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DCLG/DEFRA Research into Drivers of Service Costs in Rural Areas

National Analysis of Unit Costs – Main Report

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1 Summary

- 1.1 DLGG/DEFRA commissioned research to establish evidence in relation to whether there are potentially unavoidable additional costs associated with service delivery in rural areas compared with urban areas. As part of this research, desktop analysis of administrative and statistical data sets was carried out, based on nationally-available local authority data.
- 1.2 The aim of this desktop analysis, reported here, was to assess whether there were statistically significant relationships between the costs of service provision and various measures of sparsity, rurality and remoteness. The general methodology used was to (i) calculate unit costs for local authority services, based on actual expenditure data and appropriate service-based denominators, and (ii) test for statistical relationships between these unit costs (the dependent variable) and various measures of sparsity, used as a proxy for rurality, while, in some cases, controlling for relative levels of deprivation (the independent variables).
- 1.3 The methodology used in this study (multiple linear regression analysis) was broadly similar to that used by CLG to identify local authorities' relative funding requirements, and that used to calculate the Unavoidable Excess Cost Adjustment for hospital care in Scotland.
- 1.4 A key assumption underpinning these studies is that differences between authorities reflect unavoidable costs, rather than differences in the quality and efficiency of service delivery. In other words, it is assumed that patterns of current expenditure are a reasonable proxy for underlying need. There are therefore limitations to any such regression analysis; for example, given the close relationship between funding and expenditure, lower unit costs could also potentially be a reflection of lower levels of funding.
- 1.5 Local authorities' expenditure in 2012/13 (based on the latest available Revenue Outturn returns) was organised into 51 service groupings. Unit costs were then calculated for each of these categories. Separate statistical models were then estimated for each of these 51 service groupings, using multiple linear regression analysis.
- 1.6 When developing the 'best' statistical model for each service, it was necessary to include other variables that explain (or control for) differences in unit costs between authorities, in addition to sparsity. In this analysis, the control variables were restricted to a set of deprivation indicators. Deprivation indicators were chosen as the main control variables, as they are one of the main determinants of need in CLG's Relative Needs Formula. However, due to the small number of control variables used, the explanatory powers of the models used are restricted. It is also possible that important explanatory variables have been omitted, which limits the robustness of the analysis.
- 1.7 The unit cost data was not adjusted for the quality of the service provided in local authorities. As such, lower unit costs may represent lower quality or more restricted service. This should be noted when interpreting the regression results.
- 1.8 This study was intended to be a preliminary investigation into possible statistical relationships between sparsity and service unit costs. As such, it does not aim to develop detailed models for each service area, and full regression diagnostics have not been carried out to test that the assumptions of linear regression have been met. This should be borne in mind when interpreting the results, which should not be considered complete or comprehensive.

1.9 A summary of the results is as follows:

- Of the 51 expenditure groups considered, sparsity was found to be positively and significantly¹ related to unit costs in 11 cases. These services accounted for £7.0bn (or 15.0%) of local authorities' total expenditure in 2012/13.
- Sparsity was significantly and negatively associated with unit costs in 15 cases. These expenditure groups accounted for £14.6bn (or 31.1%) of total expenditure in 2012/13.
- In the remaining 25 cases, sparsity was not found to have a statistically significant effect on unit costs. These groups accounted for £25.3bn (or 53.9%) of total expenditure.

1.10 Figure 1 illustrates those services for which sparsity was found to be statistically significant, and whether this was positively or negatively related to unit costs. The results are expressed in terms of standardised coefficients; that is, the change in unit costs, in standard deviations, following a one standard deviation change in sparsity.

1.11 Figure 2 illustrates the relative size of each expenditure grouping in terms of total spending in 2012/13. As can be seen, those services for which the relationship between sparsity and unit costs was positive and statistically significant made up the smallest share of expenditure.

¹ Throughout this report, results are deemed statistically significant where the P-value is less than 0.05.

Figure 1 – Services affected significantly ($P < 0.05$) by sparsity and the magnitude and direction of the relationship

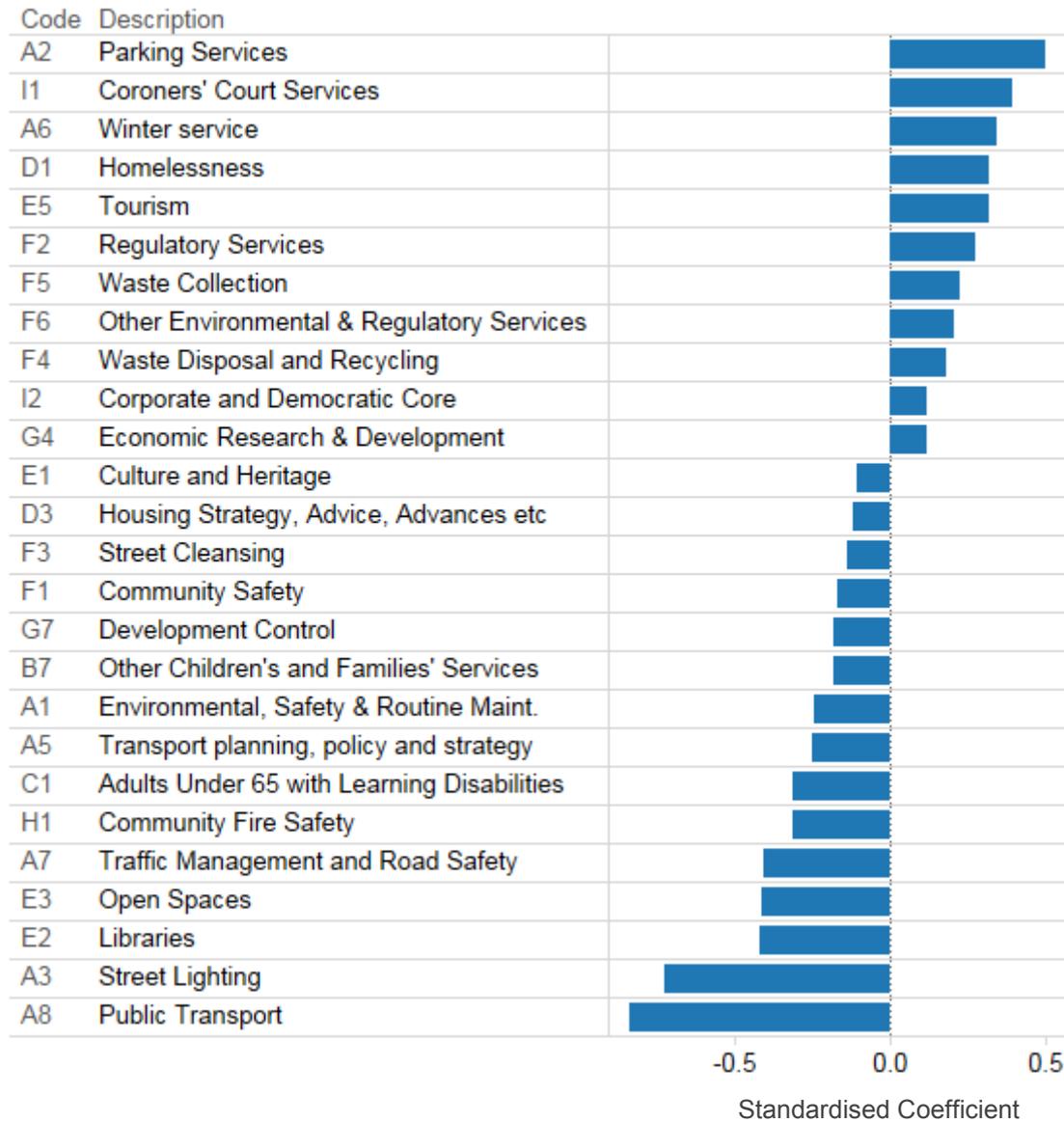
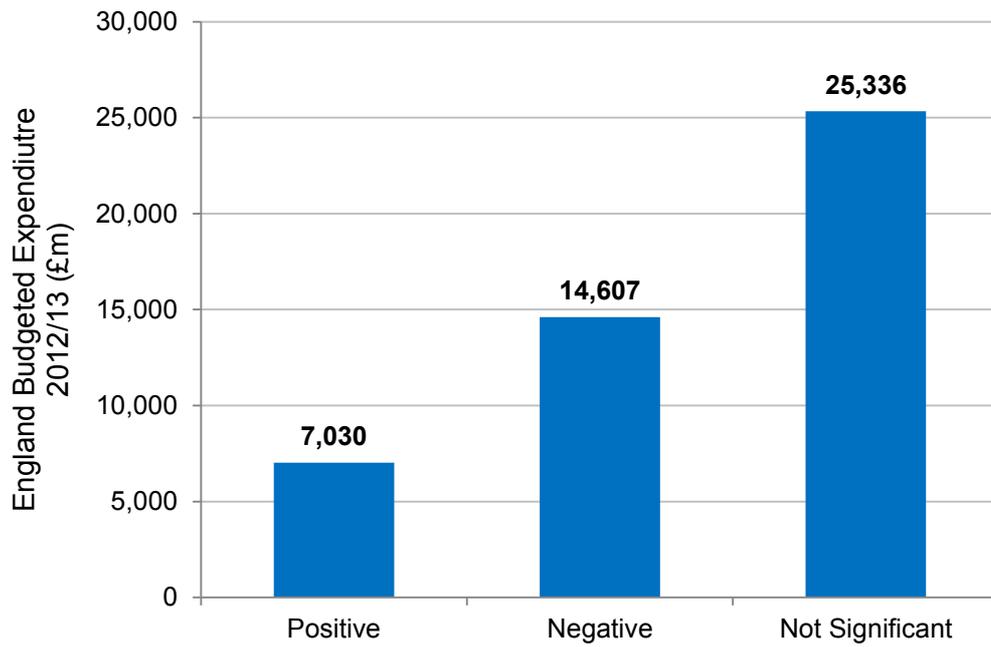


Figure 2 – Expenditure share of services grouped by their relationship with sparsity



2 Background

Overview of Methodology

- 2.1 The aim of this analysis was to assess whether there was a relationship between sparsity and remoteness, on one hand, and additional unavoidable costs facing local authorities on the other. Sparsity and remoteness were measured using a number of indicators that included population density, settlement patterns and average travel times.
- 2.2 The potential relationship between sparsity and costs was assessed using regression analysis, based on nationally available expenditure and activity data. Regression analysis is a statistical process for estimating the relationships between a dependent variable and one or more independent variables. In this case, the dependent variable (the variable being 'explained') is local authorities' unit costs.
- 2.3 Separate regression analyses were carried out for each service. In each case, the dependent variable was unit costs. Different models were then used to "explain" the observed difference in unit costs between local authorities, using different measurements of sparsity and deprivation (the independent variables). Different measurements of sparsity and deprivation were tested to see which combination yielded the best model; that is, whichever explained the greatest variation in local authorities' unit costs. This process was repeated 51 times, i.e. separate multiple regression analyses were carried out for each of the expenditure groupings.
- 2.4 The technique is broadly similar to that used to calculate the local government Relative Needs Formulae (RNF). This assumes that differences in local authority spending levels reflect differences in actual levels of need. In the RNF, regression analysis is used to estimate the average relationship between expenditure per head² and a range of explanatory variables, such as deprivation (e.g. benefit recipient rates), demography (e.g. pupils in low achieving ethnic groups) and socio-economic factors (e.g. qualification levels). The resulting statistical models allow CLG to 'predict' each local authority's relative level of need, based on the values of the explanatory variables that apply to each local authority.
- 2.5 Sparsity is included in the RNF on the basis of judgement, rather than detailed statistical evidence. One of the key objectives of the current research is to assess whether statistical relationships between unit costs and sparsity can be discerned at a more detailed level of expenditure, compared to those used in the RNF.
- 2.6 The approach used in this study is similar to the first stage of CLG's methodology for calculating the Relative Needs Formula, in which possible independent variables are assessed individually, to determine whether their distribution is related to that of costs. Those with the strongest relationship are then further tested to establish firstly, whether their distribution is too similar to that of other independent variables (since this can give misleading results), and, secondly, which independent variables together explain the greatest variation in costs.

² In most cases, the dependent variable is expenditure per resident, using the projected population for the relevant age band. For Highway Maintenance, expenditure per kilometre of road is used.

- 2.7 However there are a number of key differences, as follows:
- The analysis is carried out at individual service level. For example, rather than examining the relationship between sparsity and expenditure on Environmental, Protective and Cultural Services (EPCS), the analysis considered relationships between sparsity and specific services within EPCS; for instance, between sparsity and waste collection, between sparsity and libraries, and so on.
 - The analysis can therefore use unit costs specific to the service in question. When CLG estimates the Relative Needs Formula for EPCS, for example, the variable being explained is expenditure per resident, which is the most appropriate denominator for such a broad service group. This analysis, on the other hand, is able to use unit costs specific to each service. For example, for waste collection, unit costs can be expressed in terms of expenditure per domestic property.
 - The analysis focuses on the relationship between unit costs and sparsity, incorporating a range of variables. It specifically investigates the relationship between sparsity and unit costs by including sparsity in every model from the outset, and relatively limited control variables.
- 2.8 CLG has not found a statistically significant relationship between sparsity and service expenditure in the past. If such a relationship exists, our approach may be more likely to identify it due to the three differences noted above - for example, sparsity may be a significant variable explaining the variation in local authorities' waste collection costs, but this significance may be lost when explaining the variation in overall EPCS costs.
- 2.9 Regression analysis was also used to estimate the additional sparsity costs of hospital care in Scotland, used as part of the Unavoidable Excess Cost Adjustment (UECA) for health boards. The dependent variable was the ratio of local to national patient care costs, at the data zone level.³ The explanatory variable was the urban-rural category into which each data zone fell, based on the Scottish Government Urban-Rural Classification. The results were used to calculate an adjustment for each of the ten rural-urban categories. For example, areas categorised as 'rural areas – very remote islands' would attract an excess cost adjustment of 1.162, while those categorised as 'urban settlements' would receive an adjustment of 0.982.
- 2.10 A major assumption underlying regression analysis is that patterns of current expenditure are at least a reasonable proxy for underlying need. In other words, differences in expenditure (or unit costs) between local authorities are assumed to reflect differences in the real costs associated with providing those services. There is the risk, however, that differences between predominantly rural/sparse authorities and densely populated/urban authorities reflect current funding patterns, not just differences in costs. For instance, if sparse authorities were to be relatively 'underfunded' and therefore had lower expenditure, then the regression analysis would indicate a negative relationship between sparsity and service provision costs, all else being equal.

³ Data zones contain around 350 households and have an average population of 808 people (as at 2011).

3 Data

Dependent Variable – Unit Costs

- 3.1 The dependent variable used in this study was unit costs. The numerator was taken from the Revenue Outturn returns for 2012/13. This provided actual (rather than budgeted) expenditure for each local authority in England.
- 3.2 A total of 140 expenditure lines were grouped into 51 expenditure categories. This helped to simplify the analysis and to ensure that the data were sufficiently robust.⁴ Individual lines were grouped on the basis of their characteristics (for example, ‘on-street parking’ was combined with ‘off-street parking’) and their share of total expenditure (smaller expenditure lines were more likely to be aggregated with other lines). Whilst this reduced the total number of expenditure groups, it still enabled the regressions to be carried out at a greater level of detail than is used in the Relative Needs Formulae.
- 3.3 Some expenditure lines were excluded altogether. This included schools and Police services, which were outside the scope of the study. Other expenditure lines were excluded where (i) services only applied to a sub-set of authorities, and so would not enable a meaningful comparison between sparse and non-sparse areas, (ii) lines accounted for a negligible share of service expenditure, or (iii) where differences in unit costs were likely to reflect accounting practices rather than real differences in unit costs; for example, ‘Total Other Services’ and ‘Non-Distributed Costs’.
- 3.4 Denominators were derived from a range of sources. By default, the denominator was the projected resident population for 2012.⁵ However, wherever possible, the denominator related specifically to the expenditure grouping in question. For example, the number of homeless households was used as the denominator for Homelessness, and the number of social care clients aged 65 and over was used as the denominator for Older People’s Personal Social Services.
- 3.5 Unit costs were calculated by dividing each local authority’s net current expenditure by the appropriate denominator. The resulting figure was then deflated by the Area Cost Adjustment (ACA), to account for input cost differences.⁶ CLG’s unit costs are based on net *revenue* expenditure, which is net current expenditure less specific grants, on the grounds that they only fund the element of need that is not funded through specific grants. However, it was not possible to attribute specific/special grants to each expenditure line used in this analysis (given the greater level of detail), and so net current expenditure was used instead. This is also consistent with the data requested in the separate workstream in this research which requested quantitative survey returns from local authorities across a range of services.
- 3.6 Annex A shows the relationship between the Revenue Outturn expenditure lines, expenditure groupings and the denominators used to calculate unit costs.

⁴ There can be differences in the way that local authorities assign expenditure to particular expenditure lines. This problem can be mitigated by grouping expenditure lines together into broader categories.

⁵ The 2012-based Subnational Population Projections, published by the Office of National Statistics.

⁶ The relevant ACAs are for (i) Highways Maintenance, (ii) Personal Social Services, (iii) Fire & Rescue and (iv) Environmental, Protective and Cultural Services (EPCS). Any expenditure line which did not fall under the first three groups was assigned the EPCS cost adjustment.

Independent Variables – Sparsity

- 3.7 The key variable of interest in this study was sparsity. Four sparsity variables were considered for inclusion in the regression models, derived from the following data sources and these indicators are described in turn below:
- DEFRA’s Rural-Urban Classification;
 - Population density at the Lower Super Output Area (LSOA) level;
 - Population density at the Output Area level; and
 - DfT accessibility statistics.
- 3.8 Isolated pockets of deprivation were also considered; for example, the proportion of a local authority’s population living in small geographical areas which were both sparsely populated (and/or remote) and economically deprived. However, such data were not available in a published format, and so, to undertake such analysis, a bespoke indicator would have needed to be created for the purposes of this study.

(i) DEFRA’s Rural-Urban Classification

- 3.9 The first sparsity indicator was constructed using DEFRA’s 2011 Rural-Urban Classification for small areas.⁷ This classification assigns small geographical areas (Output Areas⁸) to one of four urban or six rural categories. At the local authority level, DEFRA also publishes the percentage of residents living in each category. Using this local authority-level data, LG Futures constructed a sparsity variable for each local authority based on the percentage of residents living in Output Areas that were classified as either (i) villages, (ii) villages in sparse settings, (iii) hamlets or isolated dwellings, or (iv) hamlets and isolated dwellings in sparse settings. These represent the most remote and sparsely-populated areas. DEFRA’s Rural-Urban Classification, and the categories used to construct the sparsity indicator, are presented in the table below.

⁷ For more information see: <https://www.gov.uk/government/collections/rural-urban-definition>

⁸ Output Areas are the smallest geographical areas to be assigned a rural-urban classification. In 2011, they contained an average of 129 households and 309 residents.

Table 1 – Sparsity Indicators

Defra's 2011 Rural-Urban Classification		Included in Sparsity Indicator
Urban	Major Conurbation	
	Minor Conurbation	
	City & Town	
	City & Town in Sparse Setting	
Rural	Town & Fringe	
	Town & Fringe in Sparse Setting	
	Village	✓
	Village in a sparse setting	✓
	Hamlets and Isolated Dwellings	✓
	Hamlets and Isolated Dwellings in a sparse setting	✓

(ii) Population Sparsity at the Lower Super Output Area

3.10 The second sparsity indicator was calculated using population density at the Lower Layer Super Output Area (LSOA)⁹ level. This was the lowest level of geography for which the latest population data were available (i.e. mid-2012 population estimates). These figures were published by the Office of National Statistics.

3.11 LG Futures aggregated this data to local authority level. To calculate local authority averages, the density figures for each LSOA were first converted from 'people per square kilometre' to 'hectares per person'. This was purely presentational, so that higher values of the indicator would reflect greater levels of population *sparsity* rather than density. For each local authority, the average sparsity was then calculated as the average for each LSOA, weighted by the size of its population.

(iii) Population Sparsity at the Output Area Level

3.12 The third indicator was the population of each local authority measured at Output Area level, one of the sparsity indicators currently used in the 2013/14 Relative Needs Formula.¹⁰ This is constructed using the sum of two values:

- The resident population living in Output Areas with more than 0.5 but less than or equal to 4 residents per hectare; plus
- Three times the number of residents living in Output Areas with 0.5 or fewer residents per hectare.

3.13 For each local authority, a sparsity index was calculated by taking the sum of residents described in the two categories above (the numerator), divided by the total resident

⁹ LSOAs are higher-level geographies comprising of four to six Output Areas. In 2011, they contained an average of 672 households and 1,614 residents.

¹⁰ Department of Communities and Local Government, *Data Definitions of Indicators for 2013-14, Part 1*, December 2012.

population of the local authority (the denominator). LG Futures used the sparsity index as published by CLG in the Relative Needs Formula model. This indicator has the advantage of identifying sparsity at a finer level of geographical detail (as Output Areas are smaller than LSOAs), and assigning greater weights to areas with very high levels of sparsity. The drawback is that the data are based on figures from the 2001 Census, and so does not reflect subsequent changes in population densities.

(iv) DfT Accessibility Statistics

- 3.14 The final indicator considered for inclusion in the regression analysis was based on travel time, rather than population density or settlement patterns. This was taken from DfT's accessibility statistics, which measures the availability of transport to eight key services (including food stores, primary schools, secondary schools, higher education institutions, GPs, hospitals, town centres and employment centres). DfT calculates the average travel time required to reach these services at the small area level (LSOA), and also publishes the average travel time for each local authority, which was used in the regression analysis.
- 3.15 For the purposes of this study, we used the average minimum travel time to reach the nearest key services by car, measured in minutes.¹¹ This is expected to be correlated with population sparsity, but could also reflect other aspects of remoteness; for example, areas located on estuaries or islands which face longer travel times to more built-up areas. Because travel speeds are based on congestion data, local authorities with relatively high population densities can still have relatively long travel times based on this measure (Tower Hamlets, for example, has the fifth longest minimum travel time by car in the country). Clearly, there will be services which are delivered to the resident's home e.g. domiciliary care, waste collection, where this indicator is less directly relevant, but it could still indirectly reflect the additional time taken for local authority service providers to reach less accessible areas.
- 3.16 DfT's transport connectivity statistics were also considered for use as an indicator. These are experimental statistics that provide estimated travel times from each neighbourhood to a set of major transport network access points: airports, major railway stations and major road junctions. This data source was excluded, however, as data were not available for shire districts or for the metropolitan districts (with the latter being aggregated at the Integrated Transport Authority level). Given these missing authorities, the analysis could not be carried out using a representative sample of authorities across England. It should also be noted that CLG has not previously used experimental statistics in the calculation of the Local Government Finance Settlement, instead preferring to wait until they have been classified as either national statistics or departmental statistics.
- 3.17 Figure 3, below, illustrates the relationship between the four sparsity indicators. There are six charts, representing the six unique combinations of these indicators. In most cases, there is a strong, positive correlation between the sparsity variables. The correlation is weakest with DfT's accessibility indicator, with some authorities having long minimum travel times, despite having relatively low levels of sparsity, as in the Tower Hamlets example above.

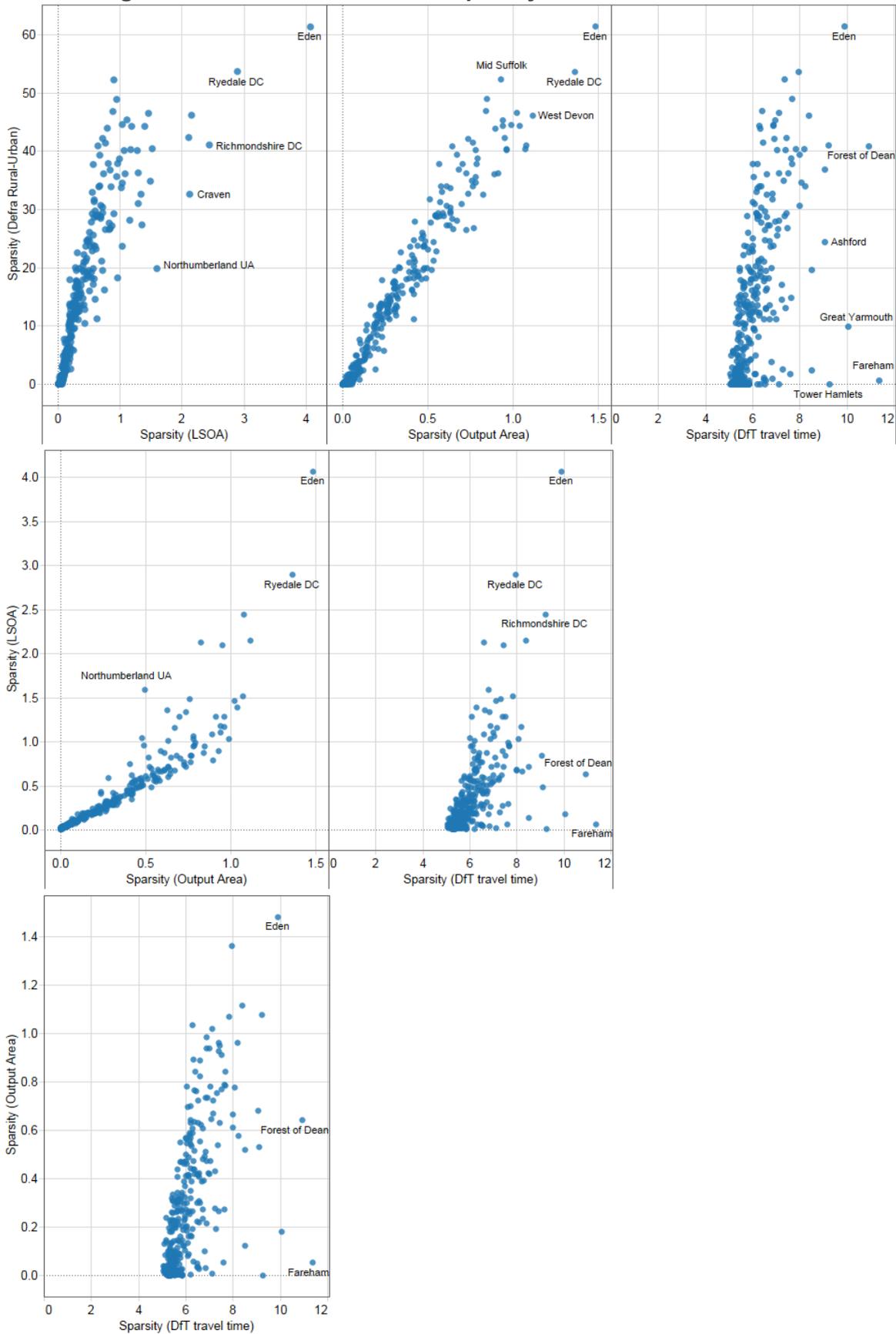
¹¹ <https://www.gov.uk/government/statistical-data-sets/acs01-availability-of-transport-to-key-services-or-work-among-households>, Table ASC0107

- 3.18 The strongest correlations are seen between the Output Area measurement (as used in the RNF calculations) and sparsity measurements based on the Defra Rural-Urban Classification and population sparsity at the LSOA level. Given its high correlation with these other indicators, and the fact that it is based on 2001 census data, it was decided to exclude the Output Area measurement of sparsity from the regression analysis.
- 3.19 The following table summarises the three variables that are used in the regression analysis. For ease of notation, these are identified throughout the report by the labels *SparsityDefra*, *SparsityLSOA* and *SparsityCarTime*. This provides a more diverse set of indicators than are currently used in the RNF, encompassing different measurements of sparsity such as settlement patterns (using the DEFRA definition) and journey travel times, (based on the DfT definition). This study also looks for statistical relationships at a more disaggregated level of expenditure than tends to be used when estimating the RNF formula.

Table 2 – Sparsity indicators used in this analysis

Variable Name	Source	Year	Description
<i>SparsityDefra</i>	Defra	2011	Proportion of the local authority's population living in Output Areas that are classified as either (i) villages, (ii) villages in a sparse settings, (iii) hamlets or isolated dwellings, or (iv) hamlets and isolated dwellings in sparse settings.
<i>SparsityLSOA</i>	ONS	2012	Local authority's population sparsity (measured in hectares per person), calculated at the LSOA level.
<i>SparsityCarTime</i>	DfT	2012	Average minimum travel time by car (in minutes) to reach a key service as defined by DfT.

Figure 3 – Correlations between Sparsity Indicators



Independent Variables – Deprivation

3.20 The other explanatory variable used in the analysis was deprivation. As with sparsity, a number of measurements were used to reflect different definitions of deprivation. These were derived from three key sources:

- The English Indices of Deprivation 2010;
- Benefit recipient data, for various age groups, as used by CLG in the calculation of RNF; and
- Additional benefit recipient data from the Department for Work and Pensions (DWP).

3.21 A total of ten deprivation indicators were used in the analysis, a list of which is provided in Table 3 overleaf. There was overlap between many of these indicators, which tended to vary in terms of time, measurement or demographic coverage. For example, the Income Deprivation Affecting Children Index (*DepriveIMDChild*) is similar to the proportion of children in families receiving tax credits (*DepriveBenefitChild*), but involves a more complex set of measurements and is several years older.

Table 3 – Deprivation indicators used in the regression analysis

Variable Name	Source	Year	Description
<i>DepriveIMDIncome</i>	English Indices of Deprivation	2008	The proportion of local authority residents classed as income deprived based on the Income Domain of the English Indices of Deprivation.
<i>DepriveIMDOlder</i>	English Indices of Deprivation	2008	The proportion of older adults in the local authority (aged 60 and over) classed as income deprived based on the Income Deprivation Affecting Older People Index (IDAOPI).
<i>DepriveIMDChild</i>	English Indices of Deprivation	2008	The proportion of children (aged 0-15) in the local authority (classed as income deprived based on the Income Deprivation Affecting Children Index (IDACI).
<i>DepriveIMDExtent</i>	English Indices of Deprivation	Various ^a	Proportion of an authority's population living in the 30% most deprived LSOAs in the country. ¹²
<i>DepriveBenefitKey</i>	DWP	2012-13	Proportion of the working age population (aged 15 to 64) in receipt of one or more key benefits from DWP.
<i>DepriveBenefit18Plus</i>	CLG	2009-12	The average number of persons receiving Income Support, Income Based Jobseeker's Allowance or Guarantee Element of Pension Credit.
<i>DepriveBenefitChild</i>	CLG	2008-11	The proportion of children in out-of-work families who are in receipt of Child Tax Credit.
<i>DepriveBenefitOlder</i>	CLG ^b	2009-12	The proportion of people who were, or whose partner was, aged 60 years and over and in receipt of Income Support or Income Based Jobseeker's Allowance or the Guarantee element of Pension Credit.
<i>DepriveBenefitDLA</i>	CLG	2009-12	The proportion of people aged 18 to 64 who are in receipt of disability living allowance

a. Extent of deprivation is taken across a range of domains which relate to different years.

b. CLG publishes total numbers, which were converted into rates using population projections.

3.22 For Highways and Transport, deprivation indicators were not considered the most appropriate control variable. In this case, two additional variables were considered: (i) daytime population per kilometre (ii) and traffic flow. These variables are more likely to reflect demand for expenditure on highways than deprivation levels. These variables, both of which are used by CLG in the calculation of the RNF formula for Highways, are defined in the table overleaf.

¹² In this measure, 100% of the people living in the 10% most deprived LSOAs in England are captured in the numerator, plus a proportion of the population of those LSOAs in the next two deciles on a sliding scale – that is 95% of the population of the LSOA at the 11th percentile, and 5% of the population of the LSOA at the 29th percentile.

Table 4 – Explanatory Variables used in Highways and Transport

Variable Name	Source	Year	Description
<i>HighwayPopKm</i>	CLG	Various	The sum of (i) the resident population, (ii) positive day-time net inflow and (iii) overnight visitors, all divided by unweighted road lengths.
<i>HighwayFlow</i>	CLG	2009-11	The sum of (i) the annual average flow of all motor vehicles, in millions, plus (ii) 100 multiplied by the annual average flow of HGVs, buses and coaches, in millions.

3.23 An analysis of correlation coefficients¹³ showed a very high correlation between population per kilometre (*HighwayPopKm*) and the three main sparsity variables, particularly outside of London. High correlations between two or more explanatory variables can affect the validity of regressions, a phenomenon referred to as ‘multicollinearity’. As a rule of thumb, correlations of greater than 0.80 should be avoided. The correlation between population per kilometre and the other sparsity variable were very high outside of London, with correlations exceeding 0.80 when London was excluded.¹⁴ For this reason, population per kilometre (*HighwayPopKm*) was used as a sparsity variable for Highways regressions, rather than as a control variable.

Regression Analysis

- 3.24 Regression analysis was carried out using the ordinary least-squares (OLS) method. This assumes a linear or straight line relationship between unit costs and the explanatory variables. No tests for linearity were carried out, so it is possible that this assumption was violated.
- 3.25 For each service, each measure of sparsity was tested as an explanatory variable, in addition to controls for deprivation. The model which had the highest adjusted R^2 (a measure of goodness-of-fit) was then selected as the final model.
- 3.26 Deprivation variables were included in the regressions to control for variations in unit costs not associated with sparsity. Given that the focus of this study was only on the possible existence of a statistical relationship between sparsity and costs, no other control variables were included. It is therefore possible that some of the regressions suffer from omitted variable bias, which may cause the results to be mis-estimated. This would occur if there is a variable which is a determinant of service costs, and also strongly correlated with sparsity.
- 3.27 The goodness of fit of the models in which sparsity was found to have a statistically significant relationship with unit costs is described in the table below.

¹³ Throughout this report, correlation coefficients refer to the Pearson correlation coefficient, also referred to as the Pearson Product-Moment Correlation Coefficient or Pearson’s r .

¹⁴ London boroughs were excluded from a number of Highways and Transport regressions, i.e. where their unit costs were not comparable with other authorities due to expenditure by the Greater London Authority.

Table 5 – Goodness-of-Fit where sparsity had a statistically significant relationship with unit costs

Service Area	Goodness-of-fit (Adjusted R ²)
Environmental, Safety & Routine Maintenance	5.1%
Parking Services	24.3%
Street Lighting	52.2%
Transport Planning, Policy and Strategy	14.8%
Winter Service	10.8%
Traffic Management & Road Safety	27.4%
Public Transport	69.8%
Other Children's and Families' Services	8.6%
Adults under 65 with Learning Disabilities	18.1%
Homelessness	8.8%
Housing Strategy, Advice, Advances etc.	1.0%
Culture & Heritage	26.3%
Libraries	16.7%
Open Spaces	47.2%
Tourism	12.6%
Community Safety	40.7%
Regulatory Services	35.2%
Street Cleansing	25.9%
Waste Disposal and Recycling	2.6%
Waste Collection	9.9%
Other Environmental & Regulatory	3.4%
Economic Research & Development	32.9%
Development Control	3.3%
Community Fire Safety	21.0%
Coroners' Court Services	22.6%
Corporate & Democratic Core	21.3%

3.28 As a benchmark, the table below presents the results of modelling carried out as part of the Unavoidable Excess Cost Adjustment (UECA) for health boards in Scotland. A number of different models were considered, each using a different variable associated with sparsity and remoteness. As can be seen, for each care programme, the best fit achieved by any of the models ranged from 5.2% to 13.2%. The final recommendation was based on the

results of a single model, using rural-urban classifications, for which the goodness-of-fit ranged from 1.0% to 8.9%.

Table 6 - Goodness-of-Fit for the UECA model

Care Programme	Goodness-of-fit (Adjusted R ²)	
	Recommended Model ¹⁵	Best across all Models
Acute	1.0%	5.2%
Outpatients	1.0%	9.5%
Maternity	9.5%	9.7%
Geriatric Long Stay	5.3%	5.3%
Mental Health	8.9%	13.2%

- 3.29 When carrying out regressions, we experimented with different model specifications of sparsity and deprivation to maximise the overall goodness-of-fit. Deprivation variables were excluded if they were insignificant and/or did not improve the goodness-of-fit of the model.
- 3.30 Outliers were identified and excluded from the analysis. For each expenditure grouping, this was done in two stages:
- First, and prior to the regression analysis, local authorities were excluded if their unit costs were greater than ± 3 standard deviations from the mean.
 - Second, once regressions had been carried out and a viable model had been identified, authorities with standardised residuals that were more than ± 3 standard deviations from the mean were excluded. (Standardised residuals measure the difference between an authority's *actual* unit costs and the unit cost *predicted* by the statistical model). The model was then re-estimated excluding these authorities.
- 3.31 The City of London and Isles of Scilly were excluded from the analysis, given their small populations.
- 3.32 There was a negative correlation between every sparsity indicator and every deprivation indicator considered as part of the study. Multicollinearity did not appear to be an issue, however, with the highest absolute Pearson correlation coefficient between any two sparsity and deprivation variables being 0.59 (below the threshold of 0.80). This was for *DepriveBenefitChild* and *SparsityDefra*.

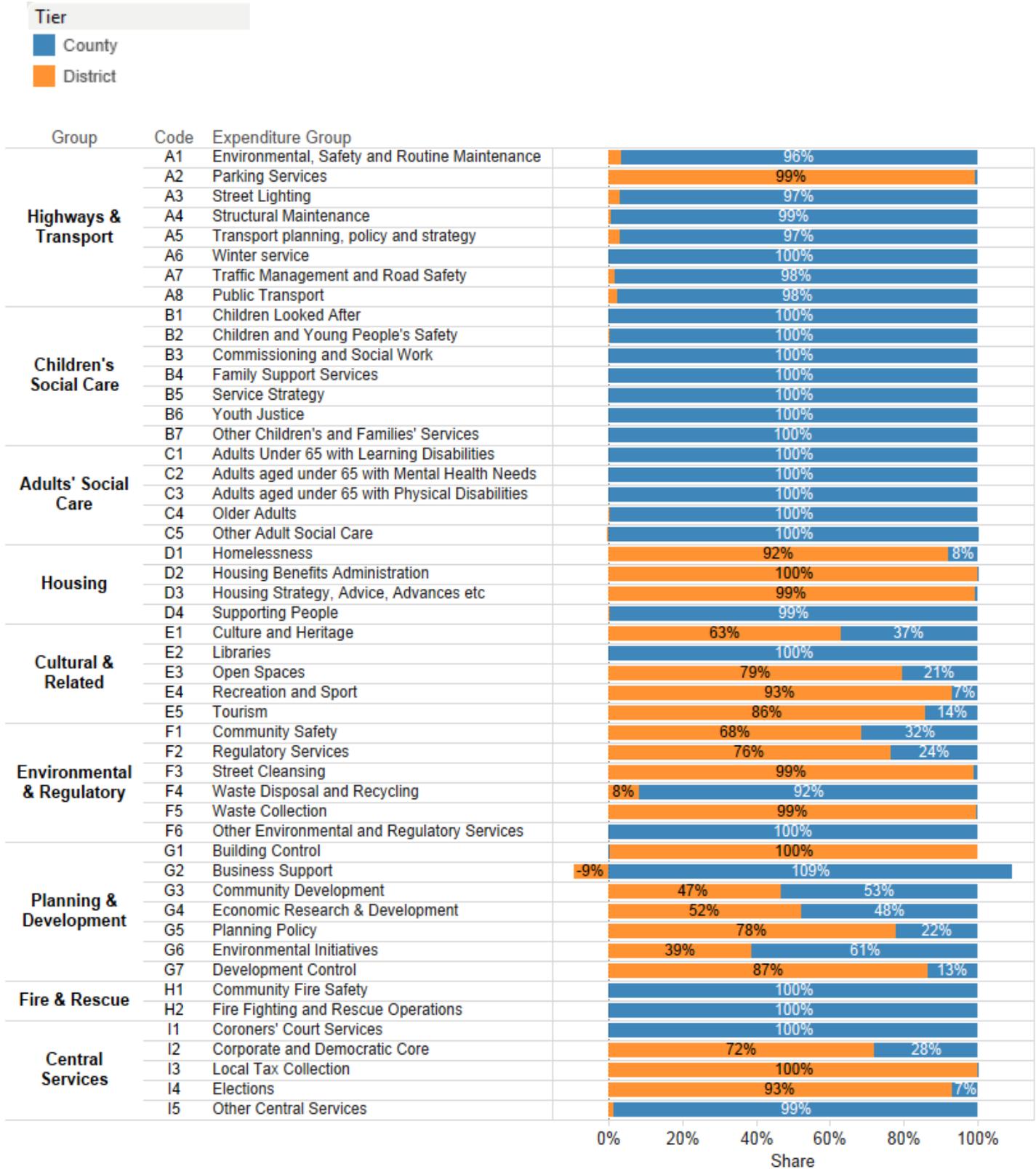
¹⁵ The results presented here relate to the final option recommended to the NHS Scotland Resource Allocation Committee by the Health Economics Research Unit, University of Aberdeen. (*Report to the NHS Scotland Resource Allocation Committee, Addendum E1 to Technical Report E, May 2007*). While the final UECA was based on urban-rural classifications, as proposed under this option, it is not clear whether this exact model (for which the R² are quoted) was used in the final UECA calculation.

Treatment of Two-Tier Areas

- 3.33 In two-tier areas, expenditure on some services is carried out by both shire districts and county councils. This means that unit costs would be lower for these authorities (individually) than they would have been for a unitary authority providing an identical set of services in the same area, all else being equal. This is an issue for the regression analysis, as it means that differences in unit costs would reflect not only sparsity and deprivation levels, but also local authorities' organisational structures.
- 3.34 To address this issue, dummy variables were used for those services where a significant share of expenditure was met by both shire districts and county councils.¹⁶ Separate dummy variables were assigned to county councils and shire districts, with the omitted (reference) category being authorities providing both lower- and upper-tier services, i.e. unitaries, metropolitan districts and the London boroughs.
- 3.35 Figure 4 shows the share in expenditure met by shire districts vs. county councils, at the national level, for each expenditure grouping. The dummy variables were used in regressions whenever the share of expenditure of shire districts and county councils both exceeded 10%. For any expenditure groups where more than 90% of expenditure was met by either shire districts or county councils, then all authorities from that tier were included in the analysis (without a dummy variable) and those from the remaining tier were excluded. Education (non-school) service groupings were excluded from this table, as expenditure data are not published for shire districts.

¹⁶ Dummy variables are used to represent a single, discrete attribute; for example, whether or not an authority is a shire district. In this case, the dummy variable would take on the value 1 for shire districts and 0 for all other local authorities. The coefficients for the dummy variable are estimated as part of the regression. To illustrate: if the dependent variable was unit costs (£ per resident), and the estimated coefficient on shire districts was -10, then we would conclude that unit costs for shire districts were £10 per resident lower for shire districts than all other local authorities, at any given level of sparsity.

Figure 4 – Expenditure splits between shire districts and county councils

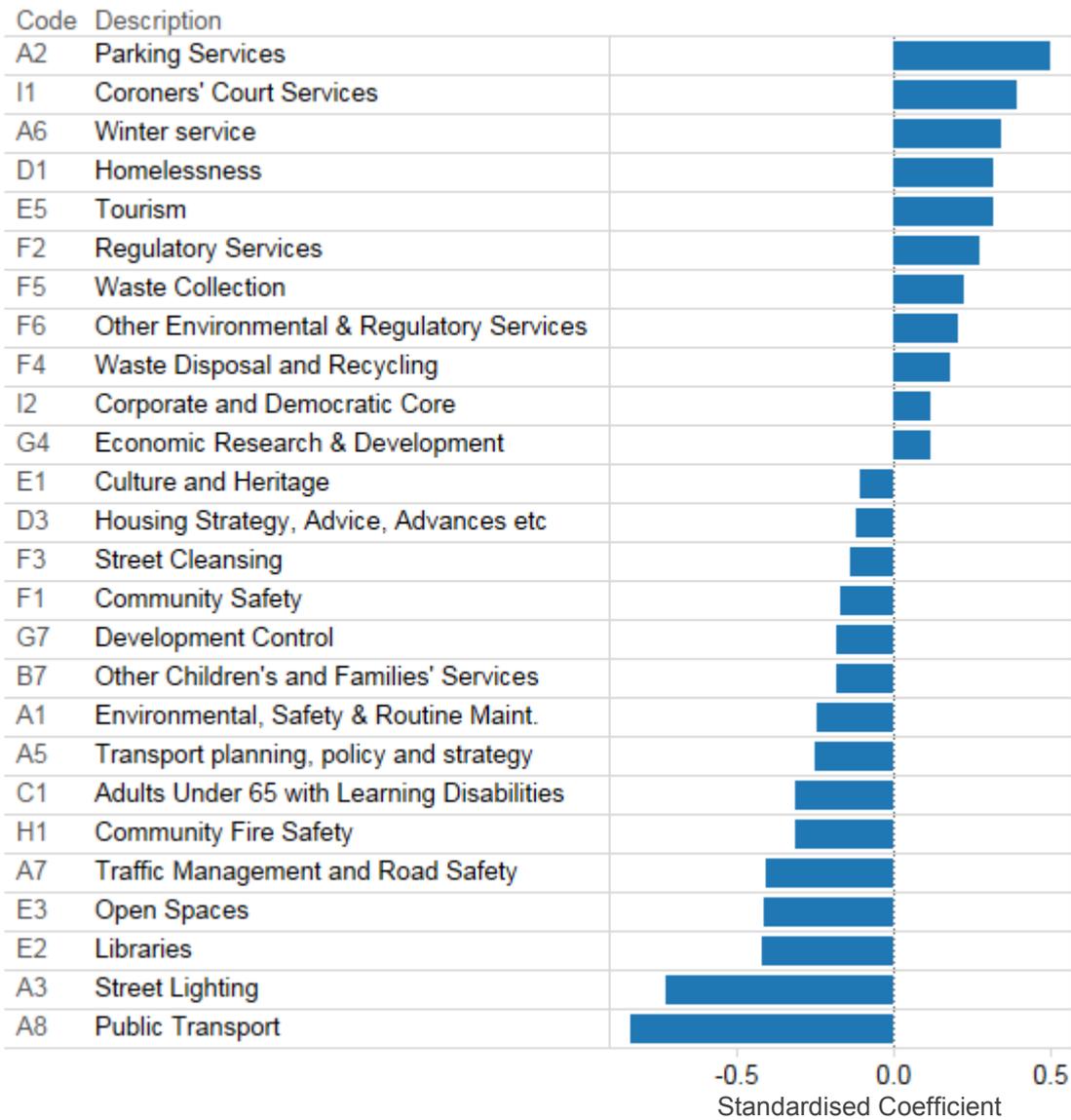


4 Results

- 4.1 Overall, sparsity was found to have a positive (and statistically significant) relationship with unit costs in 11 of 51 expenditure groupings. Evidence of a negative (and statistically significant) relationship was found in 15 of the 51 expenditure groupings. In the remaining 15 groupings, a statistically significant relationship between sparsity and unit costs was not found.
- 4.2 Figure 5 illustrates the results for each model using ‘standardised coefficients’. Because sparsity was measured using different units (i.e. percentage of population in sparse/remote areas, hectares per person, or minutes of travel time), the coefficients on sparsity could not be directly compared across all models.¹⁷ Standardised coefficients are therefore used, to show the number of standard deviations that unit costs increase or decrease with a one standard deviation increase in sparsity. This enables a comparison across the various models, whether they incorporate sparsity measured in percentages, hectares per person or minutes.

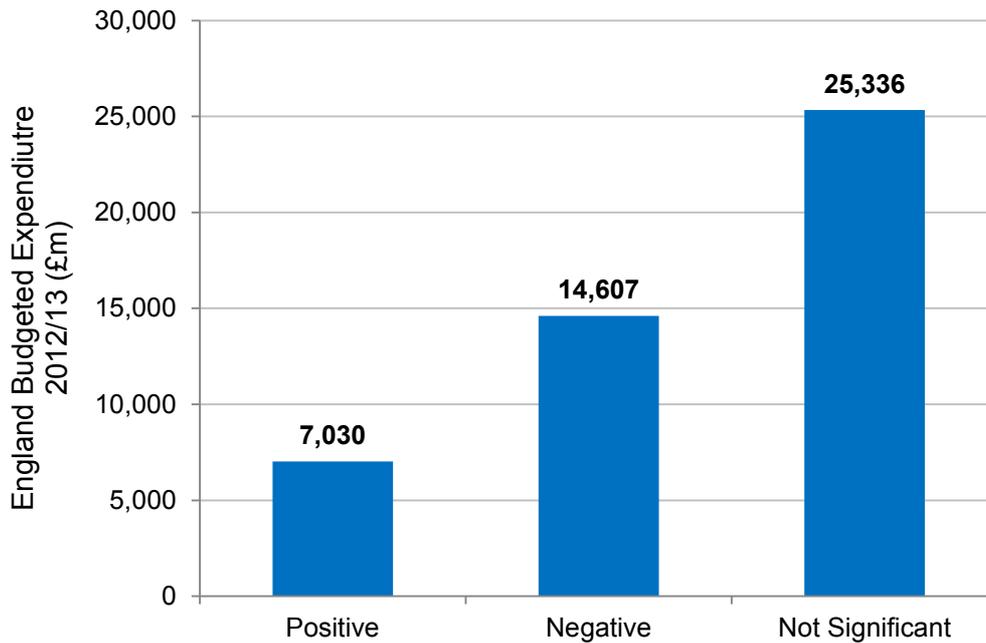
¹⁷ The coefficient quantifies the relationship between each explanatory variable (e.g. sparsity) and the dependent variable (unit costs). The value of the coefficient is estimated as part of the regression analysis. The interpretation of coefficients depends on the units of measurement used. For example, if the dependent variable is expenditure per person, and the sparsity variable is measured as minutes of travel time, then a coefficient of 10 on sparsity would mean that every additional minute of travel time is associated with an increase of unit costs of £10 per person.

Figure 5 – Relationship between Sparsity and Unit Costs



4.3 Figure 6 below analyses each expenditure grouping based on whether sparsity was estimated to be (i) positively related to unit costs and statistically significant, (ii) negatively related to unit costs and statistically significant, or (iii) not statistically significant. Each expenditure grouping was also weighted by its share of national expenditure in 2012/13, to illustrate the significance of each expenditure group in terms of its share of overall spending.

Figure 6 – Relationship between Sparsity and Unit Costs (by Expenditure Share)*



4.4 A positive and statistically significant relationship was found between sparsity and unit costs in services which accounted for 15.0% of local authorities' total expenditure in 2012/13. A statistically significant negative relationship was found in services which accounted for a larger share of expenditure (31.1% of the total).

4.5 When interpreting these results, a number of caveats must be borne in mind:

- It has been assumed that that relative expenditure is an adequate proxy for relative need, and that differences in expenditure do not reflect differences in funding, service quality or efficiency.
- It is assumed that any differences in unit costs between rural and non-rural areas are additional and unavoidable; or at least that avoidable costs are randomly distributed across rural and non-rural authorities.
- Full regression diagnostics have not been carried out, and it is possible that the models specified do not meet the basic assumptions of linear regression analysis.
- The focus on sparsity alone means it is possible that important explanatory variables have been excluded. This may mean the relationship between sparsity and service costs is over or under stated in the analysis.

4.6 The separate Appendix A describes the final model that was developed for each of the 51 expenditure groupings illustrated above, and the separate Appendix B provides the SPSS output for each of these models.

Annex A – Relationship between Revenue Outturn 2013/13 and Unit Cost Calculations

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Highways and Transport Services		4,835,055			
Highways and roads - maintenance	Environmental, safety and routine maintenance - principal roads	351,715	Environmental, Safety and Routine Maintenance	Weighted Road Length (km)	A1
	Environmental, safety and routine maintenance - other LA roads	575,989			
Parking services	On-street parking	-316,792	Parking Services	Daytime Population	A2
	Off-street parking	-271,916			
Highways and roads - maintenance	Street lighting (including energy costs)	497,239	Street Lighting	Weighted Road Length (km)	A3
Highways and roads - maintenance	Structural maintenance - principal roads	86,139	Structural Maintenance	Weighted Road Length (km)	A4
	Structural maintenance - other LA roads	238,953			
	Structural maintenance - bridges	54,294			
Transport planning, policy and strategy	Highways maintenance planning, policy and strategy	137,191	Transport planning, policy and strategy	Weighted Road Length (km)	A5
	Public and other transport planning, policy and strategy	235,606			
Highways and roads - maintenance	Winter service	195,806	Winter service	Weighted Road Length (km)	A6
Traffic management and road safety	Congestion charging	-138,581	Excluded		
	Road safety education and safe routes (including school crossing patrols)	88,138	Traffic Management and Road Safety	Weighted Road Length (km)	A7
	Other traffic management	148,047			

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Public Transport	Statutory concessionary fares	988,584	Public Transport	Weighted Road Length (km)	A8
	Discretionary concessionary fares	139,198			
	Support to operators - bus services	841,669			
	Support to operators - rail services	474,684			
	Support to operators - other	71,859			
	Public transport co-ordination	441,857			
	Airports, harbours and toll facilities	-4,619	Excluded		
	Capital charges relating to construction projects	0			
Children's Social Care		6,605,383			
Children's Social Care	Children's social care - Children Looked After	2,958,657	Children Looked After	Looked After Children	B1
	Children's social care - Children and Young People's Safety	188,496	Children and Young People's Safety	Children with a Protection Plan	B2
	Children's social care - Commissioning and social work	1,286,382	Commissioning and Social Work	Children in Need	B3
	Children's social care - Family Support Services	825,184	Family Support Services	Children in Need	B4
	Children's social care - Service strategy	397,234	Service Strategy	Children in Need	B5
	Children's social care - Youth Justice	199,322	Youth Justice	Residents (10-17)	B6
	Children's social care - Asylum Seekers	88,127	Excluded		
	Children's social care - Other children's and families services	661,982	Other Children's and Families' Services	Children in Need	B7

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Adult Social Care		14,522,889			
Adult Social Care	Adults aged under 65 with learning disabilities	4,958,777	Adults Under 65 with Learning Disabilities	Younger Adult clients with Learning Disabilities	C1
	Adults aged under 65 with mental health needs	1,064,339	Adults aged under 65 with mental health needs	Younger Adult Clients with Mental Health Needs	C2
	Adults aged under 65 with physical disability or sensory impairment	1,463,811	Adults aged under 65 with physical disability or sensory impairment	Younger Adult clients with Physical Disabilities	C3
	Older people (aged 65 or over) including older mentally ill	6,662,240	Older people (aged 65 or over) including older mentally ill	Older Adult Clients	C4
	Social care strategy - Adults	65,438	Other Adult Social Care	All Adult Social Care Clients	C5
	Other adult social care - Other	286,057			
	Other adult social care - asylum seekers	22,227			

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Housing Services		1,996,228			
Homelessness	Other nightly paid, privately managed accommodation	2,226	Homelessness	Homeless Households Accepted by the Local Authority	D1
	Private managed accommodation leased by the authority	2,786			
	Hostels (non-HRA support)	4,834			
	Bed/breakfast accommodation	47,954			
	Private managed accommodation leased by RSLs	6,060			
	Directly with a private sector landlord	735			
	Accommodation within the authority's own stock (non-HRA)	3,621			
	Other temporary accommodation	18,203			
	Homelessness: Administration	162,619			
	Accommodation within RSL stock	5,633			
	Homelessness: Prevention	58,079			
	Homelessness: Support	29,136			
Housing benefits	Housing benefits administration	449,589	Housing Benefits Administration	Housing Benefit Claimants	D2
	Rent rebates to HRA tenants - discretionary payments	-1,729	Excluded		
	Non-HRA rent rebates - discretionary payments	-2,008			
	Rent allowances - discretionary payments	16,788			

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
	Housing strategy, advice and enabling	188,331	Housing Strategy, Advice, Advances etc.	Residents (All Ages)	D3
	Housing advances	3,090			
Private sector housing renewal	Administration of financial support for repairs and improvements	42,730			
	Other private sector housing renewal	54,987			
Housing welfare	Supporting People	874,925	Supporting People	Residents (All Ages)	D4
	Other council property (Non-HRA)	5,490	Excluded		
Housing welfare	Other welfare services	22,147			
Cultural & Related Services		2,939,988			
Culture and heritage	Heritage	38,352	Culture and Heritage	Residents (All Ages)	E1
	Arts development and support	115,399			
	Museums and galleries	184,939			
	Theatres and public entertainment	157,296			
Culture and heritage	Archives	43,229			
	Library service	824,486	Libraries	Residents (All Ages)	E2
	Open spaces	740,415	Open Spaces	Local Area in Hectares	E3
Recreation and sport	Community centres and public halls	62,477	Recreation and Sport	Residents (All Ages)	E4
	Foreshore	2,739			
	Sports development and community recreation	237,164			
	Sports and recreation facilities, including golf courses	447,999			
	Tourism	85,487	Tourism	Residents (All Ages)	E5

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Environmental & Regulatory Services		5,041,704			
Community Safety	Crime Reduction	188,842	Community Safety	Residents (All Ages)	F1
	Safety Services	119,933			
	CCTV	54,718			
Regulatory services	Trading standards	133,540	Regulatory Services	Residents (All Ages)	F2
	Food safety	103,041			
	Port health (excluding levies)	118			
	Port health levies	1,117			
	Licensing - Alcohol and entertainment licensing; taxi licensing	8,460			
	Water safety	3,883			
	Environmental protection; noise and nuisance	146,318			
	Housing standards	34,253			
	Health and safety	39,481			
	Pest control	30,060			
	Public conveniences	75,187			
Animal and public health; infectious disease control	93,165				
	Street cleansing (not chargeable to Highways)	719,659	Street Cleansing	Daytime Population	F3

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Waste management	Recycling	561,456	Waste Disposal & Recycling	Waste (Tonnes)	F4
	Waste disposal	1,786,882			
	Waste collection	903,767	Waste Collection	Number of Households	F5
	Trade waste	-25,011	Other Environmental and Regulatory Services	Residents (All Ages)	F6
	Waste minimisation	22,611			
Flood defence, land drainage and coast protection	Defences against flooding	22,624			
Land drainage and related work (excluding levy / Special levies)	21,508				
Land drainage and related work - Levy / Special levies	16,577				
	Coast protection	12,571			
	Agricultural and fisheries services	-8,179			
Waste management	Climate change costs	14,395			
	Cemetery, cremation and mortuary services	-39,265			
Planning & Development Services		1,430,283			
Planning & Development Services	Building control	73,201	Building Control	Planning Applications	G1

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Unit Cost Expenditure Grouping	Unit Cost Denominator	Code
Planning Policy	Business support	27,575	Business Support	Number of Businesses	G2
	Community development	333,018	Community Development	Residents (All Ages)	G3
	Economic development	377,161	Economic Research & Development	Residents (All Ages)	G4
	Economic research	5,246			
	Conservation and listed buildings planning policy	32,237	Planning Policy	Residents (All Ages)	G5
	Other planning policy	228,231			
	Environmental initiatives	67,681	Environmental Initiatives	Residents (All Ages)	G6
Planning & Development Services	Development control	285,933	Development Control	Planning Applications	G7
Police Services		11,337,454			
	Total Police Services	11,337,454	Outside of scope of study		
Fire & Rescue Services		2,117,794			
Fire and Rescue Services	Community fire safety	241,741	Community Fire Safety	Residents (All Ages)	H1
	Fire fighting and rescue operations	1,864,098	Fire Fighting and Rescue Operations	Residents (All Ages)	H2
	Fire and rescue service emergency planning and civil defence	11,955	Excluded		

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Central Services		3,016,362			
	Coroners' court services	69,745	Coroners' Court Services	Residents (All Ages)	11
Central Services	Corporate and democratic core	1,410,591	Corporate and Democratic Core	Residents (All Ages)	12
Local tax collection	Council tax discounts locally funded	2,874	Local Tax Collection	Chargeable Dwellings	13
	Council tax benefits administration	241,942			
	Council tax collection	301,414			
	Council tax discounts for prompt payment	556			
	Non-domestic rates collection	14,692			
	BID ballots	985			
Non-distributed costs	Retirement benefits	592,029	Excluded		
	Costs of unused shares of IT facilities and other assets	26,325			
	Depreciation / impairment of surplus assets etc.	0			
	Revenue expenditure on surplus assets	11,389			
Elections	Registration of electors	69,825	Elections	Residents (All Ages)	14
	Conducting elections	67,238			
	Registration of births, deaths and marriages	20,850	Other Central Services	Residents (All Ages)	15
	Emergency planning	45,350			
	Local land charges	-13,019			
	General grants, bequests and donations	79,465			
Management and Support Services	Management and Support Services	72,580			
	Other court services	1,536			
	Emergency planning	45,350			

Revenue Outturn Heading	Revenue Outturn Expenditure Line	England Net Current Expenditure (£000)	Expenditure Grouping	Denominator	Code
Education		37,107,307			
Services to Young People and Other Community Learners	Adult and Community Learning	429,005	Services to Young People & Other Learners	Residents (13 and over)	J1
	Other services to young people	789,934			
Other Strategic Functions	Special Education	606,896	Other Strategic Functions	Pupils (excl. academies)	J2
	Learner Support	1,162,821			
	Access	257,705			
	Local authority education functions	763,759			
Schools	Early Years	2,539,290	Outside of Scope of Study	Outside of Scope of Study	
	Primary schools	17,367,541			
	Secondary schools	10,740,331			
	Special schools	2,450,025			
Total Other Services		117,520			
Total Other Services	Total Other Services	117,520	Excluded		
Total Service Expenditure		91,067,969			