction of a traffic management scheme.

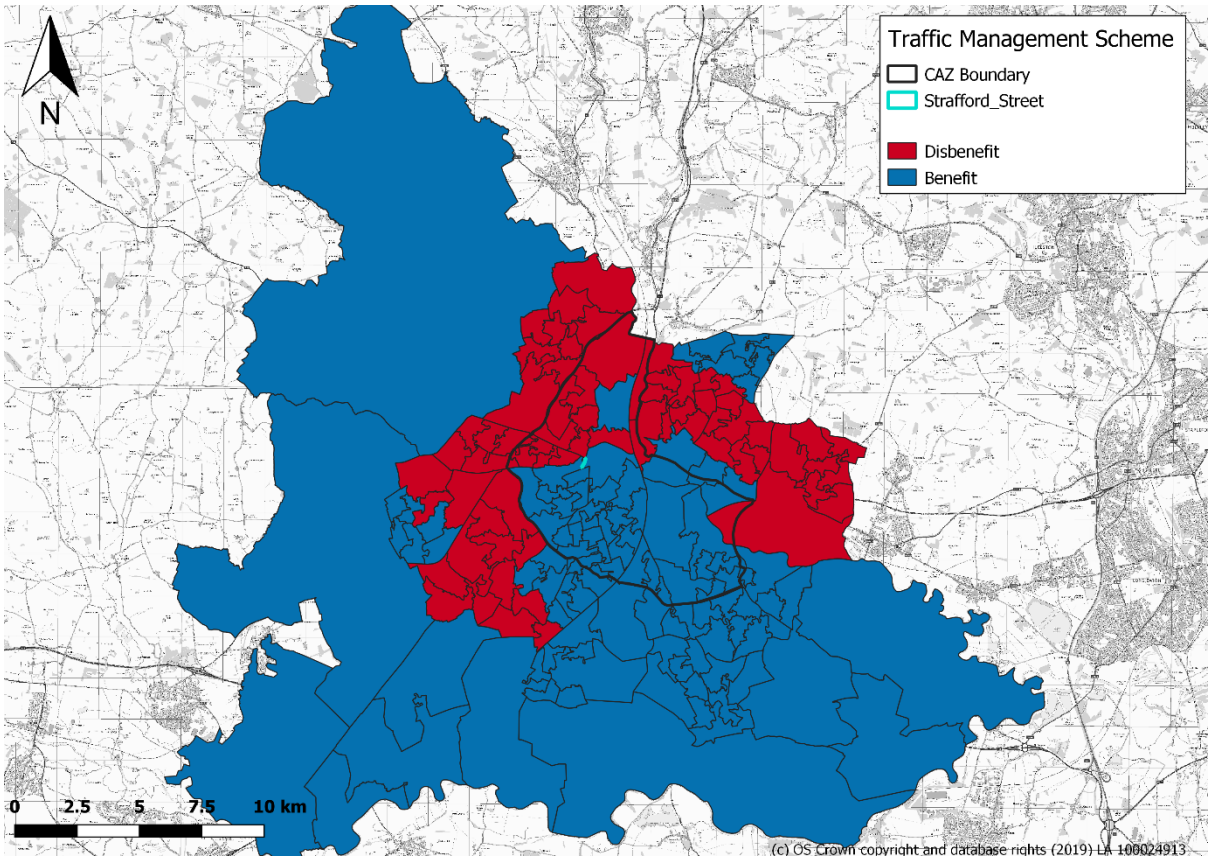
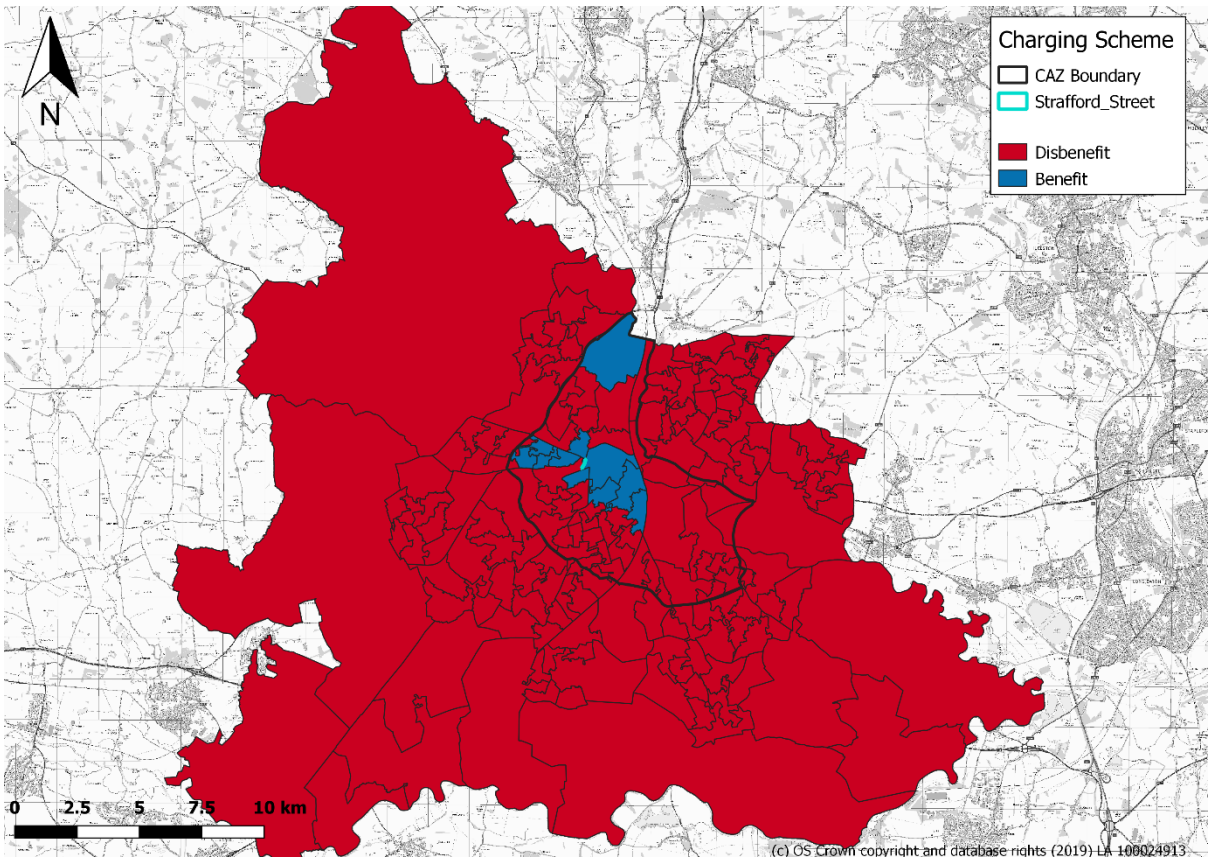


Figure 15: Business with total benefit or disbenefit with the introduction of a charging scheme.



4.5 Conclusions

The overall impact on businesses of the traffic management scheme is expected to be minimal, though the TUBA analysis does indicate some areas with dis-benefits as a results of changes in travel time.

In contrast the implementation of a charging scheme will have direct impacts on businesses, with smaller businesses operating dirtier vehicles in the local vicinity being more at risk. Smaller firms are more likely to face greater affordability risks through their operation as described above (e.g. they tend to operate older vehicles). The nature of them being smaller business itself further increases the risk facing these businesses, in particular smaller firms:

- do not have large fleets which can be redistributed, reducing the response options available to them
- are likely to have smaller cash reserves to fund upgrades
- have smaller operations over which costs can be spread
- may also find it more difficult to access capital, or may face higher borrowing charges.

The impacts are also shown in the TUBA analysis with most areas seeing a disbenefit due to imposition of charges.

Table 20 – Summary of business affordability distributional impacts

Scenario		Summary assessment
Traffic management scheme	-	• Only a change in travel time potentially affecting to a small extent delivery services. No predominant impacts are being assessed for affordability for business for this scheme.
Charging Scheme	xxx	• Mandatory charges will affect all non-compliant vehicles operating in the Charging Scheme area. • The majority of each vehicle type is expected to be non-compliant in 2020. It is expected that larger operators of HGVs/LGVs will be able to redistribute fleets or are in a better position to upgrade with Charging Scheme requirements. Therefore, smaller operators are likely to be impacted. • Places a direct cost on business.

Note:

- no impact

X negative impact

✓ positive impact

5 Affordability and user benefits for households

5.1 Impacts of the policy options

Expected direct and indirect impacts on households are explored in Table 21 and Table 22. These tables assume that residents are primarily concerned with those policy options that impact on cars and consumer goods and services.

The traffic management scheme may have a negative impact on a household if their journeys are directly impacted by the scheme and as a result suffer increased travel times, route changes or opt to change mode. Similar impacts of the scheme on goods delivery may have an indirect impact on the cost/convenience of consumer goods and services.

The charging scheme is mandatory for all non-compliant vehicles and therefore imposes a direct impact on households. Indirect impacts are also likely to be more pervasive under the charging scheme as direct impacts on businesses are more certain.

Table 21: Relevant policy options for households and their direct impacts

	Traffic management scheme	Charging Scheme
Relevant measures for Cars	Changes to traffic management on Stafford Street	£12.50/day
Direct impacts on Cars	Potential travel time increase from delay/diversion (↓- 4)	Cost added to the OPEX of non-compliant vehicles. (↓ - 5)

Net Impact - ↑ = minor positive impact, ↑↑ = positive impact, ↓ = minor negative impact, ↓↓ = negative impact ↑/↓ = mixed impact.
Confidence - 1-5 = low confidence – certainty.

Table 22: Relevant policy options for households and their indirect impacts

	Traffic management scheme	Charging Scheme
Commuting	Workforce may experience travel time increases of change mode in response to scheme. (↓ - 3)	Employees may be charged for commuting. May have impacts on car sharing and commuting patterns which could lead to increased commuting time and loss of welfare. (↑/↓ - 2)
Cost of goods and services	Consumer goods may increase in price if delivery delays occur (↓ - 1)	Taxi private hire and public transport services may increase cost. (↓ - 5) Consumer goods may increase in price if businesses pass on upgrade or charge costs (↓ - 2) Reduction in resale values of vehicles (↓ - 2)

5.2 Distribution of households and car ownership

A charging scheme will directly impact on households with cars that do comply with the CAZ standard and so would be subject to a charge or the cost of upgrading their vehicle. As such, an analysis of car ownership at the household levels provides information on how this impact would be distributed in relation to a charging scheme.

Figure 16 shows the IMD rankings in the Derby region.[23] This illustrates that the city of Derby has several LSOAs that fall within the most deprived 10% in England and Wales. Figure 17 shows the % of non-compliant vehicles (those that are below the Euro 6 Diesel and Euro 4 Petrol criteria) across the LSOAs in Derby. Comparing this with the areas of deprivation indicates a level of overlap between non-compliant vehicle ownership and deprivation as might be expected.

A mix of dates has been used in these calculations, household data is only available based on the 2011 census data. This census data was inflated to 2017 household using UK Government Household projections[24]. IMD data is based on 2015 calculations. Thee number of cars is based on 2017 data.

Figure 16: The IMD rankings of LSOAs contained in Derby (2015)

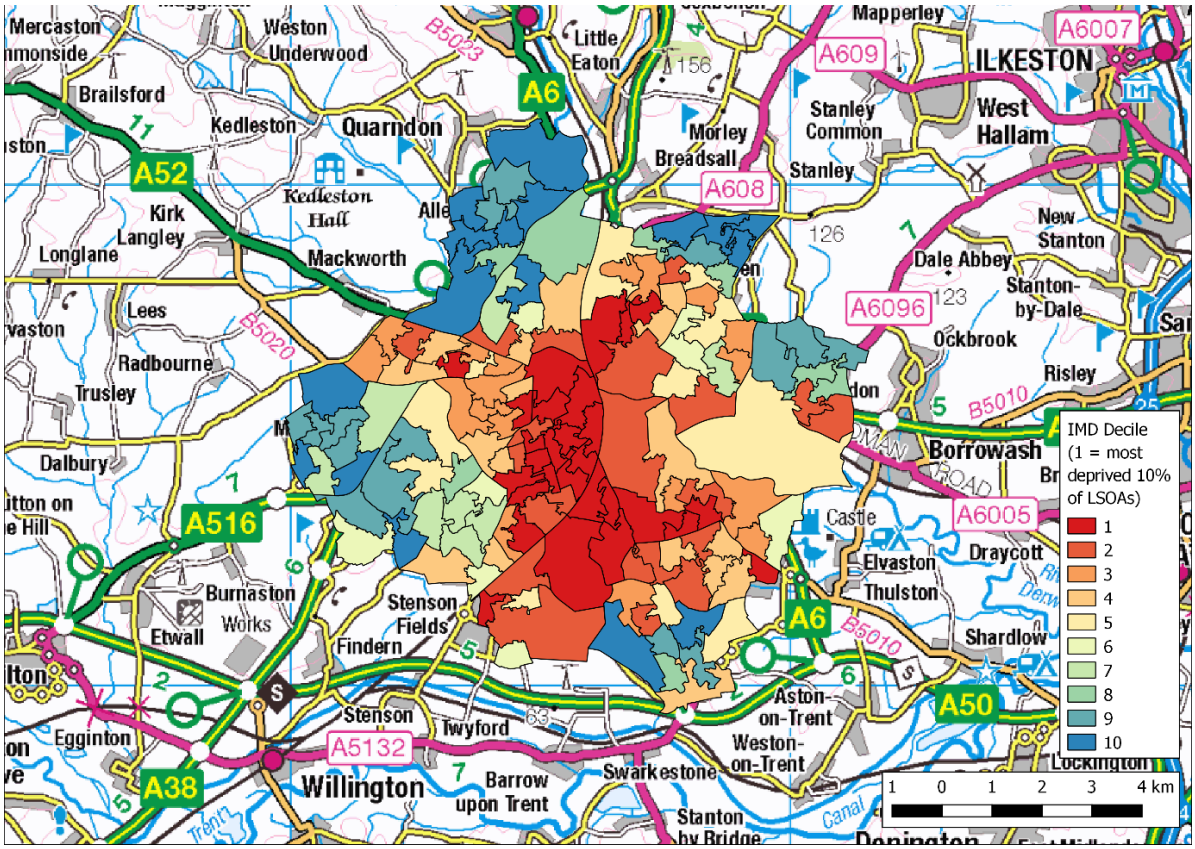


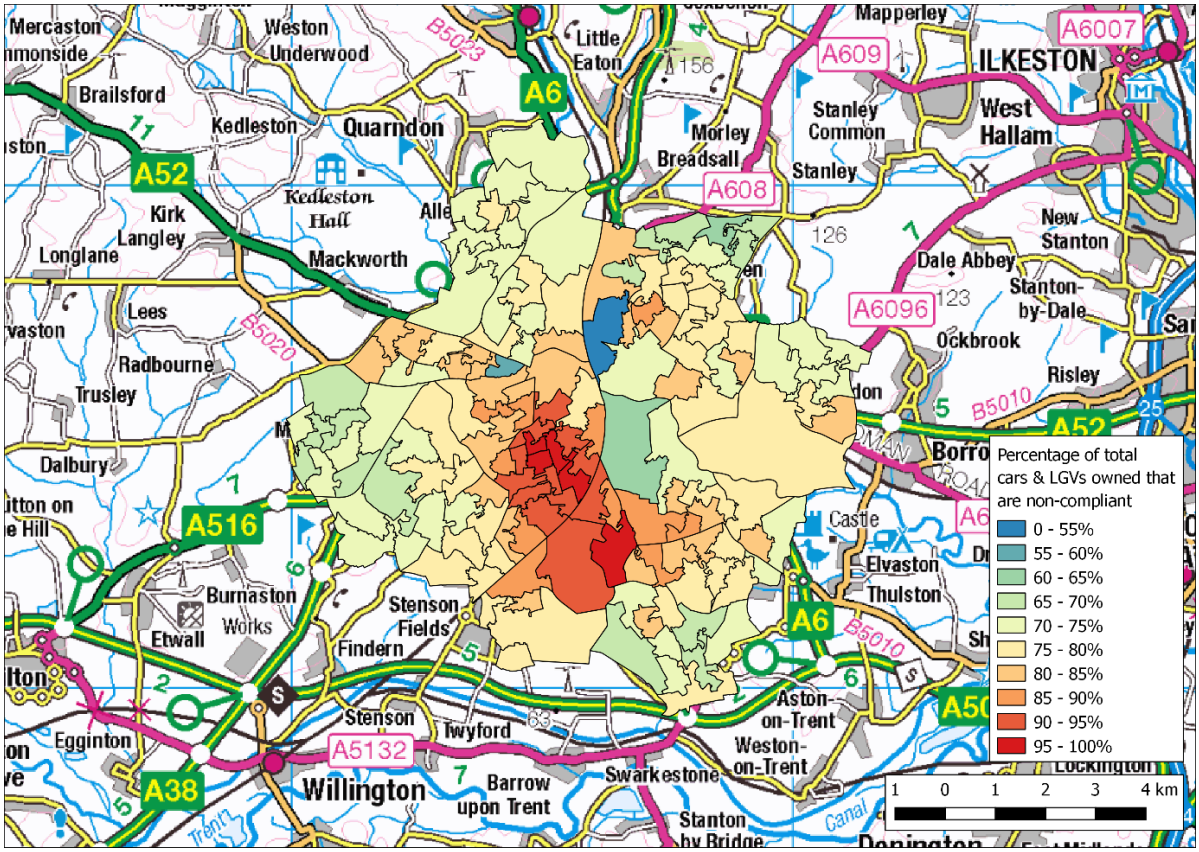
Figure 18, Table 23 and Table 24 demonstrate that on average, areas of high deprivation (the first low quintile score), are more likely to own non-compliant vehicles than compliant vehicles. This is especially true in the Charging Area. However, households in the Charging Scheme own marginally fewer cars than in the TTW.

[23] English indices of deprivation 2015, Available from https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

[24] Ministry of Housing, Communities & Local Government (2016), Live tables on household projections Available at: https://www.gov.uk/government/statistical-data-sets/live-tables-on-household-projections

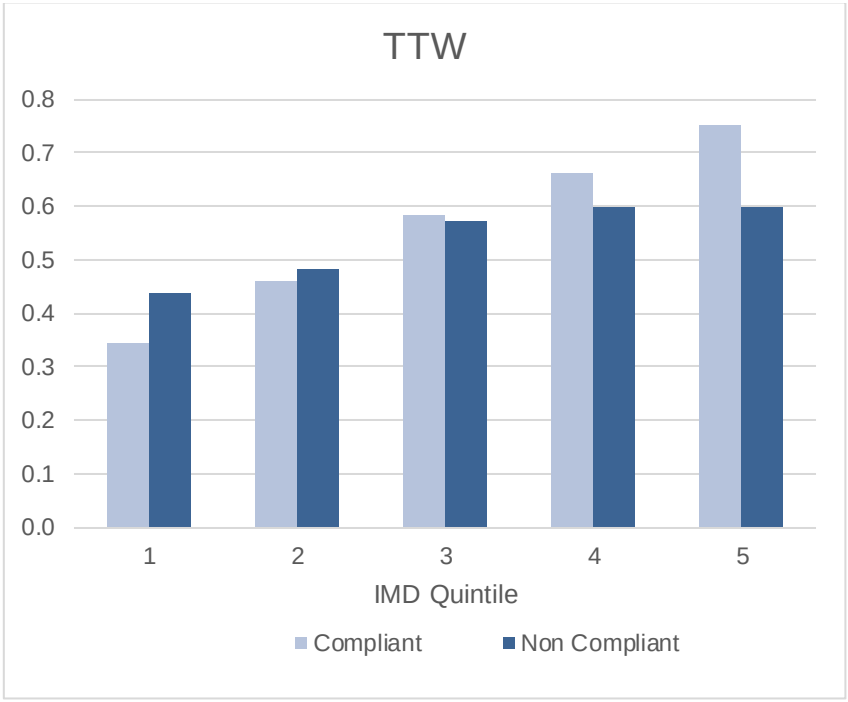
This result matches evidence from the literature: studies note that in general, there is a negative relationship between car age and household income (i.e. older cars tend to be owned by poorer households) [25]. Hence there is a strong possibility that the additional costs levied on households by the Charging Scheme will be regressive, with poorer households shouldering a greater proportion of the costs.

Figure 17: The percentage of total vehicles registered which are non-compliant in each LSOA contained in Derby (Area 1)



[25] See for example: http://economics.ca/2009/papers/0455.pdf

Figure 18: Compliant and Non-Compliant Vehicles per household in different domains by Deprivation Quintile



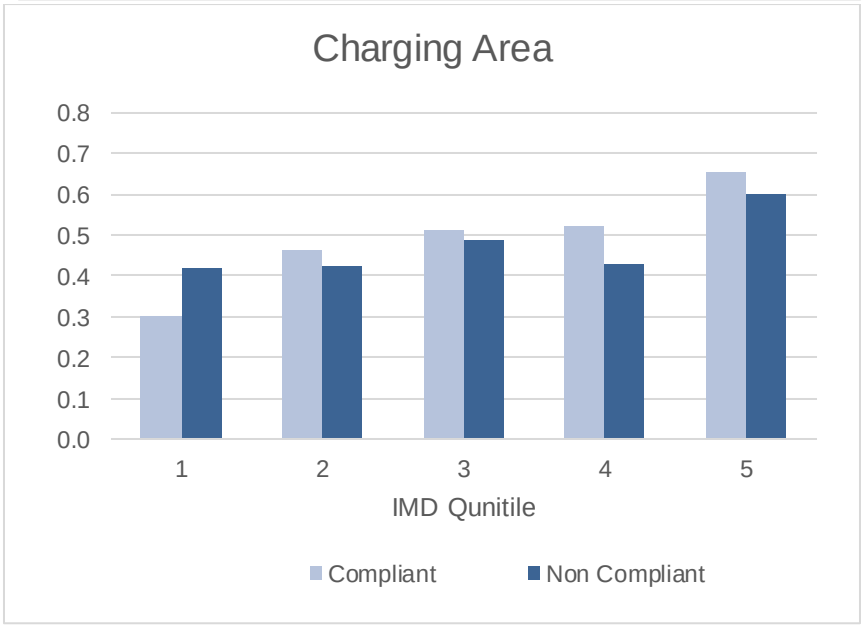


Table 23: Cars per household in TTW domain (including charging scheme)

IMD Quintile	TTW Total (cars/hh)	TTW Compliant (cars/hh)	TTW Non Compliant (cars/hh)
1	0.8	0.3	0.4
2	0.9	0.5	0.5
3	1.2	0.6	0.6
4	1.3	0.7	0.6
5	1.4	0.8	0.6
Total	1.1	0.6	0.5

Table 24: Cars per household in Charging Scheme

IMD Quintile	Charging Scheme Total (cars/hh)	Charging Scheme Compliant (cars/hh)	Charging Scheme Non Compliant (cars/hh)
1	0.7	0.3	0.4
2	0.9	0.5	0.4
3	1.0	0.5	0.5
4	1.0	0.5	0.4
5	1.3	0.7	0.6
Total	1.0	0.6	0.5

Note – these statistics have excluded 2 LSOAS which had 6 and 15 cars per household as this is likely to represent fleets used for business purposes.

5.3 Distribution of user benefits from TUBA

The TUBA model provides cost benefit analysis disaggregated by user groups for different variables. For the Distributional Analysis report, Time benefits, user charges benefits, and fuel vehicle operating costs (fuel VOC) have been analysed at the LSOA level. For the analysis only one time period (AM peak) has been chosen for both scenarios as representative of the impacts. Results are aggregated for all the trips from an LSOA of origin. For the affordability for households the vehicle types chosen are “cars” and “LGV personal” and the trip purposes are “commute” and “other” (non-commuter).

With a traffic management scheme in Stafford Street, households in the northern part of the city will, see a disbenefit from the scheme (Figure 19). As no user charges are applied for this scenario, this is only due to a longer travel time (potentially leading to increased fuel vehicle operating costs). On the other hand households in the southern part of the city would see a benefit due to a reduced travel time (also leading to reduced fuel vehicle operating costs).

The introduction of a charging scheme would lead to increased costs for households in almost the whole city (Figure 20). Only the population living in the CAZ boundary will see a decrease in their costs, which like the analysis for business is due to savings in travel time being greater than the user charges. Overall higher costs for households are due to the user charges and not an increase in travel time. These charging costs are equally distributed among the IMD quintiles (Table 25). However, as the charging scheme will be the same regardless of income, the impact on budget for the most deprived population is expected to be higher and so potentially generates a distributional impact.

Table 25: Number of LSOAs where the time, user charges or fuel VOC is the main factor when the total benefit is negative with a charging scheme.

Variable	IMD Quintile 1	IMD Quintile 2	IMD Quintile 3	IMD Quintile 4	IMD Quintile 5
Time	10	5	1	2	6
User charges	29	25	18	17	30
Fuel VOC	0	0	0	0	0

Figure 19: Total benefit or disbenefit for households at LSOA level with the introduction of a traffic management scheme.

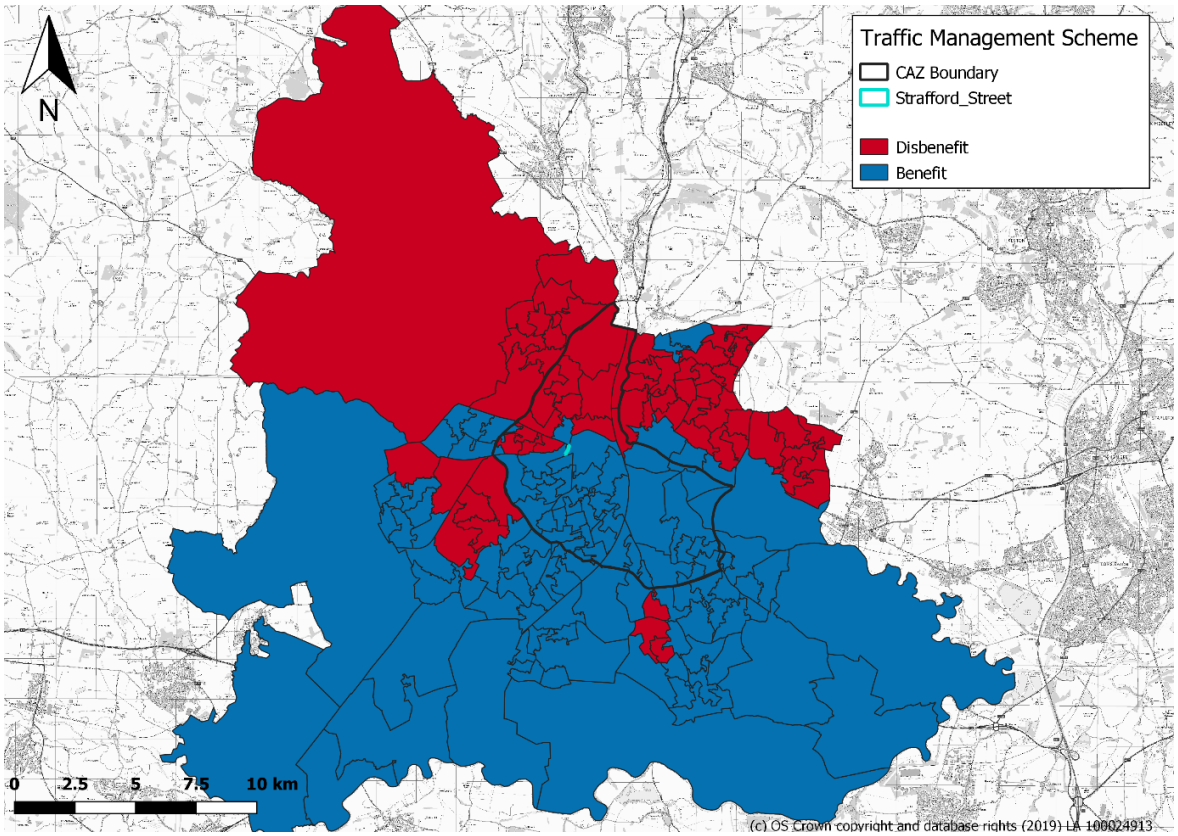
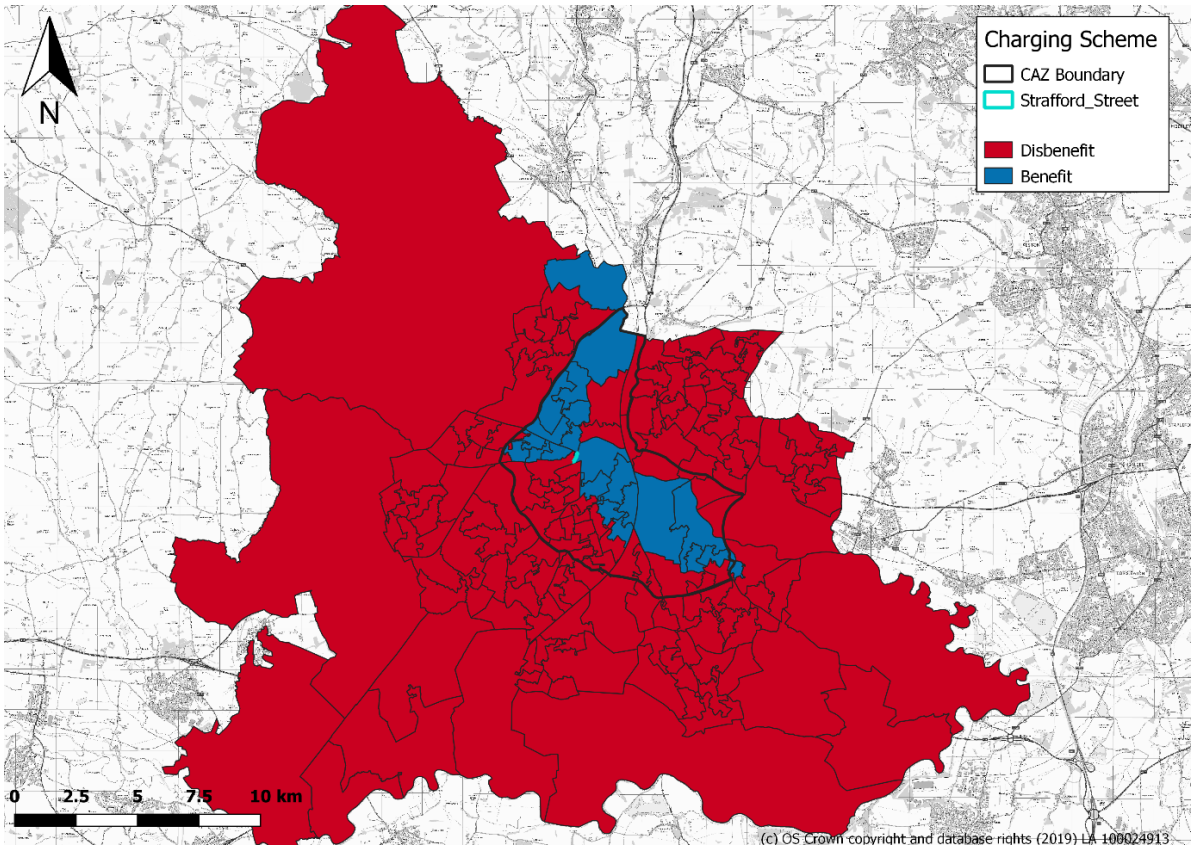


Figure 20: Total benefit or disbenefit for households at LSOA level with the introduction of a Charging Scheme.



The overlay of the impact and demographic variables following the Webtag guidance for IMD is presented in Table 26 for the Traffic Management Scheme and Table 27 for the Charging Scheme.

Table 26: Webtag 'quintile' analysis for the Traffic Management Scheme – IMD overlay with TUBA outputs and total benefits.

Income IMD	Most deprived ←			→ Least deprived		Total
	0%-20%	20%-40%	40%-60%	60%-80%	80%-100%	
CAZ B Plus reduced boundary	1	2	3	4	5	
Number of population with reduced costs	72,286	42,498	19,299	18,148	25,292	
Number of population with no changes[26]	0	0	0	0	0	
Number of population with increased costs	17,418	17,277	14,790	11,057	27,575	
Net winners/losers	54,868	25,221	4,509	7,091	-2,283	
Total number of winners across all groups						190,255
Net winners/losers in each area	28.84%	13.26%	2.37%	3.73%	-1.20%	
Share of the total population in the impact area	33.77%	22.50%	12.83%	10.99%	19.90%	
Assessment	✓ ✓	✓	✓	✓	X	

Table 27: Webtag 'quintile' analysis for the Charging Scheme Scheme – IMD overlay with TUBA outputs and total benefits.

Income IMD	Most deprived ←			→ Least deprived		Total
	0%-20%	20%-40%	40%-60%	60%-80%	80%-100%	
CAZ B Plus reduced boundary	1	2	3	4	5	
Number of population with reduced costs	17,663	9,553	3,496	4,016	3,066	
Number of population with no changes[27]	0	0	0	0	0	
Number of population with increased costs	72,041	50,222	30,593	25,189	49,801	

[26] For this category it has been assumed a total change in costs to be 0.
[27] For this category it has been assumed a total change in costs to be 0.

Net winners/losers	-54,378	-40,669	-27,097	-21,173	-46,735	190,255
Total number of winners across all groups						
Net winners/losers in each area	-28.58%	-21.38%	-14.24%	-11.13%	-24.56%	
Share of the total population in the impact area	33.77%	22.50%	12.83%	10.99%	19.90%	
Assessment	X X	X X	X X	X X	X X	

This analysis indicates that the traffic management scheme has a positive impact on the most deprived quintile of the population. The effect is progressive as the impact becomes negative for the least deprived population. A charging scheme would lead to higher costs for all quintiles of income, mostly because of the direct costs.

5.4 Summary

Overall the traffic management scheme generates a positive impact on households with journey time savings outweighing any journey time penalties. This benefit is greatest for low income households and as the scheme can be considered progressive as the benefit increases as income decreases.

On the other hand, the charging scheme generates a disbenefit for most households through the charges from the scheme. In a few cases this is balanced by journey time savings from reduced congestion. In addition the charges likely to have most impact on low income households who are least able to afford them.

Table 28 – Summary of household affordability distributional impacts

Scenario	Summary assessment
Traffic management scheme	✓ Overall household benefit which increases as income decreases.
Charging Scheme	×× Overall household disbenefit with poorer households least able to afford the charges and most likely to own non-compliant vehicles.

Note:

- no impact
X negative impact
✓ positive impact

6 Traffic impacts

6.1 Overview of changes in traffic flows

The overall change in AADT on each of the model roads is shown in Figure 21 to Figure 23. These figures show the change in flows against the Do Minimum scenario. From this we can see the following key impacts:

- Traffic management scheme – as discussed in section 3.2.2 this shows a reduction of flows in Stafford Street and linked roads primarily along the west and north of the inner ring road, Uttoxeter New Road and Ashbourne Road. This is complemented by some increases elsewhere as traffic is diverted along the Southern and Eastern part of the inner ring road and to alternative routes such as Uttoxeter Old Road, Kedleston Road and Duffield Road.
- Charging Scheme - the predominant behavioural response to the Charging scheme is anticipated to be for vehicles to either 'upgrade' or 'pay the charge', each of which has no resulting impact on traffic movements. However, where vehicle users opt to 'avoid the zone', 'cancel journey' or 'mode shift', this will impact on the volume and location of traffic travelling around the network, principally reducing flows within the charging zone and increasing flows around the zone, however a smaller number of links with increasing traffic flow than decreasing traffic flow have been predicted (Figure 23)

Figure 21 Relative changes in traffic flows (AADT) from between the Traffic Management scheme and the Do Minimum for 2020

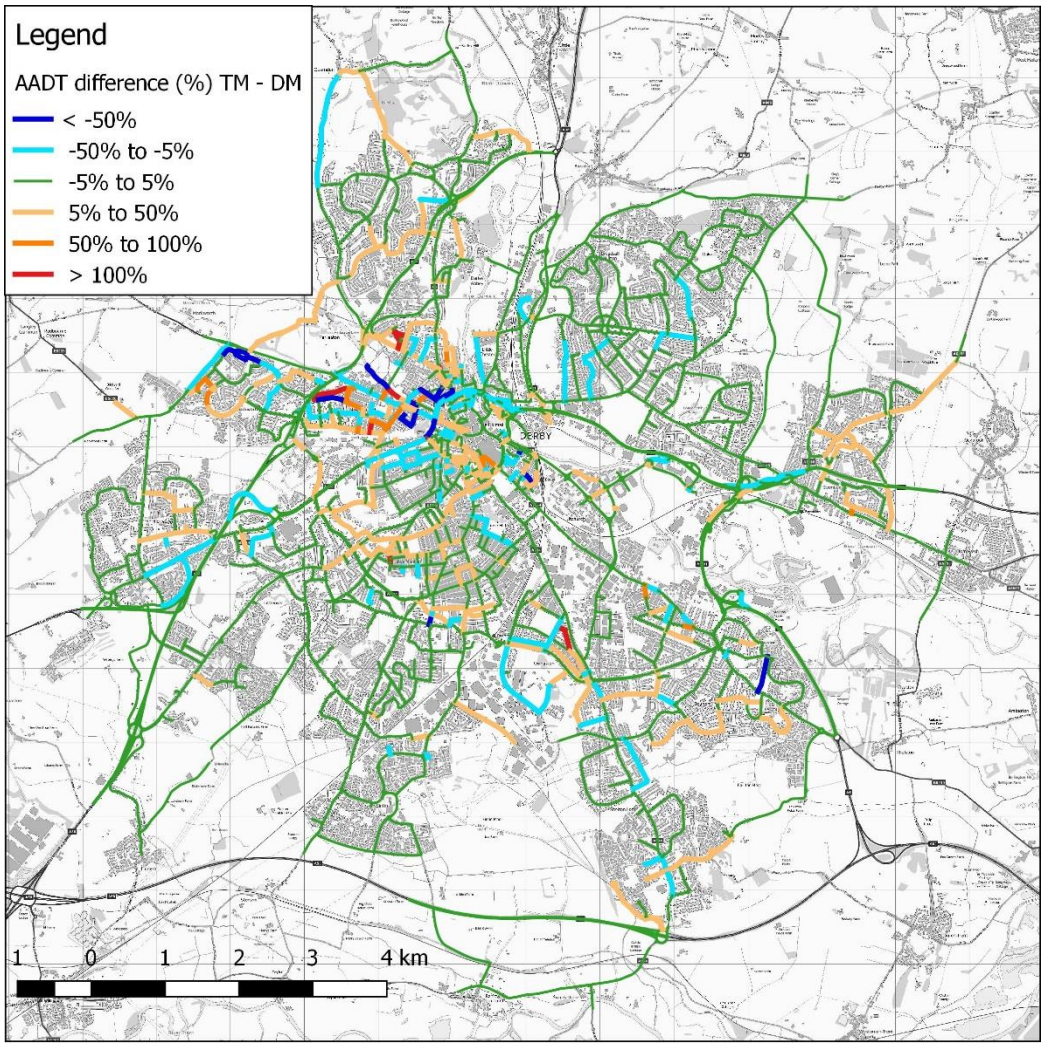


Figure 22: Relative change in traffic flow (AADT, in %) between the traffic management scheme (TM) and the Baseline (DM) for 2020.

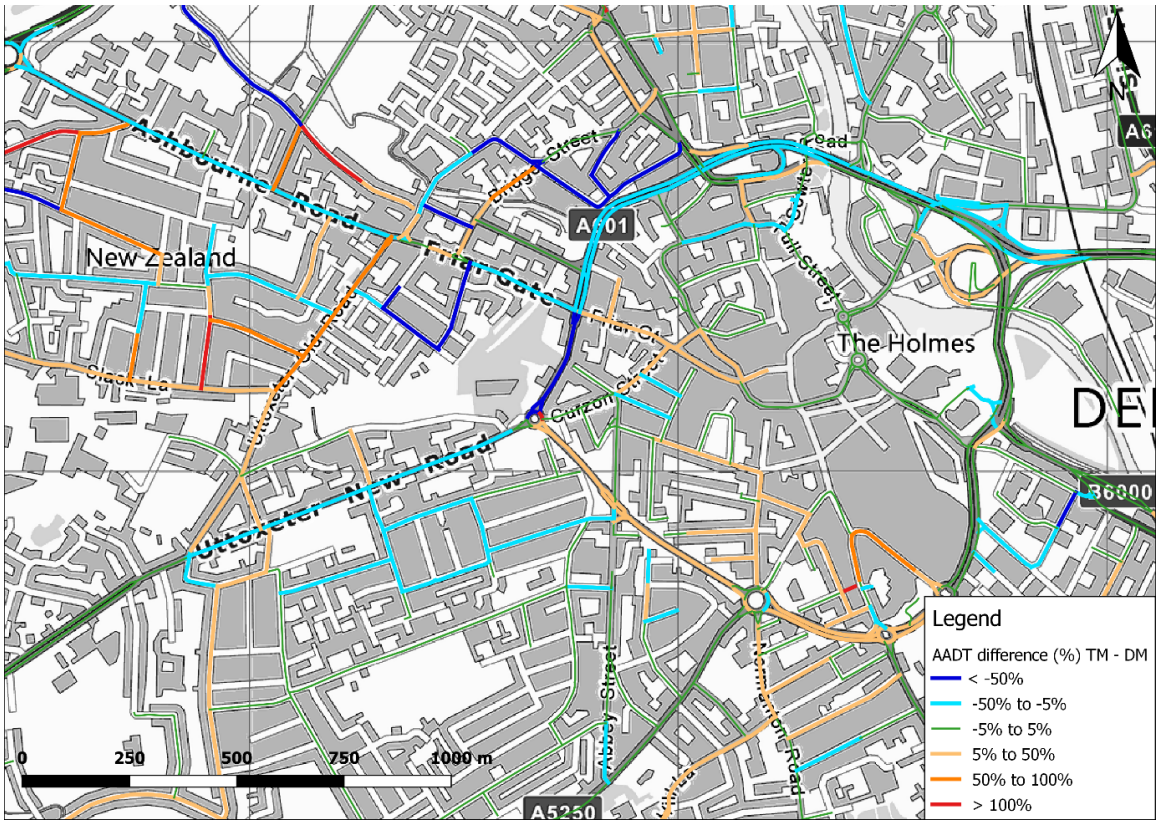
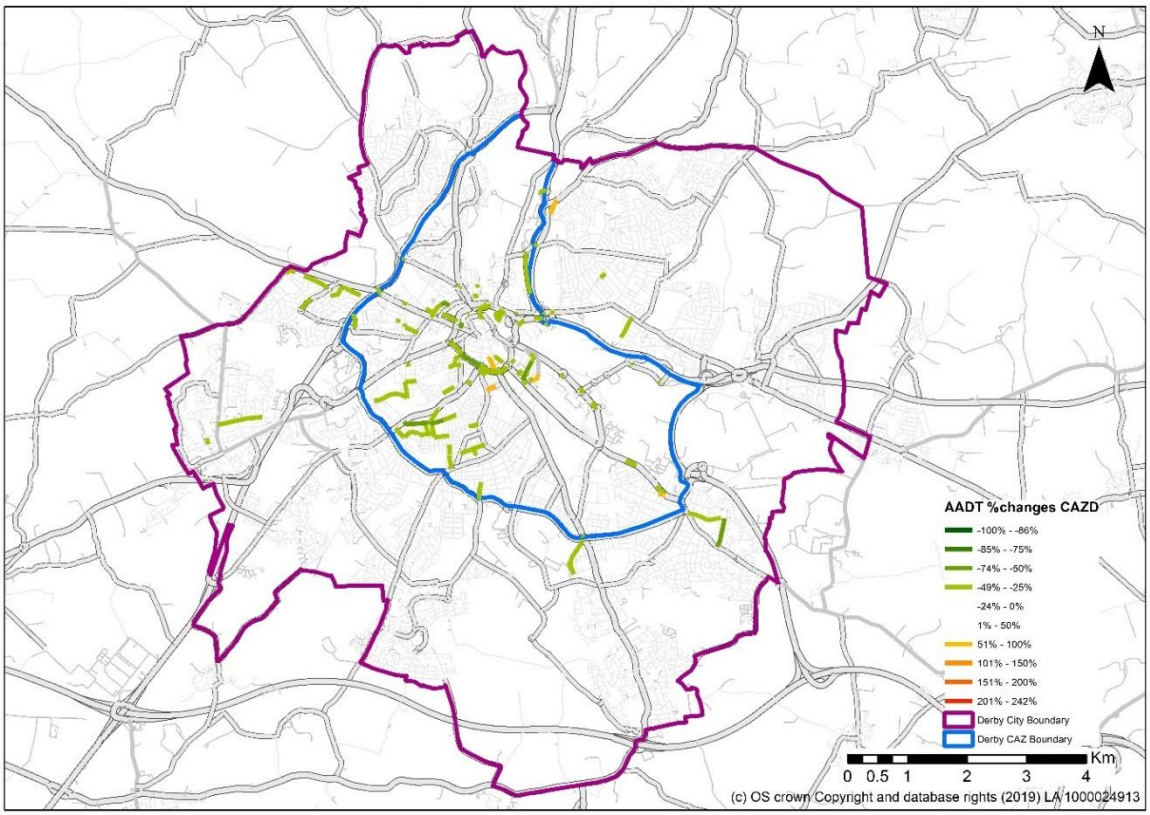


Figure 23 Relative changes in traffic flows (AADT) from between the Charging scheme and the Do Minimum for 2020



Looking specifically at the traffic management scheme it is also useful to consider origin and destination of trips passing through Stafford Street and therefore most likely to be impacted by the traffic management scheme (shown in Figure 24 and Figure 25). The large majority of trips from within Derby originate fairly near to Stafford Street and along the South Western route to the city centre. The destination are again in and round the centre but also to the East and West of the centre indicating trips are both going into and through the central area.

Figure 24: Number of trips going through Stafford Street and their origin aggregated at LSOA level.

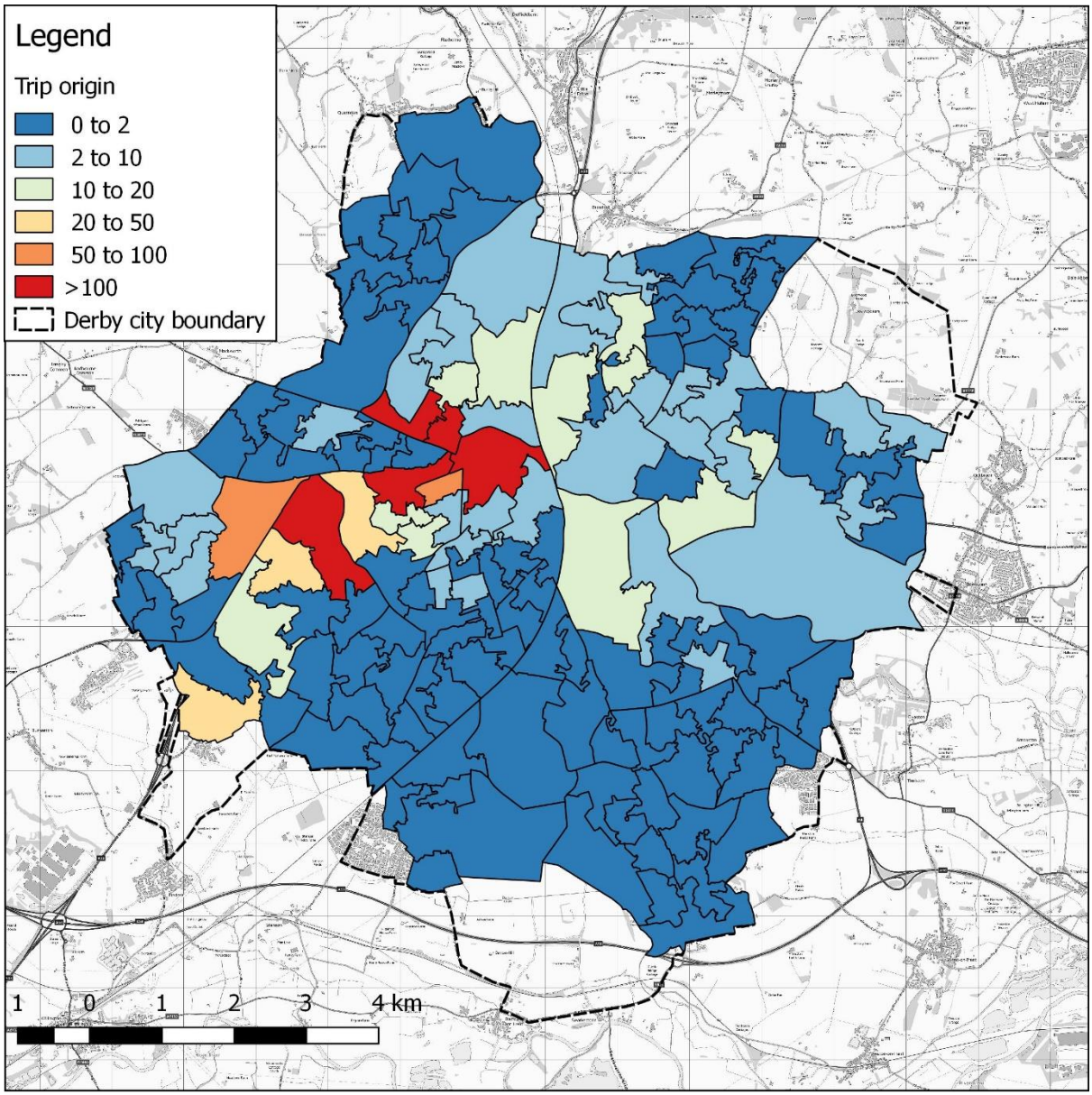
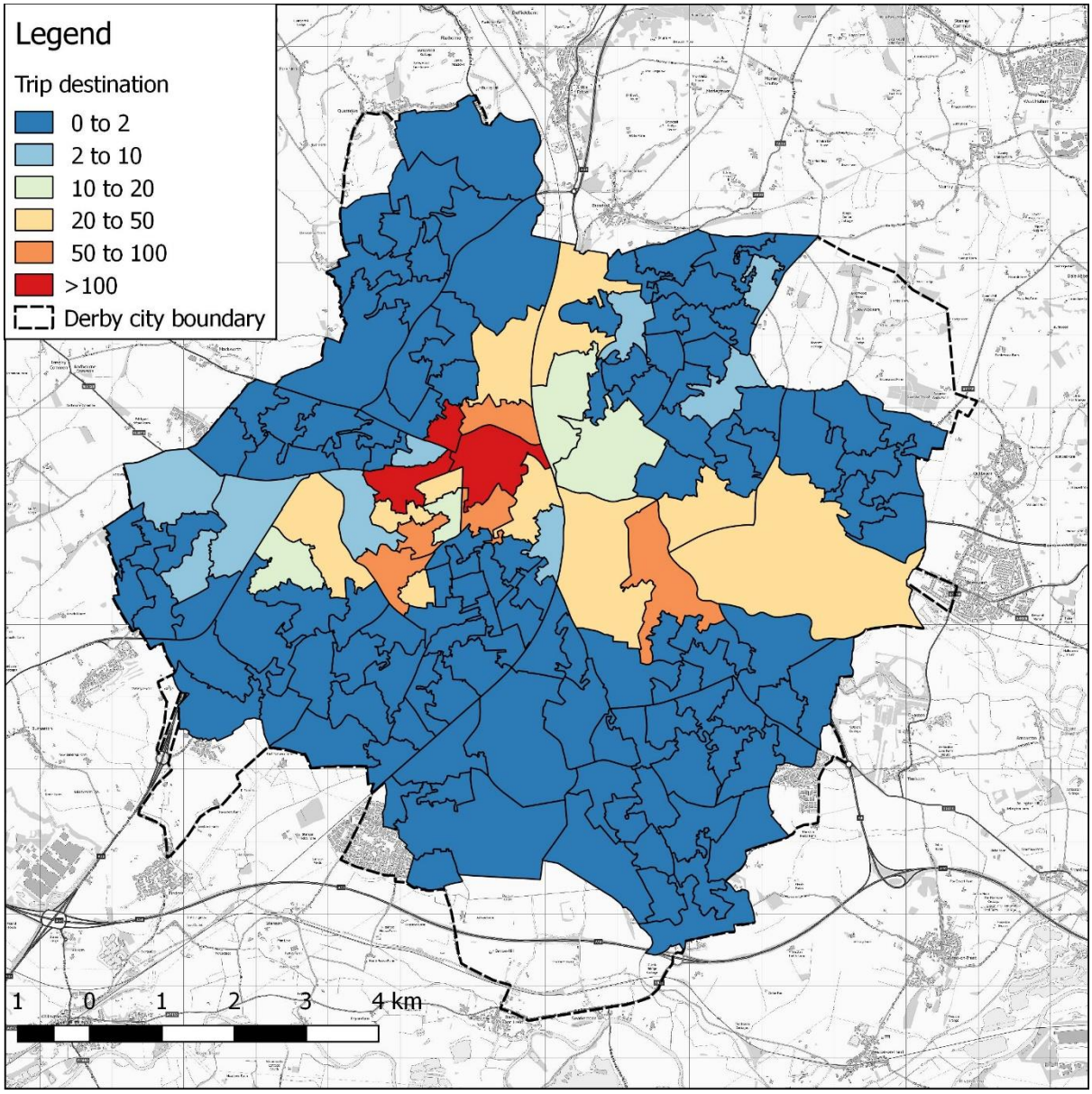


Figure 25: Number of trips going through Stafford Street and their destination aggregated at LSOA level.



The number of trips by LSOA of origin was also disaggregated by quintiles of demographic groups (Table 29). This indicates that a greater proportion of trips are being generated in areas with low income, young children and elderly and so would be disproportionately impacted by the scheme.

Table 29: Number of trips going through Stafford Street and their quintile of origin for income, under 16 and over 65.

Demographic groups	Lowest proportion 1	2	3	4	Highest proportion 5
Income (IMD) with quintile 1 referring to the most deprived population	664	574	179	91	81
Under 16	1,034	114	62	215	64
Over 65	950	332	239	36	32

These changes in traffic flows will then have the propensity to impact on noise levels and accident rates, which are associated with the volume of traffic and speed. Any distributional impact will of course depend on the location and specific links where significant changes occur.

Specific modelling of changes in noise and accident rates has not been undertaken for both scenarios. Instead, changes in Annual Average Daily Traffic (AADT) (i.e. the traffic flow) and traffic speed between the baseline and the scenarios are used as a proxy for changes in accidents and noise, given both impacts will be correlated to changes with this parameter. This is explored in the following sections.

6.2 Safety

The number of road traffic accidents recorded in each LSOA in 2017 was obtained from Road Safety Data STATS19, available from https://data.gov.uk. Using this dataset, we have been able to compute the national accident rates disaggregated by demographic groups as well as for the domain of study, based on the population at LSOA level from the Census 2011 data:

Table 30: Accident rates at national and Derby level disaggregated by quintiles for four demographic groups.

Accident rates		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Income	UK	0.24%	0.23%	0.23%	0.21%	0.15%
	Derby	0.22%	0.16%	0.17%	0.21%	0.13%
Children	UK	0.27%	0.23%	0.20%	0.19%	0.19%
	Derby	0.24%	0.18%	0.15%	0.12%	0.16%
Elderly	UK	0.26%	0.20%	0.19%	0.21%	0.20%
	Derby	0.25%	0.15%	0.14%	0.17%	0.18%
Disability	UK	0.22%	0.20%	0.20%	0.22%	0.23%
	Derby	0.21%	0.16%	0.15%	0.17%	0.23%

At a national level, accidents occur where the most deprived population lives, as well as the lowest proportion of children and the elderly. The situation remains comparable for the region of Derby but with lower accident rates in comparison to national statistics. Figure 2 highlighted that over half of the population living within the charging scheme domain belong to the 20% most deprived population and are therefore more likely to be affected by road accidents.

The traffic management scheme is expected to impact the volume of traffic, mostly near Stafford Street, which can have an impact on the residents in the vicinity. In addition, the predominant behavioural response to the Charging Scheme is anticipated to be for vehicles to either 'upgrade' or 'pay the charge', each of which has no resulting impact on traffic movements. However, where vehicle users opt to 'avoid the zone', 'cancel journey' or 'mode shift', this will impact on the volume and location of traffic travelling around the network, which will also impact on the volume of traffic on individual links and the speed of travel.

Implementing either a Traffic Management scheme or a Charging scheme could therefore lead to changes in the traffic flow through rerouting of vehicles to different roads, potentially leading to an increase of noise levels from vehicles as well as accident rates and therefore safety implications for inhabitants, however expected to be less significant in the case of the traffic management scheme. Any distributional impact will of course depend on the location and specific links where significant changes occur.

Two criteria have been applied to restrict the study to the main affected links:

1. Absolute change in AADT or traffic speed must be at least 5% (increase or decrease) of the baseline AADT link to be defined as a 'significant' change – given noise around the transport modelling, it is difficult to have confidence that smaller changes observed are truly an impact of the scenarios or model noise. In addition, changes of 5% are considered as "neutral" in the WebTAG analysis.
2. Absolute AADT 2020 DM link should be higher than the first quintile in order to select significant roads – this removes links which show a large percentage change due to a low starting point: e.g. an increase in AADT from 1 to 2 will show an increase in 100%.

Based on these criteria, links have been highlighted for the two scenarios.

WebTAG analysis indicates that a change in traffic flow or speed is considered as significant if it is at least 10%. Based on this assumption, Table 31 summarizes the number of links with significant increase or decrease in traffic volume or speed for both scenarios:

Table 31: Number of links with significant changes for both scenarios

Number of links	Traffic Management Scheme	Charging Scheme
Significant decrease in traffic volume	172 [3.61%]	1267 [26.57%]
Significant decrease in traffic speed	51 [1.07%]	45 [0.94%]
Significant increase in traffic volume	221 [4.63%]	251 [5.26%]
Significant increase in traffic speed	53 [1.11%]	46 [0.96%]

Implementing a Charging Scheme will lead as expected to a much greater number of links experiencing reductions in traffic flows as vehicles divert away from the zone, but with a much smaller number of links experience any significant increase. With the traffic management scheme this effect is much less as it is targeted at a single road link, with overall decreases in traffic flows being roughly balanced by links having increases.

Speed changes meeting the WebTAG criteria as significant are much fewer overall and in fact slightly greater with the traffic management scheme. This is because the impact of the traffic management scheme is greater for individual links but affects fewer links overall. For the charging scheme the impact is more widespread and diluted across the city.

Overall about 10% of total links for the traffic management scheme and over 30% of links with a charging scheme will have a significant change in traffic characteristics. For the traffic management scheme these changes roughly balance with a similar number of links experiencing decreases as increases. For the charging scheme the overwhelming impact is a reduction in traffic flows.

To account for changes in accidents at LSOA level, the links have been classified based on traffic volume and speed, as summarised in Table 32 below:

Table 32: Classification of changes in accident rates

Relevant **decrease** in accident rates	Significant **decrease** in traffic speed AND significant **decrease** in traffic volume	
Slight **decrease** in accident rates	Significant **decrease** in traffic speed AND non-significant change in traffic volume	Significant **decrease** in traffic volume AND non-significant change in traffic speed

Relevant **increase** in accident rates	Significant **increase** in traffic speed AND significant **increase** in traffic volume	
Slight **increase** in accident rates	Significant **increase** in traffic speed AND non-significant change in traffic volume	Significant **increase** in traffic volume AND non-significant change in traffic speed

Based on the above criteria, links have been classified and LSOAs have been defined based on the number of links with an increase or decrease in accidents within its LSOA. Results are shown in Table 33 and Table 34. Overall the analysis indicates that links are predominately showing either a relevant decrease, slight decrease or no impact, with very few increases. So for clarity of interpreting the data at LSOA level only the relevant decrease category is shown for the Traffic management scheme (Table 33) as this is largely predominant and only the slight decrease category is shown for the Charging Scheme (Table 34).

Table 33: Number of LSOAs with a relevant decrease in accidents disaggregated by quintiles of demographic population for the Traffic management scenario

Quintiles	1	2	3	4	5
Income	13	12	2	1	0
Under 16	10	2	1	4	11
Over 65	14	9	3	2	0
Disability	0	0	2	11	15
Women	12	4	1	4	7
Proportion of "non-white" people	0	0	6	20	2

Table 34: Number of LSOAs with a slight decrease in accidents disaggregated by quintiles of demographic population for the Charging Scheme scenario

Quintiles	1	2	3	4	5
Income	46	30	15	14	18
Under 16	18	25	21	13	46
Over 65	42	24	24	17	16
Disability	2	17	22	35	47
Women	30	19	22	30	22
Proportion of "non-white" people	0	3	45	38	37

The traffic management scheme shows a clear benefit trend for low income groups, with areas with the lowest levels of income experiencing the greatest reduction in accidents. There is no clear trend for children under 16 with both the highest and lowest quintiles having similar impacts. The other group that shows a clear trend is household with disabled people with those with the highest proportion seeing the biggest benefit.

The charging scheme has an overall larger positive impact throughout the city with more LSOA seeing accident reductions. Based on the demographic population, this positive impact is greatest for children under 16, those on low incomes and areas with a high proportion of people with disability.

6.3 Noise

As previously discussed, both schemes could impact traffic volume and traffic speed, both influencing the noise levels for habitants near roads. Tag Unit A3 defines a significant change in noise levels to be at least 3dB. Considered independently, this threshold is obtained when there is at least a change in traffic volume of 50% (for L_{Aeq}) and in some cases a speed change of at least 10 km/h (for L_{AE})

(Annecke et al., 2008). Only 23 links (0.48% of the total links) experience a change in traffic speed of at least 10 km/h for the traffic management scheme and for the Charging Scheme. Given this it was viewed as proportionate in the analysis only to consider changes in traffic flows that meet these criteria. Table 35 reports the number of links with a change in traffic volume of at least 50% for both scenarios:

Table 35: Number of links corresponding to a significant change in traffic volume for the two scenarios.

Change in traffic volume [corresponding change in noise levels L_{AEQ}]	<-75 % [at least 6.0 dB]	-75% - -50% [3.0 dB – 6.0dB]	50%-75% [3.0 dB -6.0 dB]	>75% [at least 6.0dB]
Traffic Management Scheme	8 [0.17%]	17 [0.36%]	11 [0.23%]	13 [0.27%]
Charging Scheme	0 [0%]	23 [0.48%]	12 [0.25%]	1 [0.02%]

The traffic management scheme shows the greatest number of links that meet these noise criteria changes and the major proportion of these links are located near Stafford Street, where the traffic management scheme takes place. No clear area of the city seems to be impacted by a charging scheme in terms of noise levels. More streets would experience a significant decrease rather than an increase in noise levels. It corresponds however to a very small fraction of the total number of links (less than 0.5% at the highest) and so the overall impact on noise levels remains limited for both schemes.

6.4 Summary

The traffic management scheme will see significant reductions in traffic on Stafford Street and related roads, as well as significant increases from the displaced traffic. However, these are very localised rather than city wide. These changes will specifically affect trips passing through Stafford Street and so will have an impact on locations which generate these trips. Our analysis has shown that the areas with low incomes and a greater proportion of children and elderly disproportionately generate trips through the Stafford Street scheme and so are impacted by it.

These changes in traffic flows will have a potential consequent impact on road accidents and noise. Overall the traffic management scheme or charging scheme would have a rather neutral impact on noise on the population living in Derby, but an overall positive impact on accident rates. The effect appears to be most beneficial for the traffic management scheme but it is also in a more concentrated area around Stafford Street as expected. The benefit in terms of accidents is likely to be more widespread with the charging scheme.

Table 36: Summary assessment for traffic impacts

Scenario		Summary assessment
Traffic management scheme	✓	• The population living near Stafford street would experience an improvement of the traffic safety, but the impact remains limited elsewhere.
Charging Scheme	✓	• Implementing a charging scheme would lead to an overall decrease in traffic flow throughout the city, and therefore an improvement in traffic safety.

Note:
- no impact
X negative impact
✓ positive impact

The distributional impact in relation to demographic groups is therefore only seen for accidents but is potentially limited. In general the greatest benefits are seen for low income households and those with children under 16.

7 Summary and conclusions

Our analysis has explored how the benefits and costs are distributed for the two options under consideration in Derby: the traffic management scheme and the charging scheme. The costs and benefits have been looked at under four categories: air quality, business affordability, household affordability and traffic impacts. The key findings against each of these categories are set out below:

Air Quality

- Measured at the LSOA level across the city the traffic management scheme has a very small impact (on average less than 0.2 $\mu.mg^{-3}$) and so has no significant distributional impact for any social group. However, when considered for individual roads there are significant reductions in emissions and concentrations along Stafford Street and some related roads, as well as increases where traffic has been displaced. So there is a distributional affect in relation to specific roads.
- The charging scheme overall has an air quality benefit for most LSOAs with the greatest benefit within the charging zone and some small dis-benefits outside. These benefits are not distributed evenly and there is a clear trend with both income and households with children under 16. Low income households are seeing the greatest benefit and higher income households the least benefit. In terms of children those households with the least children are seeing the greatest benefit and those with the most the least benefit. These both correspond with the characteristics of households within the charging zone.
- When looking at sensitivity receptors again there is little impact on receptors with the traffic management scheme, whereas for the charging scheme those receptors with a greater prevalence within the charging zone show clear benefits. Those that benefit most are educational residences, followed by communal residences, care homes and nurseries.

Business affordability

- The traffic management scheme is unlikely to have any significant direct impact as there are no charges, for example. However, there may be small impacts on delivery vehicles in the area around Stafford Street and access to business premises. Also, the TUBA analysis indicates travel time increases and associated costs with business operating from a few areas to the north of Stafford Street that will see increases in traffic levels.
- The charging scheme is likely to have a significant direct impact on business through the charges applied to non-compliant vehicles. This borne out through the TUBA analysis which shows most areas will see costs, mostly related to the charges, as a result to the CAZ D scheme. This impact will be greatest for smaller businesses operating older vehicles, who will have less financial resource to upgrade their vehicles and less flexibility to manage vehicles accessing the zone to only compliant vehicles. With a Class D charging scheme all vehicle types will be affected and so a wide range of businesses will be impacted in particular taxis, small local bus and coach firms and small freight operators.
- The charging scheme is also likely to have an indirect impact to business within the charging zone through deliveries to their businesses which may incur charges and pass these on to the businesses.

Household affordability

- The traffic management scheme may generate a small direct impact on households in relation to journeys that could be affected by the scheme either by diversion or changing mode. However overall the TUBA analysis shows the scheme generates positive benefits for households in terms of travel time savings. These savings are also shown to be greatest for low income households. There are some areas showing a disbenefit, specifically to the north of Stafford Street with user costs associated with increased travel time. There may also be a small indirect impact through affects to business, primarily deliveries. However, no specific distributional impact between different social groups is expected.
- The charging scheme will have a direct impact on households with non-compliant vehicles. The TUBA analysis indicates that this will be the case for most areas of the city with only a few areas where travel time savings from reduced congestion inside the charging zone would out weigh the charging costs themselves. The analysis has also shown that low income households will have the greatest proportion of older non-compliant vehicles and so will be disproportionately affected.

Traffic impacts

- Both of these schemes are generating impacts through diversion of vehicles as either a result of the traffic management scheme or avoiding the charging zone. Therefore, both have the potential to have noise or accident impacts related to changes in traffic activity.
- The traffic management scheme will affect fewer road links, primarily around the Stafford Street area, but to a greater degree. It will also impact more on trip origins along the south western route into the city, with our analysis indicating that these also have higher levels of deprivation, children and elderly.
- The charging scheme on the other hand will affect a greater number of links as it covers a much larger area but to a lesser degree with increases in traffic around the zone and decreases within the zone.
- Overall the traffic management scheme generates both increases and decreases in traffic flows and speeds that roughly balance. The charging scheme predominately generates traffic flow decreases.
- In terms of noise neither of the schemes would be expected to have a significant impact based on the WebTAG guidance.
- In contrast both of the schemes are generating benefits in terms of expected accident reduction related primarily to traffic flow reductions. The traffic management scheme generates greater reductions but on fewer links, whereas the charging scheme generates smaller improvements but for many more links.
- The accident analysis also shows a clear distributional trend with respect to income with lower income households seeing greater accident benefits from both schemes.

The traffic management scheme solves the compliance problem on Stafford Street but is not generating wider air quality benefits. It does however generate travel time savings for many areas, with the greatest benefits being for lower income areas, and some localised accident benefits. It is also generating few if any costs and so has no distributional impact on the population as a whole. That said there are some very localised impacts on some roads and in a few areas comprising:

- The localised redistribution of traffic onto specific roads such as Uttoxeter Old Road and the western and southern parts of the Inner Ring road, as a result of the restrictions to Stafford Street

- The wider redistribution of traffic from some areas in the south eastern corridor into the city centre which generates significant numbers of trips that would normally pass through Stafford Street
- Some areas to the north of Stafford Street that are experiencing travel time increases for both businesses and households.

In contrast the charging scheme will generate broad air quality benefits across the city and some accident reduction benefits within the charging zone. These benefits are greatest for lower income groups. However, this is balanced with much greater costs to businesses and households in terms of the direct and indirect impact of the charges. These costs will also fall disproportionally on smaller local businesses and low-income households.

Given this the traffic management scheme would seem to provide the most direct way of solving the NO_2 compliance issue in Derby without causing wider distributional impacts. It does however have some localised impacts that should be mitigated. The mitigation measures being developed comprise:

- Wider traffic management measures (to be delivered through the implementation fund as part of the preferred scheme but not considered as part of this analysis) to optimise redistributed traffic flows on routes where traffic has been displaced from Stafford Street.
- A mobility credit scheme to encourage a mode shift away from cars to walking, cycling and public transport. This scheme would be targeted at:
    - Areas that are generating traffic going through Stafford Street, namely along the south western route into the city, to reduce the number of vehicles that will be displaced;
    - Areas that are seeing travel time increases, to the north of Stafford Street, to support alternatives which would not suffer these impacts;
    - Routes which are seeing traffic increases to help reduce local traffic so that overall volumes are reduced.
- Supporting measures for the uptake of zero and low emissions vehicles, primarily in the form of electric vehicle charging infrastructure. This would again be targeted at:
    - Areas that are generating traffic going through Stafford Street to encourage as many vehicles as possible that may be diverted to be zero or low emission and hence reducing the impact of this diverted traffic on emissions and air quality.
    - Routes which are seeing traffic increases to help reduce emissions from local traffic so as to help reduce overall emissions on these roads.

Appendices

Appendix 1: Socioeconomic impact group quintile distribution maps

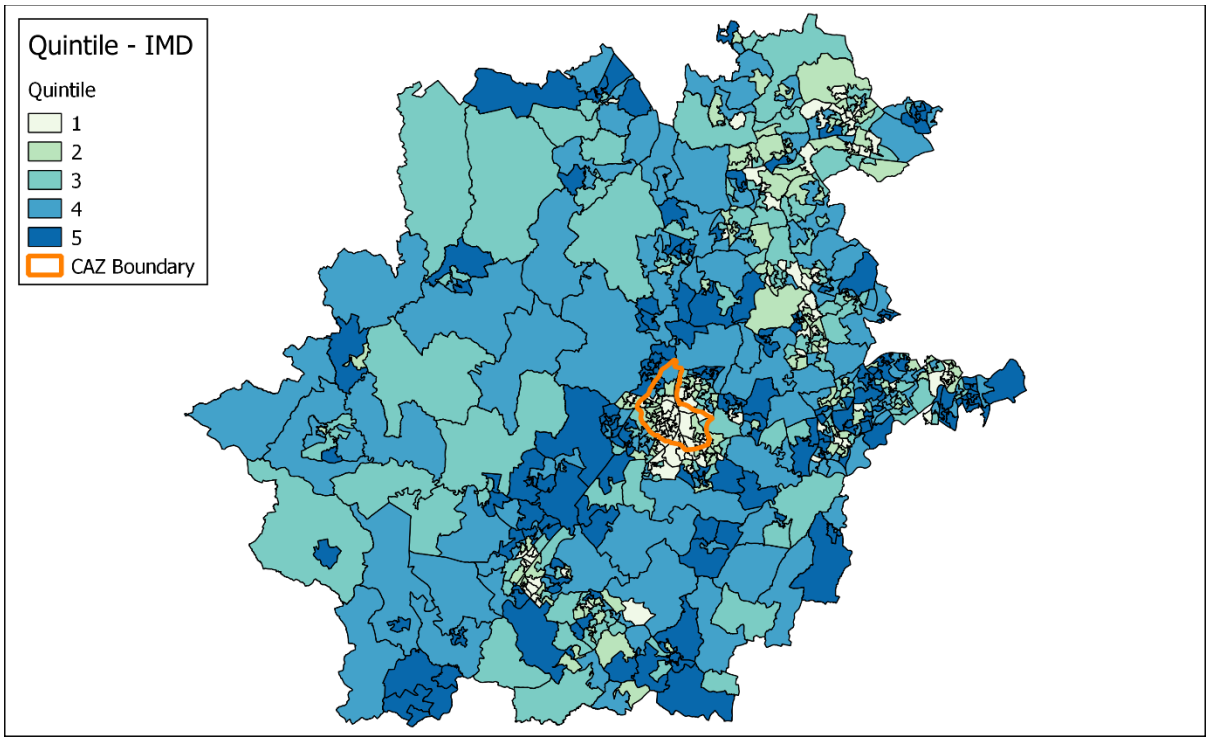
Appendix 2: Average NO_2 concentration by LSOA

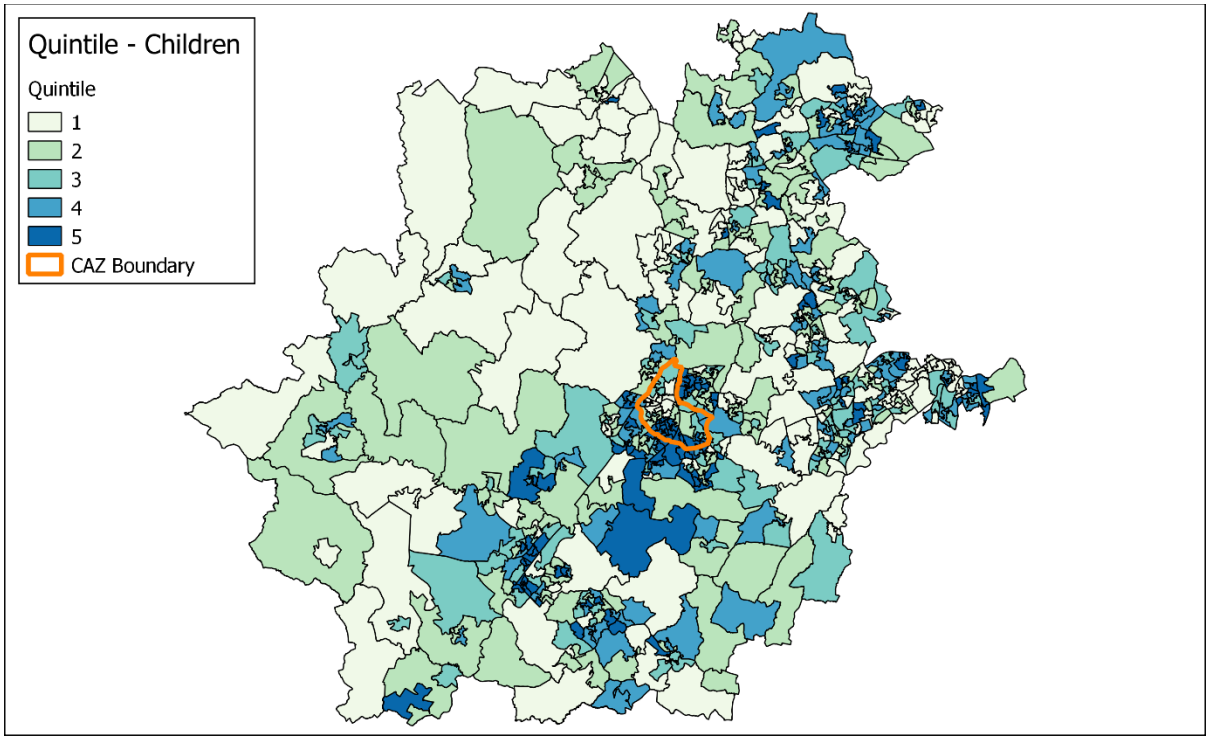
Appendix 3: NOx emissions at road links for the traffic management scheme

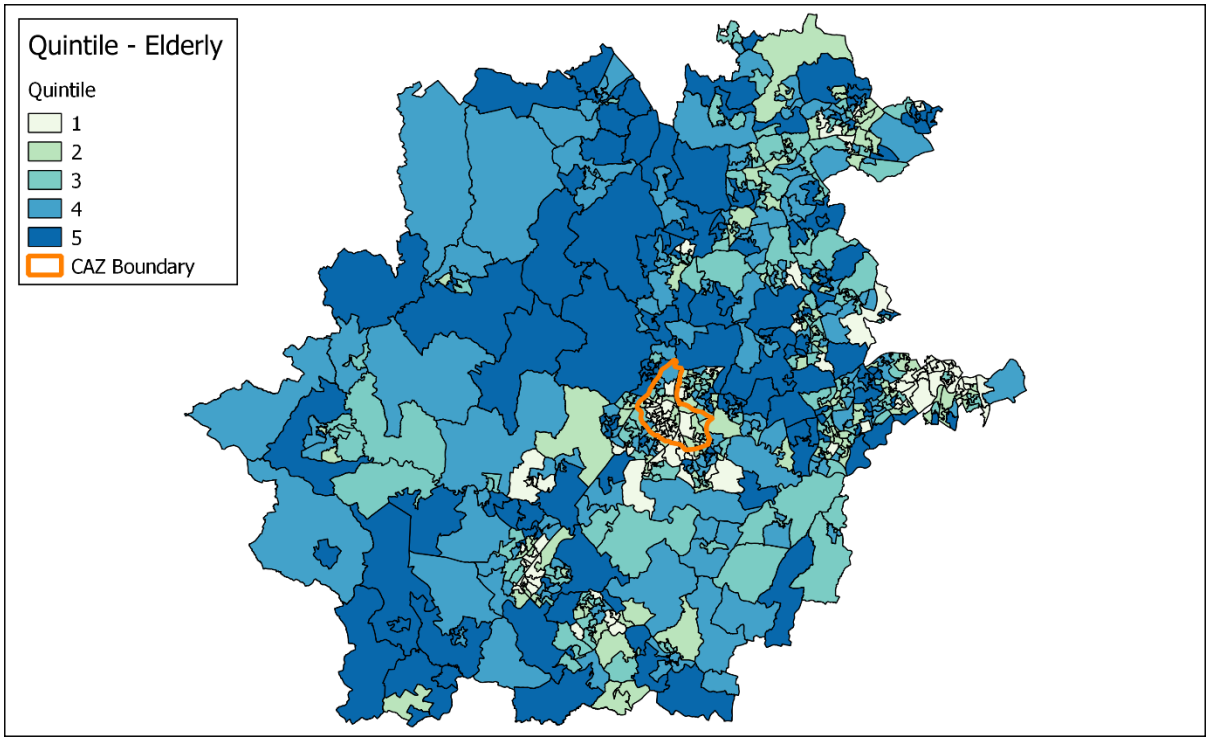
Appendix 4: Maps of TUBA outputs

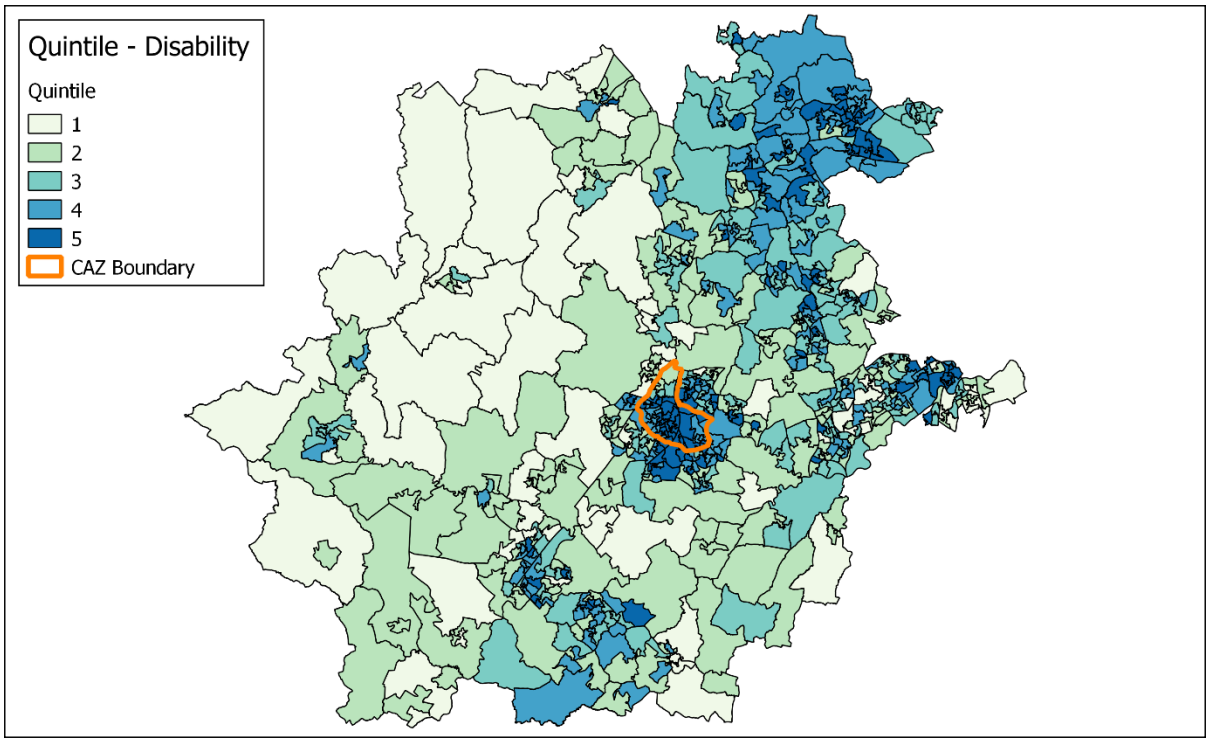
Appendix 5: Literature review

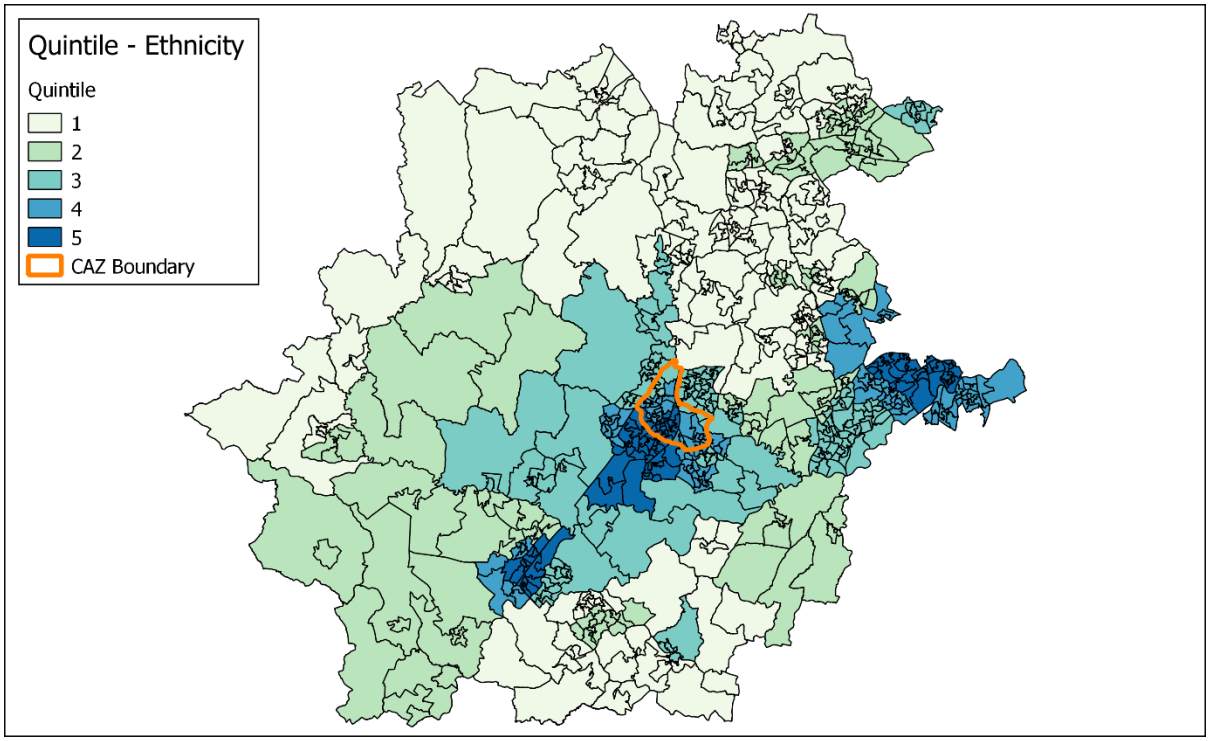
Appendix 1: Socioeconomic impact group quintile distribution maps

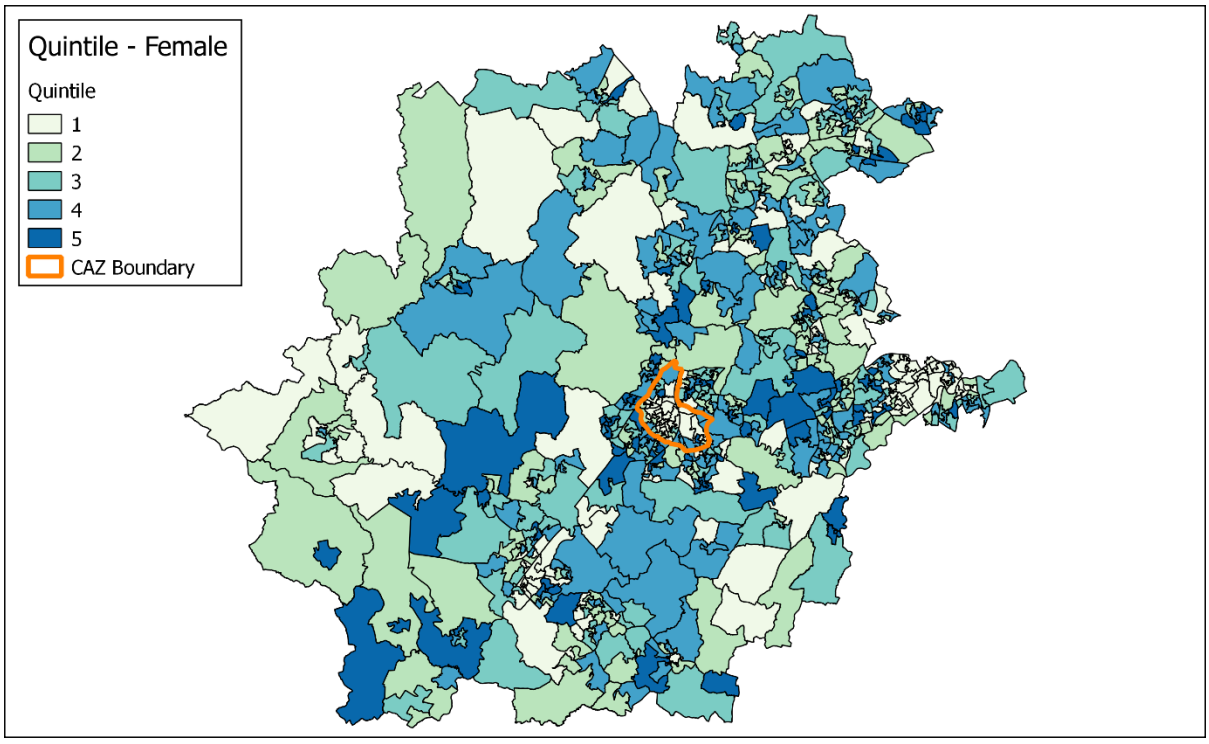




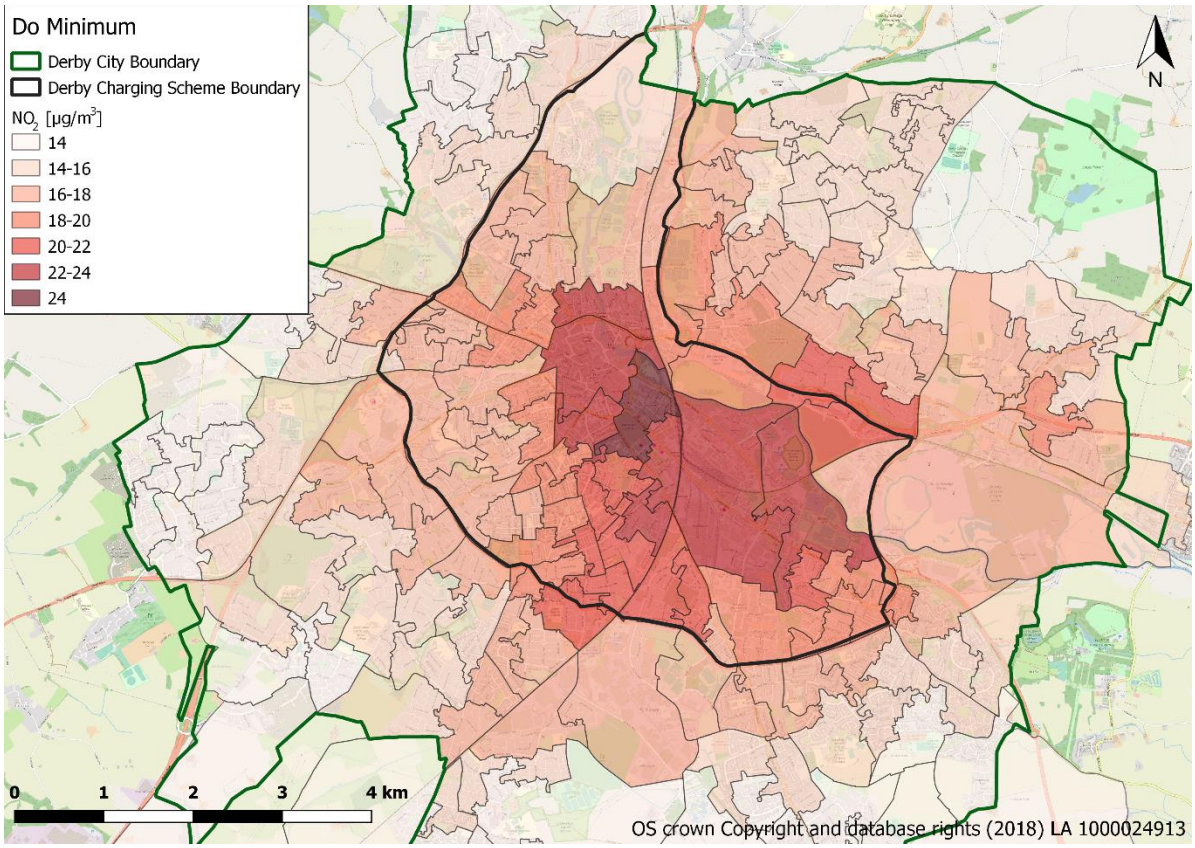

Quintile - Elderly
Quintile
1
2
3
4
5
CAZ Boundary

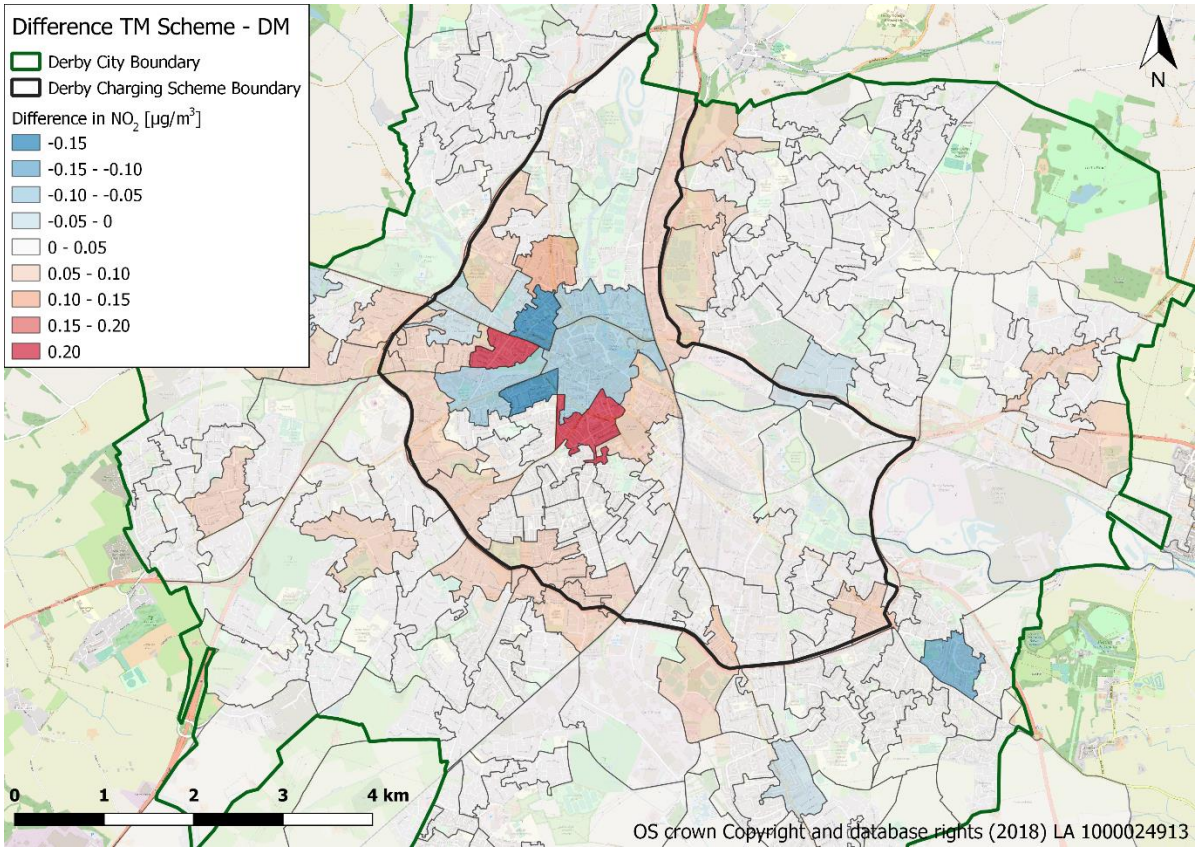

Quintile - Disability
Quintile
1
2
3
4
5
CAZ Boundary

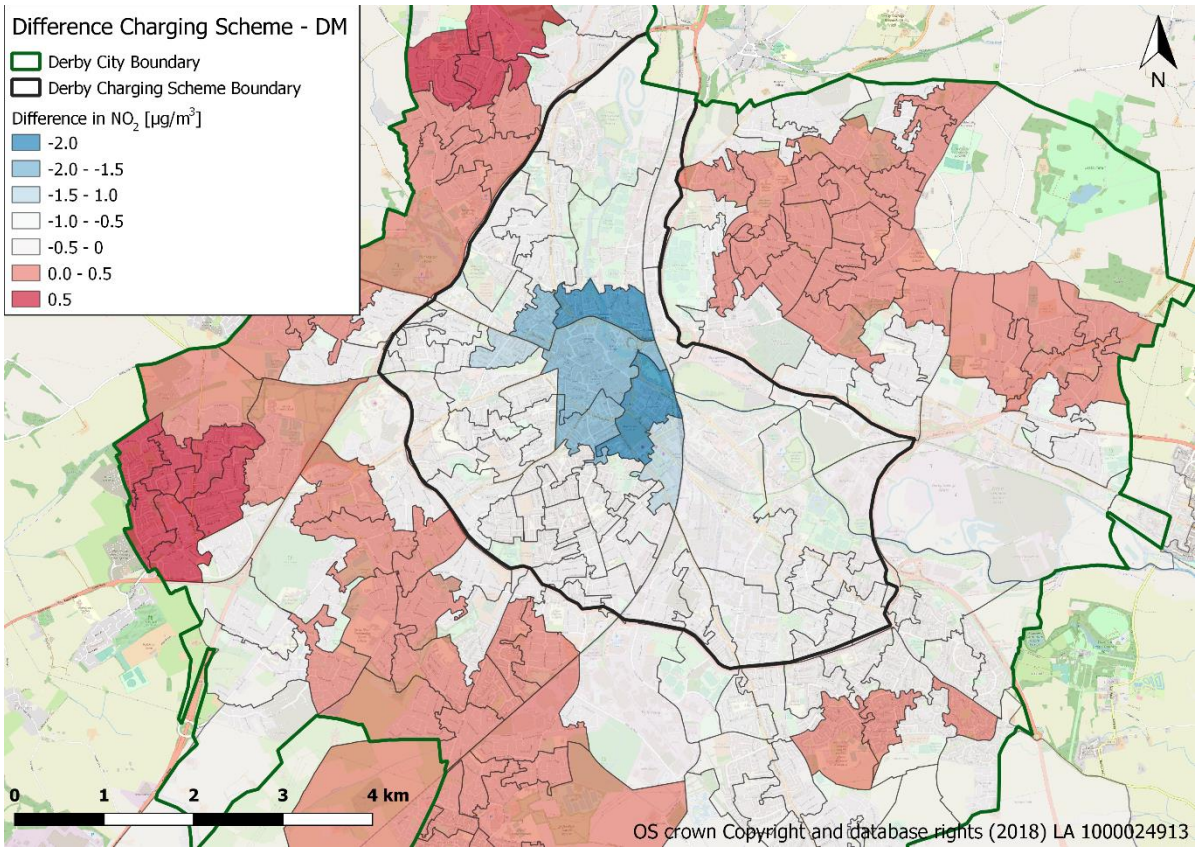

Quintile - Ethnicity
Quintile
1
2
3
4
5
CAZ Boundary


Quintile - Female
Quintile
1
2
3
4
5
CAZ Boundary

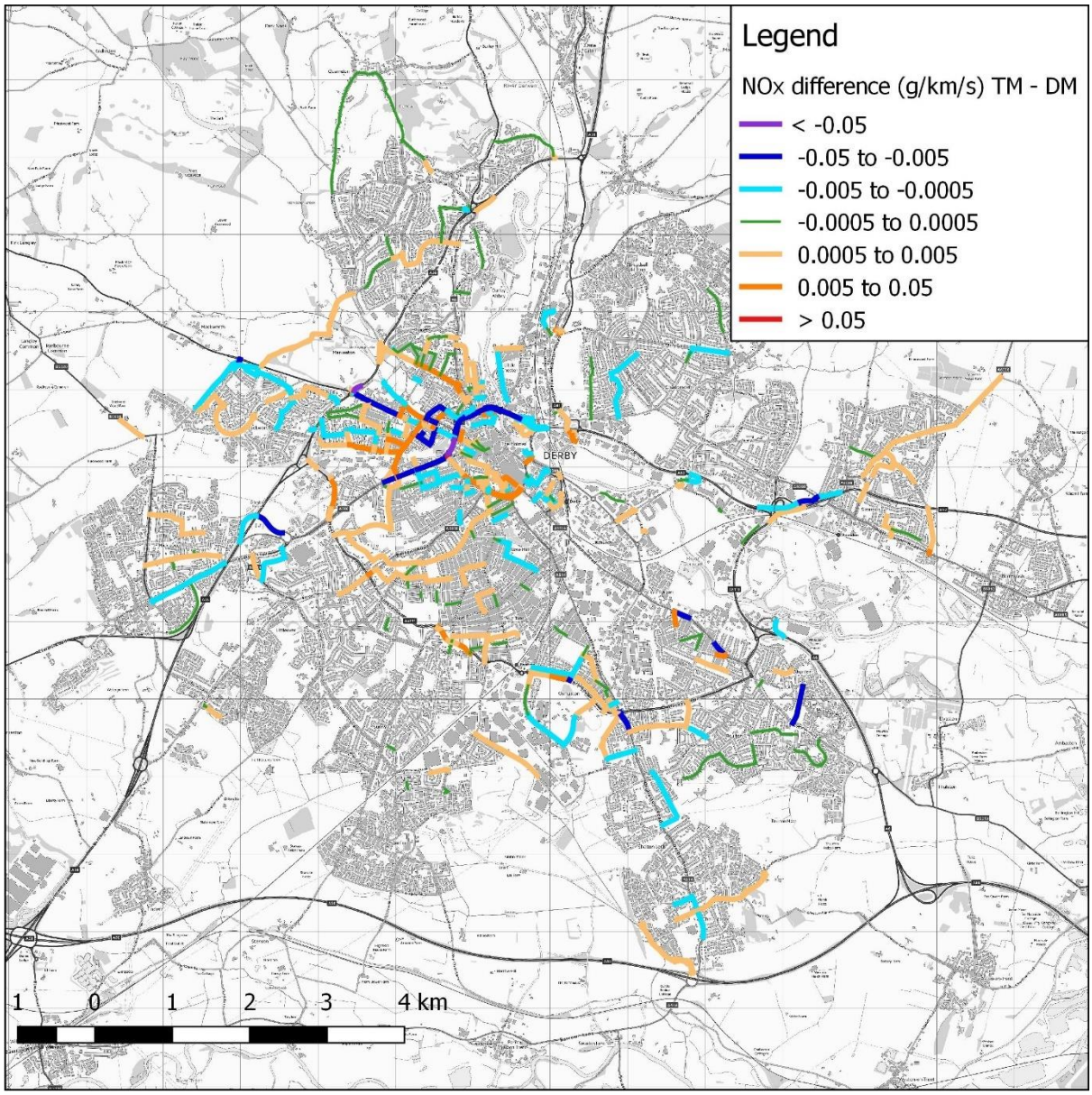
Appendix 2: Average NO_2 concentration by LSOA

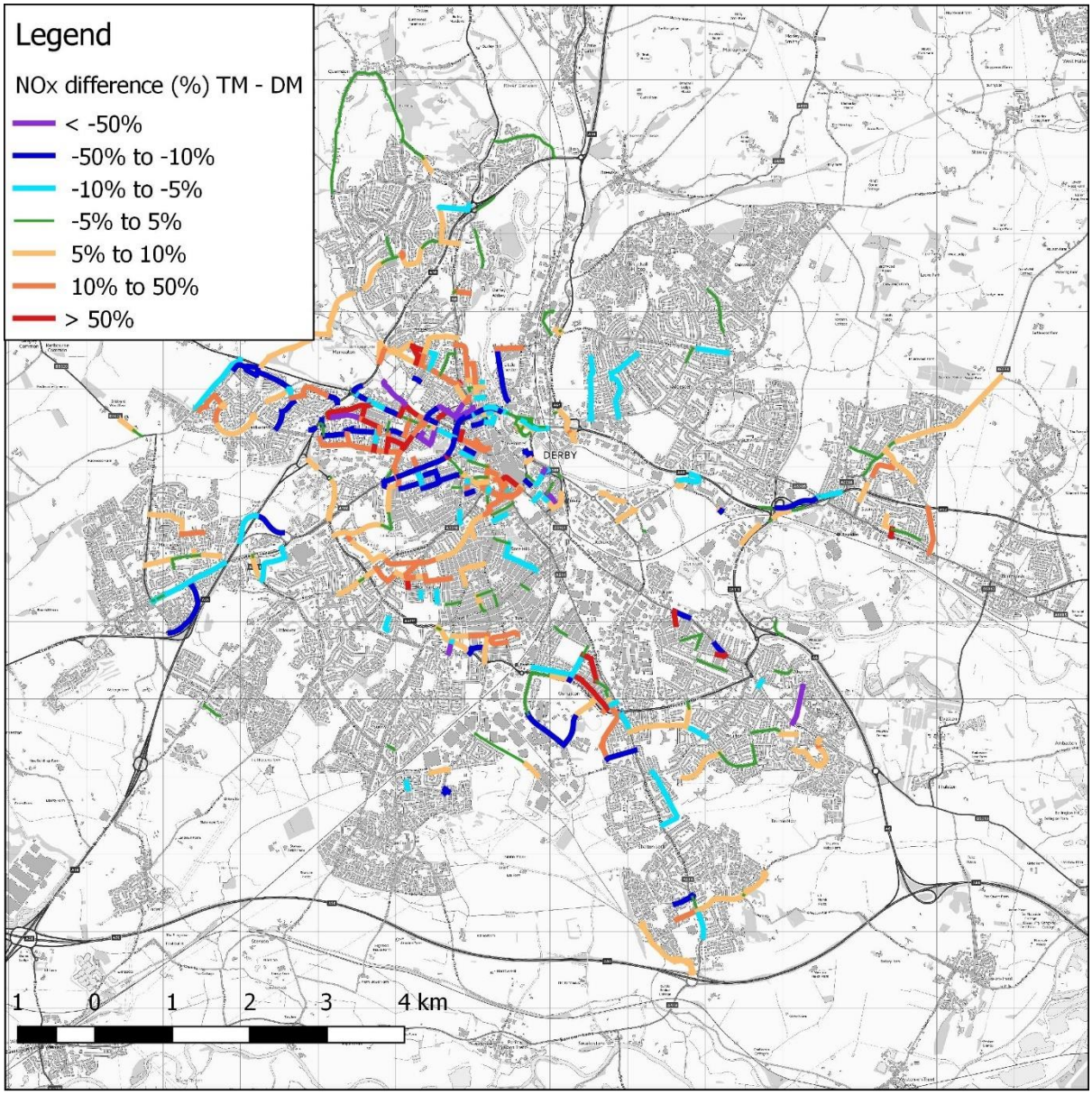



Difference TM Scheme - DM
Derby City Boundary
Derby Charging Scheme Boundary
Difference in NO2 [µg/m3]
-0.15
-0.15 - -0.10
-0.10 - -0.05
-0.05 - 0
0 - 0.05
0.05 - 0.10
0.10 - 0.15
0.15 - 0.20
0.20
N
0 1 2 3 4 km
OS crown Copyright and database rights (2018) LA 1000024913

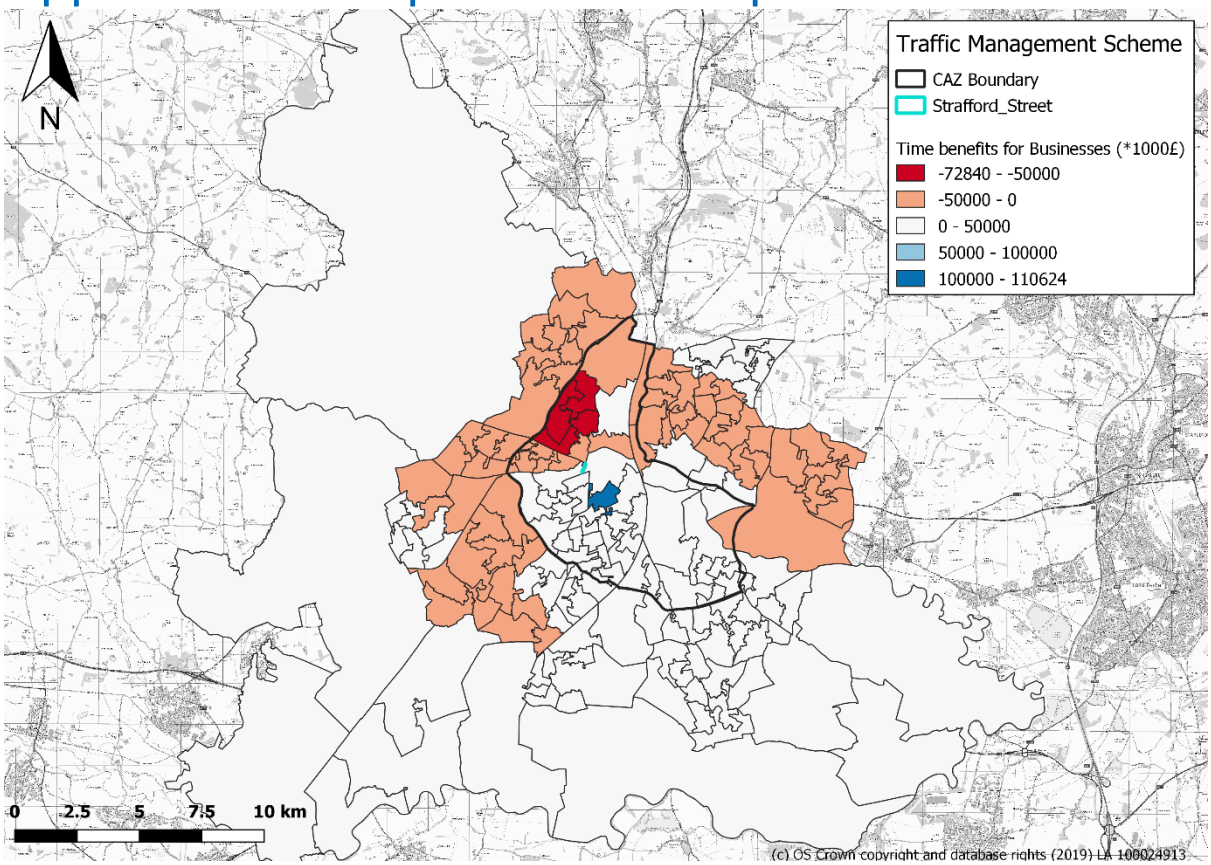

Difference Charging Scheme - DM
Derby City Boundary
Derby Charging Scheme Boundary
Difference in NO2 [µg/m3]
-2.0
-2.0 - -1.5
-1.5 - 1.0
-1.0 - -0.5
-0.5 - 0
0.0 - 0.5
0.5
N
0 1 2 3 4 km
OS crown Copyright and database rights (2018) LA 1000024913

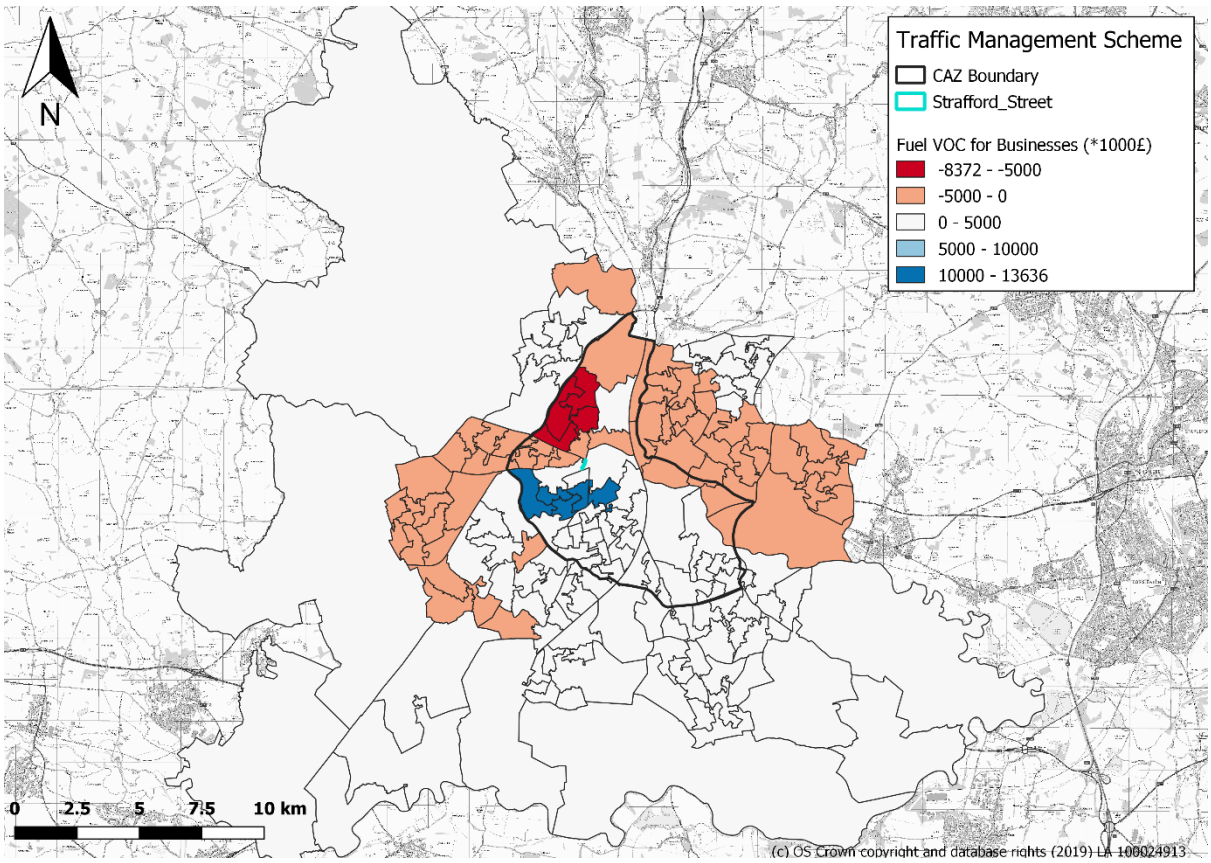
Appendix 3 – NOx emissions at road links for the traffic management scheme

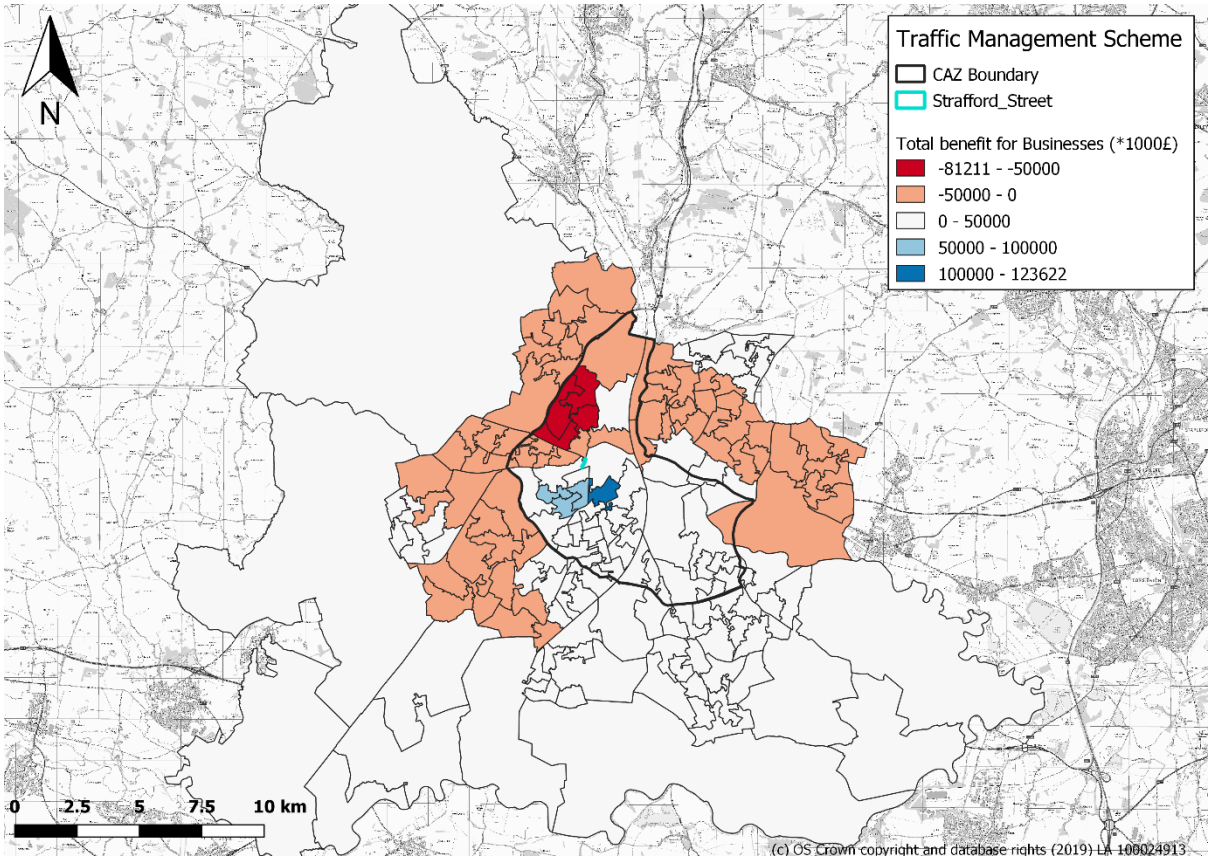


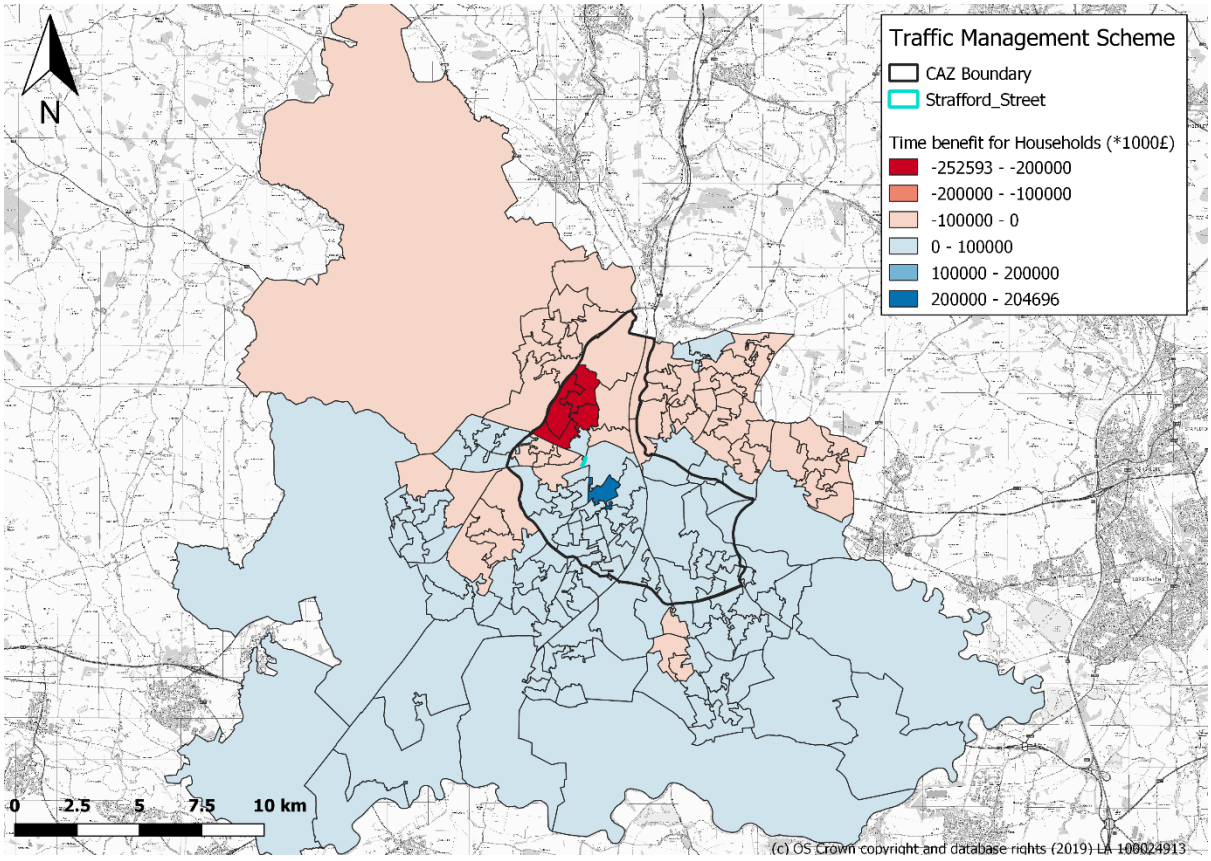

Legend
NOx difference (%) TM - DM
< -50%
-50% to -10%
-10% to -5%
-5% to 5%
5% to 10%
10% to 50%
> 50%
DERBY
1 0 1 2 3 4 km

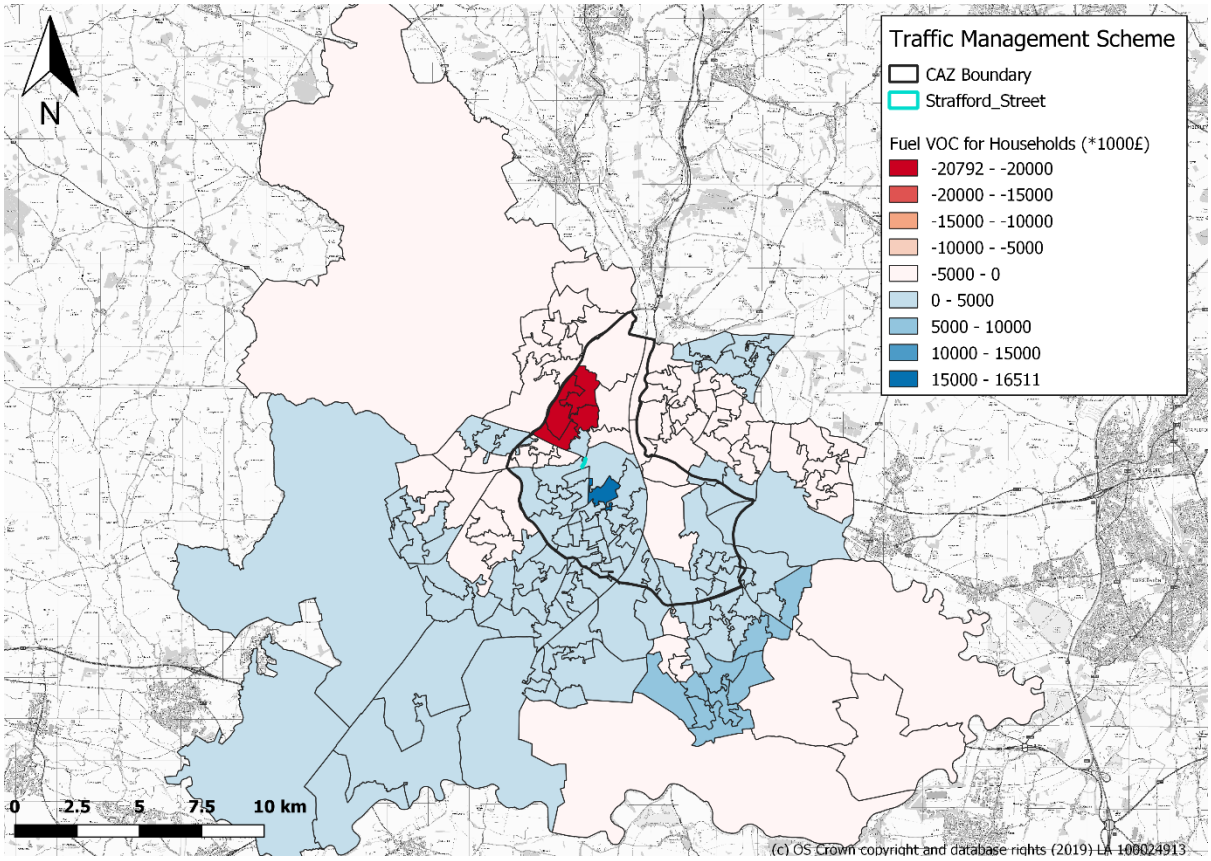
Appendix 4 – Maps of Tuba outputs

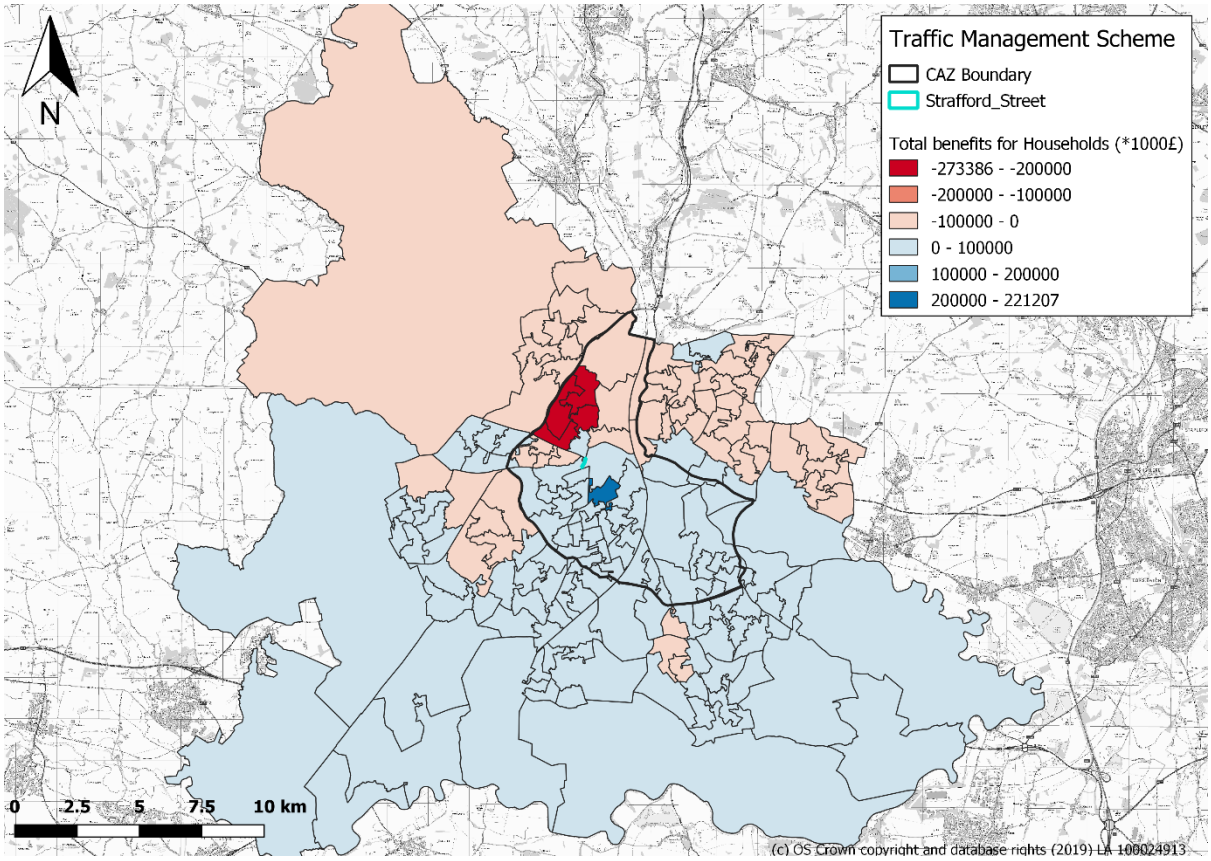


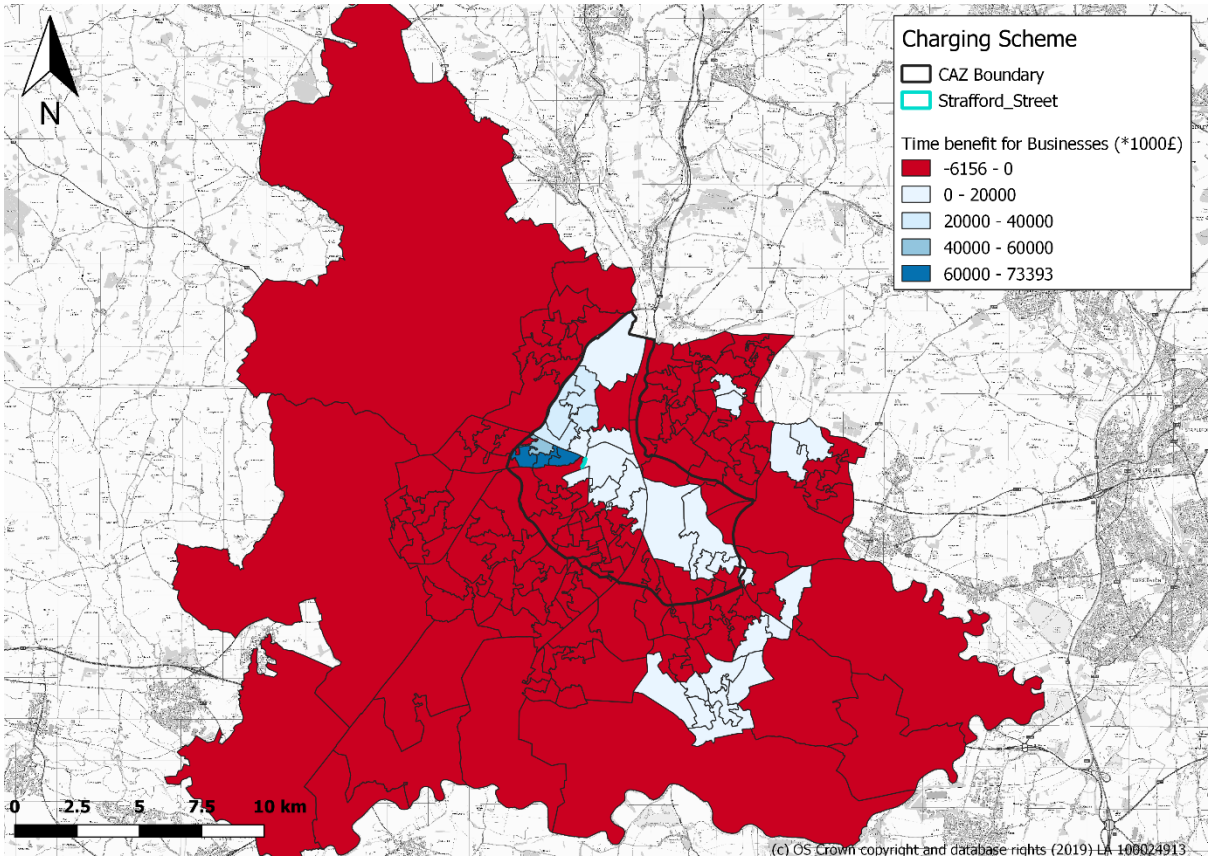


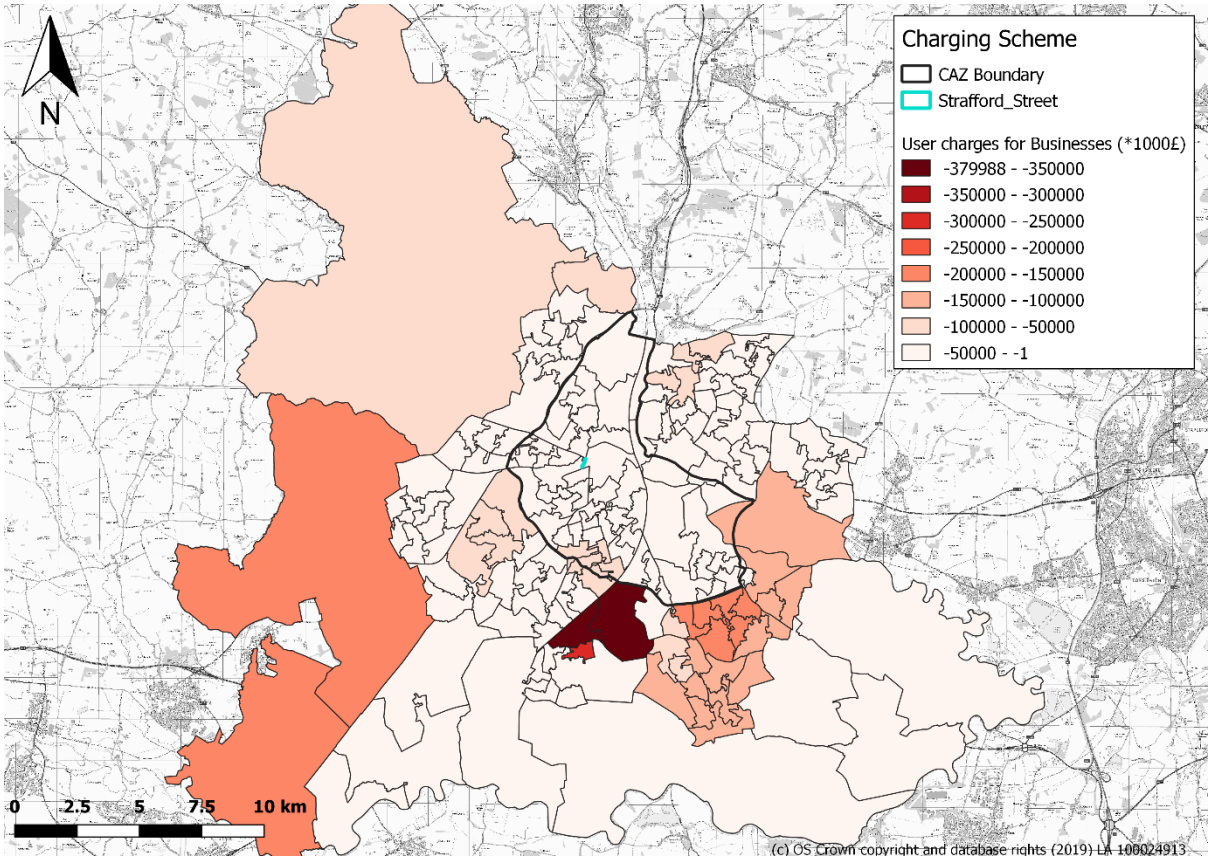

Traffic Management Scheme
CAZ Boundary
Strafford_Street
Total benefit for Businesses (*1000£)
-81211 - -50000
-50000 - 0
0 - 50000
50000 - 100000
100000 - 123622
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

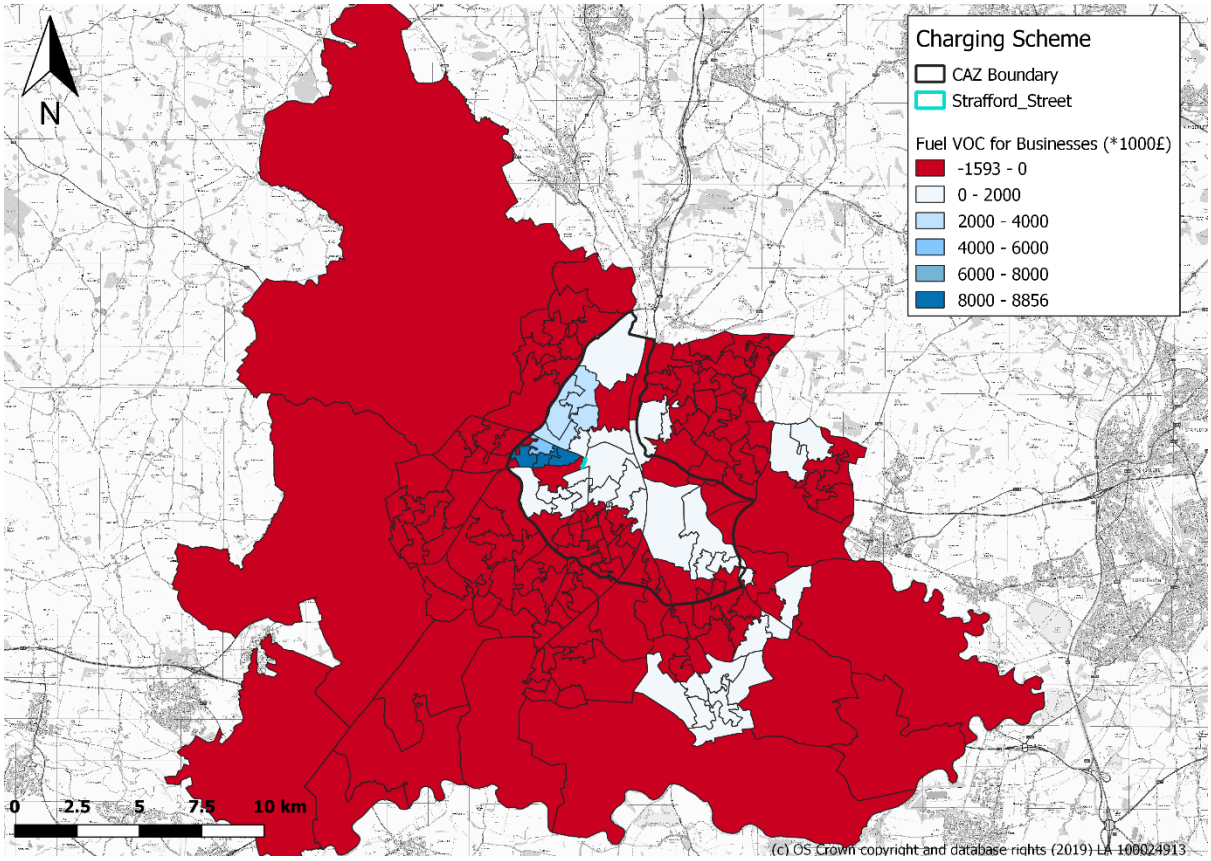

Traffic Management Scheme
CAZ Boundary
Strafford_Street
Time benefit for Households (*1000£)
-252593 - -200000
-200000 - -100000
-100000 - 0
0 - 100000
100000 - 200000
200000 - 204696
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

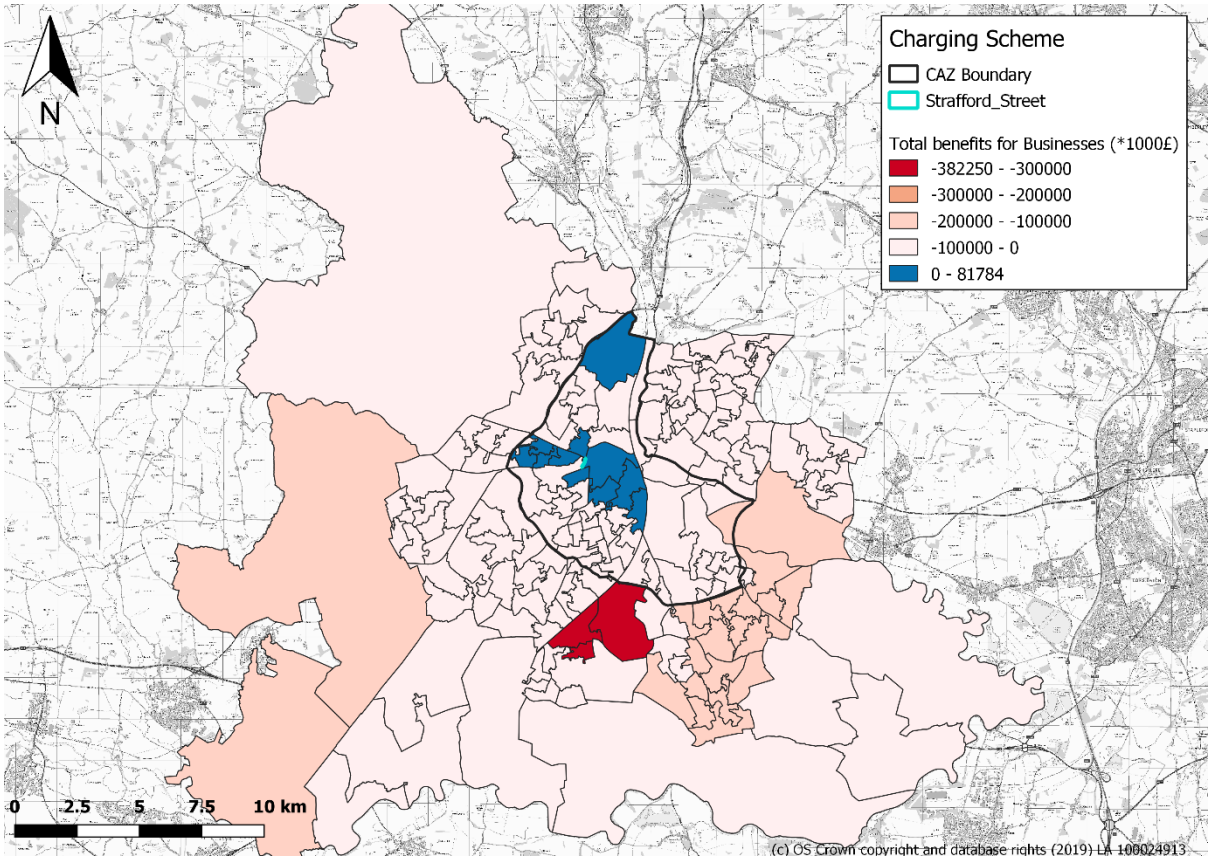

Traffic Management Scheme
CAZ Boundary
Strafford_Street
Fuel VOC for Households (*1000£)
-20792 - -20000
-20000 - -15000
-15000 - -10000
-10000 - -5000
-5000 - 0
0 - 5000
5000 - 10000
10000 - 15000
15000 - 16511
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

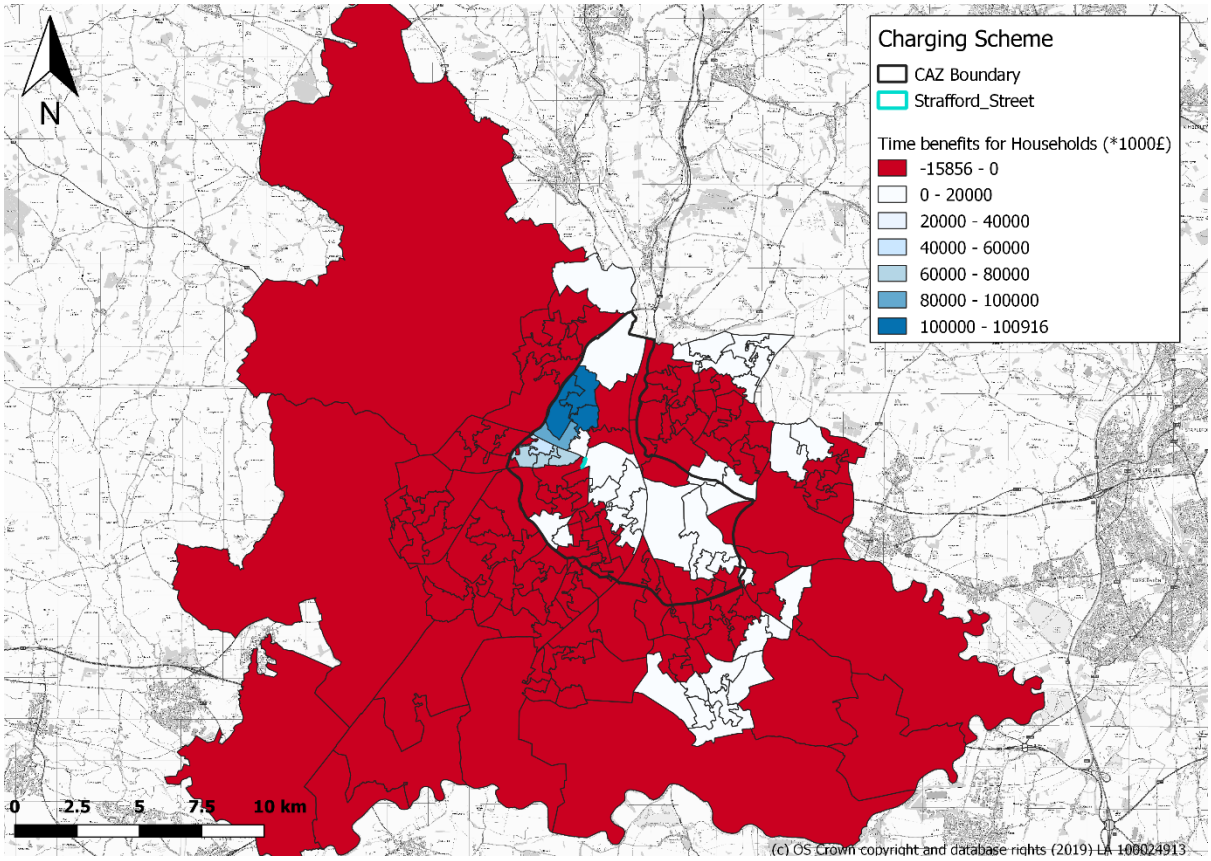

Traffic Management Scheme
CAZ Boundary
Strafford_Street
Total benefits for Households (*1000£)
-273386 - -200000
-200000 - -100000
-100000 - 0
0 - 100000
100000 - 200000
200000 - 221207
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

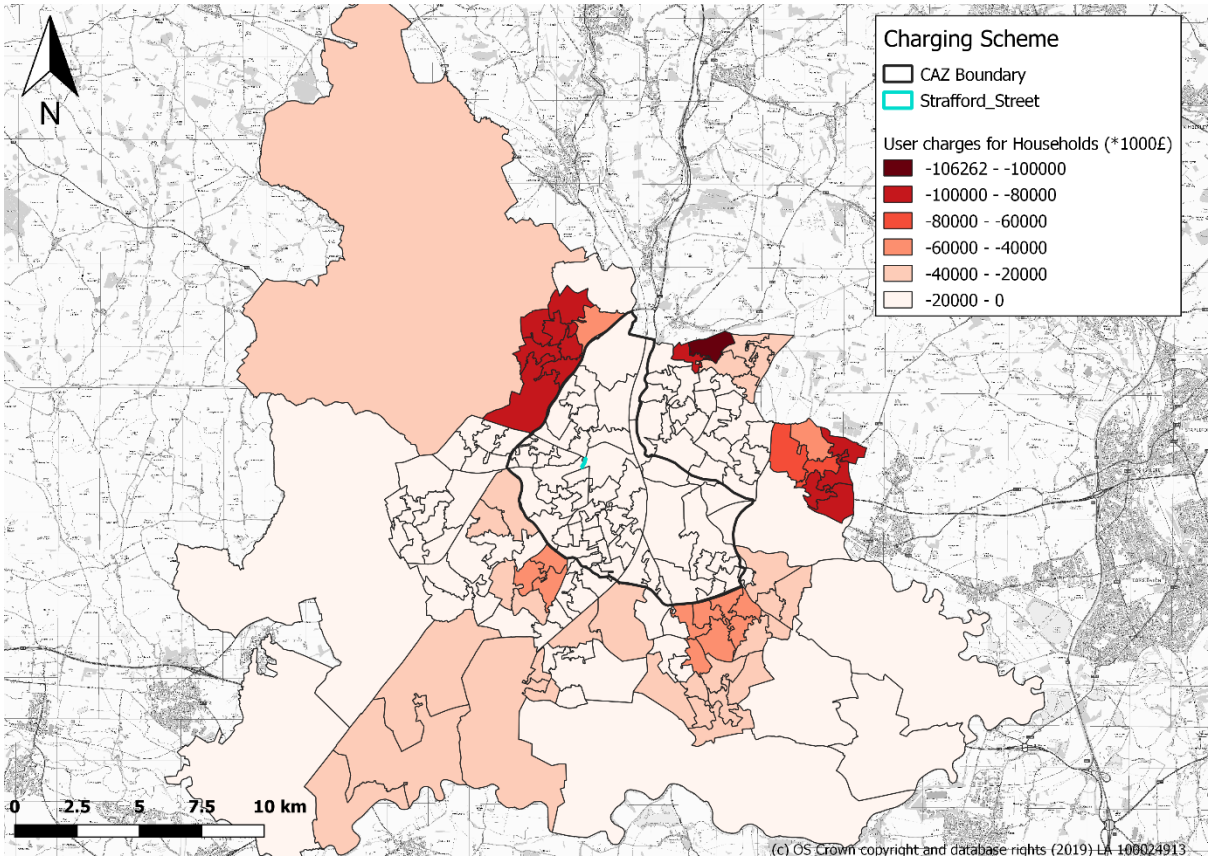

N
Charging Scheme
CAZ Boundary
Strafford_Street
Time benefit for Businesses (*1000£)
-6156 - 0
0 - 20000
20000 - 40000
40000 - 60000
60000 - 73393
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

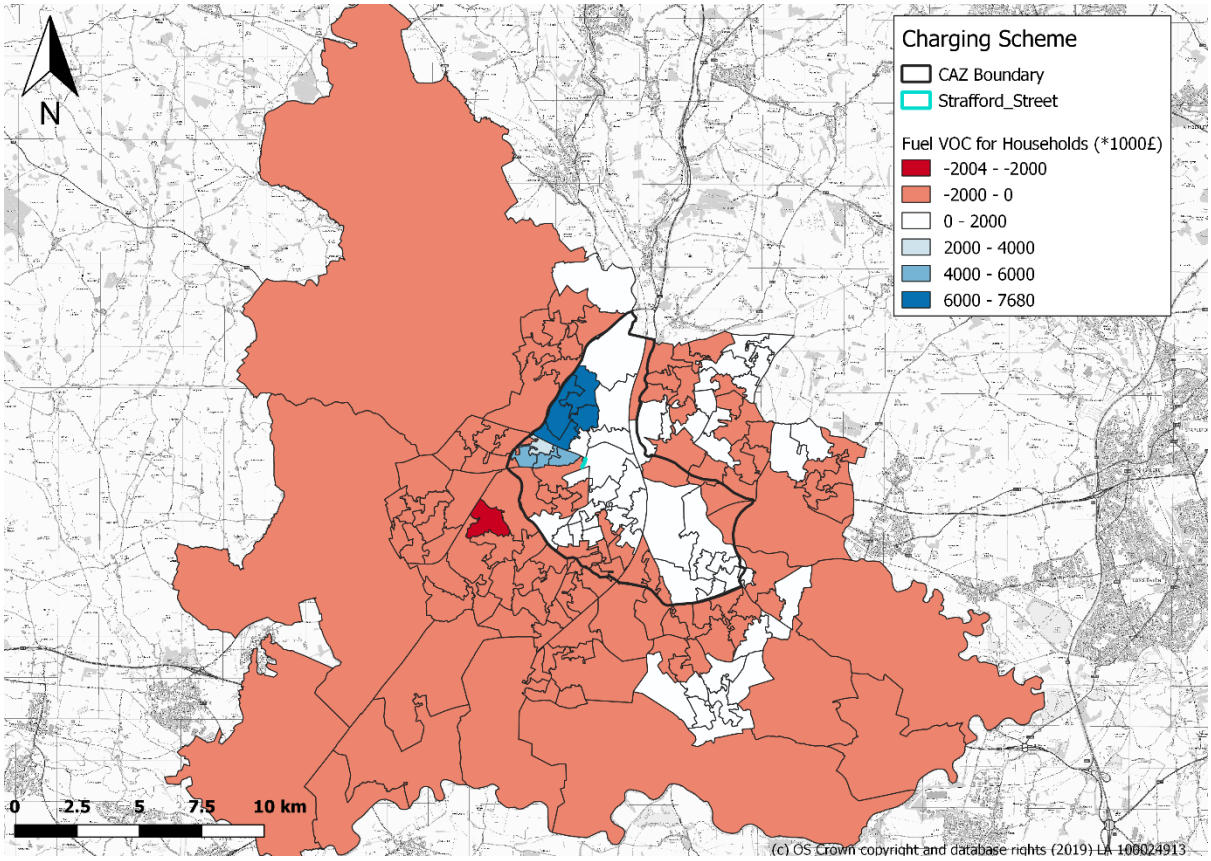

N
Charging Scheme
CAZ Boundary
Strafford_Street
User charges for Businesses (*1000£)
-379988 - -350000
-350000 - -300000
-300000 - -250000
-250000 - -200000
-200000 - -150000
-150000 - -100000
-100000 - -50000
-50000 - -1
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

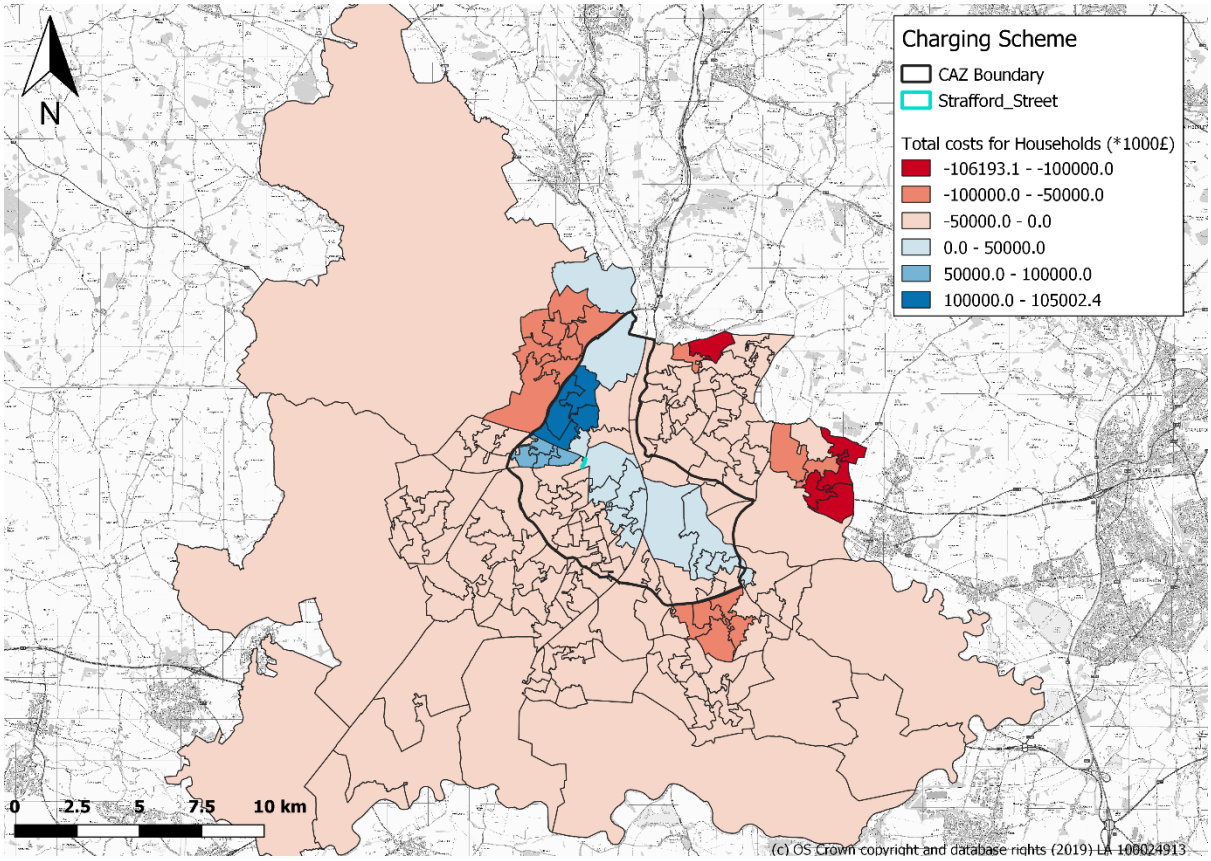

Charging Scheme
CAZ Boundary
Strafford_Street
Fuel VOC for Businesses (*1000£)
-1593 - 0
0 - 2000
2000 - 4000
4000 - 6000
6000 - 8000
8000 - 8856
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913


Charging Scheme
CAZ Boundary
Strafford_Street
Total benefits for Businesses (*1000£)
-382250 - -300000
-300000 - -200000
-200000 - -100000
-100000 - 0
0 - 81784
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913


Charging Scheme
CAZ Boundary
Strafford_Street
Time benefits for Households (*1000£)
-15856 - 0
0 - 20000
20000 - 40000
40000 - 60000
60000 - 80000
80000 - 100000
100000 - 100916
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913


Charging Scheme
CAZ Boundary
Strafford_Street
User charges for Households (*1000£)
-106262 - -100000
-100000 - -80000
-80000 - -60000
-60000 - -40000
-40000 - -20000
-20000 - 0
N
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913


N
Charging Scheme
CAZ Boundary
Strafford_Street
Fuel VOC for Households (*1000£)
-2004 - -2000
-2000 - 0
0 - 2000
2000 - 4000
4000 - 6000
6000 - 7680
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913


N
Charging Scheme
CAZ Boundary
Strafford_Street
Total costs for Households (*1000£)
-106193.1 - -100000.0
-100000.0 - -50000.0
-50000.0 - 0.0
0.0 - 50000.0
50000.0 - 100000.0
100000.0 - 105002.4
0 2.5 5 7.5 10 km
(c) OS Crown copyright and database rights (2019) LA 100024913

Appendix 5 – Literature review on impacts on businesses

In general, businesses and individuals will react to the implementation of a charging zone so as to attempt to minimize the financial impact. Options available to owners of non-compliant commercial vehicles in response to the implementation of a charging zone include:

- they can redistribute their fleet to ensure that vehicles entering the charging zone are compliant;
- they can invest in new compliant vehicles, whether those vehicles are brand-new or compliant second-hand vehicles;
- they can retrofit existing vehicles to make them compliant;
- they can rent compliant vehicles;
- they can pay the charge;
- they can exit the market

The response adopted by the owner of a non-compliant commercial vehicle will depend on factors such as the size of their fleet, the geographic area(s) in which they currently do business, the sector they are in, and whether the affected vehicle is specialized. The ability of a business to pass compliance costs on to their customers will be influenced by factors such as the current proportion of compliance within the sector, and the degree of competitiveness within the sector.[32] Specifically, businesses in sectors which already have a relatively large portion of compliant vehicles and businesses in highly competitive sectors will be less able to pass compliance costs on to their customers.

While several UK cities have introduced a low emission zone (LEZ), including Brighton, London, Oxford and Norwich, the majority of these only affect local buses under agreements[28] and are therefore similar in function to a non-charging clean air zone (CAZ). London is a well-known exception to this, and has implemented a number of charging schemes targeting a wide range of vehicles. These charging schemes include the Congestion Charge introduced in 2003, the Low Emission Zone (LEZ) introduced in 2008, the Emissions Surcharge (also known as the T-Charge) introduced in 2017, and the proposed Ultra Low Emission Zone (ULEZ) to be implemented in 2019. It is also worth noting that Durham City introduced the first congestion charge in the UK in October 2002. [29] The Durham City congestion charge is a fee of £2 per vehicle, irrespective of vehicle type or Euro standard, entering the Durham Peninsula between 10:00 and 16:00, Monday to Saturday.

Various forms of LEZs have also been implemented on mainland Europe, for example in Germany, Sweden, Belgium and Italy.[28] These zones are similar in some regards to the LEZs and charging schemes which have been implemented in the UK, as they are also intended to reduce vehicle emissions by defining areas where access by some polluting vehicles is restricted. There are also some key differences between the LEZs implemented on mainland Europe and those implemented in the UK. First, the LEZs on mainland Europe tend to affect a wide range of vehicle types (i.e. from lorries down to cars and motorcycles), rather than affecting only one or two vehicle types (i.e. local buses). Second, there is generally no option to pay a fee in order to enter the restricted zone with a polluting vehicle; vehicles must either meet the minimum Euro standard specified by the zone, or they may not enter. This second difference has implications for the way in which owners of non-compliant vehicles respond to the implementation of a LEZ. In cases where a charging scheme is implemented, such as in London, paying the fee may be the most economical option for some vehicle owners, particularly those who enter the zone only infrequently. Since paying a fee to enter the zone is not an option for the LEZs on mainland Europe, owners of non-compliant vehicles effectively have one less option available to them.

[28] "Urban Access Regulations in Europe", http://urbanaccessregulations.eu/countries-mainmenu-147/united-kingdom-mainmenu-205, accessed 23/04/2018.

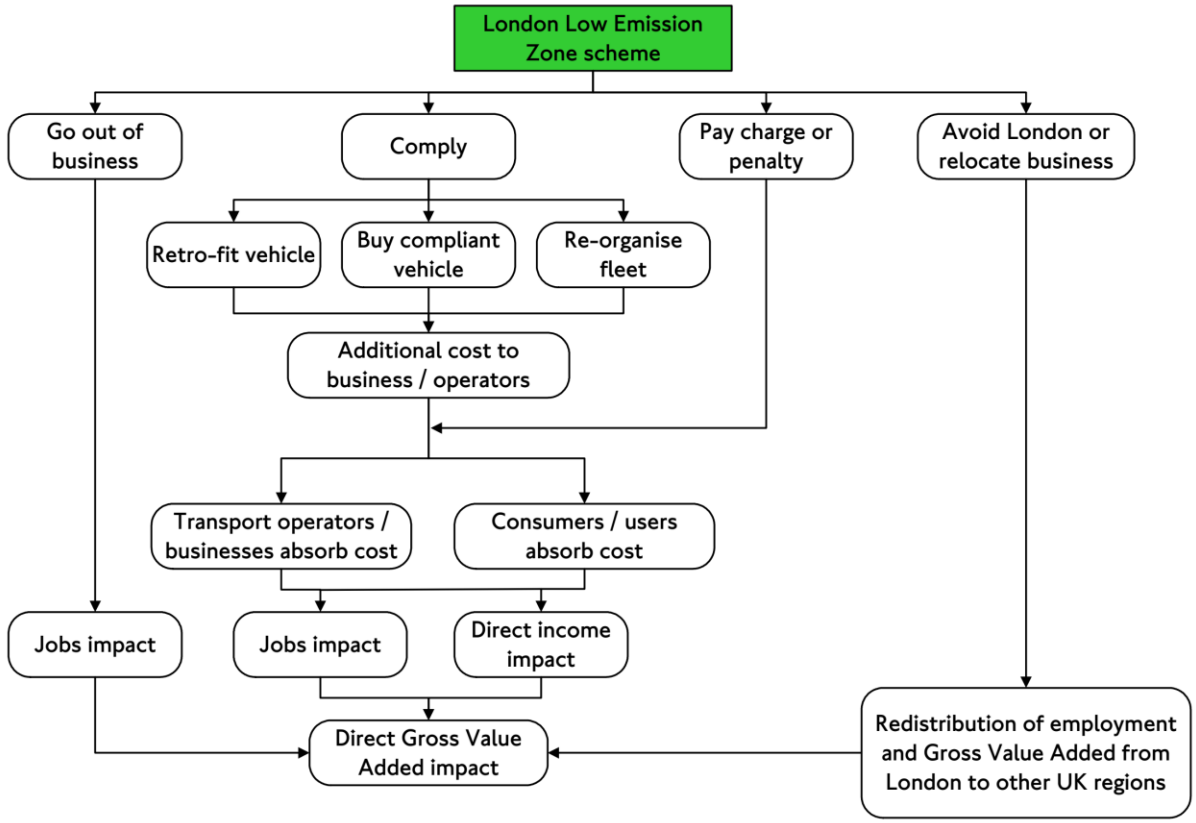
[29] The Chartered Institution of Highways & Transportation, "Durham City Centre Road Charging Scheme", http://www.ciht.org.uk/download.cfm/docid/560EA947-66D1-490D-8E91A97F34D979D0, accessed 23/04/2018.

The London charging schemes are generally quite well-studied. Much of the information in this literature review is drawn from impact assessments related to the London schemes (either pre- or post-implementation) and research studies that included London schemes in their analysis.

7.1.1 Overview of business and economy impacts

In July 2008, Transport for London published an Impacts Monitoring Report relating to the London LEZ introduced earlier that year.[30] The monitoring report summarized the impacts of the LEZ on businesses and the wider economy using the flow chart in Figure 26. The options available to owners of non-compliant commercial vehicles include complying (by retro-fitting existing vehicles, investing in compliant vehicles, and/or re-organising or redistributing the vehicle fleet); paying the charge; or exiting the market (by either avoiding the zone or going out of business). Each of these options, in turn, can have induced or second-order impacts on other areas of the economy. Second-order impacts can be negative (for example, lowering business profitability and impacting jobs) or positive (for example, creating a market demand for more businesses that retrofit emissions technology onto existing vehicles).

Figure 26 - Flowchart illustrating the potential business and economic impacts of the London Low Emission Zone scheme30



7.1.2 Impacts by vehicle type

The following sections consider impacts based on vehicle type, beginning with some background information on the vehicle fleet and discussing factors which affect the fleet's response to a charging scheme.

7.1.2.1 Heavy goods vehicles (HGVs)

The HGV fleet is split between hire and reward vehicles (vehicles which are used to transport other people's goods in return for payment, such as couriers, furniture removers, etc.) and own account vehicles (vehicles used to transport the vehicle owner's goods). Within the UK, the latter category is comprised mostly of rigid HGVs and constitutes a larger fleet size in terms of number of vehicles. The

[30] Transport for London, "London Low Emission Zone: Impacts monitoring baseline report", July 2008, http://content.tfl.gov.uk/lez-impacts-monitoring-baseline-report-2008-07.pdf, accessed 03/04/2018.

former category is comprised mostly of articulated HGVs, which tend to be larger vehicles undertaking longer journeys and account for the majority of freight carried. HGV fleet owners encompass a wide range of business sizes, including a relatively small number of large fleet operators with thousands of vehicles, and a relatively large number of single vehicle operators. Based on information from the Office of the Traffic Commissioners, there is an ongoing trend in the industry towards consolidation, as demonstrated by a decline in the number of HGV operators over time.[31]

In an impact assessment for the proposed London Ultra Low Emission Zone (ULEZ), it was found that over 10% of the HGVs regularly entering the proposed ULEZ area (those entering on a weekly or more frequent basis) were aged over 10 years.[32] The proposed ULEZ is the same area currently covered by London's Congestion Charging Zone (CCZ) and is within London's existing Low Emission Zone (LEZ). This demonstrates that older vehicles are still extensively used within the industry, even in locations that financially penalize their use. The main sectors served by HGVs in central London relate to retail and wholesale distribution, and construction, with niche sectors including exhibition services, media support, theatre and music industries, waste collection, and breakdown and removal.[32]

In response to the introduction of the London LEZ, HGV owners with large fleets serving large geographical areas tended to react by conducting an in-depth analysis of how they organized their transport activities. Fleets were then redistributed so that the newest and cleanest vehicles were used in the Greater London region, while older vehicles were operated in zones without charging schemes. While there are some costs associated with fleet analysis and redistribution, these costs were generally considerably lower than the cost of other options.[33] In Germany, non-charging low emission zones were coordinated at a national level and implemented across multiple cities at once, with the result that large fleets could not adapt solely by fleet redistribution. Instead, HGV owners in Germany tended to upgrade their fleets and sell their non-compliant vehicles in neighbouring countries without charging schemes.[33] As charging schemes become more commonplace in the UK, it is likely that fleet owners will increasingly need to adapt using methods other than fleet redistribution.

With the introduction of the London LEZ, HGV owners with smaller fleets and/or serving smaller geographical areas were not able to adapt by redistributing their fleet. These businesses needed to put money aside ahead of time in order to purchase newer vehicles or retrofit existing vehicles. Where these options were not feasible due to financial constraints, these businesses rented newer vehicles, paid the charge, or went out of business.[33] Statistics regarding the number of freight companies that went out of business following implementation of the London LEZ are scarce. The freight sector is highly competitive and has a lower-than-average survival rate for new businesses. In 2008, the year the London LEZ was introduced, 3250 new freight companies were created in the UK; however, only 37.7% of these new businesses were still operational 5 years later, compared to an average survival rate of 41.3% for all economic activities.[33] When considering this survival rate, it is important to recognize that it is impossible to isolate the effects of the London LEZ from wider economic contexts, such as an ongoing trend in the freight industry towards consolidation (i.e., towards fewer firms with larger fleets) and the impacts of financial recessions since 2008. Nonetheless, the speed and extent to which new UK charging zone proposals are expected to be implemented has raised concerns, from stakeholders such as the Road Haulage Association, that many small businesses are likely to be affected and will possibly cease to trade.[34]

The compliance burden and business impacts associated with implementation of a charging scheme vary considerably depending on the size of business. The largest freight companies, with hundreds or thousands of vehicles, tend to have the newest vehicle fleets and therefore a relatively large portion of their fleet is likely to be compliant with proposed charging schemes. These companies will also tend

[31] Office of the Transport Commissioner, "Traffic Commissioners' Annual Reports", 2016-2017, https://www.gov.uk/government/collections/traffic-commissioners-annual-reports, accessed 23/04/2018.

[32] Jacobs, "Ultra Low Emission Zone: Integrated Impact Assessment", and associated documents, prepared for Transport for London, October 2014, https://consultations.tfl.gov.uk/environment/air-quality-consultation-phase-3b/user_uploads/integrated-impact-assessment.pdf, accessed 24/04/2018.

[33] Cecilia Cruz and Antoine Montenon, "Implementation and impacts of low emission zones on freight activities in Europe: Local schemes versus national schemes",

[34] Road Haulage Association, "Response of the Road Haulage Association to Transport for London's Consultation: Changes to the Ultra-Low Emission Zone and Low Emission Zone", https://www.rha.uk.net/getmedia/96072b8d-0e68-4f99-8754-ba276099df0d/180227-RHA-Response-London-LEZ-extension-Consult-v1.pdf.aspx, accessed 24/05/2018.

to react to a charging scheme first by attempting to redistribute their fleet. The business impact assessment for the London ULEZ predicted that 95% of fleet operators with more than 10 vehicles registered may be able to adapt to the ULEZ using fleet redistribution.[32] Where redistribution is not possible and vehicles must be upgraded, either by purchasing newer vehicles or by retrofitting existing vehicles, larger freight companies are more likely than smaller freight companies to have the resources available for this upfront investment.[33]

Smaller businesses, particularly those with only one HGV, tend to have the oldest vehicle fleets. These businesses are less likely to be able to adapt by fleet redistribution, and are also less likely to have the resources available for upfront investment in compliant vehicles. Smaller businesses will therefore tend to have a more difficult time adapting to the implementation of a charging scheme, particularly when charging schemes are implemented with short notice.[33]

The proportion of compliance within the sector and the level of competition between fleet owners are the main factors influencing the ability of a business to pass compliance costs on to customers.[32] For sectors such as the freight industry, where large fleet owners already have a large portion of compliant vehicles and there is a high degree of competition between companies, it is unlikely that costs would be passed on to customers. HGV owners that serve niche markets and/or have specialized vehicles may be able to pass some of the cost on to customers.[32]

7.1.2.2 Light goods vehicles (LGVs):

LGVs are important elements in many sectors of the economy. In London, LGVs serve sectors ranging from financial and business service companies to independent retailers and food outlets.[32] In an impact assessment for London's proposed ULEZ, it was found that LGV ownership is split roughly half and half between companies and private owners, and LGVs are important to a range of owner run businesses.[32]

As is the case with HGVs, the response adopted by a LGV owner will depend on factors such as the size of their fleet, the geographic area(s) in which they currently do business, the sector it is in, and whether the vehicle is specialized. Many of the factors influencing the response for HGVs, as discussed above, are also applicable to LGVs.

Where it is possible to minimize the financial impact of a proposed charging zone using fleet redistribution, this is likely to be a preferred response due to the relatively low costs involved. This is more likely to be the response adopted by those with large fleets. In the impact assessment for the London ULEZ, it was anticipated that fleet redistribution would be a viable option for approximately 95% of fleet operators with more than 10 LGVs registered, whereas this number fell to 75% for fleet operators with smaller fleets.[32] Again, as charging schemes become more commonplace in the UK, it is increasingly likely that fleet owners will need to adapt using methods other than fleet redistribution.

The London ULEZ impact assessment suggests that, due to the high proportion of non-compliant vehicles in the LGV fleet, it may be possible for operators to pass some of the additional compliance costs on to customers.[32] An updated impact assessment for the London ULEZ suggested that self-employed tradespeople, independent retailers and market traders, including farmers' market traders, may be disproportionally impacted by the introduction of a charging scheme.[35]

The importance of LGVs for a broad range of business types was recognized by a 2003 feasibility study for the London LEZ. The study recommended that the LEZ scheme begin by targeting lorries, buses and coaches. It was recommended that LGVs could potentially be included in subsequent phases of the LEZ, subject to further investigation of the socio-economic effects of a charging scheme on small companies and owners of LGVs.[36] A strategic review of the London LEZ[37] asserted that LGVs are essential to business for many small operators, such as self-employed tradesmen, and that

[35] Jacobs, "Proposed changes to the Ultra-Low Emission Zone: Update to the 2014/2015 Integrated Impact Assessment", prepared for Transport for London, April 2017, https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010021/TR010021-001701-8.127%20ULEZ%20Integrated%20Impact%20Assessment.pdf, accessed 24/04/2018.

[36] AEA Technology Environment, "The London Low Emission Zone Feasibility Study: A summary of the phase 2 report to the London Low Emission Zone Steering Group," July 2003, https://tfl.gov.uk/cdn/static/cms/documents/phase-2-feasibility-summary.pdf, accessed 25/04/2018.

[37] Deloitte, "LEZ Strategic Review Report", 2004, http://content.tfl.gov.uk/3-lez-strategic-Review-Report-250205.pdf, accessed 24/05/18.

for many micro businesses, their LGV is both their greatest asset and largest expenditure. As such, any additional cost in relation to owning and operating the LGV would potentially impose a significant strain on the small business' financial operation. It is worth noting that when the first phase of the London LEZ was implemented in February 2008, it only targeted heavier vehicles (lorries over 12 tonnes) with a daily fee of £200. The second phase, implemented in July 2008, included buses and coaches (at £200 per day) and smaller vehicles such as vans (at £100 per day).

7.1.2.3 Buses, coaches and minibuses

An impact assessment for the London ULEZ considered impacts to various sub-categories of buses, coaches and minibuses.[32] Vehicles less than 5 tonnes can be classified as minibus vehicles, and are generally used for small scheduled services, inter-company shuttles, airport-hotel link services, as well as private hire and private uses (for organisations such as schools and clubs). Vehicles over 5 tonnes can be classified as buses and larger coaches. Coaches are used for scheduled long distance and commuter services as well as sightseeing, tourist and leisure trips. It is worth noting that the London ULEZ charging scheme proposes different rates for minibuses (£12.50 per day) and larger buses and coaches (£100 per day).[32]

As is the case with HGVs and LGVs, operators with a relatively large number of vehicles are more likely to be able to adapt to the implementation of a charging scheme by redistributing their fleets. Where fleet redistribution alone is not sufficient to meet the requirements of a charging scheme, owners of large vehicle fleets are also more likely to be able to afford the upfront investment required to obtain a new or used compliant vehicle, compared to owners of smaller fleets. An assessment for the London LEZ predicted that smaller, London-based operators with older fleets operating in niche markets may face large one-off costs upon implementation of the charging scheme.[30]

The response adopted by owners of vehicles providing commuter services will depend on factors such as the current age profile of the fleet, and whether the commuter service can be re-routed to avoid the charging zone. Some bus operators, such as National Express, have policies requiring its coach operators to use vehicles that are no more than 7 years old[32] and would therefore be relatively well-positioned to adapt to the implementation of a charging zone. Some commuter services, especially those on long-distance service lines, may be able to re-route their services to avoid passing through a charging zone. Where fleet redistribution and re-routing are not sufficient to adapt to the charging scheme, as may be the case for operators with smaller fleets serving a smaller geographical area, or for operators that must enter the charging zone, compliance costs are likely to be higher.

Commuter bus services which compete with rail services are unlikely to be able to pass compliance costs on to the customer, as the increase in bus fares would make rail services more attractive to customers. The impact assessment for the London ULEZ suggested that a loss of some bus commuter services could have an impact on individuals using those services, making it more difficult and/or more expensive to commute to their workplaces; and some businesses might face additional recruitment costs if employees decide to give up working in London.[32] The distribution of similar impacts in Derby would depend on the profile of the current bus fleets, the level of competition with other modes of transportation, and whether some areas of Derby would be left underserved due to a loss of commuter bus services following implementation of a charging zone.

The response adopted by owners of vehicles used for tourist or leisure activities will depend on factors such as the age profile of the fleet, whether compliance costs can be passed on to the customer, and whether there are competing tourist and leisure destinations outside of the charging zone. Owners of non-compliant vehicles which enter the proposed charging zone on an infrequent basis are more likely to consider alternative destinations for their services.

Some vehicles, and particularly minibuses, are owned and operated by community organisations that mainly provide voluntary and charitable services. These organisations tend to have small fleets comprised of older vehicles, and they may have a lack of transport alternatives. Such organisations are likely to have a more difficult time adapting to the implementation of a charging zone, due to cash and fund-raising constraints.[30]

7.1.2.4 Taxis and Private Hire Vehicles (PHVs)

In London, taxis (black cabs) and private hire vehicles (PHVs) must be licensed by Transport for London (TfL). In London, black cabs are exempt from the proposed ULEZ fee structure. London is addressing vehicle emissions from taxis and PHVs through licensing policies. New taxi vehicle licenses will only be granted to vehicles if they meet (at a minimum) the Euro 6 standards for

emissions and are zero emissions capable; and taxi vehicles that are already licenced must be no older than 15 years.[38] New PHV licences will only be granted to vehicles if they meet (at a minimum) the Euro 6 standards, or have a Euro 4 petrol-hybrid engine; and PHV vehicles that are already licenced must be no older than 10 years.[39]

The London ULEZ impact assessment recognized that virtually all taxi drivers are self-employed and therefore would need to bear the cost of a new vehicle themselves.[32] In order to mitigate the compliance burden on taxi drivers who are required to replace their vehicle earlier than expected due to recent changes in the licensing policies, TfL has implemented a taxi delicensing scheme. The scheme offers a payment of between £1,200 and £5,000 to delicense a taxi aged from 10 to 15 years.[40]

7.1.3 Other economic impacts

7.1.3.1 Businesses related to vehicle sales, rentals and service

Following the implementation of a charging zone, there is likely to be a period of higher than average fleet turnover, as was the case for the London LEZ.[30] New vehicle sales, and associated businesses, are very likely to see increased activity. The second-hand vehicle market may also become more active, as used non-compliant vehicles are sold by businesses affected by the charging scheme and potentially purchased by businesses outside of the charging scheme zone.

However, as charging schemes become more common, it is increasingly likely that used non-compliant vehicles will become more difficult to sell. This will affect used vehicle dealerships as well as vehicle rental companies. Many vehicle rental companies have agreements with vehicle manufacturers which allow them to renew their fleet on a fairly frequent basis. Used vehicles are sold as new vehicles are acquired, and this is a component of the business' profitability. As the demand for second-hand non-compliant vehicles decreases in response to a growing number of charging schemes, this will affect the profitability of any businesses which sell second-hand vehicles.[33]

Businesses that develop, fit and service emissions abatement equipment onto existing vehicles are also likely to see increased activity.[Error! Bookmark not defined.]

7.1.3.2 Restaurants and cafes

The impact assessment for the London ULEZ anticipates that the ULEZ may be seen as a potential benefit to restaurants and cafes within the scheme zone, as improvements in air quality may encourage customers to use on-street seating.[32] Post-implementation monitoring of the Durham charging scheme found an increase of 10% in pedestrian activity,[29] which may also have a positive effect on increased patronage for restaurants and cafes located within the charging zone.

[38] Transport for London, "Apply for a taxi vehicle licence", https://tfl.gov.uk/info-for/taxis-and-private-hire/licensing/apply-for-a-taxi-vehicle-licence, accessed 04/05/2018.
[39] Transport for London, "Apply for a private hire vehicle licence", https://tfl.gov.uk/info-for/taxis-and-private-hire/licensing/private-hire-vehicle-licence, accessed 04/05/2018.
[40] Transport for London, "Cleaner greener taxis", https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/cleaner-greener-taxis, accessed 04/05/2018.

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