Final

Analysis of recycling performance and waste arisings in the UK 2012/13

This report provides an analysis of recycling performance and waste arisings for local authorities in England and the UK for 2012/13. It explores how the nature of the collection systems and local area characteristics influence recycling performance and waste arisings.

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Executive summary

In 2010, WRAP analysed 2008/09 household dry kerbside recycling performance data from WasteDataFlow and produced *Analysis of kerbside dry recycling performance in the UK 2008/09* [1]. That report looked at the factors affecting the variation in yields of household kerbside dry recycling among all local authorities (LAs) in England and also for the UK. Understanding the factors affecting recycling performance in general, not just at kerbside, has become increasingly important when considering drivers to reach 50% recycling by 2020.

This study had two specific objectives:

- To identify the main factors responsible for variability in recycling performance among local authorities across England and the UK; and
- To quantify the impact that specific factors have on the recycling performance at a local authority level.

When identifying the factors, it was important to gauge whether the factor was within the control of the authority (LA controlled factors) or out of the control of the authority (contextual factors). General Linear Models (GLM) using response and predictor variables analysed 2012/13 performance data[2] to investigate these objectives.

Methodology - Response variables

The response variable in a regression model is the one whose variability is explained, where possible, by a series of predictor variables. A GLM consisting of three tests ('Analysis of Variance', 'Pair-wise comparison' and 'Parameter Estimates') was run for each response variable. In this study, five response variables were tested:

- Nationally reported local authority recycling rates (%);
- Total dry recycling yield collected from all sources[3] (kg per household per year);
- Total organic waste yield collected for recycling from all sources (kg/hh/yr);
- Total residual waste yield from all sources (kg/hh/yr); and
- Total waste arisings yield (kg/hh/yr).

The recycling rate model was run with three datasets; England Waste Collection Authorities (WCAs), England Unitary Authorities (UAs) and UK UAs. The four yield models were run with England UAs and UK UAs only as yields from Household Waste Recycling Centres (HWRCs) could not be attributed at the WCA level.

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[1] *http://www.wrap.org.uk/sites/files/wrap/EVA143-000%20Kerbside%20Dry%20Benchmarking%20UK%2008-09%20Report%20FINAL%20for%20publication%20V2%201.pdf*

[2] *2012 data for Scotland.*

[3] *Including kerbside, bring sites, HWRCs, street bins, voluntary kerbside, voluntary bring sites and other methods of collection. Excluding 10.85% of kerbside yield as 'contamination 'for the mixed streams of co-mingled and two stream collections.*

Methodology - Predictor Variables

To identify and quantify the factors affecting recycling performance, variation among local authorities in each response was modelled as a function of 10 predictor variables; seven scheme type factors that are within the control of the authority (LA controlled variables) and three contextual factors which are out of the control of the authority.

Dry scheme type

Using WRAP's recycling scheme data, scheme types were assigned to an authority if *80% or more households in the authority that are offered a recycling scheme are all given the same scheme*. The schemes collect glass, card, paper, cans and plastic bottles at the kerbside (except for the specific co-mingled category where glass is collected at bring sites). The following scheme types were identified for the model:

- Co-mingled (fortnightly);
- Co-mingled (weekly);
- Co-mingled (fortnightly with glass at bring sites);
- Multi-stream (weekly);
- Multi-stream (fortnightly); and
- Two-stream (fortnightly).

Other dry kerbside materials (in addition to the five main materials)

Each authority was classified as offering or not offering:

- Kerbside collection of plastic pots, tubs and trays (PTT); and
- Kerbside collection of textiles.

Effective weekly residual containment capacity

The containment volume available to the householder for their residual waste depends upon the size of the container available and the collection frequency (usually weekly or fortnightly, but with some authorities collecting more than once a week). Combining frequency and container size into a single measure of *effective weekly residual containment capacity* helps to understand the volume available. Local authorities ranged from 70 to 240 litres, with the median at 120 litres per week.

Additional dry recycling extracted from residual waste

Unitary authorities can include recycling extracted from the residual stream in their recycling rate. This data was restricted to England UAs and therefore only included in the England UA model.

Garden waste collection type

Each authority was classified as offering:

- Free garden waste collection;
- Subscription garden waste collection; or
- No garden waste collection.

Food waste collection type

Each authority was classified as offering:

- Separate food waste collection;
- Mixed food and garden waste collection; or
- No food waste collection.

Contextual variables

- The percentage of the working age population in social grades D and E (as an indicator of deprivation);
- The percentage of population classified as "rural" (as an indicator of rural nature); and
- Nation - England, Wales, Scotland or Northern Ireland (for the UK model only).

The contextual predictors above are ones that authorities have no control over. An authority can make choices between different LA controlled predictors.

Methodology – Local Authority Sample

135 authorities were in the England WCA sample, 57 in England UA and 104 in UK UA. For one of the GLM tests (Parameter Estimates), the effect of the predictor variables on the response was expressed relative to a reference authority with the following characteristics:

- Weekly multi-stream collection;
- No additional dry kerbside materials (PTT or textiles);
- 120 litres effective weekly residual containment capacity;
- Free garden waste collection;
- No food waste collection;
- 0% rural nature (i.e. purely urban);
- 13.2% of the working-age population in social grades D and E (UA model) (the lowest value in the sample);
- 10.7% of the working-age population in social grades D and E (WCA model) (the lowest value in the sample; and
- England (UK model only).

Outputs and Conclusions

Recycling Rate - Understanding which factors affect the variability in recycling performance

The recycling rate models were run on the three different datasets; England WCAs, England UAs and UK UAs. The predictor variables explained up to **81%** of the variability of the recycling rate for the datasets.

There was some commonality in significance across all datasets. Contextual variables were always significant to varying degrees. Effective weekly residual containment capacity and the presence of a food waste collection tended to be very significant indicating very strong evidence in the association of the predictor on recycling rate. The relative impact (positive or negative) is shown in the table below using an arrow. Where a predictor is highlighted as significant, the direction of impact on recycling rate is consistent across the three datasets. The significance (p-value) of the predictor is shown by the level of blue shading.

Level of significance	What this means	Strength of evidence
Highly significant (p≤0.001)	<0.1% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	Strong
Moderately significant (0.001<p≤0.01)	0.1%-1% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	Moderate
Marginally significant (0.01<p≤0.05)	1%-5% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	Weak
Non-significant	>5% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	None

Table 1 Impact on recycling rate from statistical significant of predictor variables (n = sample size)

	Direction of impact on recycling rate		
Variable	**England WCA (n=135)**	**England UA (n=57)**	**UK UA (n=104)**
Contextual			
Higher level of Deprivation	↓	↓	↓
Increased Rural nature	↑	↑	↑
Nation	n/a	n/a	↓
LA Controlled			
Increased Effective Weekly Residual Containment Capacity	↓	↓	↓
Increased dry recycling extracted from residual	n/a	↑	n/a
Food Waste Collection	↑	↑	↑
Garden Waste Collection	↓	↓	Non-sig
Collecting PTT at kerbside	↑	Non-sig	Non-sig
Collecting Textiles at kerbside	↑	Non-sig	Non-sig
Dry Scheme Type	Dependent on scheme type	Dependent on scheme type	Non-sig
Percentage of recycling rate variability explained by:			
All variables	71%	81%	67%
Contextual variables	20%	16%	29%
LA Controlled variables	51%	65%	39%

The analysis then delved further into the recycling rate, looking also at the yield (kg/hh/yr) models for the UK UA dataset. The following overall conclusions were found:

Contextual variables are defined as those that are out of the control of the local authority. It is therefore important to understand the context of the local authority and how this impacts on performance:

- **Contextual variables explain 16-29% of the variation in recycling rates.**
- **Higher level of deprivation** (percentage of social grade D&E) **is associated with lower recycling rates**. It is associated with lower dry yields and lower total arisings, but is not associated with a difference in residual yields.
- **Increased rural nature** (percentage of the population classified as "rural") **is associated with higher recycling rates**, as a result of higher dry, organic and total arisings yields.
- The UK model highlights one or more of the **nation variables** (Northern Ireland and/or Scotland) as significant in all but the organic yield model. The reason for these differences is not clear, but could reflect differences among nations in other, unmeasured, factors, or more subtle differences in how households make use of kerbside collection schemes.

LA controlled variables are those that the authority have control over and are related to the recycling and residual waste service:

- **LA controlled variables explain 39-65% of the variation in recycling rates.**
- Effective weekly residual containment capacity was significant in all datasets. An **increase in effective weekly residual containment capacity** from 120 to 240 litres is **associated with decreases in recycling rate** by 7.2±2.9 percentage points. This was due to decreases in dry recycling yields and increases in residual waste yields. The impact is greater for the England datasets compared to the UK.
- **Separate food waste and mixed food and garden collections are associated with higher recycling performance** compared to authorities with no food waste collection. It is associated with increases in recycling rate by 8.8±3.6 percentage points. The impact is greater for the UK dataset compared to England.
- **Very little certainty can be applied in establishing a difference in recycling performance between dry scheme types.**
- **The collection of PTT at the kerbside tends to be associated with higher recycling rates for England WCAs.**
- There was strong evidence for an association of lower recycling rates and a **subscription garden waste collection**, or no garden waste collection for the England WCA dataset. The association for the England UA dataset was much weaker and very little evidence is observed for the UK UA dataset.

Other interesting points to note include:

- There is **no significant relationship between effective weekly residual containment capacity and total waste arisings**. The fact that this predictor is not significant when looking at total waste arisings indicates that even though some authorities may experience reduced kerbside arisings when residual containment is reduced, there is not necessarily a reduction in total waste arisings so the material is likely to be diverted to other streams (i.e. HWRCs).

- **The type of garden waste collection is not significant in the residual yields model** for England and UK UA datasets suggesting that householders that have no service or do not use the subscription garden service dispose of garden waste using other ways such as home composting, rather than putting it in the residual bin or taking it to HWRCs. With such a small sample size in the analysis, this conclusion would need to be investigated further with more data and waste composition analysis.

Contents

1.0 Introduction and Background

In 2010, WRAP analysed 2008/09 household dry kerbside performance data from WasteDataFlow and produced *Analysis of kerbside dry recycling performance in the UK 2008/09* [4]*.* That report looked at the factors affecting the variation in yields of household kerbside dry recycling among all local authorities (LAs) in England and also for the UK. Understanding the factors affecting recycling performance in general, not just at kerbside, has become increasingly important when considering drivers to reach 50% recycling by 2020.

This study had two specific objectives:

- To identify the main factors responsible for variability in recycling performance among local authorities across England and the UK; and
- To quantify the impact that specific factors have on the recycling performance at a local authority level.

WRAP's previously published study on dry recycling performance in 2008/09 included a regression analysis. Regression models were run to try to establish the effects that separate predictor factors had on the variation on a single response variable, which in 2008/09 was the yield of dry recycling collected at the kerbside. This study builds on that earlier work by also considering the impact of scheme type on recycling performance. Scheme type was applied to authorities in the study that met particular thresholds and resulted in 60% of all England and UK authorities being included in the analysis.

In 2012/13, 17% of total household waste was collected as dry recycling at the kerbside. The rest was organic and residual waste from the kerbside (59%) and recycling and residual waste collected from bring sites, Household Waste and Recycling Centres (HWRCs) or other methods[5] (24%). This meant that focussing on dry recycling yields at the kerbside was not giving a complete picture. The 2008/09 study was therefore extended for the 2012/13 study to look at which factors explain the variation in:

- Nationally reported local authority recycling rates (%);
- Total dry recycling yield collected from all sources[6] (kilograms per household per year, kg/hh/yr);
- Total organic waste yield collected for recycling from all sources (kg/hh/yr);
- Total residual waste yield from all sources (kg/hh/yr); and
- Total waste arisings yield (kg/hh/yr).

The remainder of the report is divided into five sections. Section 2 focuses on the methodology and data behind the regression models, including any key assumptions

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[4] *http://www.wrap.org.uk/sites/files/wrap/EVA143-000%20Kerbside%20Dry%20Benchmarking%20UK%2008-09%20Report%20FINAL%20for%20publication%20V2%201.pdf*

[5] *Including from the kerbside by non-contracted voluntary/community sector groups, bring sites operated by voluntary/community sector groups, and from community skips.*

[6] *Kerbside, bring sites, HWRCs, community skips, kerbside and bring sites operated by voluntary/community sector groups.*

that were made. Section 3 presents the outputs for the recycling rate models and Section 4 focusses on the outputs from the UK yield model. Section 5 presents the overall conclusions and statistical tables from the models are available in the appendices (section 6).

2.0 Methodology

The goal of the analysis was to test and quantify the effect of a suite of predictor variables (describing the type of collection scheme and contextual factors) on variation in recycling performance among local authorities across England and the UK. The following sections describe the five response variables analysed (Section 2.1), the ten predictor variables (Section 2.2), and the statistical approach used to model the data (Section 0).

2.1 Response variables

The response variable in a model is the one whose variability is explained, where possible, by a series of predictors. Five response variables were analysed in this study: a headline measure of overall recycling rate, plus four measures of yield (dry, organic, residual and total). These yield measures provide more detailed information about patterns of variation in component waste streams and how these influence the overall recycling rate. The data was taken from WasteDataFlow (WDF) and relates to 2012/13 for England, Wales and Northern Ireland, and 2012 for Scotland.

2.1.1 Recycling rate indicator

Each UK nation reports annually a household recycling rate indicator[7] for each authority. The indicator is the percentage of waste sent for recycling, composting or for reuse less any rejects from the gate of the reprocessor, treatment or sorting facilities.

2.1.2 Total dry recycling yield

Total dry recycling yield (kg/hh/yr) derived from tonnages reported as being collected from the kerbside (Q10 WDF)[8], bring sites (Q17), HWRCs (Q14 and Q16), street bins (Q34), voluntary kerbside (Q12), voluntary bring site (Q33) and other sources (Q18).

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[7] *England* - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/255594/2012-13_ANNUAL_publication_LA_level_WITHOUTLINKS.xls

Wales - http://wales.gov.uk/docs/statistics/2013/131114-local-authority-municipal-waste-management-2012-2013-en.pdf Using Municipal waste recycled 2012/13 "old definition" as a *household* figure is not available for individual authorities.

Scotland - http://www.sepa.org.uk/waste/waste_data/waste_data_reports/lacw_reporting/idoc.ashx?docid=a6e5f42e-0aa1-4cf3-a417-05c2e0c3f044&version=-1

Northern Ireland - http://www.doeni.gov.uk/lac-municipal-waste-2012-13-appendix.xls

[8] *Yield is calculated by dividing the tonnage (multiplied by 100 to give kilograms) by the dwelling stock number reported in Q2 of WDF to give kg/hh/yr*

Unitary authorities are responsible for directly reporting all their tonnages into WDF[9]. The tonnage data used from each question in WDF is from a source of collection (e.g. kerbside, bring sites etc.) Where further material for recycling is extracted from the residual waste at a later stage (from a residual MRF or a MBT plant), it is not included in the recycling tonnages here.

The tonnage that feeds into Q10 can either be collected as multiple single material streams, or as a mix of co-mingled materials. Where the materials are collected separately, the tonnages reported are usually net of some non-targeted materials (contamination). These either are identified at the kerbside by waste collection operatives and left with the householder to put in the residual stream, or are identified at the transfer station and removed into residual. The tonnages reported as co-mingled include any non-targeted material that cannot be recycled as it is not usually noticed until it reaches the MRF (which is after it has been reported in Q10). To make the kerbside dry tonnages in the analysis equivalent, a proportion of the co-mingled tonnage that represents the non-targeted material is removed. The figure of 10.85% was chosen as this is the figure noted by the Environment Agency[10]. This figure also matches very well with a recent review of waste composition studies used to update the percentage co-mingled splits for WasteDataFlow[11] which found 11% of the total mix of materials was non-targeted. The removal of non-targeted materials from the yields does not take into account the further losses of materials either through the sorting facility or at the gate of the reprocessor.

Non-targeted material levels from bring sites, HWRCs or other collection methods are unknown which means that contamination from these sources are included in the total dry yield used in the analysis.

2.1.3 Total organic yield

Total organic waste yield (kg/hh/yr) for composting (garden waste, food waste and other compostable waste) derived from tonnages reported as being collected from the kerbside (Q10), bring sites (Q17), HWRCs (Q14 and Q16), street bins (Q34), voluntary kerbside (Q12), voluntary bring site (Q33) and other sources (Q18). This value includes contaminated material that is ultimately rejected at the treatment facility.

2.1.4 Total residual yield

Residual waste yield (kg/hh/yr) from the household derived from tonnages reported in Q23 from kerbside ("regular collection"), HWRC, bulky waste, street cleaning, "other", and separately collected healthcare waste. Also included is the non-targeted material yield removed from the dry recycling yield in Section 2.1.2.

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[9] *The responsibility for reporting tonnages from WCAs is shared across WCAs and WDAs.*

[10] *http://www.wastedataflow.org/documents/guidancenotes/LATS/GN9a_LATS_MRF_Rejects_1.0.pdf*

[11] *http://www.wastedataflow.org/documents/guidancenotes/Specific/GN15_Recording_Co-mingled_Materials_2.0a.pdf - an analysis of non-targeted material was an unpublished by-product of the study to update the splits listed here.*

As the residual tonnage is measured at the transfer station or disposal facility following collection, some recyclable materials can be recovered after this point if the material goes via a residual MRF. This is not factored in to the yield studies for residual and recycling as the recycling tonnages above are those that are separately collected for recycling.

2.1.5 Total waste arisings

The sum of total dry, organic and residual yields (kg/hh/yr) as defined above plus the dry kerbside contamination estimate. Therefore this value includes contamination from all streams.

2.1.6 Summary of datasets used

For the recycling rate response variable, separate analyses were performed for Waste Collection Authorities (WCAs) and Unitary Authorities (UAs) because of different responsibilities and the way they report waste tonnages. Specifically, the reporting of tonnage of recycling and residual collected at HWRCs is the responsibility of the waste disposal authority (WDA) and so not attributed to individual WCA, whereas UAs are responsible for their HWRC recycling and waste. UAs also directly include in their recycling rate any recycling extracted from the residual waste stream. Separate models were therefore run for three different groups of authorities: England WCAs, England UAs, and UK UAs, as shown in Table 2.[12] There are too few UAs in Wales, Scotland and Northern Ireland to permit a separate analysis for each of these nations.

For the four yield response variables, the analysis focused on UAs only (due to WDAs having the responsibility for HWRCs in England). Separate models were built for England and the UK as a whole (Table 2). Again there were too few UAs in Wales, Scotland and Northern Ireland to permit a separate analysis for each of these nations.

Table 2 Summary of datasets analysed

	Dataset		
Response variable	**135 England WCAs**	**57 England UAs**	**104 UK UAs**
Recycling rate	✓	✓	✓
Total dry recycling yield		✓	✓
Total organic yield		✓	✓
Total residual yield		✓	✓
Total waste arisings		✓	✓

[12] *Each UK nation calculates the recycling rate indicator slightly differently, but these differences are noted and discussed in the text where relevant.*

2.2 Predictor variables

Variation in recycling performance among local authorities was modelled as a function of 10 predictor variables; seven scheme type factors that are within the control of the authority (LA controlled variables) and three contextual factors which are out of the control of the authority.

The data used to produce variables relating to service provision are from WRAP's annual local authority scheme information update. This scheme information is fixed to the financial year and can therefore be matched with performance data.

Data for other variables was extracted from Census 2011.

2.2.1 Dry scheme type

To be able to understand the influence of scheme type on performance, data from an authority was assigned a scheme type if *80% or more households in the authority that are offered a recycling scheme are all given the same scheme*. This means that authorities that had a scheme change mid-year, or had two schemes in operation in large areas within the authority were omitted from the analysis. The threshold was important so that performance could be assigned to a single scheme type:

- Co-mingled (fortnightly);
- Co-mingled (weekly);
- Co-mingled (fortnightly with glass at bring sites);
- Multi-stream (weekly);
- Multi-stream (fortnightly); or
- Two-stream (fortnightly).

Two further scheme types – Two-stream (weekly) and Co-mingled (weekly with glass at bring sites) – were assigned to less than 10 authorities and so excluded from the analysis.
The dry scheme types have the following definitions:

Multi-stream Collection - Materials are separated into multiple material streams by the householder or on collection at the kerbside. The material streams may include a selected mix of some materials, typically cans and plastics, which are collected together and commonly separated using basic sorting processes at the transfer station, or sold to reprocessors as a mixed commodity;

Co-mingled Collection (or Single Stream Co-mingled) - All materials are collected together in one compartment on the same vehicle and require sorting at a MRF;

Two Stream Collection - Materials are collected as two material streams, usually fibres and containers, or glass separate to other materials. At least one of the streams requires sorting at a MRF.

Authorities were included in the analysis only if they collected glass, cans, plastic bottles, paper and card at the kerbside (except for the specific co-mingled category where it is stated that glass is collected at bring sites and therefore not collected at the kerbside). Specifying this minimum threshold meant that the analysis was able to focus on the effect of a wider range of predictors, rather than being influenced heavily by the number of materials collected.

Table 3 shows the number of authorities by scheme type and nation.

Table 3 Number of authorities in UK sample by scheme type

	WCA	UA				
Scheme type	**England**	**England**	**Wales**	**Scotland**	**NI**	**UK**
Co-mingled (fortnightly)	43	15	1	3	11	30
Co-mingled (fortnightly with glass at bring sites)	27	6	0	5	8	19
Co-mingled (weekly)	3	7	1	0	0	8
Multi-stream (fortnightly)	18	11	2	1	0	14
Multi-stream (weekly)	12	7	9	1	3	20
Two-stream (fortnightly)	32	11	0	2	0	13
TOTAL	**135**	**57**	**13**	**12**	**22**	**104**

The dry containment capacity available within each authority was heavily dependent on scheme type and frequency and therefore could not be used as an additional predictor variable.

2.2.2 Collecting pots, tubs and trays at the kerbside

In addition to glass, cans, plastic bottles, paper and card, authorities may choose to collect plastic pots, tubs and trays (PTT) at the kerbside.

Table 4 Number of authorities in UK sample collecting additional kerbside material

	WCA	UA				
Additional Material	**England**	**England**	**Wales**	**Scotland**	**NI**	**UK**
Pots, tubs and trays (PTT)	84	37	8	8	13	66

2.2.3 Collecting textiles at the kerbside

In addition to glass, cans, plastic bottles, paper and card, authorities may choose to collect textiles at the kerbside.

Table 5 Number of authorities in UK sample collecting additional kerbside material

	WCA	UA				
Additional Material	**England**	**England**	**Wales**	**Scotland**	**NI**	**UK**
Textiles	42	18	6	4	8	36

2.2.4 Effective weekly residual containment capacity

The containment volume available to the householder for their residual waste depends upon the size of the container provided and the collection frequency (usually weekly or fortnightly, but with some authorities collecting more than once a week). Collection frequency and container size were therefore combined into a single measure of *effective weekly residual containment capacity* to quantify the volume available. The frequency of collection and container data came from WRAP's local authority scheme information for 2012/13. It was assumed households were not permitted to exceed the containment available (e.g. via side waste).

The effective weekly residual containment capacity of the local authorities in the sample ranged from 70 to 240 litres, with a median of 120 litres per week.

2.2.5 Additional dry recycling extracted from residual waste (England UAs only)

Unitary authorities in England that extract recycling from their residual waste stream report the tonnage in Q19a. Where this tonnage was reported, it was converted to a yield (kg/hh/yr) and used as a predictor. The yields ranged from 0.08-91.04 kg/hh/yr with the median value of 3.92 kg/hh/yr. Q19a is not used by WCAs and also not used by all nations therefore this predictor was used in the England UA models only.

2.2.6 Garden waste collection type

Garden waste collections were classified as free service, subscription service, and no service (Table **6**). This predictor was concerned with the presence of and type of collection; it did not look at method of containment, availability of the service, the subscription price or the frequency of collection.

Table 6 Number of authorities in UK sample by garden waste collection type

	WCA	UA				
Type of garden waste collection	**England**	**England**	**Wales**	**Scotland**	**NI**	**UK**
Free garden waste service	72	40	10	12	18	80
Subscription garden waste service	60	14	2	0	0	16
No garden waste service	3	3	1	0	4	8
Total	*135*	*57*	*13*	*12*	*22*	*104*

2.2.7 Food waste collection type

Food waste collections were classified as: separate food waste collection, mixed food and garden collection, and no collection. This variable was concerned with the presence of and type of collection; it did not look at method or frequency of collection (kerbside or communal), or availability of the service across the local authority area.

Table 7 Number of authorities in UK sample by food waste collection type

	WCA	UA				
Type of food waste collection	**England**	**England**	**Wales**	**Scotland**	**NI**	**UK**
Separate food waste	36	14	13	2	1	30
Mixed food and garden	32	7	0	3	15	25
No food waste collection	67	36	0	7	6	49
Total	*135*	*57*	*13*	*12*	*22*	*104*

2.2.8 Deprivation indicator (contextual)

The Index of Multiple Deprivation (IMD)[13] is a commonly used deprivation measure. It is calculated slightly differently for each nation so the indices are not directly comparable. The percentage of working age population in social grades D and E is one of the component measures of IMD. It is measured consistently across all nations and was therefore adopted as the deprivation measure for this analysis.

The range of the deprivation measure across the datasets is given below:

Table 8 Range of deprivation measure within sample datasets

% social grade D&E	England WCA	England UA	UK UA
Minimum	10.7%	13.2%	13.2%
Median	23.5%	27.5%	28.8%
Maximum	41.6%	40.9%	40.9%

2.2.9 Rural nature indicator (contextual)

The percentage of the population classified as "rural" was calculated for each authority to give a consistent measure of rural nature across all nations. It was calculated by looking at the population density of Lower Super Output Areas (LSOAs) from the 2011 Census; categorising them as rural if less than 750 inhabitants per square kilometre, and then looking at the proportion of "rural" LSOAs for each authority.

The range of rural nature across the datasets is given below:

[13] *http://data.gov.uk/dataset/index-of-multiple-deprivation*

Table 9 Range of rural nature across sample datasets

% rural population	England WCA	England UA	UK UA
Minimum	0.0%	0.0%	0.0%
Median	23.5%	9.6%	22.7%
Maximum	79.9%	71.6%	91.7%

2.2.10 Nation (contextual)

Due to the relatively small number of authorities in Scotland, Wales and Northern Ireland, a separate regression could not be run for each nation. Instead, nation was included as predictor variable in a UK-wide model to test for systematic differences among nations in total waste arisings and recycling performance when all other factors are equal.

2.2.11 Defining a reference authority

The effect of each predictor variable on the response variables was expressed relative to a 'reference' authority with the following characteristics:

- **Weekly multi-stream collection;**
  Representing the most common UK UA scheme type where glass, metal, paper and plastic are collected as separate streams in line with Regulation 13 of the Waste England and Wales Regulations.
- **No additional dry kerbside materials (PTT or textiles);**
- **120 litres effective weekly residual containment capacity;**
  The UK median value.
- **Free garden waste collection;**
- **No food waste collection;**
  These are the most common collection characteristics for authorities in the sample.
- **0% rural nature (i.e. purely urban);**
  In the sample, the lowest percentage of rural nature for an authority was 0%. This was used as a reference against which to compare authorities with more urban populations.
- **13.2% of the working-age population in social grades D and E (UA model);**
  In the UA sample, the lowest percentage of social grades D and E for an authority was 13.2%. This was used as a reference against which to compare more deprived authorities.
- **10.7% of the working-age population in social grades D and E (WCA model);**
  In the WCA sample, the lowest percentage of social grades D and E for an authority was 10.7%. Again, this was used as a reference against which to compare more deprived authorities.
- **England (UK model only).**

To achieve this, the continuous predictors (effective weekly residual containment capacity and deprivation) were adjusted by subtracting the minimum value from every authority. For example, the lowest percentage of working-age population in social grades D and E was 13.2% in the UA sample as a whole, so an authority with a value of 30% was converted to a value of 30%-13.2% = 16.8% (i.e. 16.8 percentage points above the reference).

For each categorical predictor, one category was defined as the reference, and the effect of the other categories was expressed relative to it using dummy variables. For example, 80 out of 104 authorities in the UK UA dataset had a free garden waste service, so this was defined as the reference, against which the other two collection types (no garden waste service and subscription garden waste service) were compared.

2.2.12 Sample representation

As with all sample-based studies, there is a risk that the authorities selected for inclusion in the analysis may not be typical of the population of UK authorities and could skew the results. Table 10 shows that Scottish authorities were slightly under-represented and Northern Irish authorities were slightly over-estimated in the UK sample, but this was to some extent mitigated by including UK nation as a predictor in the UK models.

Table 10 Distribution of sample authorities across nations

	WCA	UA				
	England	**England**	**Wales**	**Scotland**	**NI**	**UK**
Count of authorities in sample	**135**	**57**	**13**	**12**	**22**	**104**
Percentage of all authorities in that nation	59%	63%	59%	38%	85%	61%

Within each UK nation, the sample of authorities was broadly representative of the wider population in terms of both recycling rate and total waste arisings (Table 11), giving us confidence that the results from the regressions models can be used to predict the recycling performance of authorities outside the sample.

Table 11 Average recycling rate and total waste arisings across nations in sample and whole UK 2012/13

	Recycling Rate (%)		**Total Waste Arisings (kg/hh/yr)**	
	Average for all LAs	Average for sample LAs	Average for all LAs	Average for sample LAs
England - WCA	41.9%	43.7%	1005	1010
England - UA	40.9%	41.8%	956	968
Wales	52.4%	52.1%	982	986
Scotland	41.4%	45.8%	1038	1025
NI	40.7%	40.9%	1154	1171

2.3 Statistical methodology

For each response variable and dataset, a general linear model (GLM) was used to analyse the variation among local authorities as a function of the predictor variables listed in section 2.2. All predictors relevant to the dataset were included in the model, regardless of whether or not they had a statistically significant effect on the response (i.e. no model selection procedures were applied to find the most parsimonious model). This was done to ensure that the reference local authority was the same in every regression model, making the results across the models consistent and comparable.

The relatively small size and highly unbalanced nature of the datasets limited the ability of the models to test for interactions between predictors variables. Following exploratory analyses, which revealed some marked differences in yield and recycling rate among nations, selected interactions were examined to try to verify the assumption that LA controlled predictor variables have the same effect in all four nations. The final models, however, assume that each predictor has a fixed effect regardless of the value of the other predictors in the model.

For each model, the standard assumptions of normality, equal variances and linearity were verified by plotting the standardised residuals against the predicted values and against each predictor variable in turn; no issues were found. Collinearity statistics were used to check that the validity of the models was not compromised by strong correlations between the predictors. All models were run using the statistical software package SPSS.

2.3.1 Model outputs

The overall effect of each predictor variable on the response was first tested using **analysis of variance (ANOVA)**. The significance of each predictor was quantified by a p-value, which represents the probability of observing an effect of that magnitude or larger if there were truly no effect of that variable. Variables with p-values at or below 0.05 were interpreted as being statistically significant, indicating evidence against the null hypothesis of no effect. The strength of the evidence and significance is presented in three ranges:

Level of significance	**What this means**	**Strength of evidence**
Highly significant	<0.1% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	Strong
Moderately significant	0.1%-1% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	Moderate
Marginally significant	1%-5% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	Weak

Non-significant	>5% chance of observing an effect size this large, or bigger, if there was truly no effect of the predictor on the response	None

Non-significant predictors are displayed in italic grey text in the results tables.

The proportion of variance in the response variable (e.g. variation in recycling rate) explained by the model as a whole was quantified by the model **R^2 value**. The higher the R^2, the greater the proportion of variation among local authorities explained by the predictor variables.

In the case of categorical predictors with three or more categories, a significant ANOVA test indicates that a predictor is important, but does not establish which individual categories differ significantly from which others. In this situation, unplanned **pairwise comparisons** were then performed to compare all possible pairs of categories. In the case of food waste collection type, for example, three unplanned comparisons were performed:

- separate food waste collection vs. mixed food and garden waste collection;
- separate food waste collection vs. no food waste collection; and,
- mixed food and garden waste collection vs no food waste collection.

A Šidák correction was applied when testing the statistical significance of the pairwise comparisons. The Šidák correction is a safeguard against the increased risk of a false positive result when conducting multiple tests of statistical significance using the same data. In other words, the Šidák correction reduces the chance of mistakenly concluding that two categories are different when in fact they aren't. Using this approach means that a greater degree of evidence is required before declaring a result to be statistically significant. Consequently, some sets of pairwise comparisons occasionally fail to yield a statistically significant result despite that predictor previously having been reported to have a (marginally) significant effect on the response as a whole in the ANOVA test.

Finally, the **parameter estimates** analysis from the GLM was used to **quantify** the impact of each predictor variable on the response.

- The constant coefficient estimates the mean of the response variable (e.g. 41.9% recycling rate) for the reference authority described in section 2.2.11.
- For categorical predictors, each coefficient estimates the average difference in the response between a *particular category* and the reference category; for example, the difference in recycling rate between authorities with no garden waste collection and those authorities with a free garden waste collection. (Note: a Šidák correction is unnecessary in this instance because specific comparisons are being drawn with a reference category, and therefore some parameter estimates were identified as significant even though the equivalent pair-wise comparison tests were non-significant).
- For continuous predictors, each coefficient estimates the average change in the response with associated with every unit increase in that variable; for example, the increase/decrease in recycling rate with every percentage point above the reference of 10.7% deprivation measure.

Uncertainty in the parameter estimates was measured using **95% confidence intervals**, which give the range of values within which we can be 95% confident it includes the true (unknown) population parameter. The wider the confidence interval, the greater the uncertainty about how the predictor variable affects the response and therefore the weaker the evidence.

Together, these parameter estimates allow the models to be used to predict the recycling rate or yield of a local authority with any type of collection scheme and any set of contextual factors.

The following sections look firstly at the recycling rate model for each dataset and then at the yield models for the UK UAs to look at the interactions of the waste streams. The outputs for the individual models can be found in the appendices.

3.0 Recycling Rates

The significance values from the overall ANOVA test of the recycling rate models for each dataset are presented in Table 12. Dark blue shading indicates highly significant predictors (p≤0.001), mid blue indicates moderately significant predictors (0.001<p≤0.01) and pale blue indicates marginally significant predictors (0.01<p≤0.05). Non-significant predictors are shown in grey text. The R^2 value shows that up to 81% of the variation in recycling rate among local authorities was explained by the predictors tested. The majority of the variation explained by the predictors is due to LA controlled predictors.

Table 12 Statistical significance of predictor variables on recycling rate

	Significance (p-value)		
Variable	**England WCA (n=135)**	**England UA (n=57)**	**UK UA (n=104)**
Contextual			
Higher Deprivation	<0.001	0.002	0.004
Increased Rural nature	<0.001	0.011	0.001
Nation	n/a	n/a	<0.001
LA Controlled			
Increased Effective Weekly Residual Containment Capacity	<0.001	<0.001	0.002
Increased dry recycling extracted from residual	n/a	0.001	n/a
Food Waste Collection	<0.001	0.039	<0.001
Garden Waste Collection	<0.001	0.021	0.115
Collecting PTT at kerbside	<0.001	0.070	0.081
Collecting Textiles at kerbside	0.017	0.085	0.623
Dry Scheme Type	0.039	0.005	0.191
Percentage of recycling rate variability explained by:			
All variables	71%	81%	67%
Contextual variables	20%	16%	29%
LA Controlled variables	51%	65%	39%

The significant variables in each separate dataset are discussed in sections 3.1 to 3.3. Key similarities and differences across the datasets are described in section 0.

3.1 England WCA dataset

The England WCA dataset contained 135 authorities that met the thresholds set out in section 2.2.1.

3.1.1 Identifying the main factors responsible for variation in recycling rate among authorities

Six predictors had a highly significant effect on recycling rate. The remaining two predictors in the model had a marginal significance indicating only weak evidence supporting the effect they had on recycling rate. The eight predictors overall explained 71% of the variation among local authorities with 20% explained by contextual predictors and 51% by LA controlled predictors. The significance values from the overall ANOVA test are presented in Table 13.

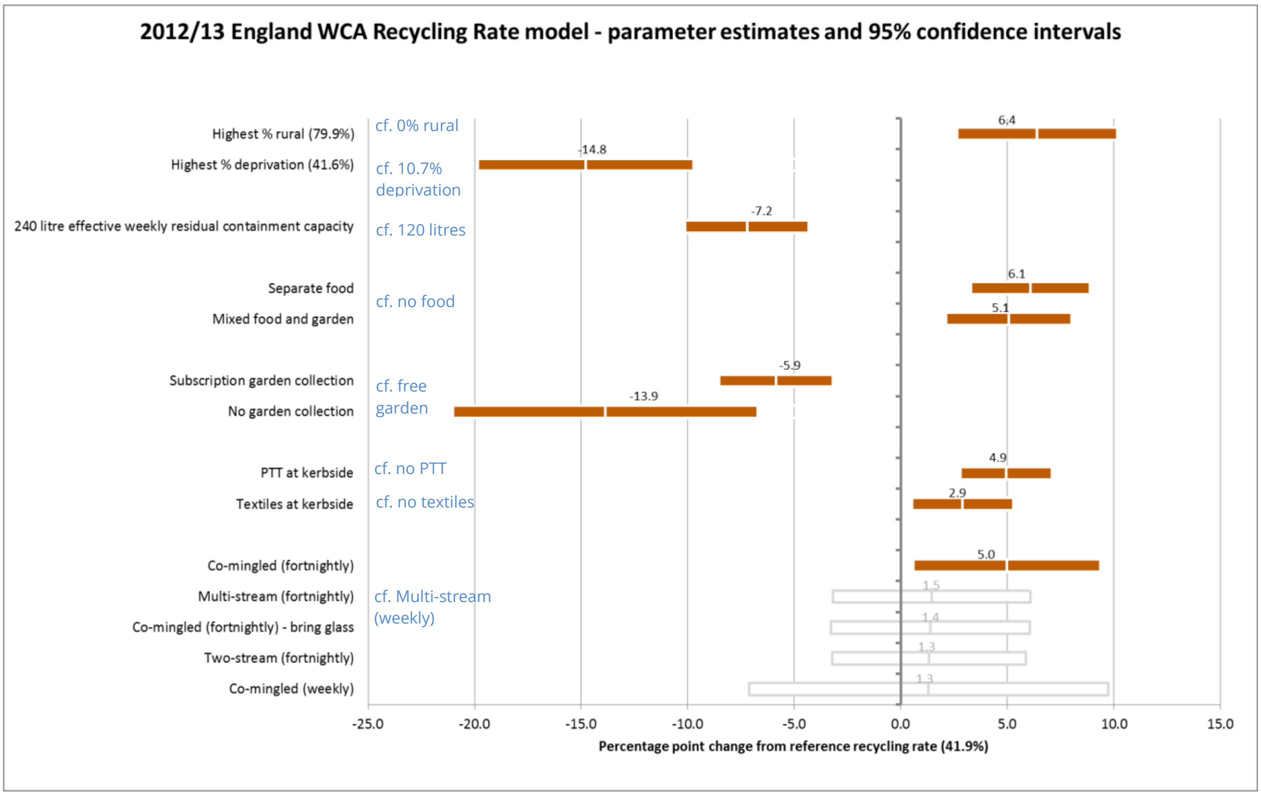
Table 13 Statistical significance of predictor variables on recycling rate in England WCAs (n=135)

Variable	Significance (p-value)
Contextual	
Deprivation	<0.001
Rural nature	<0.001
Nation	n/a
LA Controlled	
Effective Weekly Residual Containment Capacity	<0.001
Dry recycling extracted from residual	n/a
Food Waste Collection	<0.001
Garden Waste Collection	<0.001
Collecting PTT at kerbside	<0.001
Collecting Textiles at kerbside	0.017
Dry Scheme Type	0.039

3.1.2 Quantifying the impact of specific predictors on recycling rate

Figure 1 plots the parameter estimates (± 95% confidence intervals) from the GLM, showing the effect of each term on mean recycling rate relative to the reference (Section 2.2.11). For comparability, the maximum values of the rural nature and deprivation predictors (79.9% rural and 41.6% deprivation) have been used to show the range of the impact that these variables have. Parameters that show a significant difference compared to the reference (i.e. do not span zero) are coloured orange. Non-significant parameters are outlined in grey.

Figure 1 Parameter estimates and 95% confidence intervals for England WCA recycling rate model



The reference authority defined in Section 2.2.11 was estimated to have a recycling rate of 41.9%.

Each predictor variable in Table 13 and its significance compared to the reference authority in

Figure 1 is discussed below.

Contextual predictors

Authorities with higher levels of **deprivation** were associated with *lower recycling rates*. For the maximum deprivation across the sample of WCAs of 41.6%, the recycling rate was estimated to be 14.8±4.5 percentage points lower than the reference authority (which had 10.7% deprivation). This equates to reduction in recycling rate by 0.48±0.16 percentage points for each percentage point increase in deprivation.

Authorities with a greater **rural nature** were associated with *higher recycling rates*. For the maximum rural nature of 79.9% the recycling rate was estimated to be 6.4±3.8 percentage points higher than the reference authority (which was 0% rural). This equates to reduction in recycling rate by 0.08±0.05 percentage points for each percentage point increase in rural nature.

LA controlled predictors

Each additional litre of **effective weekly residual containment capacity** was associated with a reduction in mean recycling rate of 0.06±0.02 percentage points. This indicates that *authorities with higher effective weekly residual containment capacity were associated with lower recycling rates*. Comparing 240 litres effective weekly residual containment capacity (typical for a weekly residual collection) with a reference value of 120 litres a week (typically seen with a fortnightly residual collection), is therefore predicted to reduce recycling rate by 7.2±2.9 percentage points.

The type of **food waste** collection had a statistically significant effect upon recycling rate (Table 13).

Figure 1 shows that separate food collections and mixed food and garden collections have large, positive impacts on recycling rate compared to the reference of no food waste by 6.1±2.8 percentage points and 5.1±2.9 percentage points, respectively. There was no significant difference in mean recycling rate between authorities with separate and mixed food and garden collections, however. This would appear contrary to other evidence on food waste collections that indicate higher yields of food diversion are achieved by separate collections[14] compared to mixed food and garden collections[15]. However, this model looks at recycling rate overall, not specifically at food waste yields, and the food waste predictor variable did not take into account the coverage of the food waste scheme across each authority.

The **garden waste** predictor was also identified as highly significant in Table 13. Figure 1 shows that no garden collection and subscription garden collections have large, negative impacts on recycling rate compared to the reference of free garden collection by 13.9±7.1 percentage points and 5.9±2.7 percentage points respectively. The pair-wise comparison between no garden waste and subscription garden waste was just marginally non-significant suggesting very little evidence to suggest a difference between no collection and a subscription collection. However, there were only 3 LAs with no garden waste service in the sample therefore confidence around the relative impact of that predictor is low.

The collection of **PTT** at the kerbside was highly significant and associated with an increase in recycling rate of 4.9±2.1 percentage points compared to the reference of no collection.

The collection of **textiles** and the type of **dry recycling scheme** in operation was only marginally significant and therefore indicating very little certainty or evidence of a difference in recycling rate when all other factors are equal. The wide confidence intervals in Figure 1 and the proximity of the confidence interval to zero highlights the weak evidence. For dry recycling, this is further supported by the absence of any significant pairs of comparison schemes in the more rigorous pair-wise comparison test.

3.1.3 Predicting Recycling Rate

The parameter estimates from the GLM can be used to predict the recycling rate for any local authority, as shown by the worked example in Table 14. Note that both significant and non-significant predictors are included in the calculations because even though a non-significant predictor has a non-significant impact on the response, it still has an influence on the parameter estimates for other predictors in the model. Importantly, the model's predictions are only valid over the range of the predictor variables used to construct it. For example, the effect of effective weekly residual waste containment is based on what authorities are currently operating (i.e. in 2012/13) and does not indicate what would happen if the residual waste containment capacity was reduced beyond these levels (e.g. to less than 70 litres per week). Therefore the model should not be used to make predictions on data that exceed these ranges.

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[14] *http://www.wrap.org.uk/sites/files/wrap/Evaluation_of_the_WRAP_FW_Collection_Trials_Update_June_2009.pdf*

[15] *http://www.wrap.org.uk/sites/files/wrap/Food_Garden_Waste_Report_Final.pdf*

As an example, an authority with a fortnightly two-stream collection, 180 litres effective weekly residual containment capacity, 45% rural nature, 28% working age population in social grades D and E, a subscription garden waste service, a separate food waste collection and collects PTT at the kerbside is predicted to have a recycling rate of 40.8%. This is 1.2 percentage points lower than the reference authority, when all other factors are equal.

There is no simple way to manually calculate a confidence interval for the predicted recycling rate of a specific authority, however looking at the level of unexplained variation within the model gives an indication of the uncertainty in the predicted yield. For the recycling rate model, the error at 95% confidence is **±10.9 percentage points**. Please note, this value **underestimates** the true confidence interval so should only be used as a guide.

Table 14 Recycling rate parameter estimates model 2012/13, England WCAs – predictor tool worked example

Predictor	Parameter Estimate	Difference from reference	Calculation	Difference in Rate (% points)
Reference authority				**41.9**
Contextual Predictors				
Deprivation Index	-0.48	28%-10.7% = 17.3%	17.3 x -0.48	-8.3
Percentage of rural nature	0.08	45%-0% = 45%	45 x 0.08	3.6
LA Controlled				
Effective weekly residual containment capacity	-0.06	180-120 = 60	60 x -0.06	-3.6
Food waste - separate collection	6.1	Service difference	-	6.1
Garden waste - subscription	-5.9	Service difference	-	-5.9
Two-stream (fortnightly)	*1.3*	*Service difference*	*-*	*1.3*
Collects PTT at kerbside	4.9	Service difference	-	4.9
Predicted Rate				**40.1**

3.2 England UA dataset

The England UA dataset contained 57 authorities that met the thresholds set out in section 2.2.1 (63% of England UAs). **This low number of samples for a statistical analysis means that the influence of specific predictors can be more difficult to detect.**

3.2.1 Identifying the main factors responsible for variation in recycling rate among authorities

Only one predictor (effective weekly residual containment capacity) had a highly significant effect on recycling rate. Three predictors had a moderately significant effect and three others had a marginal significance indicating only weak evidence supporting the effect they had on recycling rate. Two predictors (collecting textiles and collecting PTT at kerbside) were non-significant.

Overall the predictors explained 81% of the variation among local authorities with 16% explained by contextual predictors and 65% by LA controlled predictors. The significance values from the overall ANOVA test are presented in Table 15.

Table 15 Statistical significance of predictor variables on recycling rate in England UAs (n=57)

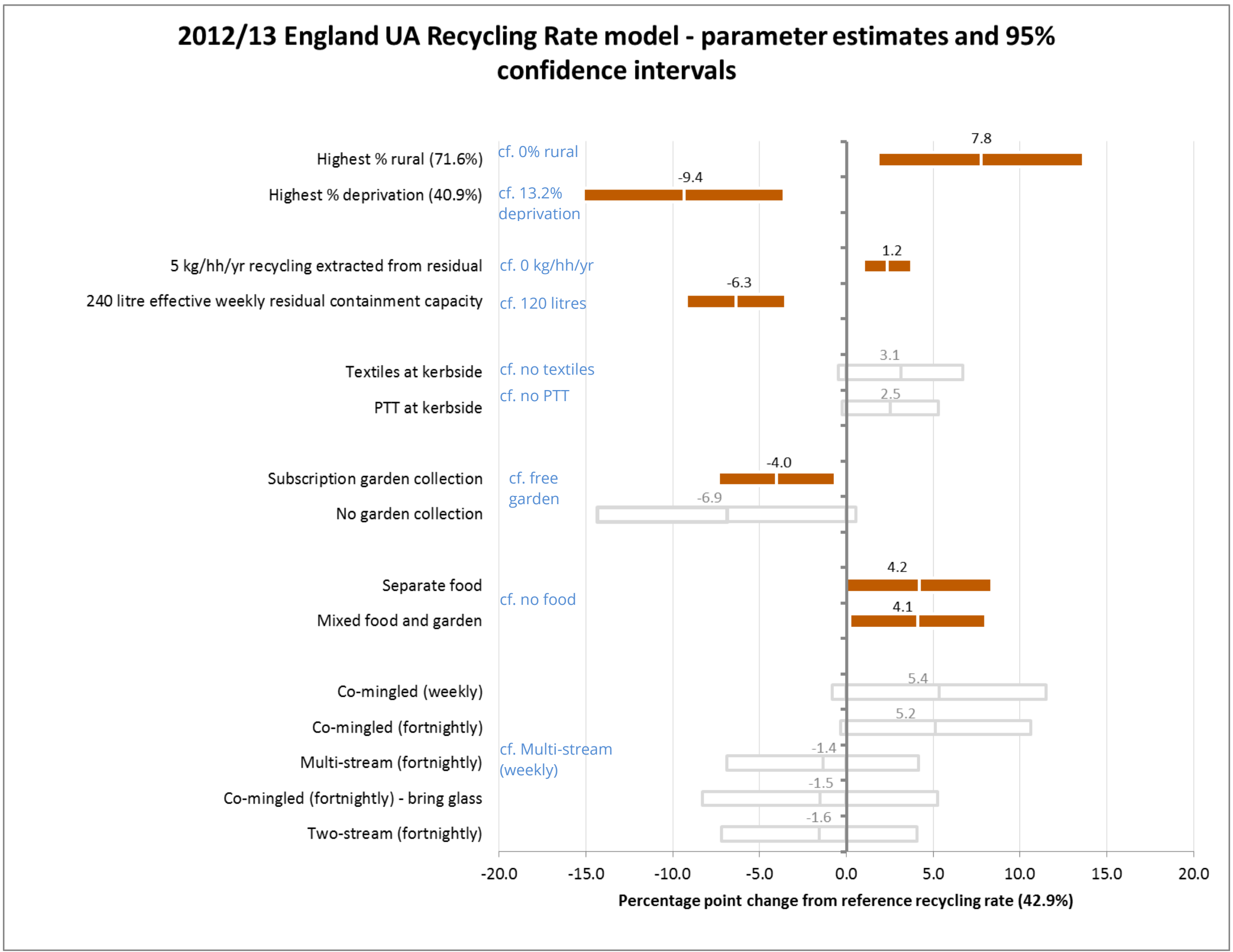
Variable	Significance (p-value)
Contextual	
Deprivation	0.002
Rural nature	0.011
Nation	n/a
LA Controlled	
Effective Weekly Residual Containment Capacity	<0.001
Dry recycling extracted from residual	0.001
Food Waste Collection	0.039
Garden Waste Collection	0.021
Collecting PTT at kerbside	0.070
Collecting Textiles at kerbside	0.085
Dry Scheme Type	0.005

It is likely that the general weaker significance of the predictors compared to the England WCA model is in part due to the considerably smaller sample size.

3.2.2 *Quantifying the impact of specific predictors on recycling rate*

Figure **2** plots the parameter estimates (± 95% confidence intervals) from the GLM, showing the effect of each term on mean recycling rate relative to the reference (Section 2.2.11). For comparability, the maximum values of the rural nature and deprivation predictors (71.6% rural and 40.9% deprivation) have been used to show the range of the impact that these variables have. Parameters that show a significant difference compared to the reference (i.e. do not span zero) are coloured orange. Non-significant parameters are outlined in grey.

Figure 2 Parameter estimates and 95% confidence intervals for England UA recycling rate model



The reference authority defined in Section 2.2.11 was estimated to have a recycling rate of 42.9%.

Each predictor variable in Table 15 and its significance compared to the reference authority in
Figure **2** is discussed below.

Contextual predictors

Authorities with higher levels of **deprivation** were associated with *lower recycling rates*. For the maximum deprivation across the sample of 40.9%, the recycling rate was estimated to be 9.4±5.8 percentage points lower than the reference authority (which had 13.2% deprivation).

Authorities with a greater **rural nature** were associated with *higher recycling rates*. For the maximum rural nature of 71.6% the recycling rate was estimated to be 7.8 ± 5.9 percentage points higher than the reference authority (which was 0% rural).

The strength of the evidence of these contextual predictors is weaker than in the England WCA dataset (deprivation has moderate strength whilst rural nature is weak compared to the strong evidence for England WCAs). This is likely to be due, in part, to the much smaller sample size (57 compared to 135).

LA controlled predictors

Each additional litre of **effective weekly residual containment capacity** was associated with a reduction in mean recycling rate of 0.05±0.02 percentage points. This indicates that *authorities with higher effective weekly residual containment capacity were associated with lower recycling rates*. Comparing 240 litres effective weekly residual containment capacity (typical for a weekly residual collection) with a reference value of 120 litres a week (typically seen with a fortnightly residual collection), is therefore predicted to reduce recycling rate by 6.3±2.9 percentage points. This predictor has the *highest level of certainty* within the dataset.

Extracting dry recycling from the residual stream is associated with higher recycling rates. Where an authority extracts 5 kg/hh/yr of dry recycling from the residual, the mean recycling rate is estimated to be 1.2±0.7 percentage points higher than a reference authority that does not extract recycling from residual. In reality, the recycling rate increase from extracting recycling from residual will depend on the amount of recycling currently collected as a separate stream and the overall waste arisings in the authority. Therefore the figures from this predictor should be used with caution and set in context.

Dry scheme type was identified as moderately significant in Table 15 suggesting some evidence that there is a difference in recycling rate.
Figure **2** shows no statistically significant difference in performance between the reference (weekly multi-stream) and any other scheme type. Only when looking at the pair-wise comparison, marginally significant differences were found between:

- Fortnightly co-mingled and fortnightly two-stream; and
- Fortnightly co-mingled and fortnightly multi-stream

However, *the level of significance was weak* suggesting very little certainty can be applied in establishing a difference between the scheme types.

Food waste and **garden waste** predictors had a marginally significant effect on recycling rate (Table 15), suggesting weak evidence in these findings for this dataset. This is mirrored in

Figure **2** where the confidence intervals are very large and almost span zero. The weakness of these predictors compared to the England WCA dataset is likely to be due, in part, to the small sample size.

3.3 UK UA dataset

The UK UA dataset contained 104 authorities that met the thresholds set out in section 2.2.1.

3.3.1 Identifying the main factors responsible for variation in recycling rate among authorities

Two predictors had a highly significant effect on recycling rate. Three other predictors had a moderately significant effect indicating only moderate evidence supporting the effect they had on recycling rate. The remaining four predictors were non-significant.

The predictors explained 67% of the variation among local authorities with 29% explained by contextual predictors and 39% by LA controlled predictors. The contextual predictors explain more of the variation in the UK UA dataset compared to the England WCA and England UA datasets because it includes the additional contextual predictor of Nation. The significance values from the overall ANOVA test are presented in Table 16.

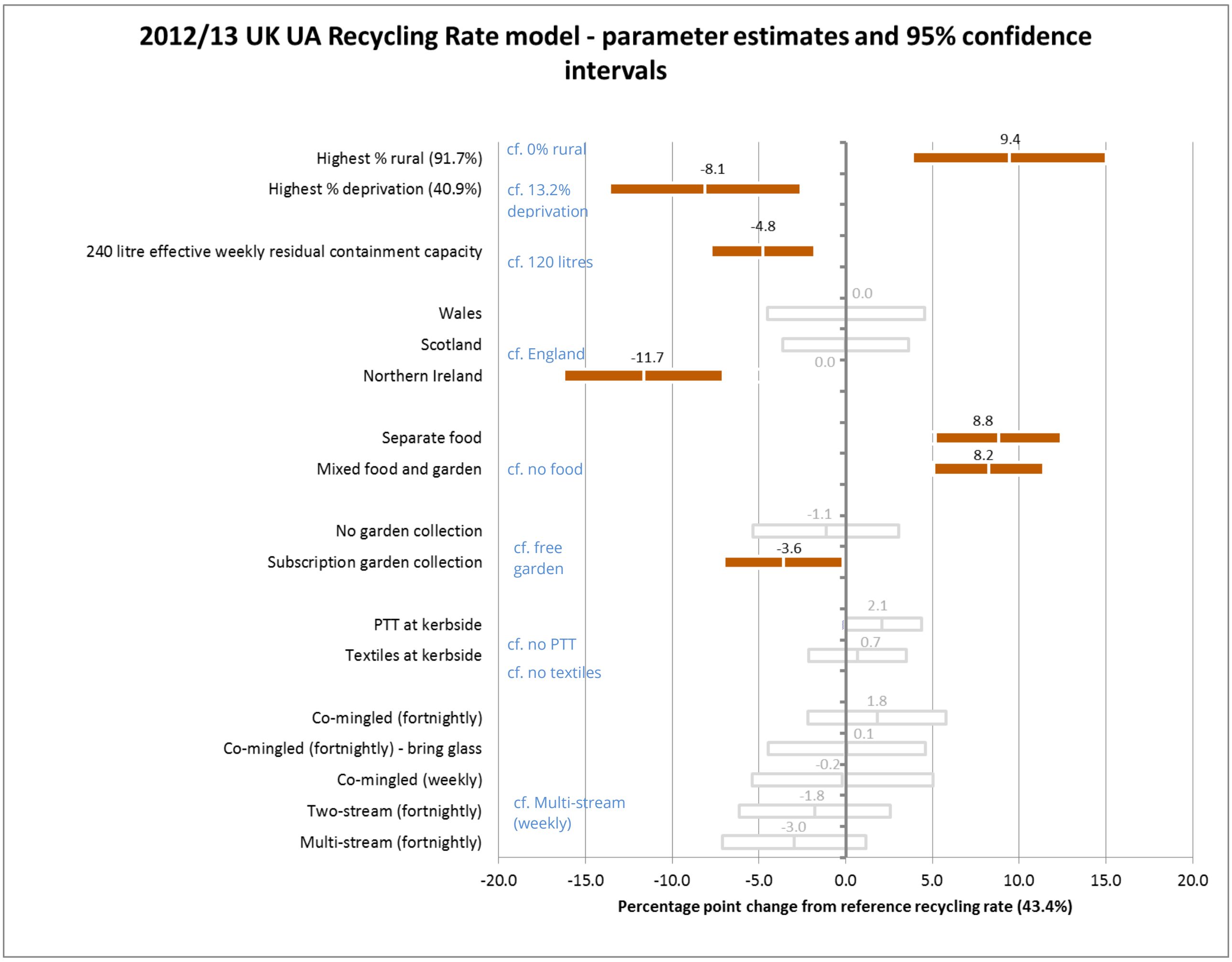
Table 16 Statistical significance of predictor variables on recycling rate in UK UAs (n=104)

Variable	Significance (p-value)
Contextual	
Level of Deprivation	0.004
Rural nature	0.001
Nation	<0.001
LA Controlled	
Effective Weekly Residual Containment Capacity	0.002
Dry recycling extracted from residual	n/a
Food Waste Collection	<0.001
Garden Waste Collection	0.115
Collecting PTT at kerbside	0.081
Collecting Textiles at kerbside	0.623
Dry Scheme Type	0.191

3.3.2 Quantifying the impact of specific predictors on recycling rate

Figure 3 plots the parameter estimates (± 95% confidence intervals) from the GLM, showing the effect of each term on mean recycling rate relative to the reference (Section 2.2.11). For comparability, the maximum values of the rural nature and deprivation predictors (e.g. 91.7% rural and 40.9% deprivation) have been used to show the range of the impact that these variables have. Parameters that show a significant difference compared to the reference (i.e. do not span zero) are coloured orange. Non-significant parameters are outlined in grey.

Figure 3 Parameter estimates and 95% confidence intervals for UK UA recycling rate model



The reference authority defined in Section 2.2.11 was estimated to have a recycling rate of 43.4%.

Each predictor variable in Table 16 and its significance compared to the reference authority in
Figure 3 is discussed below.

Contextual predictors

The **nation** predictor is highly significant on recycling rate. Compared to England in the reference, there is no significant difference between England, Wales and Scotland. There is a significant difference between England and **Northern Ireland** (11.7±4.6 percentage points) and the pair-wise comparison confirms a very similar difference for Northern Ireland compared to both Wales and Scotland (11.7 percentage points). Each nation calculates their recycling rate slightly differently which would be reflected in this predictor however there are likely to be several other reasons for the significant difference for Northern Ireland.

Authorities with higher levels of **deprivation** were associated with *lower recycling rates*. For the maximum deprivation across the sample of 40.9%, the recycling rate was estimated to be 8.1±5.5 percentage points lower than the reference authority (which had 13.2% deprivation).

Authorities with a greater **rural nature** were associated with *higher recycling rates*. For the maximum rural nature of 91.7% the recycling rate was estimated to be 9.4 ± 5.6 percentage points higher than the reference authority (which was 0% rural).

Both deprivation and rural nature are moderately significant indicating a moderate level of confidence to support the difference.

LA controlled predictors

The **food waste** predictor was identified as highly significant in Table 16 indicating very strong evidence of a difference in recycling rate. Figure 3 shows that separate food collections and mixed food and garden collections have large, *positive impacts* on recycling rate compared to the reference of no food waste by 8.8±3.6 percentage points and 8.2±3.2 percentage points respectively. The pair-wise comparison showed no significant difference between the impact of the two types of food waste collection. This is similar to the interactions observed in the England WCA model.

Each additional litre of **effective weekly residual containment capacity** was associated with a reduction in mean recycling rate of 0.04±0.02 percentage points. This indicates that *authorities with higher effective weekly residual containment capacity were associated with lower recycling rates*. Comparing 240 litres effective weekly residual containment capacity (typical for a weekly residual collection) with a reference value of 120 litres a week (typically seen with a fortnightly residual collection), is therefore predicted to reduce recycling rate by 4.8±3.0 percentage points.

The **garden waste** predictor was not identified as significant in Table 16. There were also no significant pair-wise differences identified.
Figure 3 however, shows that subscription garden collections are associated with lower recycling rates compared to the reference of free garden collection, by 3.6±3.4 percentage points. However, the wide confidence interval, combined with the non-significance in the ANOVA and pair-wise tests, indicates that garden waste collection type has, at best, only a weak effect on recycling rate.

Dry scheme type, the collection of **PTT** at kerbside or the collection of **textiles** at kerbside were not identified as significant in any of the three tests indicating no evidence to suggest a significant difference in performance due to these predictors.

3.4 Comparison of datasets

Table 17 shows the predictors that are significant for each dataset and whether it has a positive or negative impact on recycling rate (compared to the reference authority in the parameter estimates test). Where a predictor is highlighted as significant, the direction of impact on recycling rate is consistent across the three datasets.

For the dry scheme type predictor, which is only marginally significant, the impact on recycling rate depends on the pair of schemes compared.

Table 17 Impact on recycling rate from statistical significant of predictor variables

	Direction of impact on recycling rate		
Variable	**England WCA (n=135)**	**England UA (n=57)**	**UK UA (n=104)**
Contextual			
Higher level of Deprivation	↓	↓	↓
Increased Rural nature	↑	↑	↑
Nation	n/a	n/a	↓
LA Controlled			
Increased Effective Weekly Residual Containment Capacity	↓	↓	↓
Increased dry recycling extracted from residual	n/a	↑	n/a
Food Waste Collection	↑	↑	↑
Garden Waste Collection	↓	↓	Non-sig
Collecting PTT at kerbside	↑	Non-sig	Non-sig
Collecting Textiles at kerbside	↑	Non-sig	Non-sig
Dry Scheme Type	Dependent on scheme type	Dependent on scheme type	Non-sig
Percentage of recycling rate variability explained by:			
All variables	71%	81%	67%
Contextual variables	20%	16%	29%
LA Controlled variables	51%	65%	39%

The relative difference in strength of significance in the England WCA dataset compared to the UA datasets is in part, likely to be due to the larger sample size.

LA controlled predictors tend to explain more of the variation in recycling rates compared to contextual predictors.

Contextual Predictors

The contextual predictors are significant in all of the models. Higher level of **deprivation** is associated with lower recycling rates whilst increased **rural nature** is associated with higher recycling rates. When nations are compared, **Northern Ireland** is associated with lower recycling rates.

LA Controlled Predictors

There are several key similarities across the datasets on some LA controlled predictors:

- **Effective weekly residual containment capacity** is statistically significant in all models. *Authorities with higher effective weekly residual containment capacity (e.g. 240 litres compared to 120 litres) are associated with lower recycling rates.*

- **Food waste collections** are highly statistically significant in the England WCA and UK UA datasets indicating strong evidence of an *association with higher recycling rates*. The pair-wise comparison test shows that the predictors are not significant compared to each other but are significant compared to the reference authority (no food waste).

- **Dry scheme variables (LA controlled)** are relatively unimportant across all models with very little certainty applied to differences between scheme types.

There was strong evidence for an association of lower recycling rates and a subscription **garden waste** collection, or no garden waste collection for the England WCA dataset. The association for the England UA dataset was much weaker and very little evidence is observed for the UK UA dataset.

The England WCA dataset had a greater number of highly significant predictors identified. Some of these associations may exist for UAs but the small sample size for the UA models makes it more difficult to establish statistically significant results.

4.0 Yield Models by material stream - Identifying the impact of specific predictors

To understand the impact on recycling rate of various predictors, it can be helpful to look at the impact that each of the predictors has on yields for each material stream (dry, organic and residual waste). This has been carried out for the UK UA dataset. WCAs do not have responsibility for operating HWRCs so the complete picture for tonnages at a WCA level is not available as tonnages are reported at a county-level by the WDA. The UK UA dataset is relatively small (104) which limits the power of the analysis to detect statistically significant impacts and leads to large confidence intervals.

The most succinct way to look at the results for all the predictors is to focus on the 'parameter estimates' models. The parameter estimates presented in

Table 18 shows the average change in the response associated with a particular significant predictor variable. Any changes identified are the difference compared to the reference authority (Section 2.2.11). The confidence intervals and the parameter estimates for non-significant predictors are provided in the appendices.

In the table, the parameter estimates for the recycling rate model are slightly set apart from the others as the response in the recycling rate model was around percentage points whilst yields were considered for the other four models and can be directly compared. Statistically significant increases in yields or rates by the predictor are shaded in green, whilst decreases in yields or rate are shaded in yellow. The outputs for non-significant predictors are left blank (e.g. all dry scheme predictors).

Table 18 Parameter estimates for all significant predictors in all models – UK UAs (n=104)

	Model					
	Dry yield (kg/hh/yr)	**Organic yield (kg/hh/yr)**	**Residual yield (kg/hh/yr)**	**Total Waste Arisings yield (kg/hh/yr)**		**Recycling Rate (percentage points)**
	Parameter Estimates					
Constant	247.5	235.6	554.4	1037.4		43.4
Contextual predictors						
Deprivation	-2.2	-4.7	-	-5.2		-0.3
Rural nature	0.7	0.9	-	1.8		0.1
Northern Ireland	-37.3	-	178.6	127.0		-11.7
Scotland	-	-	59.9	-		-
Wales	-	-	-	-		-
LA controlled - Residual waste predictors						
Effective weekly residual containment capacity	-0.2	-	0.5	-		-0.04
LA controlled - Food waste predictors						
Separate food	30.2	55.2	-90.2	-		8.8
Mixed food and garden	-	66.3	-66.4	-		8.2
LA controlled - Garden waste predictors						
No garden collection	-	-90.4	-	-97.2		-
Subscription garden collection	-	-68.1	-	-71.4		-3.6
LA controlled - Dry scheme predictors						
Co-mingled (fortnightly)	-	-	-	-		-
Two-stream (fortnightly)	-	-	-	-		-
Multi-stream (fortnightly)	-	-	-	-		-
Co-mingled (fortnightly) bring glass	-	-	-	-		-
Co-mingled (weekly)	-	-	-	-		-
LA controlled - Dry material predictors						
Textiles at kerbside	-	-	-	-		-
PTT at kerbside	-	-	-	-		-

4.1 Contextual predictors

Deprivation

Similar to the England models, the measure of deprivation is significant in all but the residual model. *Authorities with higher levels of deprivation tend to show lower recycling rates, lower dry yields, lower organic yields and lower total waste arisings.*

The parameter estimates give an indication of the level of impact that a one percentage point increase in deprivation has on each response:

- 2.2±1.4 kg/hh reduction in dry recycling;
- 4.7±1.9 kg/hh reduction in organic recycling;
- 5.2±3.2 kg/hh reduction in total waste arisings.

It is interesting to note that deprivation is not associated with a change in residual yields. Even with the reduction in total waste arisings, the decrease in recycling yields result in a reduction in recycling rate. For every 1 percentage point increase in deprivation, the recycling rate reduces by 0.3±0.2 percentage points. This equates to a reduction of 8.1±5.5 percentage points for the highest deprivation level (41%) in the model, and a reduction of 4.6±3.1 percentage points for the median average deprivation level in the sample of 29%.

It is not possible to say from the analysis exactly why the deprivation predictor has the impact it does but it is thought that other factors related to deprivation are likely to be involved. In England, there is a correlation between deprivation and the percentage of terraced housing in the housing stock (R^2 of 25%). This correlation is likely to be a factor. The space for storing materials in some terraced properties is limited which may well have an impact on recycling levels however this would need investigating further. When considering organic yields, the correlation of deprivation with terraced housing could link to smaller or no gardens where associated with this housing type. Smaller gardens would equate with lower organic yields.

Rural Nature

The **percentage rural nature** is significant in all but the residual yield model. *Authorities with a greater proportion of rural nature are associated with higher dry yields, recycling rates, total waste arisings, and organic yields.*

An increase in one percentage point of rural nature in an authority is associated with:
- 0.7±0.4 kg/hh increase in dry recycling;
- 0.9±0.6 kg/hh increase in organic recycling; and
- 1.8±1.0 kg/hh increase in total waste arisings.

Even with the increase in total waste arisings, the increase in recycling yields result in an increase in recycling rate. For every 1 percentage point increase in rural nature, the recycling rate increases by 0.1±0.06 percentage points. This is an increase of 2.3±1.4 percentage points for the median average rural nature in the sample (22.7%). At the maximum percentage rural in the sample of 91.7%, the increase in recycling rate is by 9.4±5.6 percentage points.

Similar to the deprivation predictor, it is not possible from the analysis to identify the reasons for the changes however it is thought that a link between housing stock/garden size and rural nature is likely to be responsible for increases in organic waste and the subsequent impact on total waste arisings. The increase in dry recycling may be due to the availability of more storage space for recycling at rural properties however further study would be required to identify the link.

Nation Predictors

The model indicates that authorities in **Northern Ireland** are generally associated with lower dry yields, higher residual yields and higher total waste arisings when compared to authorities in England:

- 37.3±33.3 kg/hh reduction in dry recycling;
- 178.6±45.5 kg/hh increase in residual waste; and
- 127.0±73.6 kg/hh increase in total waste arisings.

These differences in yield feed into the 11.7±4.6 percentage point reduction in recycling rates. It should be noted that there is weaker evidence for the reduction on dry yield compared to the increases in residual and total waste arisings.

The differences in residual yield and total waste arisings may partially be explained by differences in average household size (2.4 persons per household for England, and 2.5 in Northern Ireland[16]). Another factor affecting all yields and rates could be the point in time that comprehensive kerbside recycling services started for each authority and related policies around recycling at the nation level.

Due to the large yield and recycling rate differences associated with the Northern Ireland predictor, a series of statistical tests were carried out on the data to see if there were any interactions between each nation and each LA controlled predictor. There was some evidence to suggest the effect of garden waste collection type on recycling rate varied across the nations (which is not surprising due to the distribution of garden waste types in Table **6**), however this effect was only marginally significant and the absence of certain collection types from some nations meant that there was insufficient data to fully assess this interaction. A similar effect was identified between dry scheme type and nation for the residual yield model (which again is not surprising due to the distribution of dry scheme types in Table 3), however again only marginally significant.

Scotland was significant in the residual yield model. The increase in residual yields was by 59.9±35.7 kg/hh/yr compared to England with all else being equal. The significance in the residual yield models did not carry an impact through into the recycling rate model.

Wales was non-significant in all models indicating that there was no significant difference in recycling performance between the Welsh authorities in the sample and those from England.

4.2 LA controlled predictors

Residual predictor

The **effective weekly residual containment capacity** has a large impact on residual yield, recycling rate and dry yields. *Authorities with less effective weekly residual containment capacity tend to show higher yields of dry recycling, higher recycling rates and lower residual yields.*

[16] http://www.ons.gov.uk/ons/dcp171778_304116.pdf

The parameter estimates are for every increase in weekly capacity by 1 litre compared to the 120 litres in the reference:

- 0.22±0.18 kg/hh reduction in dry recycling;
- 0.5±0.2 kg/hh increase in residual waste; and
- An associated reduction in recycling rate by 0.04±0.02 percentage points.

Comparing authorities with a weekly and a fortnightly residual waste collection operated with a 240 litre wheeled bin, the weekly collection would be associated with:

- 26.9±21.5. kg/hh reduction in dry recycling;
- 63.2±29.4 kg/hh increase in residual waste; and
- An associated reduction in recycling rate by 4.8±3.0 percentage points.

As for the other models this regression model is only valid within the ranges of the predictors used to construct it. For example, the effective weekly residual waste containment influence is based on what authorities are currently operating and does not indicate what would happen if the residual waste containment capacity was reduced beyond these levels (e.g. reducing to less than 70 litres per week). Therefore the model should not be used to make predictions on data that exceed these ranges.

It is interesting to note that **there is no evidence to suggest a correlation between effective weekly residual containment capacity and total waste arisings.** The fact that this predictor is not significant when looking at total waste arisings indicates that even though some authorities may experience reduced *kerbside* arisings when residual containment is reduced, there is not necessarily a reduction in total waste arisings so the material is likely to be diverted to other streams (i.e. HWRCs).

Garden waste predictors

The type of garden waste scheme in operation has an impact on organic yields and total waste arisings. Where **no garden waste scheme** is offered, organic yields are reduced by 90±39 kg/hh/yr compared to authorities who have a free garden waste collection. There is also a reduction for **subscription garden services** when compared to free collections (68±32 kg/hh/yr). These two numbers appear to be far apart but the pair-wise comparison test shows no statistically significant difference when comparing no garden waste scheme against a subscription garden waste scheme.

The reduction in total waste arisings is by a similar amount to the reduction in organic yields (97±67 kg/hh/yr for no garden waste and 71±55 kg/hh/yr for subscription garden services). The predictors are not significant in the residual yields model suggesting that householders that have no service or do not use the subscription garden service dispose of garden waste using home composting, rather than putting it in the residual bin or taking it to HWRCs. With such a small sample size in the analysis, this conclusion would need to be investigated further with more data and waste composition analysis.

Table 18 shows a difference in recycling rate for subscription garden services however section 4.0 has shown that the evidence behind this is weak.

Food waste predictors

Food waste collections (separate and mixed) are associated with increases in organic yields, decreases in residual yields and large increases in recycling rate compared to the reference of no food waste.

Separate food predictor:

- 55±34 kg/hh increase in organic recycling;
- 90±36 kg/hh reduction in residual waste; and
- An associated increase in recycling rate by 8.8±3.6 percentage points.

Mixed food and garden predictor:

- 66±30 kg/hh increase in organic recycling;
- 66±31 kg/hh reduction in residual waste; and
- An associated increase in recycling rate by 8.2±3.2 percentage points.

The pair-wise comparison tests show no significant difference between the two predictors when compared against each other. Neither predictor is significant in the total waste arisings model suggesting that the presence of food waste collections do not necessarily have a waste reduction effect.

The separate food waste predictor is marginally significant in the *dry* recycling model, increasing yields by 30±26 kg/hh/yr. Very little certainty can be applied to this finding due to the weak significance.

Dry predictors

None of the dry scheme predictors were significant highlighting that there is no evidence to suggest a difference between the performance of weekly multi-stream collections and other dry scheme types in this dataset.

The collection of PTT or textiles at kerbside was also non-significant in all models for UK UAs.

4.3 Comparison with the England UA dataset

The yield analysis was also carried out for the England UA dataset. Even with the limitations of the small sample size, there were many similarities. There were also a few interesting differences:

- **Food waste collections are associated with a higher impact in the UK model** compared to the England model (separate food waste predictor with 8.8±3.6 percentage points for UK and 4.2 ±4.19 percentage points for England);

- **Effective weekly residual containment capacity is associated with a higher impact in the England model** compared to the UK model (-6.3±2.9 percentage points for 120 litres increase in capacity for England and -4.8±3.0 percentage points for UK).

5.0 Overall Conclusions

This study has applied a General Linear Modelling (GLM) approach to examine the factors influencing variation in recycling performance among local authorities in three datasets (England WCA, England UA and UK UA). Recycling rates for each dataset were analysed and then yields of different waste streams were analysed for UK UAs only. The models produced the following conclusions:

Contextual variables are defined as those that are out of the control of the local authority.

It is therefore important to understand the context of the local authority and how this impacts on performance:

- **Contextual variables explain 16-29% of the variation in recycling rates.**
- **Higher level of deprivation** (percentage of social grade D&E) **is associated with lower recycling rates**. It is associated with lower dry yields and lower total arisings, but is not associated with a difference in residual yields.
- **Increased rural nature** (percentage of the population classified as "rural") **is associated with higher recycling rates**, as a result of higher dry, organic and total arisings yields.
- It is suggested that housing stock and related recycling storage space may be partially responsible for the impact of the deprivation and rural nature predictors.
- The UK model highlights one or more of the **nation variables** (Northern Ireland and/or Scotland) as significant in all but the organic yield model. The reason for these differences is not clear, but could reflect differences among nations in other, unmeasured, factors, or more subtle differences in how households make use of kerbside collection schemes.

LA controlled variables are those that the authority have control over and are related to the recycling and residual waste service:

- **LA controlled variables explain 39-65% of the variation in recycling rates.**
- Effective weekly residual containment capacity was significant in all datasets. An **increase in effective weekly residual containment capacity** from 120 to 240 litres is **associated with decreases in recycling rate** by 7.2±2.9 percentage points. This was due to decreases in dry recycling yields and increases in residual waste yields. The impact is greater for the England datasets compared to the UK.
- **Separate food waste and mixed food and garden collections are associated with higher recycling performance** compared to authorities with no food waste collection. It is associated with increases in recycling rate by 8.8±3.6 percentage points. The impact is greater for the UK dataset compared to England.

- **Very little certainty can be applied in establishing a difference in recycling performance between dry scheme types.**

- The **collection of PTT at the kerbside tends to be associated with higher recycling rates for England WCAs**.

- There was strong evidence for an association of lower recycling rates and a **subscription garden waste collection**, or no garden waste collection for the England WCA dataset. The association for the England UA dataset was much weaker and very little evidence is observed for the UK UA dataset.

Other interesting points to note include:

- There is **no significant relationship between effective weekly residual containment capacity and total waste arisings**. The fact that this predictor is not significant when looking at total waste arisings indicates that even though some authorities may experience reduced kerbside arisings when residual containment is reduced, there is not necessarily a reduction in total waste arisings so the material is likely to be diverted to other streams (i.e. HWRCs).

- **The type of garden waste collection is not significant in the residual yields model** for England and UK UA datasets suggesting that householders that have no service or do not use the subscription garden service dispose of garden waste using other ways such as home composting, rather than putting it in the residual bin or taking it to HWRCs. With such a small sample size in the analysis, this conclusion would need to be investigated further with more data and waste composition analysis.

6.0 Appendices

6.1 Appendix A – England WCA (n=135) – statistical model outputs

6.1.1 ANOVA table – Recycling Rate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8976.1	14	641.2	20.9	0.000
Constant	14254.0	1	14254.0	464.3	0.000
Dry Scheme Type	372.8	5	74.6	2.4	0.039
Food Waste Collection	759.8	2	379.9	12.4	0.000
Garden Waste Collection	894.4	2	447.2	14.6	0.000
Collecting PTT at kerbside	640.4	1	640.4	20.9	0.000
Collecting Textiles at kerbside	180.1	1	180.1	5.9	0.017
Effective Weekly Residual Containment Capacity	742.6	1	742.6	24.2	0.000
Deprivation	1030.9	1	1030.9	33.6	0.000
Rural nature	350.1	1	350.1	11.4	0.001
Error	3684.2	120	30.7		
Total	269161.3	135			
Corrected Total	12660.3	134			

6.1.2 Parameter Estimates – Recycling Rate

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	41.9	3.1	13.7	0.000	35.8	47.9
Deprivation	-0.5	0.1	-5.8	0.000	-0.6	-0.3
Rural nature	0.1	0.0	3.4	0.001	0.0	0.1
1 litre increase in effective weekly residual containment capacity	-0.06	0.0	-4.9	0.000	-0.1	0.0
Separate food	6.1	1.4	4.3	0.000	3.3	8.9
Mixed food and garden	5.08	1.5	3.4	0.001	2.1	8.0
No garden collection	-13.9	3.6	-3.8	0.000	-21.0	-6.7
Subscription garden collection	-5.9	1.3	-4.4	0.000	-8.5	-3.2
Co-mingled (fortnightly)	5.0	2.2	2.3	0.026	0.6	9.4
Two-stream (fortnightly)	1.3	2.3	0.6	0.565	-3.2	5.9
Multi-stream (fortnightly)	1.5	2.3	0.6	0.534	-3.2	6.1
Co-mingled (fortnightly) bring glass	1.4	2.4	0.6	0.559	-3.3	6.0
Co-mingled (weekly)	1.3	4.3	0.3	0.759	-7.1	9.7
Textiles at kerbside	2.9	1.2	2.4	0.017	0.5	5.3
PTT at kerbside	4.9	1.1	4.6	0.000	2.8	7.1

6.2 Appendix B –England UA (n=57) – statistical model outputs

6.2.1 ANOVA table – Recycling Rate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3126.5	15	208.4	11.4	0.000
Constant	8192.3	1	8192.3	447.8	0.000
Dry Scheme Type	363.4	5	72.7	4.0	0.005
Food Waste Collection	128.5	2	64.3	3.5	0.039
Garden Waste Collection	154.7	2	77.4	4.2	0.021
Collecting PTT at kerbside	63.2	1	63.2	3.5	0.070
Collecting Textiles at kerbside	56.9	1	56.9	3.1	0.085
Effective Weekly Residual Containment Capacity	364.6	1	364.6	19.9	0.000
Deprivation	194.4	1	194.4	10.6	0.002
Rural nature	128.1	1	128.1	7.0	0.011
Dry Scheme Type	222.4	1	222.4	12.2	0.001
Error	750.1	41	18.3		
Total	103628.1	57			
Corrected Total	3876.6	56			

6.2.2 Parameter Estimates – Recycling Rate

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	42.9	3.6	11.8	0.000	35.6	50.2
Deprivation	-0.3	0.1	-3.3	0.002	-0.5	-0.1
Rural nature	0.1	0.0	2.6	0.011	0.0	0.2
1 litre increase in effective weekly residual containment capacity	-0.05	0.0	-4.5	0.000	-0.1	0.0
Dry recycling extracted from residual	0.24	0.1	3.5	0.001	0.1	0.4
Separate food	4.20	2.1	2.0	0.050	0.0	8.4
Mixed food and garden	4.1	1.9	2.1	0.040	0.2	8.1
No garden collection	-6.9	3.7	-1.9	0.070	-14.4	0.6
Subscription garden collection	-4.0	1.7	-2.4	0.021	-7.4	-0.6
Co-mingled (fortnightly)	5.2	2.7	1.9	0.065	-0.3	10.6
Two-stream (fortnightly)	-1.6	2.8	-0.6	0.579	-7.2	4.1
Multi-stream (fortnightly)	-1.4	2.7	-0.5	0.623	-6.9	4.2
Co-mingled (fortnightly) bring glass	-1.5	3.4	-0.4	0.656	-8.3	5.3
Co-mingled (weekly)	5.4	3.0	1.8	0.086	-0.8	11.5
Textiles at kerbside	3.1	1.8	1.8	0.085	-0.5	6.7
PTT at kerbside	2.5	1.4	1.9	0.070	-0.2	5.3

6.3 Appendix C –UK UA (n=104) – statistical model outputs

6.3.1 ANOVA table – Recycling Rate

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	4650.1	17	273.5	10.5	0.000
Constant	10816.8	1	10816.8	414.3	0.000
Dry Scheme Type	198.8	5	39.8	1.5	0.191
Food Waste Collection	1086.3	2	543.1	20.8	0.000
Garden Waste Collection	115.9	2	57.9	2.2	0.115
Collecting PTT at kerbside	81.5	1	81.5	3.1	0.081
Collecting Textiles at kerbside	6.4	1	6.4	.2	0.623
Nation	771.6	3	257.2	9.9	0.000
Effective Weekly Residual Containment Capacity	265.3	1	265.3	10.2	0.002
Deprivation	223.0	1	223.0	8.5	0.004
Rural nature	292.7	1	292.7	11.2	0.001
Error	2245.1	86	26.1		
Total	202680.3	104			
Corrected Total	6895.2	103			

6.3.2 Parameter Estimates – Recycling Rate

					95% Confidence Interval	
Parameter	B	Std. Error	t	Sig.	Lower Bound	Upper Boun d
Constant	43.4	2.7	16.2	0.000	38.1	48.7
Deprivation	-0.3	0.1	-2.9	0.004	-0.5	-0.1
Rural nature	0.10	0.0	3.3	0.001	0.0	0.2
Northern Ireland	-11.7	2.3	-5.0	0.000	-16.3	-7.0
Scotland	0.0	1.8	0.0	0.995	-3.6	3.6
Wales	0.0	2.3	0.0	0.992	-4.5	4.5
1 litre increase in effective weekly residual containment capacity	-0.04	0.01	-3.2	0.002	-0.1	0.0
Separate food	8.8	1.8	4.8	0.000	5.2	12.4
Mixed food and garden	8.2	1.6	5.2	0.000	5.1	11.4
No garden collection	-1.1	2.1	-0.5	0.589	-5.3	3.1
Subscription garden collection	-3.6	1.7	-2.1	0.040	-7.0	-0.2
Co-mingled (fortnightly)	1.8	2.0	0.9	0.371	-2.2	5.8
Two-stream (fortnightly)	-1.8	2.2	-0.8	0.415	-6.1	2.6
Multi-stream (fortnightly)	-3.0	2.1	-1.4	0.155	-7.1	1.1
Co-mingled (fortnightly) bring glass	0.1	2.3	0.0	0.979	-4.5	4.6
Co-mingled (weekly)	-0.2	2.6	-0.1	0.945	-5.4	5.0
Textiles at kerbside	0.7	1.4	0.5	0.623	-2.1	3.5
PTT at kerbside	2.1	1.2	1.8	0.081	-0.3	4.4

6.3.3 Parameter Estimates – Dry Yield

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	247.5	19.4	12.8	0.000	209.0	286.0
Deprivation	-2.2	0.7	-3.0	0.003	-3.6	-0.7
Rural nature	0.7	0.2	3.3	0.001	0.3	1.2
Northern Ireland	-37.3	16.8	-2.2	0.029	-70.6	-4.0
Scotland	-5.2	13.2	-0.4	0.696	-31.3	21.0
Wales	0.2	16.4	0.0	0.990	-32.5	32.9
1 litre increase in effective weekly residual containment capacity	-0.22	0.09	-2.5	0.015	-0.4	0.0
Separate food	30.2	13.2	2.3	0.024	4.0	56.5
Mixed food and garden	14.0	11.5	1.2	0.227	-8.9	36.8
No garden collection	-6.1	15.3	-0.4	0.693	-36.4	24.3
Subscription garden collection	-0.9	12.4	-0.1	0.945	-25.5	23.8
Co-mingled (fortnightly)	15.1	14.5	1.0	0.302	-13.8	43.9
Two-stream (fortnightly)	5.6	15.8	0.4	0.724	-25.8	37.0
Multi-stream (fortnightly)	-7.9	15.0	-0.5	0.598	-37.7	21.9
Co-mingled (fortnightly) bring glass	7.2	16.5	0.4	0.664	-25.5	39.9
Co-mingled (weekly)	6.2	18.9	0.3	0.744	-31.4	43.9
Textiles at kerbside	-2.9	10.2	-0.3	0.774	-23.3	17.4
PTT at kerbside	5.0	8.4	0.6	0.557	-11.8	21.8

6.3.4 Parameter Estimates – Organic Yield

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	235.6	25.0	9.4	0.000	185.8	285.3
Deprivation	-4.7	0.9	-5.0	0.000	-6.5	-2.8
Rural nature	0.9	0.3	3.2	0.002	0.3	1.5
Northern Ireland	-14.3	21.7	-0.7	0.511	-57.4	28.8
Scotland	-31.1	17.0	-1.8	0.071	-64.9	2.7
Wales	-5.5	21.2	-0.3	0.795	-47.7	36.7
1 litre increase in effective weekly residual containment capacity	-0.13	0.12	-1.1	0.275	-0.4	0.1
Separate food	55.2	17.0	3.2	0.002	21.4	89.1
Mixed food and garden	66.3	14.8	4.5	0.000	36.8	95.8
No garden collection	-90.4	19.7	-4.6	0.000	-129.6	-51.2
Subscription garden collection	-68.1	16.0	-4.2	0.000	-99.9	-36.2
Co-mingled (fortnightly)	-4.8	18.7	-0.3	0.799	-42.0	32.5
Two-stream (fortnightly)	-27.7	20.4	-1.4	0.179	-68.3	12.9
Multi-stream (fortnightly)	-19.4	19.4	-1.0	0.318	-57.9	19.1
Co-mingled (fortnightly) bring	-13.8	21.3	-0.6	0.519	-56.0	28.5

glass						
Co-mingled (weekly)	-31.6	24.5	-1.3	0.200	-80.3	17.0
Textiles at kerbside	-9.7	13.2	-0.7	0.465	-36.0	16.5
PTT at kerbside	2.5	10.9	0.2	0.817	-19.2	24.2

6.3.5 Parameter Estimates – Residual Yield

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	554.4	26.5	20.9	0.000	501.7	607.0
Deprivation	1.7	1.0	1.7	0.095	-0.3	3.6
Rural nature	0.1	0.3	0.4	0.685	-0.5	0.7
Northern Ireland	178.6	22.9	7.8	0.000	133.1	224.2
Scotland	59.9	18.0	3.3	0.001	24.2	95.7
Wales	-0.2	22.5	0.0	0.993	-44.8	44.4
1 litre increase in effective weekly residual containment capacity	0.53	0.12	4.3	0.000	0.3	0.8
Separate food	-90.2	18.0	-5.0	0.000	-126.1	-54.4
Mixed food and garden	-66.4	15.7	-4.2	0.000	-97.6	-35.2
No garden collection	-0.8	20.8	0.0	0.970	-42.2	40.7
Subscription garden collection	-2.4	17.0	-0.1	0.886	-36.1	31.3
Co-mingled (fortnightly)	3.1	19.8	0.2	0.875	-36.3	42.5
Two-stream (fortnightly)	11.3	21.6	0.5	0.603	-31.7	54.2
Multi-stream (fortnightly)	23.8	20.5	1.2	0.248	-16.9	64.5
Co-mingled (fortnightly) bring glass	-3.5	22.5	-0.2	0.876	-48.2	41.2
Co-mingled (weekly)	30.4	25.9	1.2	0.244	-21.1	81.8
Textiles at kerbside	19.7	14.0	1.4	0.161	-8.0	47.5
PTT at kerbside	-20.4	11.5	-1.8	0.080	-43.4	2.5

6.3.6 Parameter Estimates – Total Waste Arisings Yield

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	1037.4	42.8	24.2	0.000	952.4	1122.5
Deprivation	-5.2	1.6	-3.3	0.002	-8.4	-2.0
Rural nature	1.8	0.5	3.6	0.000	0.8	2.8
Northern Ireland	127.0	37.0	3.4	0.001	53.4	200.6
Scotland	23.7	29.1	0.8	0.417	-34.1	81.4
Wales	-5.5	36.3	-0.2	0.879	-77.7	66.6
1 litre increase in effective weekly residual containment capacity	0.17	0.20	0.9	0.384	-0.2	0.6
Separate food	-4.8	29.1	-0.2	0.870	-62.7	53.1
Mixed food and garden	13.9	25.4	0.5	0.585	-36.5	64.3
No garden collection	-97.2	33.7	-2.9	0.005	-164.2	-30.2
Subscription garden collection	-71.4	27.4	-2.6	0.011	-125.8	-16.9
Co-mingled (fortnightly)	13.4	32.0	0.4	0.677	-50.3	77.0
Two-stream (fortnightly)	-10.8	34.9	-0.3	0.757	-80.2	58.5
Multi-stream (fortnightly)	-3.6	33.1	-0.1	0.915	-69.4	62.2
Co-mingled (fortnightly) bring glass	-10.1	36.3	-0.3	0.781	-82.3	62.1
Co-mingled (weekly)	5.0	41.8	0.1	0.906	-78.2	88.1
Textiles at kerbside	7.1	22.6	0.3	0.754	-37.8	52.0
PTT at kerbside	-12.9	18.6	-0.7	0.491	-50.0	24.2

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