Best Practice Guidance for Kerbside Recycling In Lancashire through Scientific Case Study Analyses

Peter Tucker & David Speirs

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University of Paisley, Environmental Technology Group, Paisley, PA1 2BE, Scotland
Tel: +44 (0)141 848 3205 / 3229
Fax: +44 (0)141 848 3209 / 3204
e-mail: tuck-ch0@paisley.ac.uk

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EXECUTIVE SUMMARY

Optimising and sustaining household recycling performance at County level demands an understanding of the local factors affecting all constituent neighbourhoods. Spatial and temporal variations in performance can be considerable. Research has shown that differences in demographics or attitudes may only provide a partial explanation for the observed variations, and that demographic influences may also be weakening over time. Contextual factors such as recycling programme design, peer pressure, and local experiences can also impact on a recycling scheme's success. In addition, education and promotion are thought to be very important. The research sought to quantify how each of these factors can affect recycling performance, and to draw that information together to provide guidance for best practice.

In this research, the kerbside yield of newspapers and magazines was taken as the key recycling performance indicator for the analyses Those yields were analysed throughout the Lancashire districts, across the North West of England, and nationally as well. The analyses investigated: (i) the spatial and temporal variations between districts, and (ii) variations amongst individual kerbside collection rounds within districts. The study also sought parallels with the findings of previous research, and illustrated some key points with documented case studies.

The most important programme design parameter was found to be the type of recycling container supplied, with rigid recycling containers (e.g. boxes and bins) statistically outperforming bags and 'no containment' schemes. Also, multi-material collections tended to outperform paper-only collections, in their paper yields as well as their overall yields. The design parameter with the weakest effect was the frequency of collection. Simply providing multi-material collections by box, however, does not guarantee success. Some multi-material box schemes perform badly. Conversely, some paper-only bag collections can perform exceptionally well.

Much of the research focused on investigating the socio-demographic associations of recycled paper yield. The research found continuing evidence that those districts and rounds containing the greater proportions of the traditional recycling classes did tend to recycle greater quantities of paper. The proportions of detached households, car ownership, and retired residents normally correlated positively yield whereas the proportion of flats (especially converted flats), private sector rentals and younger adults normally correlated negatively with yield. However no one model was found to apply to all districts, and no individual demographic variable was found to be equally significant within every district.

The research also provided evidence, in some districts at least, that those demographic differentials may be disappearing. In one district, the most rapidly improving collection round were found amongst rounds containing high proportions of flats, public sector rentals, single tenancies, with low car ownership levels, whereas some rounds with high concentrations of owner occupied, detached and semi-detached housing showed a deterioration in paper yield over the same period.

There was a reasonable degree of consistency in the seasonal fluctuations in paper yield amongst districts, though there was less coherences at collection round level. Forward projections from previous years seasonal and annual growth trends provided quite accurate forecasts for the following year. Past behaviour remains one of the best predictors of future behaviour.

Best practice is essentially about (i) making recycling convenient, and (ii) stimulating it to become the social norm. However, it is also about understanding why people behave differently, why collection rounds behave differently and why those local differentials can change with time. Each part of the district may require a different solution.

Simply making recycling more convenient can boost recycling performances, though it is not just a case of 'giving people a kerbside option' or 'giving them a bin rather than a bag'. The attendant publicity, promotion and education will play a crucial factor as well. Promotion and education can be considered to be a necessary, but not sufficient, condition for success. As yet, there is no evidence that campaigning on its own will lead to significant, substantial, and sustainable behavioural changes. The best success stories revolve around authorities making planned changes in programme design, and backing up those changes with the intensive promotional and educational activities. Effectively, that times the message delivery to the point when those messages are most salient to the individuals' own lifestyles.

1. INTRODUCTION

1.1 Rationale

Many researchers have undertaken surveys of people's attitudes and barriers to recycling, and many others have studied how socio-demographic factors might link with recycling. Whilst such studies provide some indications on what the antecedents of recycling may be, there is still much controversy and uncertainty about those factors. Previous research, at best, has only been able to account for 50-75% of the observed behavioural variations in any surveyed group, and it has been far less successful in explaining differences between groups or between municipalities. We still need to develop a better understanding of the why such differences can occur. Effectively, we are asking the question "how much of the observed spatial variations in recycling performance can ever be predicted?", or by implication "how much of the observed variations must be considered irrational" Gaining this understanding can only be achieved through analysing large data sets from many municipalities. This represents a major step change from the much more restricted analyses normally undertaken in recycling research. However, the necessary large-scale research cannot be addressed (realistically) by running out bigger and more extensive surveys or through undertaking more extensive household monitoring. The costs would be prohibitive. The analyses must be based on data that is relatively cheap to obtain. That data already exists in the form of the round-by-round tonnages that are recovered from kerbside collections. A comprehensive analysis of those data should provide an invaluable source of case study information from which inferences about best practice and the bases of recycling behaviour may be drawn As far as we are aware, cross authority analyses of this nature have never been attempted in the UK.

The emphasis of the proposed study is to undertake rigorous statistical analyses of available kerbside recycling data to provide statistical evidence of those features that work well, and on how performances may be tempered by local demographics. The statistical methods used include:

1. Significance testing of recycling performances amongst population sub-sets having different recycling provision. Here we may ask questions such as "do boxes give better yields than bags?" and so on.
2. Regression analysis of the possible antecedent factors for recycling against observed performances. Here we are concerned primarily with identifying demographic dependencies.
3. Analysis of residuals. This is essentially part of the regression analysis. The aim is to investigate potential reasons why some observations do not fit the regression model.
4. Time series analyses to determine the temporal evolution and stability of observed spatial variations. Such analyses would look at behavioural coherence across communities to investigate whether there could be some kind of pervasive 'global' factor involved. The analyses would also identify any events of significant and rapid behavioural change.

However, that statistical study is not being undertaken in isolation. It has been set firmly in the context of previous research and is guided by the conclusions that have been drawn from that research. A number of case study examples are also included, as those studies provide evidence of what is actually being achieved in practice.

1.2. Objectives and Data Considerations

The aim of the study is to delineate and quantify the major factors that may significantly affect local recycling performances. The study is centred on Lancashire, though it draws additional data and best practice examples from other parts of the country as well.

At the local level, the major project objectives were:

(i) To collate kerbside weight recovery data for 150-200 collection rounds spanning 10 or more Lancashire districts;
(ii) To fit demographic models to those data to determine how much variation is predictable by demographic factors;
(iii) To analyse the variations within districts and between districts to identify additional explanatory factors (e.g. different scheme management practices);
(iv) To undertake time series analyses of the data to identify coherent features and episodes of significant behavioural change, and to diagnose possible causes for such features.

The major deliverables of the research would be:

- A quantification of the programme design variables that generate the best recycling performance;
- A report on best practice amongst authorities;
- Identification of local areas of poorer or better than expected performance and an explanation why;
- Guidance on methods to improve performances and on the timing of interventions to sustain performances.

In the outturn, only 6 of the 14 Lancashire authorities were able to supply data in a form suitable for the detailed round-by-round collection-by-collection analyses, though most could supply aggregated totals across the whole district. Only three of those councils supplied long time series for three years or more. Whilst this did compromise the scope of analyses that could be undertaken, there was nevertheless still sufficient data there for a meaningful study from which valid conclusions could be drawn.

It is noted here that many councils did not always record ‘pure and clean’ data sets:

(i) relating solely to kerbside collection (bring recoveries were subsumed by some councils);
(ii) separately round by round (some councils only had recorded Borough-wide totals);
(iii) uniquely round by round (sometimes weighbridge tickets did not coincide with round beginning or round ends, or records were assigned to the day following rather than the actual day of collection);
(iv) some data were missing;
(v) there were occasional uncertainties in the reported numbers of houses serviced.

The analyses that were undertaken could only be based on the data received.

Finally, it was noted that actual practices amongst the Lancashire authorities did not show as much diversity as is seen nationally. Restricting the research solely to the bounds of

Lancashire, therefore, would not provide sufficient statistical samples for the analysis of many important programme design variables. To provide the necessary diversity, some of the analyses were extended to cover: (a) the whole of the North West region, and (b) nationwide respectively.

2. SUMMARY OF PREVIOUS RESEARCH INTO THE BEHAVIOURAL FACTORS INFLUENCING HOUSEHOLD WASTE RECYCLING PARTICIPATION AND CAPTURE

2.1 Introduction

The information presented in this section has been distilled from the previous research of the University of Paisley. It provides a summary of the major factors thought to influence recycling performance, with the emphasis on the kerbside collections of dry recyclables. The research can be viewed in greater detail in the technical monographs *Understanding Recycling Behaviour* (Tucker, 2001) and *Understanding Home Composting Behaviour* (Tucker and Speirs, 2001) and in other published papers from the University of Paisley.

There are five prime factors that can affect recycling performances within the community[1]:

1. Level of system provision/ programme design;
2. Information, education, and promotion;
3. Demographic factors;
4. Past experiences and history;
5. Other factors.

It should be noted, however, that these factors are not completely independent, and that information and education (in particular) cut across all categories. Past experience and history can include several sub-factors, the most important of which are: (i) Poor service from the operators, (ii) Ambient levels of local social influence (norms), and (iii) Previous informational messages. Social norms can become strengthened in specific local geographies (e.g. cul-de-sacs versus main roads, closeness to schools etc.) or in areas of strong community identity. 'Other factors' comprise all the factors that we can not explain at present, and perhaps will never explain. They can be thought of as providing an inherent randomness to household behaviours.

Establishing best practice essentially means providing the best value to the community in terms of system provision, education and promotion given its local demographics, and given its recycling history. The solution for one borough may not turn out to be the best solution for another. However, there may be key features within those solutions that act commonly towards an overall good practice. The remainder of this section summarises specific facets of recycling provision and recycling promotion that are thought to promote the highest recycling performances.

[1] It must be noted that these factors do not directly cause behaviours. They are simply proxy or surrogate variables for the antecedent attitudes.

2.2 Level of System Provision/ Programme Design

Good programme design is normally synonymous with providing the most convenient recycling infrastructure for the householder, subject to the cost constraints of the provider. Convenience is considered to be the major factor for achieving high levels of participation. Many variables must be addressed when designing a household recycling programme. These bear not only on the effectiveness of the programme (in diverting waste from landfill) but also on its cost. Previous research has highlighted the following design variables as being potentially important:

1. Programme type (mandatory or voluntary);
2. Specific materials collected and number of materials collected;
3. Number of separations required;
4. For a co-mingled collection – separate collection versus co-collection with residuals;
5. Same day collection as residuals or separate day;
6. Collection frequency;
7. Provision of a free container;
8. Type of container (one-trip bag, multi-trip bag, box or bin);
9. Container size;
10. Collection vehicle type;
11. Education programme (provided or not provided, and if provided, type of programme);
12. Economic incentives (fees, fines, rewards, etc.).

In general, research has been quite equivocal as to whether each or any of these factors is actually significant to programme success. Mandatory schemes tend to produce higher levels of participation than do voluntary schemes, however the best voluntary schemes still match the performances of the best mandatory schemes. Increasing the number of materials collected tends to provide higher participations, so a multi-material collection will generally stimulate higher levels of participation than a paper-only collection. However, if more separations are demanded of the householder (i.e. more separate containers) then there is some evidence that participation and recovery levels will drop. This is considered to be due to:(i) greater inconvenience (or higher personal cost), and (ii) increased storage demands.

The specific materials collected can also be important. Generally paper (newspaper, pamphlets and magazines) will always be included in a kerbside collection. Recovery rates of available newspapers from recyclers are generally high. Schemes which also collect glass are also looking successful, with high recoveries of glass also being achieved. Recoveries of the ‘minor’ materials: cans, foil, plastic bottles, film, and textiles tend to be lower than those for paper and glass. Possible explanations are that: (i) when small quantities are generated there can be a perception that “there is not enough to make recycling worthwhile”, or (ii) when space in the kerbside container is at a premium the bulky, light items are the most vulnerable to being left out, or (iii) hygiene, safety or distaste considerations mitigate against those items being prepared (i.e. cleaned out) for recycling, or (iv) there may be some ignorance that such materials can be recycled. Surveys also show that almost nobody recycles materials such as cans or plastic bottles if they do not recycle their newspaper or glass. A strategy that is proving successful in some districts to establish a good recycling ethos by starting off collecting a limited number of materials (e.g. paper only), then piggy-backing other materials onto the scheme. More types of materials being collected together can covey a message of greater seriousness about recycling per se. Perhaps, as important, any change in collection

regime provides a natural point for deploying re-enforcing education and awareness raising, at a time when residents may be at their most susceptible to taking heed of those messages.

There is also some evidence, though somewhat equivocal, that same day collection of recyclables with the residual waste may increase participation, though often no effect is found. However, recent research is now showing that reducing the size of the residual waste container, or its frequency of emptying can stimulate significant recovery increases in the recycling stream.

Generally, the more frequent the collection, the higher the material capture and participation achieved. Too long between collections increases the possibilities of information loss and decreases the chance of habit formation. Research has shown that changing established paper-only collections from 2-weekly to 4-weekly collections only had marginal impacts on capture and participation, provided that adequate and convenient paper bring sites were also available in the locality. The 'lower' convenience of the kerbside scheme switched more recyclers to bring recycling [or to dual use] rather than switching them off from recycling altogether. Collection frequency, however, must also be considered alongside collection container size and type, as the effects are inter-related..

Normally, the provision of a free container produces higher participation levels compared with making householders pay for their recycling container. Ideally optimally-run schemes should aim at householders 'nearly' filling the provided recycling container during one collection period. Too large a container can inhibit some low waste producers from recycling - enforcing the perception that "they do not have enough waste to make recycling worthwhile". Here, the container size can convey a perception of the expectations of the collector in terms of waste quantities required. Not every low waste producer will save and accumulate their waste until they have a respectable quantity to set out for recycling. Concerns about long term storage (e.g. linked to smells, hygiene, tidiness, storage space considerations, and so on) can provoke a "get it out the door as fast as possible" attitude.

Too small a container will lead to some households filling it completely and having additional waste as well. Some households may take that excess to a drop-off site for recycling. Others may simply commit it to the dustbin. The minor components of a multi-material collection are particularly vulnerable to loss in this way – e.g. aluminium cans and especially plastic drinks and milk bottles as they are so bulky.

The gross weight of the filled container is important. Box or bag collections of co-mingled paper, glass, cans and textiles can be 10 – 12 kg or more for high waste producers on a fortnightly collection. This can lead to handling problems. Providing two containers, one for the paper and one for the other dry recyclables can solve this and may be essential anyway for alleviating concerns about recovered paper quality issues (ref.: European Standard EN643). If the standard is followed then co-mingled paper with other recyclables will not be acceptable for reprocessing into new paper. Higher weights produced and/or less frequent collections could utilise wheeled bins for the dry recyclate but paper may still need to be kept separate from the other materials (necessitating split bins?). Too large a container or too many containers also raise storage issues.

Box collections may benefit from allowing householders a choice of container size to suit their needs. Bag collections can issue single or multiple bags on demand. In general, participation and recovery increases through the hierarchy: Own bag (e.g. old carrier bag)-

>Plastic sack->Rigid box/ bin. Specific issues also raised in boxed collections are whether to provide a lid or not. Some research is showing that significantly higher recoveries may be achieved with lidded boxes compared with unlidded boxes. Major considerations are that the lidded boxes are weatherproof and may be stored outside (alleviating in-house storage constraints). Unlidded boxes are more vulnerable to rain infiltration which may lead to rejections of some collected loads. However, this must be balanced by the greater operational burden in emptying lidded boxes, and the potential issues of the lids 'blowing away'.

Whilst analyses demonstrate on average that there could be positive benefits associated with specific scheme variables, very different responses can be achieved in different localities. Research in the US (see section 4.1) is showing that good-performances do not depend uniquely on any programme design variable, except perhaps for container provision. Put another way, no programme design variable is identified as a necessary condition for programme success.

2.3 Education and Promotion

There is relatively little well-documented information on the quantitative effects that various information and promotional campaigns actually have on recycling behaviours. Generally, most past campaigns have not been monitored adequately, if they have been monitored at all. Also, any monitoring undertaken was rarely extended into the longer term in order to assess the sustainability of the induced performances.

Intervention strategies comprise both antecedent strategies and consequent strategies. The major antecedent strategies used to try to stimulate recycling are prompting, commitment, goal-setting, normative influence, and the removal of barriers. The consequent strategies used have included feedback, reward, and punishment. An important part of most of these strategies is the message delivery medium used, and this needs to be considered in detail alongside the strategy itself. The potential and limitations of each type of strategy are now considered in turn.

Reward: The general outcome of providing economic incentives, such as lottery tickets or vouchers, as rewards for specific recycling behaviours were that (i) people's behaviours were normally enhanced during the intervention, but (ii) those enhancements were seldom maintained once the incentives were withdrawn.

Commitment: Both written and verbal commitments, normally elicited as pledges to recycle, were generally found to have positive effects on recycling behaviours. There was also some evidence that those enhanced behaviours might be sustained into the longer-term, i.e. when the participant was no longer bound by the terms of their pledge. Few interventions of this nature have been undertaken in the UK. The University of Paisley tried it in the Borough of Fylde without success.

Prompting: These include verbal or written persuasive messages. Impact can depend on the credibility of the source – association with a well-known environmentalist or personality can help. Council endorsement can emphasise the authority of the message though some residents can react against Councils' prompts. Prompts can utilise the fear factor but if they do, they also need to prescribe specific actions to be successful. Negative messages or messages that emphasise personal relevance tend to work best. For most effect, prompting

needs to be repeated regularly, and results can depend critically on the message delivery medium. It is also important to tailor the message to the audience, i.e. to segment the market.

It is generally found that the most effective delivery strategies are those which achieve a high contact with the population but are of low cost to the system provider. Personal contacts generally provide the highest success rates overall but could be very cost-intensive. Press articles (if they are read) can be effective through publicising a norm that would make others more likely to participate. Government educational campaigns via the media can be successful but tend only to produce small increases in recycling behaviour (in US studies – we await the analyses of the recent UK campaigns). Generally, more educated people are most likely to be influenced by newspaper coverage, whilst TV advertisements may be the best medium to reach those not specifically looking for recycling information. Leaflets and billboard advertising are contentious media for promoting pro-environmental information. They could be perceived by some as environmental blights, and incongruous with the message being conveyed.

Feedback and Goal Setting: As with promotions, it has been found that feedback works best if repeated over extended periods. This can become expensive. To be successful, it needs to demonstrate a relevant and tangible connection to the individual's behaviour. Goal setting is often linked to feedback. It works best for charity collections where the saliency of the goal is easily understood. Group identity can be important for success.

Normative Influence: Normative influence interventions are a special case of local promoting using indigenous, committed individuals (e.g. block leaders). Effects can be highly dependent on local social factors, the visibility of scheme, and on how high participation rates were originally. As far as we are aware, such interventions have not been tried in the UK.

Whilst research has indicated that most reported interventions have had at least some success in increasing recycling behaviour, the effects have generally been quite modest and their durability has been questionable. The weight of evidence shows that a combination of strategies might be more successful than the use of a single strategy alone. Different strategies may achieve very different results in different localities and across different cultures, though the personal touch appears fairly ubiquitous to any success.

Apart from lack of monitoring, another major problem that has hindered successful campaign development in the past is lack of adequate market research. Many campaigns have been based on the perceptions of the designer rather than on any identified needs of the recipient. Increased use of focus groups is now beginning to address this problem. Letting the focus groups design the interventions for their peers looks promising.

Research is showing that four classes of educational material may be needed to cover most educational needs:

1. Addressing general pro-recycling attitudes
2. Specific [procedural] information and awareness
3. Addressing perceived consumer effectiveness – that every little bit of material is important and that every individual's action counts (This is covered broadly by 'Are you doing your bit' but needs to be reinforced locally specifically for the perception that recycling is not worthwhile unless you have a lot of waste).

4. Actions that may involve more effort or personal cost to the recycler. These include addressing forgetfulness (often rooted in having a busy lifestyle), stimulating any extra effort needed to properly prepare materials for recycling – e.g. washing and squashing tins, what to do on experiencing personal difficulty or encountering problems with system provision, organisation of household storage etc.

We are not yet able to unequivocally say what specific pro-recycling 'attitudes' need to be tackled, though drawing on the small amount of research that exists, it would appear that the following factors may be most important to address:

- acceptance of personal responsibility
- negative perceptions

Also important may be:

- conveying the saliency of the issue to the individual – i.e. can it be linked to some local aspiration such as saving local landfill space
- raising an awareness of the consequences of action or non-action
- instilling a 'locus of control'. That is the individual must feel comfortable that he/she has the ability to perform the action satisfactorily and that the action is carried through to the desired outcome by all other individuals downstream in the recycling chain.

Addressing general environmental awareness would not appear to be particularly relevant to stimulating specific environmental actions such as recycling. Addressing economic benefits or disbenefits could also be of little relevance to most people as they may be driven more by altruistic motivations.

It is also becoming apparent that fundamentally different messages may be needed for addressing different pro-environmental waste management behaviours. Reduce/reuse behaviours may have fundamentally different roots than recycling behaviours, and composting behaviours may have different roots to both.

Timing and frequency of campaigns can be important. The effects of most promotions will decay with time (which could be extremely rapidly with reward-based promotions). There is little research on the longevity of effects of other types of promotion, though indications are that significant decays in effect may occur within 6 months. Repeat or reinforcing messages may need to be deployed at intervals shorter than this [at least initially] to sustain levels of increased behaviour. Once behaviour becomes more habitual, reinforcing interventions will not need to be as frequent. However, evidence shows that it may take some time before stable new behaviours become internalised.

Finally, it must be borne in mind that scheduling of interventions should generally follow or be concurrent with the provision of the necessary recycling infrastructure, i.e. you need to have a product before you can market it. Promotions should not raise expectations without being able to deliver.

2.4 Demographic Factors

Recycling Participation:

In general studies have found that older, better-off and more educated people are the most likely to recycle. Ethnic differences have also been noted with non-white ethic groups tending to participate less than whites. Residents of small detached and semi-detached housing have been identified as those most likely to recycle. Larger detached households in addition to those from poorer housing tend to perform less well. Those living in a single-family dwelling are generally found to be more likely to recycle than those from multi-household dwellings. Mixed findings are reported for household size, tenure or owner occupation. The presence of young children in the household appears to have a negative correlation with recycling. This has been put down to households being too busy when the children are young. Busyness of lifestyle is generally found to correlate negatively recycling activity. However, for most demographic factors, most identified relationships vary significantly amongst different studies. Also, different factors may be associated with the recycling of different materials.

Overall, the strengths of the relationships between socio-demographic factors and recycling behaviour are weak. It is now considered that any differences that existed in the past may have been eroded with time. Now that recycling and environmental concern has become more diffused throughout the community, demographic differences in recycling behaviour are progressively disappearing. Also, as recycling levels increase, statistically more new recruits must come from the less traditional recycling sectors.

Research into demographic factors, however, has tended to concentrate on small samples of the population in restricted localities. Limited studies across larger samples (whole cities) ten years ago in the US, showed that cities' household size, tenure, household income and occupational status profiles were not significantly correlated with any aspect of recycling behaviour. That is, at city scale, demographic characteristics may be relatively unimportant in explaining recycling success.

Waste Arisings:

The above discussion refers to recycling participations and captures rather than recycling yields. Demographic factors could independently affect the yields if there are differences in material consumptions amongst different demographic factions. The argument is that those sharing a given demographics may be likely to share similar lifestyles and purchasing habits as well. However, there is little published data to quantify any such dependencies. Limited inferences can be drawn from the various historical data compiled under the National Household waste analysis Programme, and independent market research, e.g. under Project Integra in Hampshire, and University of Paisley research. However data is quite fragmentary and generalisations are probably not yet possible. Newspaper yields are better understood than most materials, with better yields normally emanating from the higher socio-economic groups. This tends to reflect the relative amounts of broadsheets and tabloids taken rather than any differences in numbers of newspapers read.

2.5 Past Experience and History

Past experience and history tend to act on individual behaviours. The effects can be both positive and negative. Negative effects on performance levels are essentially the aggregated result of all the catastrophic and other adverse events that affect individual households. Common problems affecting kerbside collections are:

- News or observation that contributed material is not actually being recycled
- Poor service provision (This includes missed kerbside pick-ups, non-return of recycling containers, non-advertised changes in kerbside collection timings, etc.)
- Not having a recycling container, e.g. new residents moving in
- Insufficiency or loss of information (e.g. of the day of collection of less frequent schemes, procedural information on how to participate and what to participate with)
- Design of recycling container – bags or box lids blowing away, container too heavy etc.

Generally, attitude surveys tend to find that around half the problems are either related to information deficiency or are container-related. Regular calendaring and procedural information reminders are important, also the provision of an information pack to new residents could be worthwhile. Getting the container right at the outset is also important. The container is the prime interface between the household and the scheme and many householders tends to polarise their thoughts around that container. More flexibility in container choice could be important.

Also, the service personnel picking up at kerbside or supervising ca sites are effectively ambassadors of the recycling scheme. Getting the right personnel that interface well with the public, answer questions, give advice and help etc. can be very beneficial in alleviating any developing problems.

Spotting the onset of any developing problems can be difficult in practice. Normal temporal fluctuations in monitored performance can easily mask the outcomes of individual problems. Continuing effects may only be identified when longer-term statistical analyses are carried out on those performances, and then it may already be too late to apply the necessary corrective measures. Nevertheless regular performance monitoring is essential, at collection round level for kerbside schemes as performances and problems often tend to be localised and will not be diagnosed unless the monitoring is undertaken at that resolution.

Positive enhancements to recycling levels may act primarily through local normative influences, though pervasive background messages (e.g. from television campaigns) may also contribute – though this is not yet proven or quantified. Normative influences can act through social dialogue or remotely through visual stimuli if the visibility of the behaviour is high, as it is with kerbside schemes. It is considered that once a certain number of residents in a locality are setting out their recyclables at kerbside, others will be stimulated to do so also. This is often most noticeable in cul-de-sacs.

By and large, however, recycling behaviours are quite stable. A recycler will generally continue to recycle into the future whilst a non-recycler will not recycle, even through periods of applied impetus for behavioural change. Several psychological studies that attempted to determine the antecedents of recycling behaviour have found that past behaviour can be the dominant, and sometimes sole predictor of current recycling behaviour. It is often

found to have much more influence than any attitudinal or demographic factor. Put simply this implies that recycling may be dominated mainly by habit.

In practical terms, this means that many campaigns will inevitably fail to stimulate any significant behavioural change. On the other hand, going through bad experiences may not switch off recycling behaviour per se, unless that experience is perceived to be of catastrophic proportions (e.g. that learning the council is sending all the collected recyclables to landfill). For lesser irritations, the committed recyclers may simply adapt their behaviours to cope, provided it is practicable for them to do so. They may, for example, turn to their local bring-schemes when they experience problems with their kerbside collection. Kerbside collections will always be more convenient than bring systems (for most people) though some would consider bring sites to be more convenient for their own particular circumstances. A crucial point, however, is that you can not dispense of bring collections even if the kerbside scheme is operating well. Bring site back-up is essential in mopping up recoveries when the kerbside collection has problems or is not practical.

3. CASE STUDIES

3.1 Introduction

The preceding section illustrated some of the research results into the determinants of recycling behaviour. In theory, by knowing which specific factors support the higher recycling performances, one should then be able assemble a recycling scheme to provide the best practice. However, many of the research data on which such ideas could be founded, were derived from quite limited experimentation, based on fairly small samples. Their general applicability remains quite poorly tested. Complementary information must now be derived from looking at specific schemes (with their ready-built assemblages of design variables) to see how well they live up to expectations and to see how well they support the hypotheses of the smaller-scale research.

This section now looks at a limited number of UK case studies. Most are drawn from published sources. It is particularly noticeable here that few comparative studies have been published, with the few that do only providing fairly superficial analyses in their comparisons.

It should be noted that the studies presented here do not necessarily represent ‘Best Practice’, though they do try to illustrate key points. It should also be borne in mind that most in-depth data on schemes are collected during their initial pilot stages. Those pilots may have been ‘cherry-picked’ and nurtured, so reported performances do not necessarily translate to achievable borough-wide performances.

3.2 Millennium Recycling Scheme: Pilot in Bradford

Reference: Barton, J., Perrin, D., Barton, J. *The Millennium Recycling Scheme*. University of Leeds, 2001

This was a rather artificial experiment to establish whether high participations and high diversions could be achieved by a scheme that had been made as simple and as convenient as possible. Elsewhere in Bradford a kerbside collection of paper, card, plastics and cans, run as an opt-in scheme using 240 litre wheeled bins was only achieving 30% household participation. The Millennium scheme was designed as an opt out scheme using a 140 litre wheeled bin to collect all recyclables (including plastic containers and glass bottles). The residents were not told specifically what recyclables were allowed, though were specifically prompted that food and garden waste were not wanted. A sack was provided along with the bin for interim storage.

The pilot trial covered just 143 households, comprising bungalows, detached and semi-detached housing of 'mature established home owners' (All Acorn D group 9 type 26). Twelve weeks into the 6-month trial, feedback was provided giving information on recovery performance and clarification of what could go in the bin.

Set out rates averaged around 70-80% with the overall participation rate being around 90%. Around 5 kg/household/week recyclables were collected, rising to around 6.3 kg/household/week after the feedback was given. Diversion rates were 37% (before), 44% after. The feed back had a relatively small but positive effect on the paper and glass recoveries (rising from 74% to 79%, and 69% to 73% respectively) but increased card recoveries from 54% to 73%, plastics from 22% to 41%, and metals from 29% to 48%. Part of these changes may have been induced by the feedback message: "I don't have to be clean to be in the recycling scheme"

The total paper and glass in the combined recyclate and residuals increased across the scheme introduction, perhaps suggesting that some of the capture of those materials was due to a transfer away from bring outlets. Total newspaper and pams arising before scheme introduction were 2.17 Kg/household/week compared to 3.31 Kg/household/week after (around 2.53 Kg being recycled). So by inference, up to 45% of the Millennium newspaper and pams recyclate may have been transferred away from the bring sites. Alternatively the low recorded arisings prior to the introduction may simply have been an artefact of people saving their material in anticipation of the scheme.

Contamination levels in the recyclate were around 4% by weight, made up of 2% putrescibles and 2% composites.

Perrin and Barton (2001) compared the Millennium recycling scheme with the 'Paper Chain' scheme running in Leeds The paper chain scheme introduced kerbside recycling to 20,000 households in two suburban areas. It collected newspapers and pams in a reusable plastic sack on a fortnightly basis. At the start of the scheme, residents had been given an information leaflet and instructions were also printed on the sack. For this research, the scheme was monitored for a six month period in 1999.

The Paper Chain scheme only achieved 59% recovery (1.24 Kg/hh/w) compared with the 83% diversion of newspapers and pams (2.5 Kg/hh/w) in the Millennium scheme, and the scheme only attracted 49% of residents to participate compared to the 90% participating in the Millennium scheme. Ninety eight percent of residents of both schemes had expressed the positive intention to use their offered scheme when asked prior to scheme commencement.

Those recycling (through bring sites) prior to scheme commencement expressed similar reasons for doing so in both schemes (table 3.1). Similarly the reasons expressed by non-recyclers for not recycling were also comparable between the schemes (table 3.2).

Table 3.1. Reasons for Recycling

	Paper Chain n=183	Millennium n=48
Good facilities	50.3%	58.3%
Saves waste/landfill space	59.6%	52.1%
Saves dustbin space	42.1%	33.3%
For environment/future generations	73.2%	81.3%
Personal satisfaction/habit	51.4%	52.1%
Peer pressure/duty	7.7%	6.3%

Source: Perrin and Barton (2001)

Table 3.2. Reasons for Not Recycling

	Paper Chain n=79	Millennium n=14
Inconvenience/ time	50.0%	64.3%
Effort	16.3%	7.1%
Facilities too far/ inadequate	28.8%	28.6%
Lack of information	48.8%	42.9%
Storage/handling problems	35.0%	50.0%
Never thought about it	22.5%	7.1%
Not enough to recycle	21.3%	14.3%
Other	8.8%	0.0%

Source: Perrin and Barton (2001)

Perrin and Barton drew attention to those reasons also being similar to the reasons found in several other surveys as well. They argued that the behavioural differences between the Paper Chain and Millennium schemes may have little to do with attitudes, and may be more connected with the differences in programme design. They also noted that fewer of those served by the Paper Chain scheme claimed to recycle their glass and cans after the paper collection was introduced. The implication was that there was a drop off in bring site usage for all materials, not just paper.

The expressed reasons for recycling did not change significantly as a result of the introduction of either kerbside scheme, though the numbers citing peer pressure or duty decreased in both areas after the scheme introductions, despite 72.4% of residents admitting that they noticed their neighbours' behaviours.

Whilst the Millennium Recycling Scheme did demonstrate that high participations and high diversions could be achieved in practice, the exercise was artificial in that some of the collected materials had no local market (e.g. plastic containers, no-bottle glass). However the researchers did demonstrate that MRF recovery would be feasible on the Millennium scheme recyclate and that acceptable picking rates could be achieved.

3.3 Milton Keynes

Reference: Thomas (2001)

Milton Keynes operates a twin box kerbside collection throughout its area of 80,000 households, on an opt-in basis. Around 75% of properties have requested recycling boxes. Current participation rates are unknown but are likely to be a little less than the self-reported rate of 71% returned in a 1995 survey. The scheme targets a high potential diversion rate by targeting a large number of different materials for recycling, though it only achieves a low recovery rate, and a capture rate of 52%. Low capture with relatively high participation points to residents having a relatively poor understanding on what and how to recycle.

In 1995, twenty-two items were listed as acceptable for recycling through the scheme, and 12 items were listed as not being acceptable. Pre-1994 just 5 items were listed as acceptable and 4 as not acceptable. Not surprisingly, when questioned nobody was able to accurately recall the later list although some 61% correctly identified the full range of items on the previous list. Nearly 95% of respondents correctly identified newspapers are being wanted, with around 90% correctly identifying plastic bottles, cans, glass bottles and magazines. Plastic cartons, trays and foil were less well recalled and under 20% considered that textiles, shoes and handbags were also wanted. Less than 40% of respondents correctly knew that margarine tubs, drinking glasses and envelopes were not wanted.

In 1995, the scheme achieved a diversion rate of 17.5%. In 1993, when it was collecting fewer materials, the diversion rate was 19%.

Thomas (2001) also undertook a parallel study of public understanding across 11 kerbside schemes in Hampshire. The results showed no strong difference between level of understanding and recycling container type, though it appeared that the grasp of requirements was generally high in districts using twin wheeled bins but less so in districts providing no recycling container. There were no significant differences between weekly and fortnightly collection regimes and no correspondence between levels of understanding and social class. However, the numbers of participants correctly identifying what could be recycled were higher (80%) in schemes providing information on what materials were acceptable than in schemes where information was not provided (~60%).

3.4 Wealden

Reference: Woodard et al. (2001).

Wealden had previously operated a kerbside recycling scheme based on a weekly 55 litre box collection of paper categories (newspapers, pams and white directories) and metals (food and drink cans and clean foil) with the residual waste collected via wheeled bins. In 1998, a pilot programme ‘CROWN’ was commenced across 1000 Wealden households in which an additional green waste bin was introduced and the two bins collected on alternate weeks. CROWN stands for Compost and Recycle Our Waste Now. The scheme was extended in 1999 to cover a further 4300 households and there are plans for further expansions. The council implemented a carefully planned publicity and information campaign before, during and after each implementation.

Two hundred and forty seven households serviced by the second phase of the CROWN scheme were monitored for participation and for the approximate levels of recyclate set out. They represented a mix of 45% better off retirement areas (Acorn K37), 45% modern family housing (B7) and high status non family areas (I30). A detailed waste compositional analysis was carried out on a smaller sub-set of 32 households, 3 weeks prior and 5 weeks after the introduction.

Prior to the introductions, the residual waste arising of the 32 households averaged 18.1 Kg/household/week. After the introduction this had fallen to 8.2 Kg/hh/w, which represented a 55% reduction. The volume of dry recyclate produced increased from 5.5 litres per household (0.5 Kg/hh/w) to 17.5 litres (1.5 Kg/hh/w). Paper diversion increased from 0.44 Kg/hh/w to 1.02 Kg/hh/w and the diversion of metals from 0.1 Kg/hh/w to 0.46 Kg/hh/w. The percentage increases in both categories were higher than the increase in scheme participation (40% to 78%) suggesting that the capture from participating households also increased. Contamination levels increased marginally from 0.0 Kg/hh/w to 0.02 Kg/hh/w.

The amount of garden waste in the residuals decreased from 5.8 Kg/hh/w to 0.1 Kg/hh/w and other putrescibles from 3.4 to 2.0 Kg/hh/w. However it must be borne in mind that the prior analysis was conducted in September and the after analysis was conducted in November so seasonal effects may have contributed to those figures.

It is also noted that total waste recovered at kerbside (recyclate plus residuals plus organics) decreased by 1.3 Kg/hh/w across the introduction. Whether this was a seasonal effect, a real decrease in waste consumption, or a knock-on effect stimulating more bring recycling is unclear.

The sustainability of the CROWN recoveries was investigated for the year following the 1998 trial of 1000 households. Woodard et al. (2001) argue that enhanced recyclate recoveries have continued over the year though inspection of their charted data indicates that there may have been a drop from around 7.5 tonnes/month to around 5.0 tonnes/month over the year.

3.5 Babergh

Reference: Waste Research Ltd., AEA Technology. (2001).

In 2000, Babergh introduced a pink sack (survival bag) for dry recyclables. The borough was already operating a wheeled bin collection for refuse. The new scheme collected newspapers, pamphlets and magazines, other paper and card, plastic bags and plastic film, steel and aluminium cans, plastic bottles and plastic containers. The pink sacks were collected on the same day as the residuals, the sacks being placed out next to the wheeled bin. Sacks were transported co-mingled with the refuse and later recovered at the MRF by hand picking.

Babergh is generally more affluent that the UK average (36% acorn A, 20% B, 1% C, 42% D, 22% E, 5% F compared with 20% A, 12% B, 8% C, 24% D, 14% E, 22% F – see Appendix A for a key to Acorn profiles). Two separate neighbourhoods were sampled in August and November respectively, a very affluent neighbourhood in November (92% Acorn A+B) and a less affluent neighbourhood (though still more affluent than the UK average) in August.

Set out rates for both samples were comparable at 68-69%. The weights of recyclate recovered were 1.8 Kg/household per week (August) and 2.4 Kg/household/week (November) from a total arisings (recyclate +residual) of 24.0 and 21.6 Kg per household respectively. It was noted that the lower recovery in August may be due to the samples for analysis being recovered at the MRF in August (where there would be possible losses from split and unrecovered bags) whereas the samples were diverted directly from the kerbside in November. The overall scheme diversion ranged from 8% to 11%.

The recovery of newspapers and pams was 0.81 Kg/household per week (August) and 1.5 Kg/household/week (November) which equated to 26% and 50% recoveries respectively. Recoveries of other materials were much lower: Cans (8-15%), plastic film (4%), dense plastic (19%), and other paper (15%). It was considered that the higher newspaper recoveries in November were attributable to the higher socio-economic profile of the sample, though it must also be noted that the total arisings of news and pams were very similar across the two samples (3.08 and 3.02 Kg/hh/w), so if there was a demographic dependence is was in recovery rather than consumption.

Contaminants made up around 4.2 and 5.9% of the recyclate, split roughly evenly between textiles, glass and other materials.

3.6 Eastleigh

Reference: Waste Research Ltd., AEA Technology. (2001).

The scheme at Eastleigh was based on twin 140 litre wheeled bins for dry recyclables and residual refuse (though larger families could opt for 240 litre bins). Bins were collected on alternate weeks at kerbside. . The dry recyclables collected were newspapers, pamphlets and magazines, other paper, steel and aluminium cans, plastic bottles and plastic containers.

Like Babergh, Eastleigh is generally more affluent that the UK average (22% acorn A, 38% B, 2% C, 26% D, 7% E, 5% F – see Appendix A for key). Two separate neighbourhoods were sampled in September and April respectively, a very affluent neighbourhood in September (84% Acorn A+B) and a less affluent neighbourhood in April.

Set out rates were comparable and very high across the two samples (94% and 95% respectively). The weights of recyclate recovered were 5.4 Kg/household per week (September) and 4.5 Kg/household/week (April). The diversion rates for the two sampled areas were 36% and 31% which were comparable with the borough wide scheme performance of 30%.

The recovery of newspapers and pams was 3.3 Kg/household per week (September) and 2.7 Kg/household/week (April) which equated to 79% and 82% recoveries respectively. Recoveries of other materials were lower: Cans (80% and 45%), and plastic (75% and 63%). There was much higher arisings of paper in the samples than the national average and much lower levels of glass and putrescibles in the residuals than nationally. It was conjectured that this might imply a high local use of bottle banks and composting.

Contamination of the recyclate was relatively high at 6.1% (September) and 8.5% (April). Glass and textiles only formed a relatively minor part of this contrary material.

3.7 Kerbside Glass Recovery

Reference: WRAP (2002).

Authorities who now operated kerbside glass collections were found to have doubled their yield of glass recyclate (on average) since 1993 compared with a more modest 1.5 times increase (on average) from authorities not collecting glass at kerbside. The study considered five of those schemes in more detail. Together those schemes serviced 230,000 households and yielded 6663 tonnes of glass per annum (0.56 Kg/household/week) with 2480 further tonnes recovered via bottle banks (not including ca sites).

Cotswold collected glass through a fortnightly 44 litre box scheme collecting mixed dry recyclables. It was an opt-out scheme which was widely publicised amongst the residents. 35,000 households were serviced by the scheme. 95% of collections were on the same day as the normal refuse collection. Materials were separated at the vehicle by the collection staff. Participation rates were unknown. Yields were 0.66 Kg/hh/w (glass), 1.34 Kg/hh/w (paper) and 0.06 Kg/hh/w (cans).

Lambeth collected glass through a weekly co-collection of glass, paper, cans and textiles in a 55 litre box. Again the scheme was widely publicised at the start, backed up by quarterly newsletters and reminder cards. 74,000 households were served. Yields were 0.51 Kg/hh/w (glass), 1.07 Kg/hh/w (paper) and 0.03 Kg/hh/w (cans).

An anonymous district collected their glass together with cans in a 55 litre unlidded box, the collection was weekly (due to residents concerns over longer-term storage) but not necessarily on the same day as the refuse collection. It was noted that theft of boxes was considered to be a problem and also that box lids were available separately at a small cost. Paper and textiles were collected alongside in a separate bag. with 37,500 households being served. Participation in the scheme was estimated to be 65%. Yields were 0.54 Kg/hh/w (glass), 0.99 Kg/hh/w (paper) and 0.04 Kg/hh/w (cans).

Another anonymous district collected glass along with other dry recyclables in 35 litre baskets, collected the same day as the refuse. The collection staff carried out a kerbside sort. Advertising and public awareness were thought to be very important to the scheme where 58,247 households were served. Participation in the scheme was reckoned to be 55% (1997 figures) in both the urban and rural areas of the district. Yields were 0.46 Kg/hh/w (glass), 0.93 Kg/hh/w (paper) and 0.04 Kg/hh/w (cans).

Finally, Durham collected glass along with other dry recyclables in 55 litre boxes supplied without lids, though additional boxes or smaller 35 litre boxes were available on request. The boxes were collected the same day as the refuse and the collection staff carried out a kerbside sort. 25,000 households were served. Set out rates for the scheme were 70% and 80% in the urban and rural areas respectively. Yields were 0.8 Kg/hh/w (glass), 1.56 Kg/hh/w (paper) and 0.06 Kg/hh/w (cans).

3.8 Hertsmere

Reference: Clamp (2000)

Herstmere Borough contains 38,000 dwellings, 33,000 of which are serviced by a kerbside collection of paper. Flats are excluded. The paper categories collected are newspaper, pamphlets, magazines, catalogues, directories and white paper. Collections started in 1996 through a plastic sack collection. Recoveries were then around 95 tonnes per month (0.66 Kg/household per week) but have risen to 139 tonnes per month (0.97 Kg/hh/w) on average in 2000. Based on a waste audit under taken in 1998, 6700 tonnes of paper per annum (3.90 Kg/hh/w) are available for recycling, so there is a 25% diversion rate. Another 8% diversion is achieved via the borough's bring sites.

A trial in Potters bar started in September 1999 in which the collection bags were replaced by boxes. The trial area covered 3027 households. 1445 households were issued boxes with lids and 1647 were issued boxes without lids. The boxes were split between 53 and 35 litre capacities distributed randomly across both areas. The new scheme was promoted through a flier backed up by press articles.

The set out rate for the trial areas rose from 29% (before) to 50% (after) in the area with lids, and from 28% (before) to 40% (after) in the area without lids. Overall yields rose from just over 1.0 Kg/hh/w to 1.65 Kg/hh/w showing a 61% increase on introducing the scheme. Substantially higher yields were achieved from the lidded boxes than from the unlidded boxes (2.46 versus 1.25 Kg/hh/w) however this may not all be attributable to the lids. The unlidded trial area also contained greater proportions of local authority housing than did the lidded area, and greater proportions of the smaller boxes were distributed in the unlidded area. No investigations of the effect of box size were made.

A questionnaire survey administered 5 months into the new scheme explored the reasons why the new recruits had been stimulated to join the scheme. Those reasons covered a previous lack of awareness, experience of erratic service, poor supply of bags, and bags blowing away. Interestingly those answers implied that the new recruits may have been drawn primarily from drop-outs from the previous bag collection scheme rather than from 'fresh' non-recyclers. It may have simply drawn back those willing to give the scheme another shot now that the scheme had been changed and was perceived to have improved. On the down side, some residents (mainly the elderly) complained that the new boxes were too heavy to handle.

In conclusion, whilst the results might indicate that lidded boxes may yield more material and stimulate higher participations than unlidded boxes which, in turn, attract higher yields than bags, the experimental design was insufficient to deconvolute the effects of container type from possible contributory effects of demographics, box size, and from the associated promotional messages.

The author of the report considered that the reason why lidded boxes were apparently more successful lay in their convenience in as much as they could be stored outside rather than needing inside storage. Also rain infiltration when unlidded boxes are set out can pose problems. However this must be set against the operational considerations that it is easier for the collection staff to empty and return unlidded boxes.

3.9 Kensington and Chelsea

References: Read (1998, 1999).

Kensington and Chelsea has offered kerbside recycling to all residents since 1993. Collections were accomplished using used carrier bags, collected twice a week. Despite extensive promotion of the scheme via the traditional methods of posters, leaflets, and newspaper adverts, many households still claimed to be unaware of the service and did not recall any publicity. A new 'roadshow' approach was adopted in 1996. It aimed to make personal contacts with all residents by talking to those residents at home, delivering persuasive messages and distributing supporting leaflets, badges and stickers.

In the first 18 months, 8% of the borough's 78,600 households were contacted. The interviewers found that some 31% of residents appeared unaware that a kerbside recycling service was offered, and this lack of knowledge was cited by 73% of households as their main reason for non-participation. Across collection rounds, there were clear associations between the level of awareness and the tonnage collected. The tonnages collected post roadshow increased by 19% though there was much variability across rounds (35% down to a negative impact in one round). Figures were based on a four week average. Monitoring was not extended beyond that period. Overall, it was claimed that the roadshow helped to raise the doorstep recycling schemes recycling rate from 9% in April 1995 to over 11% in October 1996, though other factors may have contributed as well.

3.10 Other Schemes

West Lothian moved from a plastic sack collection to a wheeled bin collection for paper in 2001. Three months into the scheme plastic bottles and carriers, card and food and drink cans were also added to the list of accepted items. A third wheeled bin was additionally provided for green waste. The pilot scheme covered 7200 houses. Recoveries in the first year of the pilot scheme averaged 1.97 Kg/hh/w (mixed paper and card), 0.13 Kg/hh/w (mixed plastics) and 0.03 Kg/hh/w (mixed cans). Before figures for the pilot area were not available, but as a comparison the 59,000 households still on the sack collection for paper only recovered an average of 0.54 Kg/hh/w over the same period. Green waste recoveries in the new scheme averaged 2.98 Kg/hh/w. Most of the households in the trial area participated with all 3 bins, though some took just a dry recyclate bin or organic bin rather than both.

West Farnborough introduced a trial scheme in 1999 for a blue bin collection of mixed dry recyclables. Previously the same materials had been collected through a 'bag and hook' method, whereby recycling bags were attached onto hooks on the side of the residual waste wheelie bin. In the trial area of 1172 households, participation increased from 62% to 74% with the introduction of the new scheme, with yields rising from 1.31 kg/hh/w to 2.04 Kg/hh/w. There was noticeably more cans and plastics in the recyclate compared with previously. The bag and hook method had engendered much more selective recycling. The new scheme was also considered to offer the added advantages of more storage, possibility of outside storage, and greater ease in setting out.

In October 2001, the districts of Chesterfield and North East Derbyshire started a progressive programme of moving from a kerbside monthly paper only sack collection to a fortnightly multi-material box collection. The new scheme was designed to collect newspapers and

pams, glass, mixed cans and textiles. The first area to be converted consisted of 5662 households in Chesterfield and a further 5047 in North Derbyshire. Households were asked to continue to put newspaper in to a blue bag while the other materials were collected in a blue box. In Chesterfield this change from a paper only to multi-material scheme (with the associated extra publicity) increased weights collected by around 30%, with an estimated increase in participation from 37% to 53%. Whilst the yields from all pilot areas increased after the change, the relative differentials between the poorer and better yielding areas still appeared to be maintained.

Finally, Smith et al. (1999) studied plastic bottle recycling. They noted a difference in kerbside recovery rates depending on the type of container used for collection. Averaging over a number of schemes diversions ranged from 27% (box), 21% (supplied bag), 20% (wheeled bin) down to 11% (own bag).

4. SPATIAL VARIATIONS IN KERBSIDE RECYCLING PERFORMANCE

4.1 Cross-authority Comparisons

The case studies above relate primarily to single schemes and do not fully set those schemes in the broader context of kerbside collections per se. As such, they can only provide hypotheses rather than explanations of why those schemes are considered to be successful (or otherwise). Relatively few studies have attempted to tackle the broader issue, in any greater depth than producing league tables of authorities' recycling rates.

The DEFRA statistics attempt a classification of recycling rates by Government Office Region, which shows clear differences between the poorer-performing north English regions to those generally performing much better in the south. Parfitt et al. (2001) analysed and compared some alternative classifications. He showed that on the Office for National Statistics classification, there were significant differences between the ONS categories on household waste collected for recycling (based on a reclassification of DETR 1998/99 returns). Parfitt et al. (2001) then went on to undertake a cluster analysis of authorities based on a limited number of programme design variables. The derived classification shown in table 4.2 provided eight clusters, which could be further expanded into urban and rural respectively.

Table 4.1 Kg/household/week (ONS Categories) – Source Parfitt (2001)

Type of authority	Rural	Prosp-erous	Mature	Urban centres	Mining/ Industrial	Inner London
Household waste collected for recycling	2.7	2.9	2.7	2.0	0.9	1.1

Table 4.2 Clusters based on Programme Design Parameters – Source Parfitt (2001)

Residual Waste Containment	Description	Average % households on kerbside schemes	Bring sites per 1000 households
Wheeled bin I	Low bring/ca & kerbside	10.6	0.59
Wheeled bin II	Low bring/ca high kerbside	88.4	0.6
Wheeled bin III	High bring ca & high kerbside	60.3	1.63
No method I	Moderate bring/ca & low kerbside	10.9	0.85
No method II	Moderate bring/ca & high kerbside	84.4	0.74
Plastic sack I	Low bring/ca & low kerbside	13.4	0.84
Plastic sack II	Moderate bring/ca high kerbside	87.1	0.88
Plastic sack III	Very high bring/ca moderate kerbside	57.8	3.25

Residual waste arisings, percentages recycled and civic amenity collected weights were all found to be significantly different across clusters, with averages ranging from <5% recycled (Wheeled bin I, urban), 5-10% (other wheeled bin clusters, no method I, plastic sack I), 10-15% (no method II, plastic sack II and III). Rural authorities in any cluster generally performed better than their urban counterparts. There was however, considerable overlap between clusters, with considerable variation amongst authorities in any given cluster.

The results do show how both residual waste containment and kerbside provision may be important to the total recoveries of recyclate achieved. They do not, however, explicitly consider the different design options for recovering that recyclate. We could not find any published information that such studies had ever been undertaken in the UK, though there were a handful of publications relating to the US.

Folz (1991) analysed 264 recycling schemes across the US in 1989, 109 of which provided voluntary kerbside recycling. Overall, recycling participations (estimated by the municipalities) showed significant correlations with programme type (voluntary versus mandatory) and whether kerbside collections were provided. Statistically significant relationships occurred for several other policies as well. Cities that imposed sanctions (mandatory schemes) or issued reminders (voluntary scheme) were more likely to have higher participations. Establishing a specific goal (diversion target) was also correlated to higher participation. Schemes using private sector contractors to collect the recyclables performed significantly better than those using public services. For voluntary kerbside schemes, the provision of a free container was important, though the effects of same day collection as the refuse and co-mingled versus segregated collections were not significant. The most significant factor, however, was the involvement of citizen participation in the programme design (through citizen surveys and meetings with community groups).

In looking at socio-economic differences amongst municipalities, Folz and Hazlett (1991) showed that per-capita income was positively correlated with kerbside participation but not drop-off participation. Being female, or older, or more educated were correlated with drop-

off participation but not kerbside participation. Other characteristics tested (household size, tenure, household income and occupational status) were not significantly correlated with any aspect of recycling behaviour. Overall, demographic characteristics appeared to be relatively unimportant in explaining recycling success.

Folz carried out a repeat analysis in 1996 (Folz, 1999). Participation and diversion rates in most schemes had increased substantially since 1989 (from 49.8% to 68.8% participation for voluntary kerbside schemes). Amongst voluntary programs, participation gains were highest in cities that had established a near-future recycling goal, in cities that provided free containers, and in cities that had established 'block leaders' (indigenous local champions who reminded or encouraged citizens to recycle). Same-day pick up and separation requirements were not significantly related to participation gains in voluntary schemes, nor were speeches of city officials. Cities with variable fee or volume pricing for residual waste collections did not return significant gains in participation, though they had a much higher mean rate of participation to begin with. It was concluded that such policies, at the very least, had an enduring positive effect on recycling behaviour. Diversion levels rose alongside participation, though it was noted that generally more materials were being targeted.

Another longitudinal study by Feiock and Kalan (2000) looked at changes in diversion rates from 1989 to 1995 for 67 counties in Florida. Programme design variables were not found to be strong predictors of any changes in recycling rates over time. However, county education levels and per-capita income were significantly correlated with the temporal increases in diversion, though levels of support for environmental protection were not.

The above studies considered averages without explicitly considering variances. The results of a separate study by Noehammer and Byer (1997) compiled survey data for 104 kerbside schemes in the US from surveys undertaken between 1987 and 1991, concentrating on the ranges of behaviours. They found that the best performing schemes tended to be comparable in performance, whether they collected weekly or monthly, whether they were based on a single separation or on 3 or more separations, whether they are mandatory or voluntary and so on. However amongst poorer performing schemes, the poorest performances were returned by those with monthly collection, high numbers of separations, and voluntary participation. It follows that there may be key factors other than programme design that will determine a successful scheme. However, for less successful schemes, inappropriate design parameters can further reduce the quality of performance. This hypothesis raises a crucial issue as to what constitutes best practice: "If you are managing a kerbside scheme well, in a population that is sympathetic to the recycling ideal, then it does not matter how you collect the recyclate!, however when circumstances are less good, you can minimise the resultant under-performance through judicious programme design".

4.2 Intra-Authority Comparisons

Most analyses of recycling performance are undertaken at municipality level or at even coarser resolution. Very few published analyses have looked deeper inside the municipalities and at the spatial variations that occur within those municipalities. However those variations can be quite significant. Achieving best practice in a municipality means achieving best practice in all constituent parts of that community, and that involves identifying and understanding neighbourhood differences. For example the promotional roadshow discussed by Read (1998,1999) had a negative effect on the diversions from one neighbourhood, null

effects on two others, but generally larger, positive effects on the rest. However, the reasons for this were not answered.

Tucker (2001) analysed neighbourhood variations in recycling participation at even finer levels: (i) at enumeration district level – around 250 households, and (ii) at the level of individual streets. At street level, simple randomness was found to be a dominant factor, whilst at enumeration district level, more of the variability could be explained in terms of identified differences in 'features' of the individual neighbourhoods. Tucker (2001) carried out a large-scale study of participations in a kerbside paper collection across 20,000 households in Fylde Borough. The study found that demographic factors (housing type and the proportion of retired residents) could explain around 50% of the observed variability, however some 20% of neighbourhoods did not conform at all to this behavioural model. In investigating possible reasons, Tucker found that neighbourhoods with the more heterogeneous mixes of housing types, and those adjacent to particularly high performing areas often performed better than expected. It was hypothesised that such effects could be attributable to strong normative influences. On the other hand, residential households in the urban centres performed worse than expected. Another class of poor performers identified neighbourhoods in which half the area was performing badly whilst the other half performed as expected. It was hypothesised that local incidents of poor service provision could have triggered these polarisations.

5. DISCUSSION AND CONCLUSIONS FROM THE PREVIOUS RESEARCH

The above research has clearly demonstrated the wide variability that can occur in household waste recycling behaviours. Such variabilities occur amongst individual households within the community, amongst whole neighbourhoods within a municipality, and amongst municipalities. Much research has been undertaken to establish the determinants of these behavioural differences, but by and large the results have been equivocal. How well a municipality performs can be influenced by many factors. Basically, individual householders' attitudes form the principal drivers of their behaviour, and collectively for their collective behaviour. For best practice, a kerbside recycling programme must be designed to mesh with those attitudes, and to shape and improve any weaker or more negative attitudes that may be held about the scheme. Unfortunately, we do not yet know the precise attitudes that fundamentally underpin the recycling ethos. We do however know more about the negative factors that are cited for not recycling. Not having a kerbside scheme is a major reason if there is not a kerbside scheme, whilst problems with the kerbside scheme is a major factor if there is. The other major factors are not having enough information or not having enough waste to make it worthwhile.

Most kerbside schemes are intrinsically stable. What they collect and divert next year will not be too different to what they collect and divert this year, unless there is a step change in program design and management, or unless serious incidents occur. The participation levels achieved at scheme start up would appear to be crucial. High levels of public participation or expert consultation at the programme design stage can be important, with awareness raising and education being important at that stage too.
The actual design parameters of the programme may not be too important in a global sense, but may be important locally. Collection by bag or box or bin, weekly or fortnightly, number

of segregations required, day of collection and so on can aid the convenience of using the scheme but appear not to be essential requirements for a well-performing scheme. Good and mediocre performances can occur with all systems. Sufficiency of information may be a more necessary requirement towards achieving good performance, but may not be sufficient on its own to ensure a good performance.

Outside scheme start up, significant positive increases in performance over time appear almost entirely linked to implementing step changes in programme design. That is when an existing kerbside scheme is upgraded, from a paper only to multi-material collection, from a bag collection to a box or bin and so on.

Changing an existing scheme to become 'more convenient' can increase participation through several routes. It is easiest to visualise the possible contributory factors through a concrete example. Let us consider, as that example, the change from a paper-only bag collection to a multi-material collection in a lidded box:

Those previously not using the scheme because they "did not have enough paper" may find that their bottles and cans do now make up reasonable amounts of material that are worthwhile to recycle.
Those previously unaware of the scheme, or of its collection days, or not feeling comfortable that they know how to use the scheme will receive the necessary 'education.'
Those not using the old scheme because of various 'convenience' concerns about the scheme (e.g. those not wanting to store the bag inside, may now see definite advantages in a weatherproof storage box).
Those who had dropped out of the old scheme because of problems and incidents may write off those incidents as history, and be willing to try a fresh new start with the fresh new scheme.
(v) Committed recyclers will simply continue.

Almost universally, such changes are accompanied by attendant publicity, promotion and education campaigns, so it is hard to isolate the direct effects from the physical change from any effects caused by the promotion. Perhaps what is most important is that they occur together.

Even, in the most intensive promotional campaigns applied in the UK, promotions actually achieve very little behavioural change when there is not an accompanying system change. The Kensington and Chelsea experience (section 3.9), for example only realised around 2% increase in recycling rate after 18 months intensive door-to-door campaigning. Anglia region's 'Slim your bin' campaign returned much more dismal results. There may be two main issues here. Firstly, generic campaign messages may do little to reassure the disillusioned that their grievances will be rectified. Secondly, the message may not be received at a time when the issue is salient to the recipient. In that respect, the message needs to be both congruent with the point of action (e.g. received in the household, not [say] at a bus stop) and needs to be provided when waste management is high on the agenda of the recipient. Effectively that is when recycling issues are impacting on normal household routine and habit. Imposing/ offering a new recycling scheme provides that timing and trigger.

Finally, do demographics matter? The answer is probably yes, if they are real proxies for attitudes and lifestyle factors.

6. MULTI-AUTHORITY STUDIES ACROSS ENGLAND AND WALES: PROGRAMME DESIGN VARIABLES

6.1 Introduction

Prior to focussing more closely on Lancashire, it is worthwhile to set Lancashire authorities in the wider context of English and Welsh recycling. The US studies discussed in section 4.1 provided some insights into the relative effects of specific design variables. The first part of the current study extends now such analyses to the UK scene, and explores what guidance may be drawn from statistical analyses of compiled and published UK recycling data. The comparative data at municipality level are compiled annually in the CIPFA publication on Waste Collection and Disposal Statistics. At the time of writing the latest published edition gave the 1999/00 actuals.

The specific performance indicator selected for the comparative study was the weight of kerbside recycled material per household serviced by a kerbside collection. Firstly all recyclate recovered at kerbside is considered, though the bulk of the statistical comparisons undertaken here have concentrated on just the paper and card fractions of that recyclate. The statistics used here are derived from CIPFA (col 123/ col 71) and (col 173/ col 71) ratios respectively. The specific programme variables available from the CIPFA statistics are recycling container type: {sack, one box, multiple boxes, wheeled bin, split wheeled bin, no-container}, collection frequency, and recyclable materials separately identified, or co-mingled. The study looked at the following comparisons:

Total Kerbside Yield

(i) Paper-only vs. Multi-material (separately identified) vs. Multi-material (co-mingled).

Paper and Card Yield Only

(ii) Percentage of borough covered by scheme;
(iii) Weekly (or more frequent) vs. fortnightly (or less frequent) collections;
(iv) Paper only vs. Multi-material;
(v) Bag vs. Box;
(vi) Paper only (bag) vs. Paper only (box) vs. Multi-material (bag) vs. Multi-material (box).

Whilst the CIPFA 1999/00 statistics received returns from over 340 authorities, several of those returns did not operate kerbside collections, or were incomplete in some or all of the relevant columns, or appeared to be potentially inaccurate in the data reported. In the analyses, authorities returning > 6 Kg recyclate/hh/w or <0.1 Kg recyclate/hh/w were considered to be extreme outliers and possibly suspect, and were therefore excluded from the analyses.

It was also noted that very few of the remaining eligible schemes operated wheeled bin dry recyclable collections or offered no containment method for the recyclate. The sample bases for such schemes would be too small for meaningful statistical analyses, and those schemes too were excluded from the analyses.

6.2 Total Kerbside Yield

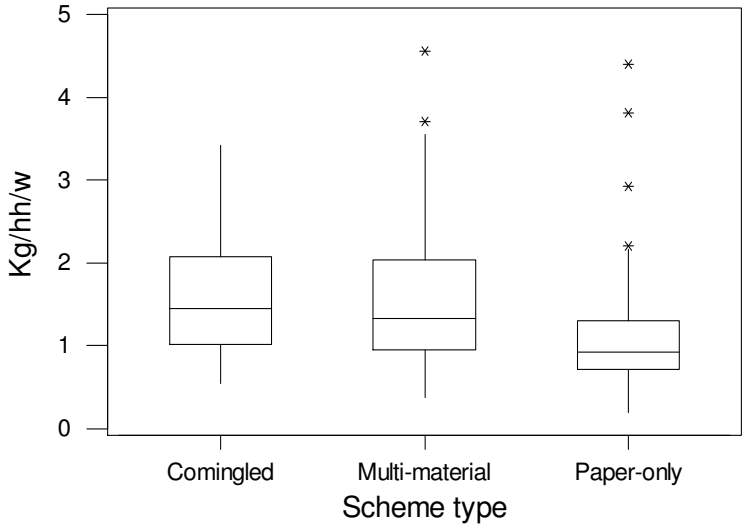
Firstly it is noted that both the paper-only and multi-material data sets were positively skewed, that is the modal value was substantially less than the mean and there was a long tail at the high weight end (figure 6.1). Both data sets were strongly non-normally distributed. The co-mingled weight distribution, whilst also positively skewed, was much closer to being normally distributed. Table 6.1 provides summary descriptive statistics where it can be seen that, as expected, more weight is collected in a multi-material collection than through a paper-only collection, with the most weight being when the multi-materials are co-mingled rather than separately identified.

Table 6.1 Total Kerbside Yield (Kg/hh/w)

	N	Mean	Median	StdDev	Min	Max
Paper only	75	1.11	0.92	0.71	0.18	4.41
Multi-material	85	1.56	1.32	0.83	0.37	4.57
Co-mingled	24	1.67	1.44	0.81	0.54	3.43

However, as per the US studies there were substantial overlap between groups with high and low performing authorities spread across all three groups (figure 6.1). A Mann-Whitney test of the medians showed that paper-only collection yields were significantly lower than multi-material collection yields (at significance level 0.0000), however there was no statistical evidence that co-mingled yields were significantly greater than multi-material yields (significance = 0.2246).

Figure 6.1 Total Kerbside Yield (Kg/hh/w)



Note: The variations in yield are presented in this report in the form of as box and whisker plots. The box delineates the inter-quartile range of the observations, with the horizontal line across the box showing the median value. The whiskers extend out to the lowest and highest observations that are still inside the region defined by the following limits:
Lower Limit: Q1 - 1.5 (Q3 - Q1)
Upper Limit: Q3 + 1.5 (Q3 - Q1) where Q1 and Q3 are the first and third quartiles respectively.
Outlying points beyond those limits are then plotted individually.

6.3 Paper and Card Yields

Not too much more can be drawn from the analyses of total yields, as there is probably too much disparity in the types and ranges of actual materials collected across the multi-material and co-mingled categories for the analyses to be extended meaningfully to any finer detail. A more comparable yield statistic may be given by the paper and card tonnages recovered. As almost every scheme collects paper and card, analysis of that fraction would still retain a large sample base. The 24 co-mingled collections must however be excluded from the analyses as paper and card yields are not separately identified in those statistics. However, it must still be recognised that the ranges of paper and card collected by different schemes can be very different. Nearly all schemes will collect newspapers, pamphlets and magazines (and normally make up the bulk of the recovered weight). Fewer schemes tend to collect other white papers, or card packaging. This needs to be borne in mind when interpreting the data.

Firstly, a test was undertaken to see if the proportion of households in the borough serviced by the scheme was related to scheme performance. The hypothesis was small pilot programmes may behave significantly better than borough-wide schemes. The results are shown in table 6.2 and figure 6.2. These results exclude five extreme outliers (>5 Kg/hh/w) all of which were associated with the low coverage fraction.

The results show that with the exception of any extreme outliers, schemes which service high proportions of a borough can yield just as much paper and card per serviced household as the more selective schemes. The differences in yield between levels of coverage were not significant (Kruskal-Wallace, p=0.144; ANOVA, p=0.182).

Figure 6.2 Paper and Card Yields by Scheme Coverage

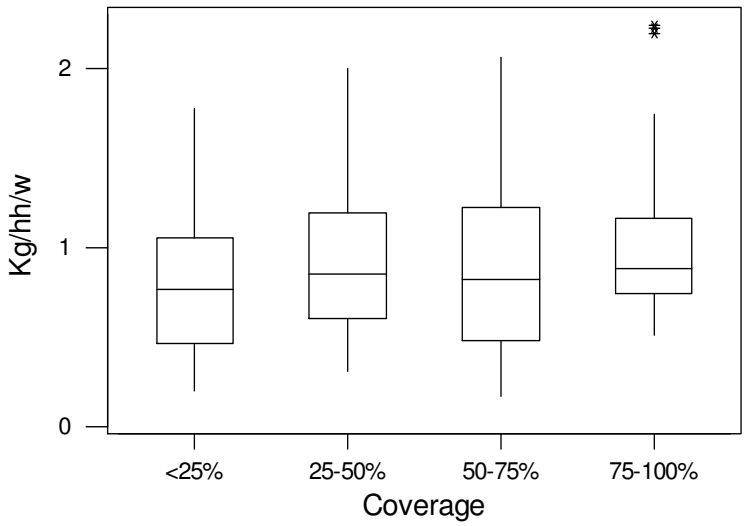


Table 6.2. Weights of Paper and Card Collected According to Scheme Coverage (Kg/hh/w)

Coverage	N	Mean	Median	StDev	Min	Max
0-25%	30	0.80	0.76	0.39	0.20	1.78
26-50%	24	1.00	1.00	0.51	0.17	2.06
51-75%	45	0.99	0.88	0.47	0.21	2.24
76-100%	72	1.12	0.99	0.50	0.39	2.41

The hypothesis that frequency of collection may affect yield was tested in tables 6.3 and 6.4 and figures 6.3 and 6.4. Table 6.3 and figure 6.3 record the results for all schemes whilst table 6.4 and figure 6.4 record the result for multi-material schemes only. Only five of the seventy-nine paper-only collections were carried out on a weekly basis and just three multi-material schemes collected on a monthly basis.

Table 6.3. Weights of Paper and Card Collected according to Collection Frequency –All Schemes (Kg/hh/w)

Frequency	N	Mean	Median	StDev	Min	Max
Weekly	35	1.04	1.10	0.48	0.22	2.41
Fortnightly	120	1.01	0.88	0.50	0.17	2.30
>2 weekly	9	0.85	0.79	0.27	0.51	1.32

Figure 6.3 Paper and Card Yields by Collection Frequency – All Schemes

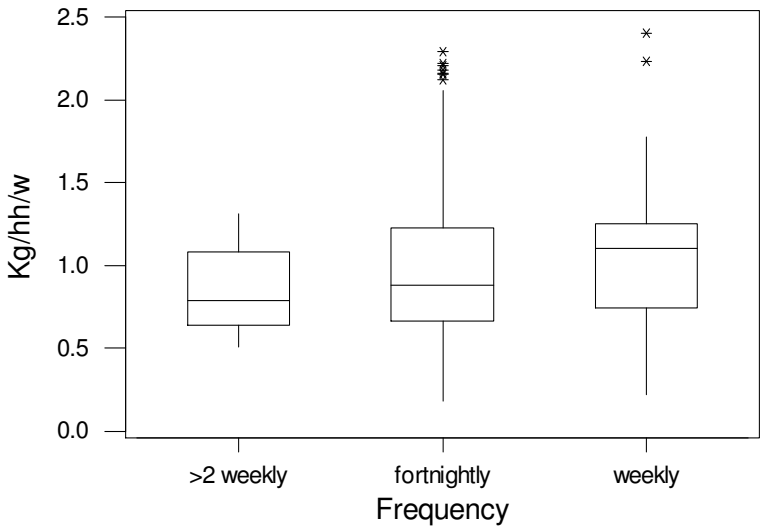
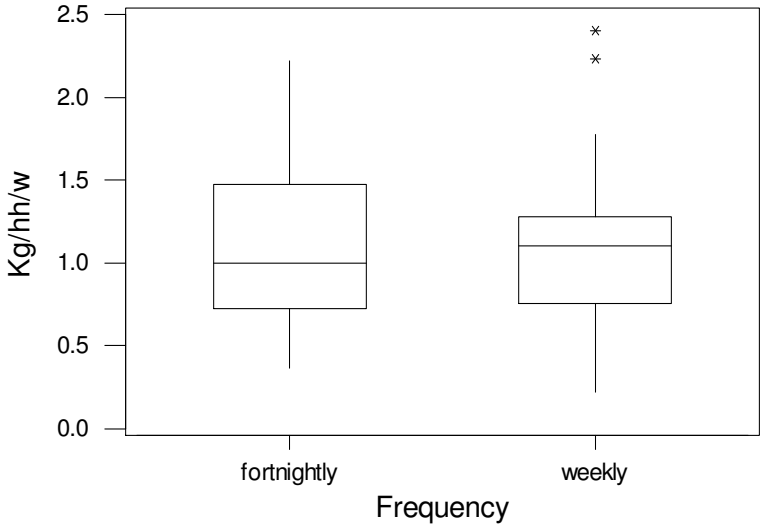


Table 6.4. Weights of paper and Card Collected according to Collection Frequency – Multi-material Schemes only (Kg/hh/w)

Frequency	N	Mean	Median	StDev	Min	Max
Weekly	49	1.06	1.00	0.53	0.36	2.24
Fortnightly	30	1.08	1.10	0.49	0.22	2.41

Figure 6.4 Paper and Card Yields by Collection Frequency – Multi-material Schemes Only



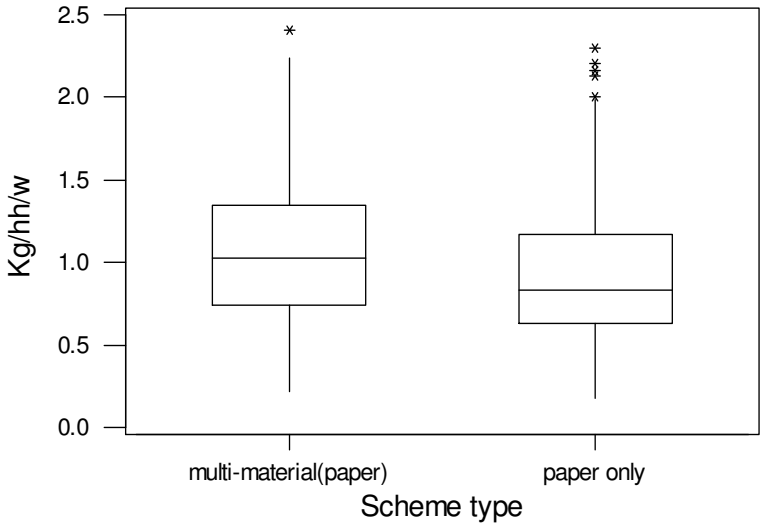
Frequency of collection proved not to be a significant determinant of yield across all the schemes (Kruskal-Wallace, p = 0.499; ANOVA, p = 0.57). Collection frequency was also not a significant predictor for multi-material schemes alone (Mann-Whitney, p = 0.860; t-test, p = 0.819).

Whether the paper was collected on it's own or alongside other materials appeared to have some effect on weights of material collected, with around 15% more paper and card being collected in a multi-material collection than in a paper and card only collection (Table 6.5, figure 6.5). These effects are statistically significant (Mann-Whitney, significance = 0.0483).

Table 6.5. Weights of Paper and Card Collected according to Collection Type (Kg/hh/w)

Scheme	N	Mean	Median	StDev	Min	Max
Paper-only	85	0.95	0.84	0.48	0.17	2.30
Multi-material	80	1.09	1.03	0.51	0.22	2.41

Figure 6.5 Paper and Card Yields by Scheme Type



The type of container used appeared to also affect the weights of paper and card collected. Collection of kerbside recyclables through bins was relatively uncommon in the source data with only four councils using this type of collection container. However the average weight of paper collected through those bins was higher than that for both bag and box collections (Table 6.6).

Table 6.6. Weights of Paper and Card Collected according to Container Type (Kg/hh/w)

Container	N	Mean	Median	StDev	Min	Max
Bag	86	0.91	0.87	0.36	0.17	2.21
Bin	4	1.31	-	-	1.05	1.69
Box	74	1.14	1.01	0.59	0.20	2.41

On average, box collections were yielding some 15-20% more paper and card per household served than were bag collections (Table 6.6, figure 6.6). The effect was found to be statistically significant (Mann-Whitney, p = 0.0306).

Overall, the results therefore show that, in general, higher yields of paper and card will be achieved by kerbside schemes that collect more than just paper and card, and use boxes rather than bags. However there is also a high correlation between these two factors with most multi-material schemes using boxes (65%) and most paper only schemes using bags (73%). Is it possible therefore that only one of these factors is significant. To test this hypothesis we then looked at the four groups separately: i.e. multi & bag, multi & box, paper & bag and paper & box.. Results are shown in table 6.7 and figure 6.7, and significance tests for each pair are shown in tables 6.8 a&b.

Figure 6.6 Paper and Card Yields by Container Type

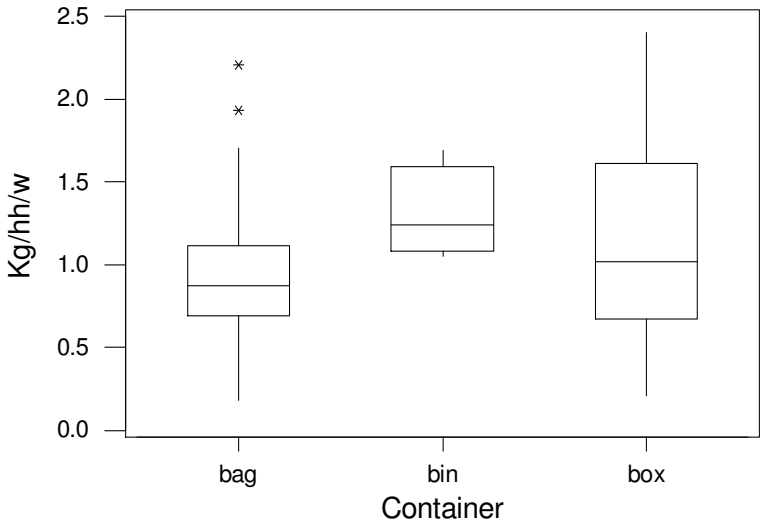


Table 6.7. Weights of Paper and Card Collected according to Scheme (Kg/hh/w)

Scheme	N	Mean	Median	StDev	Min	Max
Multi & bag	28	0.96	0.99	0.32	0.36	1.70
Multi & box	51	1.14	1.06	0.58	0.22	2.41
Paper & bag	58	0.89	0.85	0.38	0.17	2.21
Paper & box	22	1.14	0.89	0.66	0.20	2.30

Table 6.8a Significant differences (Mann-Whitney Test)

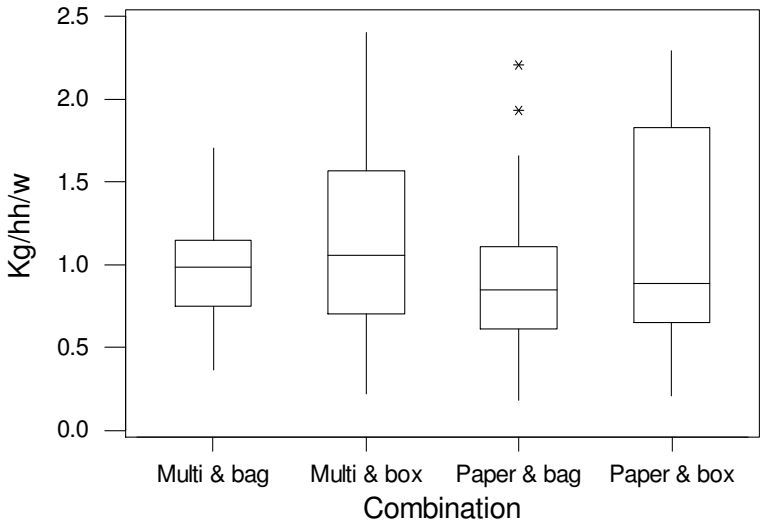
	M & Box	P &Bag	P & Box
M & Bag	0	0	0
M & Box		**	0
P & Bag			0

Table 6.8b. Significant Differences (t-test)

	M & Box	P &Bag	P & Box
M & Bag	*	0	0
M & Box		**	0
P & Bag			0

0 not significant, * significance level 90%, ** significance level 95%

Figure 6.7 Paper and Card Yields by Scheme Combination



Qualitatively, the two box collections would appear to follow similar patterns with relatively high means and large standard deviations. Bag schemes appear to have tighter distributions with lower average weights. It could therefore be hypothesised that the box may be the dominant part of the combination contributing to the highest yields. However, the only consistent significant statistical difference found was between multi-material box schemes and paper-only bag schemes.

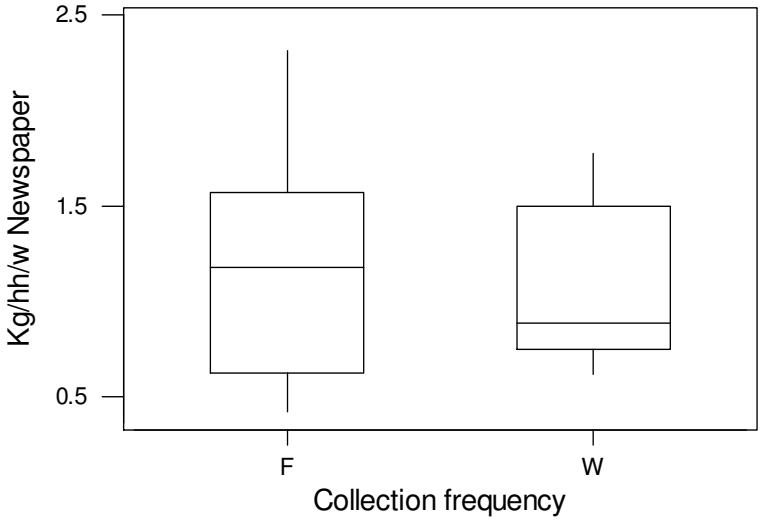
6.4 Conclusions and Further Evidence

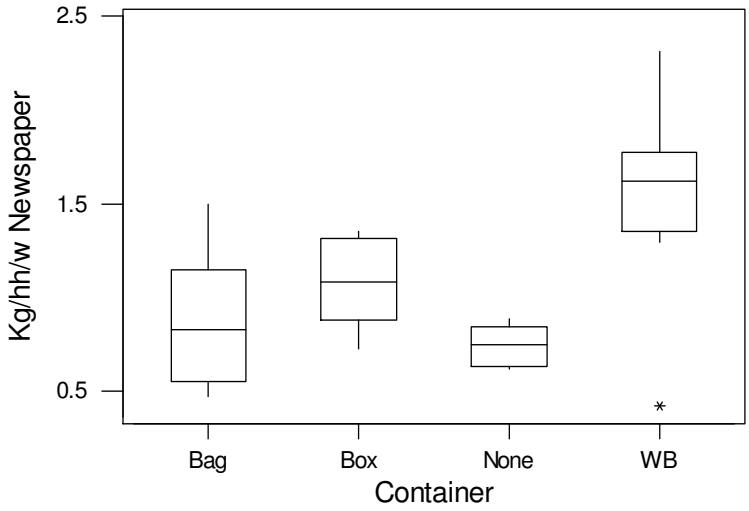
The analyses of published English and Welsh recycling statistics indicate that, on average, kerbside yields of paper and card are higher in (a) schemes that collect other materials alongside that paper and card, and (b) schemes that use collection boxes (or bins) rather than bags or sacks. The average difference in yield may be as much as 20% between multi-material box collections and paper-only bag collections. Collection frequency does not significantly affect the yield.

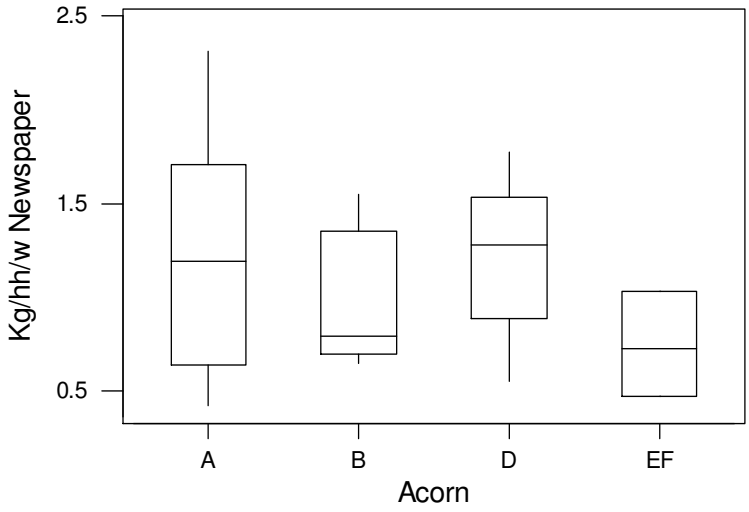
However, there remains a strong caveat to these conclusions. Paper and card yields may also be strongly dependent on the range of papers and cards targeted by individual schemes. By their very nature, multi-material collections may be more likely to target card and mixed paper than would paper-only collections. It could also be that box collections are more likely to take mixed paper and card compared to bag collections.

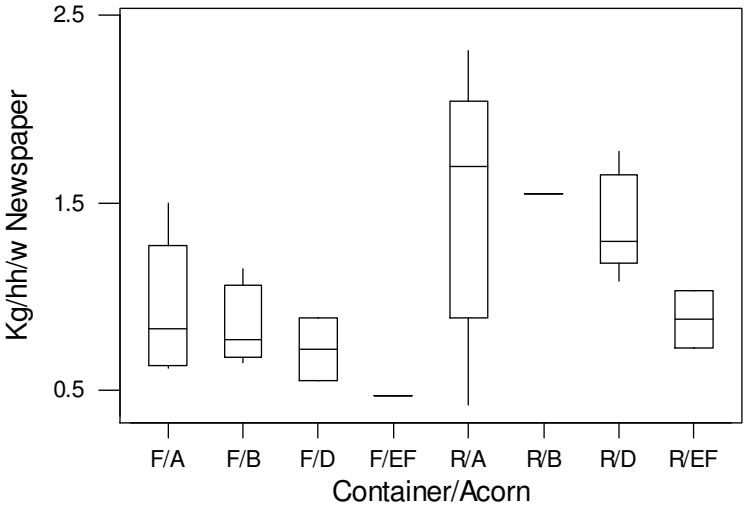
Subsequently, it proved possible to undertake some further analyses using a data set from Hampshire (MEL, 1999). These data were supplied courtesy of Project Integra. The data provided a much more detailed breakdown by material category and, as such, allowed individual paper fractions to be isolated and analysed separately. Results are shown in figures 6.8 a-f for the newspaper fraction alone. Because of the limited number of samples in some categories, formal statistics have not been tabulated. The graphs should be viewed simply as being indicative of possible trends that may be occurring.

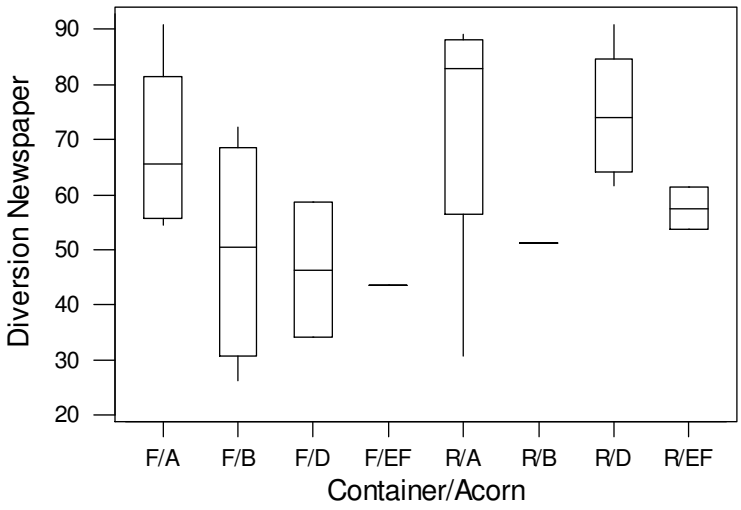
Figure 6.8 a-f. Statistics from Hampshire

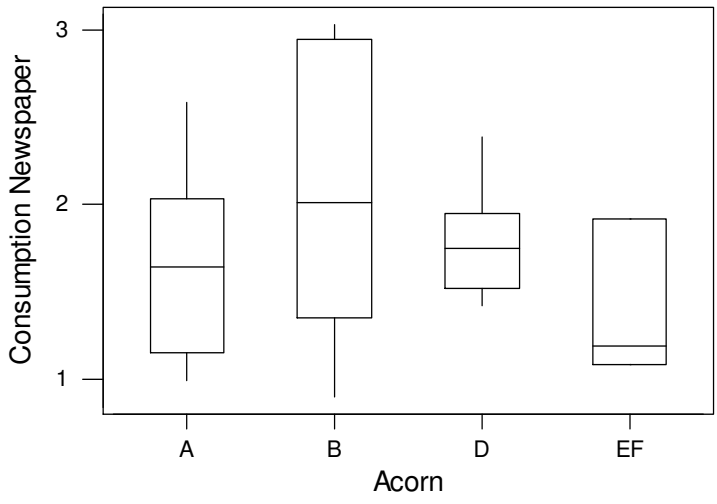







Kg/hh/w Newspaper
2.5
1.5
0.5
F/A
F/B
F/D
F/EF
R/A
R/B
R/D
R/EF
Container/Acorn


Diversion Newspaper
90
80
70
60
50
40
30
20
F/A
F/B
F/D
F/EF
R/A
R/B
R/D
R/EF
Container/Acorn


Consumption Newspaper
3
2
1
A
B
D
EF
Acorn

The results generally follow the same kind of trends that were revealed in the analyses of the CIPFA statistics. No discernible trend was seen for newspaper yield nor for its diversion with respect to collection frequency. Box or bin collections tended to collect more newspaper per household than did the bag collections or collections where no container was supplied. Acorn groups A (principally A1) and D (all D9) gave better yields of newspaper than did groups B and E/F, though it was noted that the majority of B households sampled were in areas operating bag or 'no-container' collections. The expanded breakdown by Acorn/ container combinations showed that container type appeared to be dominant over demographic category in terms of newspaper yield. This trend was less clear in terms of the kerbside diversions, with Acorn A [bags] being comparable with Acorn A [boxes]. As such this implies that the Acorn A households in districts with bag collections may either be lower 'consumers' of newspaper than their counterparts in the districts with box and bin collections, or may be making much more use of bring schemes for their newspaper recycling.

Estimated average consumptions (based on kerbside recyclate + residual, but ignoring bring diversions) were reasonably uniform across demographic groups but with perhaps slightly depressed levels of consumption in the Acorn E/F samples.

From the CIPA and Hampshire analyses together, it can be hypothesised that collection container type appears to be a major factor in determining recycling yields and diversions, whilst collection frequency and possibly demographics may be less important.

7. MULTI-AUTHORITY STUDIES ACROSS NORTH WEST ENGLAND

7.1 Introduction

Although the CIPFA data provide a reasonably large data set, those data do have limitations. The uncertainties in the paper and card compositions have already been mentioned. Also the data is now two years out of data. In order to provide a more up to date analysis based on a 'better-known' paper fraction (i.e. newspapers and pams only), the analysis must be based on information elicited directly from local authorities on their current kerbside practices and yields. However, it was neither practical nor within the project resources to contact all UK authorities in this respect But, because the data set from Lancashire was so small, some extension was deemed necessary in order to facilitate a more meaningful analysis. In this respect, it was decided to focus on the North West region of England (44 authorities) of which Lancashire forms a part. In the outturn, 26 authorities from the North West region who were running kerbside collections responded to our requests.

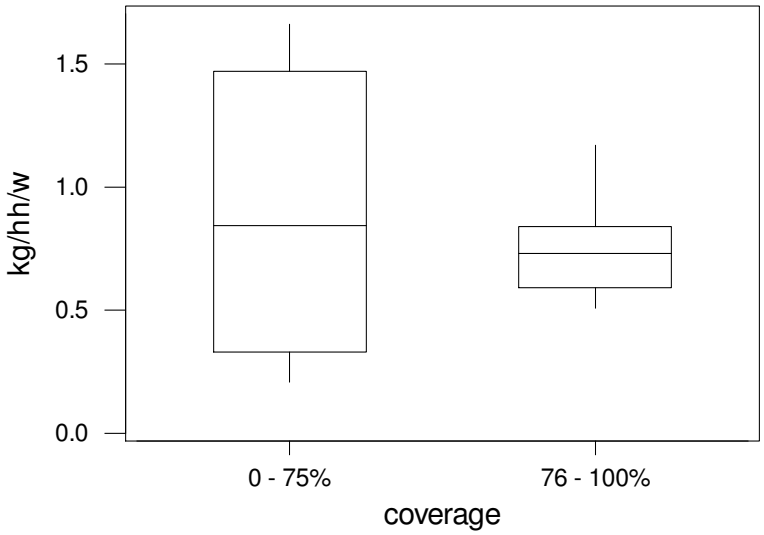
7.2 Programme Design Variables

Firstly, a test was undertaken to see if the proportion of households serviced by the scheme was related to scheme performance. The results show that newspaper and pams yields are not statistically related to coverage (t-test, $p=0.532$), though it is interesting to note that there was much less inter-district variations between districts operating kerbside [nearly] borough-wide than there were between districts operating more selective schemes (table 7.1, figure 7.1).

Table 7.1. Weights of Paper and Card Collected according to Scheme Coverage (Kg/hh/w)

Coverage	N	Mean	Median	StDev	Min	Max
0-75%	8	1.77	1.69	1.19	0.42	3.32
76-100%	18	1.49	1.47	0.36	1.03	2.34

Figure 7.1. Newspaper and PAMS Yield versus Scheme Coverage



Most design differences were impossible to test for within the North West England sample. This was because the schemes being operated there were very similar with all but one being a paper only scheme and only two not being served on a fortnightly basis. However, it was possible to investigate container type. Unlike the results from both the CIPFA and Hampshire analyses, the type of container appeared to have no significant effect for the North West of England sample (table 7.2, figure 7.2, t-test p=0.851). It is also noted, however, that the 16 bag schemes were giving much more consistent yields than the box schemes.

Table 7.2. Weights of Paper and Card Collected according to Container Type (Kg/hh/w)

Container	N	Mean	Median	StDev	Min	Max
Bag	16	0.81	0.77	0.28	0.48	1.54
Box	8	0.84	0.72	0.47	0.30	1.66

Figure 7.2. Newspaper and PAMS Yield versus Container Type

Finally, a correlation was sought between kerbside paper yield and the number of paper bring sites per 1000 population. The regression equation showed a slightly negative correlation (-0.185) but this was not found to be significant (p = 0.462). However there was a strong positive correlation between bring site newspaper and pams yields and bring site density (correlation = 0.829, p= 0.000) showing that bring site yields will be enhanced by higher density collections even when kerbside collections are operating.

7.3 Demographics

With the modest data set for the North West region, it was also possible to analyse inter-district differences against the differences in the demographic profiles of those districts. There are a number of alternative systems available for classifying socio-demographic factors. These basically comprise (i) the proprietary market research indicators such as Acorn and Mosaic, and (ii) raw census data, though it must be remembered that both Acorn and Mosaic are also derived from that same base census data. Effectively Acorn and Mosaic cluster a wide range of census statistics into a relatively small number of categories which can be regarded as providing segmentations according to different 'life-styles' The Acorn and Mosaic classifications are listed in appendix A of this report.

The problem with all three descriptors is that they are now ten years out of date, all being based on 1991 census data. At the time of writing the 2001 census data is not yet published. There has also been debate on whether Acorn and Mosaic are actually good descriptors for accounting for household waste management activities. The argument against is that they are based on multiple factors, many of which appear to be quite unrelated to waste management. However, there is no conclusive evidence whether Acorn is better than Mosaic or better than raw census data or vice versa. Many commercial organisations analysing waste management

statistics have opted for Acorn whilst academics have tended towards using raw census data. That choice may be more about marginal costs than about scientific bases.

In the current study, our choice was also determined by cost. Census statistics are freely available to universities for research purposes, and those statistics are available down to enumeration district resolutions (around 250 households). Mosaic data was also freely available, but only down to postcode sector level. Limited Acorn data at district-wide level was found in the literature. On this basis, inter-district comparisons were undertaken primarily using raw census variables and Mosaic data. The more-detailed studies of individual collection rounds (section 8) were only possible with raw census data.

Uncertainties in matching areas with kerbside coverage with the base units of the demographic descriptors were tackled by pro-rata allocation of the base statistics pro-rata according to total number of households across the uncertain areas. This assumption must be noted as a possible source of error.

Raw Census Data

The independent variables explored were:

- Housing type {detached, semi-detached, terraced, purpose-built flats, converted flats}
- Family life cycle stage {young adults/ no children, families with young children, families with older children, more mature/ children left home, retired}
- Car ownership {no car, one or more cars}
- Tenure {owner occupier, rented from private sector, other rented}
- Household size {one person, two, three, four, five or more persons}

The results of univariate analyses are shown graphically for each class of variables in figures 7.3 to 7.6. The plots refer to the whole of the North West region. A trend from bottom left to top right in the scatter plot for any variable would indicate a positive correlation between that census variable and newspaper and pams yield (and vice versa). Regression analysis was used to test the significance of any relationship. The form of regression equation applied was:

Yield (Kg/hh/w) = Constant + Proportion of households in category ‘A’ × Coefficient ‘A’

It needs to be borne in mind that when interpreting the derived regression equations that the regression is simply an empirical ‘best fit’ to the data. Firstly, the coefficients do not necessarily equate to real-life constants such as the yield of paper from say an average detached house. Secondly, the equations do not necessarily extrapolate outside the bounds of the data set on which they were derived. Extrapolating an equation to predict for say 100% detached houses would probably give nonsense answers.

Figure 7.3 Paper Yield versus Housing Type

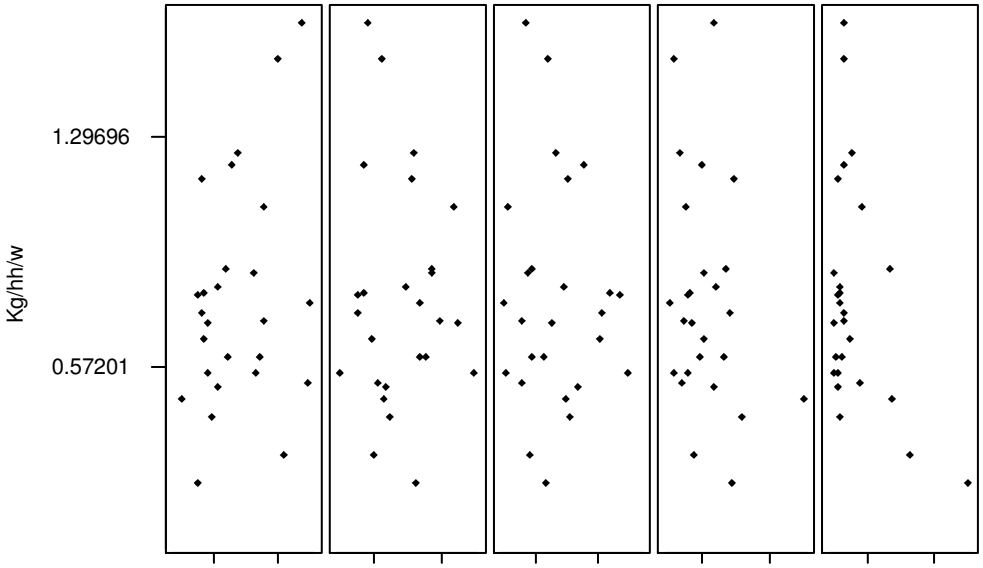


Figure 7.4 Paper Yield versus Family Life Cycle Stage

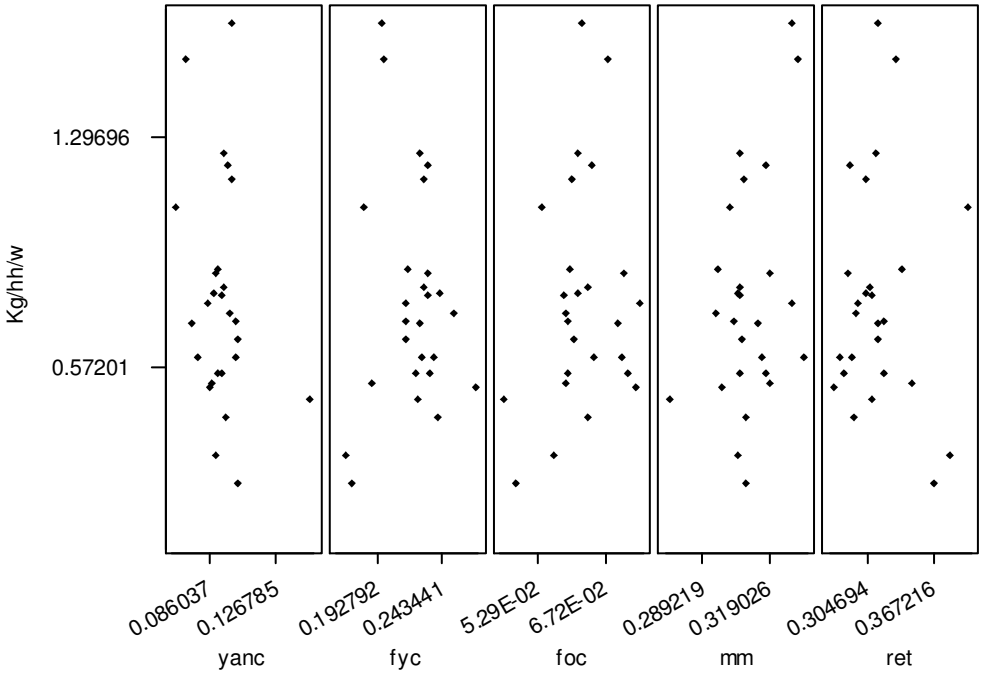


Figure 7.5 Paper Yield versus Tenure

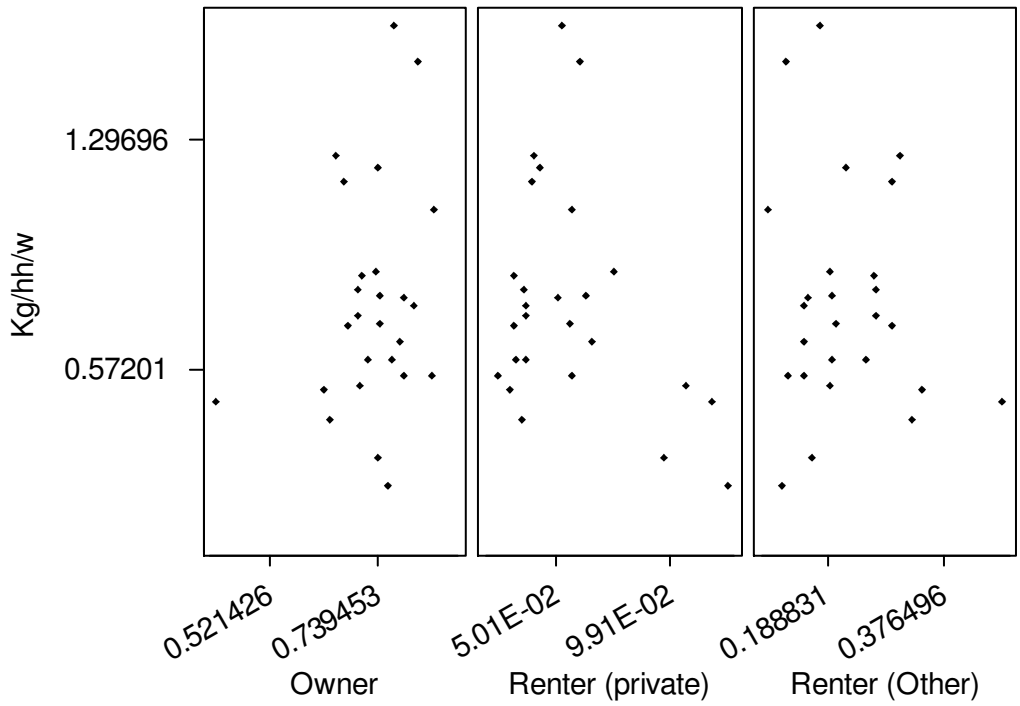
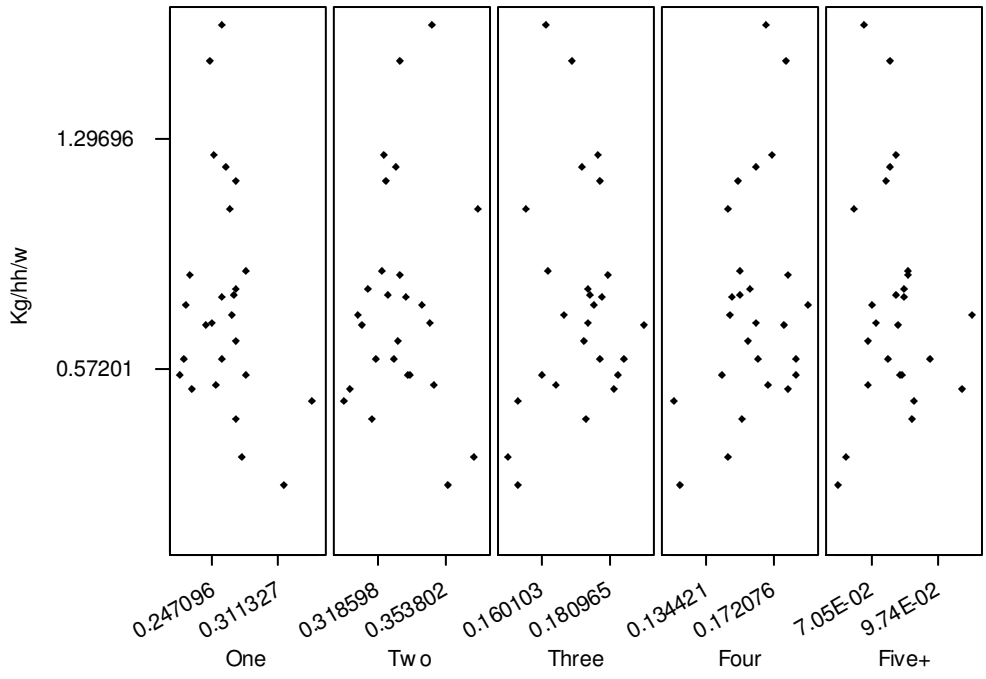


Figure 7.6 Paper Yield versus Household Size



The only significant predictors (at $p < 0.05$) across the whole spectrum of demographic factors were 'Proportion of Converted Flats' (North West), and Proportion of Young Adults without Children (Lancashire). Generally the correlations were very poor (very low R-squared values).

Next, the data were subjected to a multiple linear regression analysis. The functions fitter were of the form:

$$\text{Yield (Kg/hh/w)} = \text{Constant} + C1 \times V1 + C2 \times V2 + \ldots + Cn\text{-}1 \times Vn\text{-}1$$

where V1,2,..n-1 are the set of variables in any category (minus the last one, which in the way the data is structured is a function of all the other variables in its category). C1,2,…n-1 are the associated set of regression coefficients. The warnings already given about interpreting the derived regression coefficients still need to be heeded here.

The results show that no set of variables from any of the demographic categories, yield regression equations where even one term of the equation is significant.

The indicative trends in the strength and direction of the derived coefficients are given in table 7.3, though it would be dangerous to draw too much from these lists, bearing in mind that none of the factors listed are actually statistically significant.

Table 7.3 Indicative Trends in Strength and Direction of Demographic Factors

Region	Better → Worse	R-squared (adjusted)
North West	Detached / Flats (pb) / Terraced / Semis / Flats (conv)	7.9 %
Lancashire	Detached /Flats (conv) / Terraced / Flats (pb) / Semis	44.7 %
North West	More mature / Retired / Family (yc) / Young adults / Family (oc)	0.0 %
Lancashire	Family (oc) / Family (yc) / Retired /More mature / Young adults	0.0 %
North West	Car / No car	5.6 %
Lancashire	Car / No car	15.6 %
North West	Owner / Renter (other) / Renter (private)	5.5 %
Lancashire	Owner / Renter (other) / Renter (private)	0.0 %
North West	Four / One / Two / Five+ / Three	0.0 %
Lancashire	Four /One / Five+ / Two / Three	0.3 %

An alternative approach to deriving regression equations is to use stepwise regression techniques. In the current analysis, a forward stepwise regression technique was used. It starts off by identifying the single most significant factor then tries to add in the 'best' second factor to improve the overall regression. If that is successful, then the 'best' third factor is found, and so on. If no new factor is found to be significant then the regression is terminated.

Tables 7.4 a&b list the stepwise regression results for the North West region and Lancashire respectively. In the case of Lancashire, only one variable 'Young Adults (No Children)' was identified as significant. This variable had a negative effect on yield. In the North West,

'Converted flats' and 'Families with Young Children' were identified as together being significant, with both impacting negatively on yield.

Table 7.4a. Stepwise Regression (North West)

Independent Variable	Coefficient	P-value	R-squared (adjusted)
Constant	2.53		22.51 %
Flats (converted)	-11.3	0.006	
Families (young children)	- 7.0	0.050	

Table 7.4b. Stepwise Regression (Lancashire)

Independent Variable	Coefficient	P-value	R-squared (adjusted)
Constant	2.40		26.21 %
Young adults / no children	-18.0	0.075	

Mosaic and Acorn Data

Overall, at the inter-district level, Mosaic data provided an equally poor explanation of paper yields as the raw census data. Figure 7.7 shows the scattered relationships for the first 4 (out of 11) prime Mosaic categories for the North West region. Nothing further stood out from the other categories. Univariate statistics found that only the proportion of Mosaic 'A' (High Income households} was significant in predicting paper yields. In the multiple regression, no term was significant when the other terms were present. The forward stepwise regression could only find one significant term: Mosaic 'A'($p = 0.026$, R-sq(adj) =15.58).

For Lancashire, univariate analysis showed that Mosaic 'K' was marginally significant ($p = 0.071$), but in multivariate analysis no term was significant when all the other terms were present. Forward stepwise regression provided the results shown in table 7.5, showing the proportion of Mosaic 'K' (Country dwellers) and, more marginally, Mosaic 'I' (independent elders) to correlate positively with paper yield, whilst Mosaic 'B'(Suburban semis) and Mosaic 'F' (Victorian housing) had negative correlations.

With the Acorn groupings, the only [marginally] significant predictor of yield for Lancashire was the proportion of Acorn 'E' housing (Aspiring) ($p = 0.089$), which was negatively correlated with paper yield. Stepwise regression could add no further significant terms.

Figure 7.7. Paper Yield versus Mosaic Category

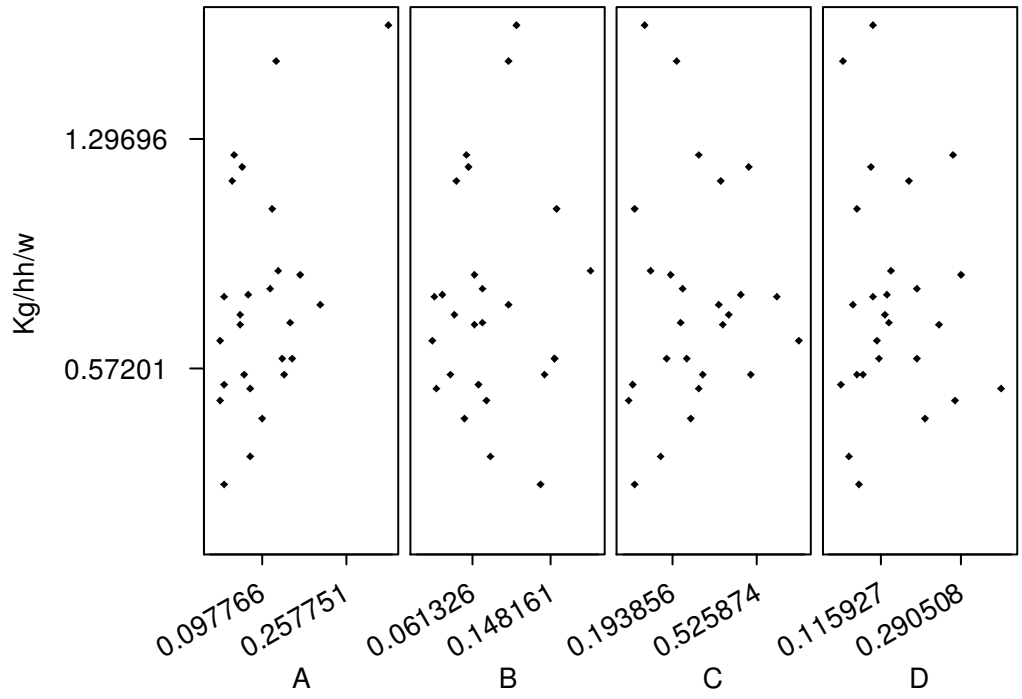


Table 7.5. Stepwise Regression (Lancashire)

Independent Variable	Coefficient	P-value	R-squared (adjusted)
Constant	1.58		71.70 %
Mosaic K	2.7	0.044	
Mosaic B	-8.3	0.012	
Mosaic F	-5.2	0.044	
Mosaic I	2.5	0.084	

7.4 Further Consideration of the Influence of Demographics on 'Whole District' Kerbside Yields

Overall, the above analyses indicate that at district level in the two populations studied, the differences in district demographic profiles may offer relatively little explanatory power for the observed differences in their kerbside paper yields. Few demographic variables appeared to be significant and there was no consistency between analyses at county level and at regional level. However, this does not necessarily mean that demographic variations may be unimportant across the country as a whole. The possibilities of demographic explanatory factors for the observed regional variations in recycling performances were not investigated. Such an investigation lay beyond the scope and resource levels of the project.

The conclusions from the North West region showed that some other factor(s) varying amongst districts may dominate household recycling performances in those districts. However, the ultimate conclusions drawn about demographics will depend on whether:

a) there are large inter-district demographic variations, or
b) the districts are demographically similar

If b), then any demographic-related differences in yield may be expected to be small anyway.

Similarity, or lack of similarity between populations with multiple attributes is normally tested through cluster analysis – similar to the techniques used to derive the Mosaic and Acorn clusters from the raw census data. In the current study, we applied cluster analysis to the identified demographic variables across the 26 North West districts in the study. The results showed that only one central cluster emerged, with all the outliers appearing to be 'unique' and not similar at all to any other outlier.

Results are illustrated here, through clustering the 26 districts to two different levels of 'similarity': 80% and 75% respectively. Only the clustering of raw census statistics is illustrated, but it is noted that a clustering of the Mosaic indicators produced very similar results.

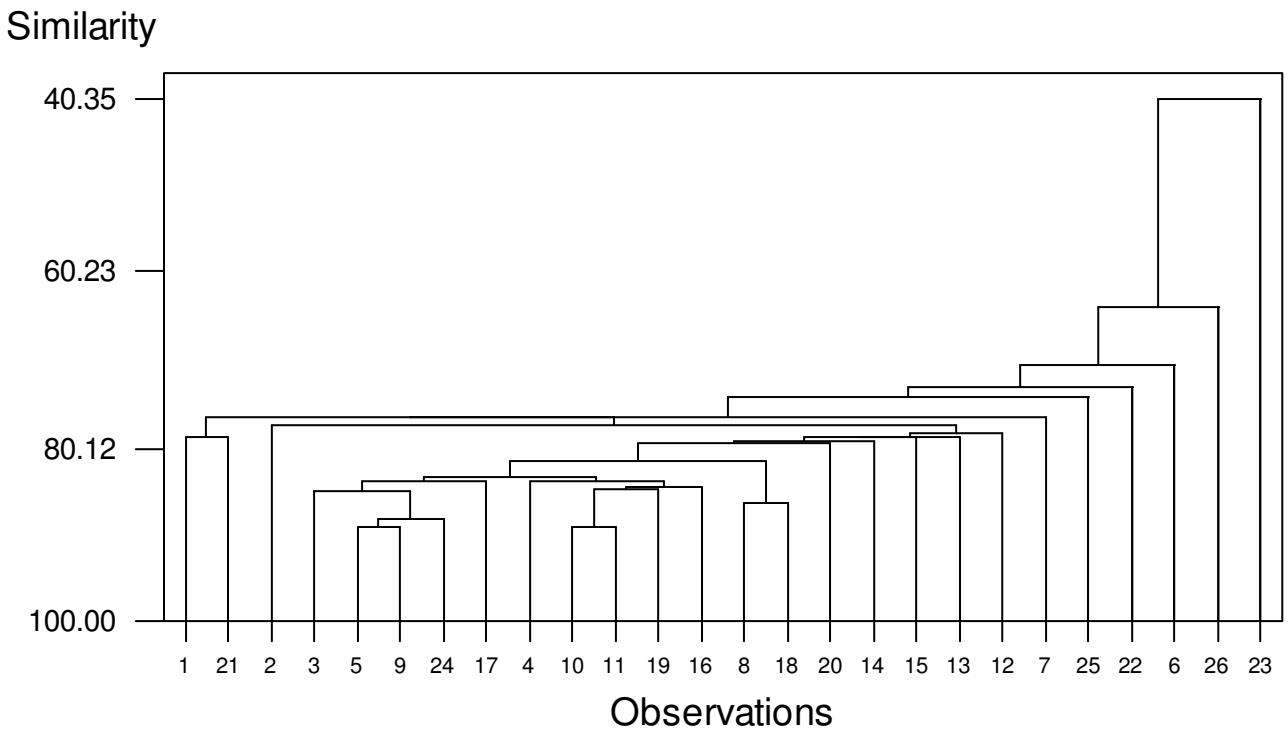
At 80% similarity, 15 clusters were formed with populations of 12,1,1,1,1,1,1,1,1,1,1,1,1,1,1.
At 75% similarity, the number of clusters reduced to 6, with populations of 21,1,1,1,1,1.

Clearly the increased clustering was simply adding the outliers progressively one-by-one into the core cluster.

The process is illustrated by the dendrogam shown in figure 7.8. This shows the progressive linkages between districts. In the figure, individual districts are represented by a number from 1 to 26. These are in order of their kerbside paper yield – 1 representing the district with the highest yield (Kg/hh/w) through to 26 being the district with the lowest yield. It is noticeable that the major outliers (districts 1, 21, 2, 7, 25, 22, 6, 26, and 23) are drawn most heavily from amongst the extreme performers (both the good and the bad).

Basically this shows that the majority of authorities in the North West might be reasonably similar demographically when taken as districts as a whole, and may all perform to a reasonably similar 'intermediate' standard in their kerbside recycling performance. This ties in well with the results from section 7.1, which show that there is little variance between the schemes with borough-wide coverages or between schemes using the fairly ubiquitous bag collections. The 'odd-bods' however may behave as such for quite different reasons. Some of those possible reasons are explored in figures 7.9 and 7.10. These figures plot the distance of the outliers from the centroid of the core cluster. Positive distances for a given demographic category indicate that that category is more prevalent in the outlier than in the core cluster, whilst negative distances indicate that the demographic category is less prevalent. Figure 7.9 shows the results for the two outliers with better than average kerbside yields, whilst figures 7.10 a&b show the results for the four outliers with lower than average yields.

Figure 7.8. Dendrogram showing clustering of Authorities by Census Statistics



The two 'better-performing' (figure 7.9) districts show a slightly older age pofile than the core districs with more retired (ret) residents and also more more-mature (mm) residents. They also have higher owner occupation and higher numbers of households with cars. The areas additionally have more detached houses with generally lower representations of all other housing types. There may also be proportionally less single person households and large households (five+) in these areas.

Amongst the 'poorer-performing' districts (figure 7.10), districts A and B show proportionally more families with children than there are in the core cluster, with significantly higher levels of young adults with no children also present in district B. More households are renting from the private and public sectors sector (rent(o) and rent(p) respectively), and car ownership levels are depressed. The areas have greater proportions of flats than the core cluster with more large households (five+) in area A and high proportions of single person households in area B. Poor-performing areas C and D, in contrast, show larger retired populations with higher than average numbers living in converted flats. There is also significant private sector rental in area D. Areas C and D have smaller household sizes than the core, with especially more single person households.

Overall, the results support the traditional wisdom that those from more affluent housing and those from the older generations tend to be the better recyclers, whilst those living in multi-family dwellings, those renting from the private sector and the younger residents tend to recycle less. However, whilst the model has revealed that those demographic features may offer some explanation of the differences in recycling performance amongst districts, no

definitive model emerged from the analyses. Part of the problem could be due to the general 'smoothing out' of differences when aggregating over large populations. As several districts were quite similar demographically, identifying models based on demographic differences may lead to uncertain results. In order to investigate the influence of possible demographic dependencies any further, it becomes necessary to concentrate on smaller populations. Such analyses will be considered in the next section.

Figure 7.9. Differences in Demographic Profile of Two Well-performing Outliers Compared to Mean Performance

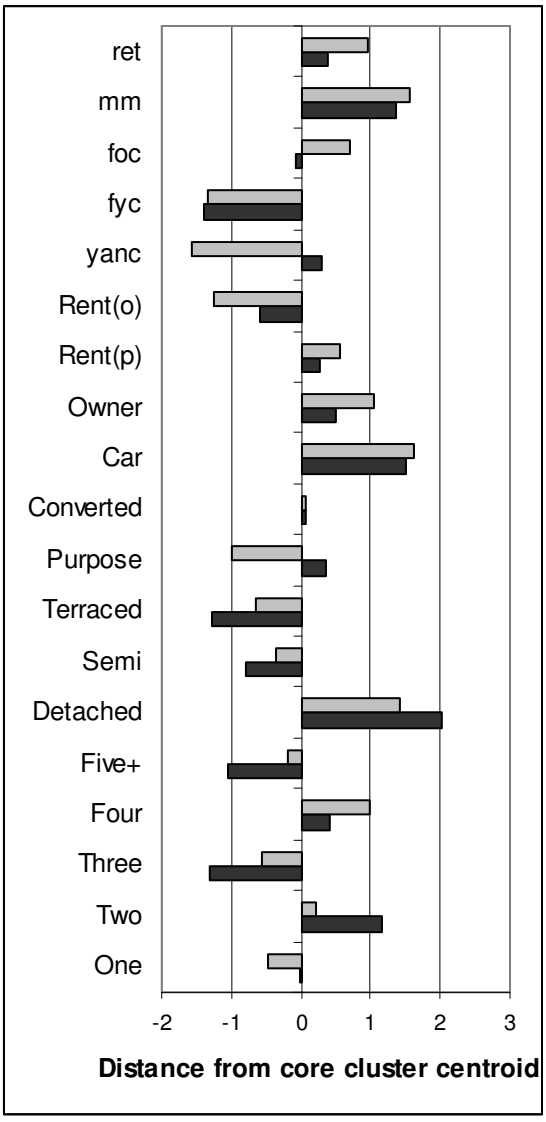
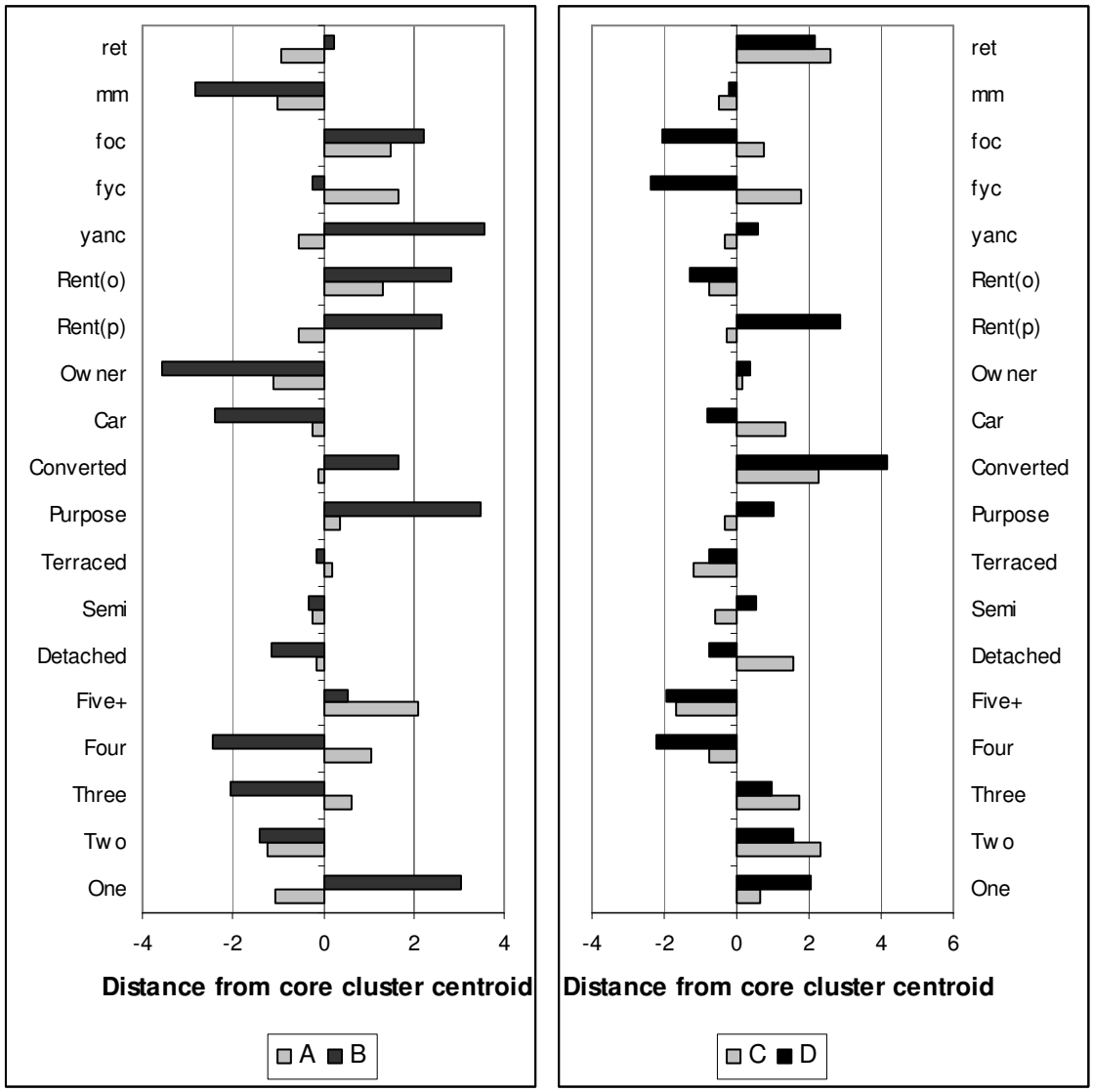


Figure 7.10 a&b. Differences in Demographic Profile of Four Poorly-performing Outliers Compared to Mean Performance



8. THE INFLUENCE OF DEMOGRAPHIC FACTORS ON RECYCLING YIELDS AT NEIGHBOURHOOD SCALE

8.1 Introduction

The demographic analyses described in section 7 are now repeated at a finer resolution amongst the individual daily collection rounds. Those collection round sizes are typically 1000 to 3000 households, and represent the finest resolution to which routine monitoring data is normally collected. However, as discussed in section 1, not all Lancashire councils recorded those data, and even where records were kept, recorded weights did not always map one-to-one onto an individual daily kerbside collection. Sometimes bring site tonnages are subsumed into the figures, and sometimes weighbridge recordings did not correspond exactly to round beginnings and round ends. Also, it must be borne in mind that the small area census

statistics enumeration district boundaries normally do not correspond with collection round boundaries. Where an enumeration district spanned a collection round boundary, the household data were proportionally allocated to each round. Also, it must again be noted again that at the time of the study, the latest available census data were quite dated. These possible sources of error must always be borne in mind when interpreting the results.

8.2 Individual Authority Analyses

As a prelude to the main inter-authority analysis, attempts were made to fit demographic models to the collection rounds of individual authorities. The models were determined by a combined forward and backward stepwise regression. Basically, explanatory terms were added sequentially one by one with any new term being the most significant available given that other terms were already included in the model [forward selection]. If any previously included term(s) lost its significance when a new term was added, then the term with the lowest significance was dropped from the model [backward elimination].

In Blackburn, the most significant predictor was the proportion of private sector rents which was negatively correlated with the paper yields amongst that district's 24 collection rounds. However that term was subsequently eliminated in a subsequent iteration of the stepwise regression. The best fitting model (r-squared (adjusted) = 54.81) contained three significant terms: The proportion of detached houses and the proportion of two-person households both showed a positive effect on yield. Curiously, the third significant term was having one car (as distinct from no cars or two or more cars). One-car households correlated negatively with yield.

For Blackpool (10 rounds) no significant predictor variables were identified.

For Burnley, like Blackburn, the most significant predictor of neighbourhood performance was the proportion of private sector rents. This predictor retained its significance throughout the stepwise regression, correlating negatively with yield. Of the different housing types, terraced housing and converted flats had negative influences whilst the proportion of detached housing corresponded positively with yield. Other significant factors were the proportion of 3 person households (negative) and the proportion of the more-mature but not yet retired fraction (positive). The final regression equation for the 20 collection rounds of Burnley included one positive factors: More-mature, and three negative factors: Privately rented, Converted flats, and 3-person households. R-squared (adjusted) = 86.62.

In Ribble Valley (6 rounds operating at the time of data collection), the proportion of young adults without children emerged as the most significant predictor (negative effect), with lack of car ownership (also negative) additionally included in the final regression equation. R-squared (adjusted)= 95.46.

In Wyre (10 collection rounds), only one significant predictor emerged. That was the proportion of detached houses, which had a positive effect. R-squared (adjusted) = 63.1.

Overall, no general model emerged that could show comparable explanatory powers across all authorities. However, in the main, the terms identified were amongst those that were expected according to traditional wisdom. One or two unexpected variables also appeared to be significant, such as 3-person households. However, on not allowing household size terms

to be considered in the model, the new regression showed that families with young children would then take on a significance. Perhaps families with one young child were the major factor? In general, the models derived are quite peculiar to the specific ranges of local demographics and could not be expected to extrapolate to areas of different demographics, or even to the neighbouring authorities in Lancashire. To derive the County-wide picture, it was necessary to consider all authorities taken together. Such an aggregation takes advantage of the wider pool of demographic profiles that are available, and should result in a more general model being identified.

8.3 County-wide Analyses

The 'County-wide' analyses were based on an aggregation of the five districts considered individually above: Blackburn, Blackpool, Burnley, Ribble Valley, and Wyre. Overall, the aggregated data set covered 70 collection rounds.

Stepwise regressions were carried out over all 70 rounds from the five districts. The demographic terms included were housing type, family life cycle stage, household size, car ownership and tenure. Initially the functions fitted were of the form:

$$\text{Yield (Kg/hh/w)} = \text{Constant} + C1 \times V1 + C2 \times V2 + \ldots + Cn \times Vn$$

where V1,2,..n are the values of the significant demographic variables and C1,2,…n are the associated set of regression coefficients.

However, it was found that the residuals from this model (i.e. the disparities between individual observations and the model predictions of those observations) were significantly correlated with districts. Whilst the residuals were normally distributed for three of the districts, the model consistently over-predicted performances in each of the rounds of the poorest performing district and under predicted the performances in all of the rounds of the best performing district.

To try to overcome this disparity, a second model was then fitted. This model took the form:

$$\text{Yield (Kg/hh/w)} = \text{Constant(k)} + C1 \times V1 + C2 \times V2 + \ldots + Cn \times Vn$$

where a separate and independent constant term was allowed for each district. The hypothesis behind this was that there may be a significant 'Borough-specific' term as well as demographic terms in the determining equations. That is, some as yet unidentified feature of the borough might be moderating any more global demographic dependencies.

The whole evolution of the first regression equation is shown in Appendix B. In this derivation, the constant term has been omitted. That is because the constant term proved not to be significant when it was included in the model ($p>0.05$). In the rerun without the constant term, the 10^{th} step was the last step where all terms remained significant, and this step formed the basis for the final derived equation.

The derived regression equation was:

Yield (Kg/hh/w) = 1.75 Detached + 2.46 Rent(public sector) - 3.00 Converted flats + 3.81 Retired - 2.53 Purpose-built flats - 1.31 Semis - 2.30 No car + 8.71 Families with older children

On including the possibility of district-specific constant factors, the method yielded a somewhat simpler equation:

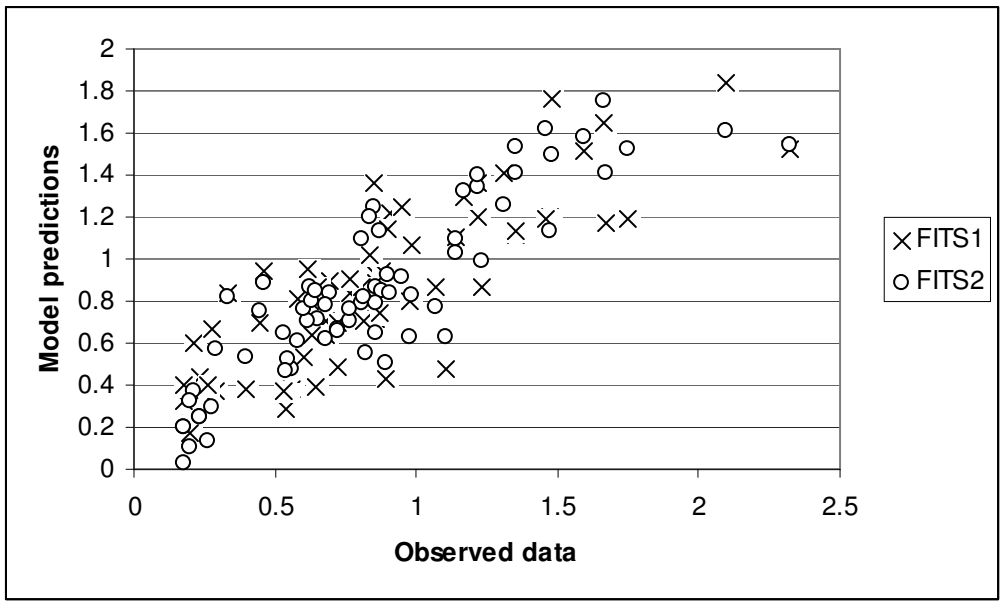
Yield (Kg/hh/w) = 2.26 Detached + 0.687 Retired - 0.680 Owner occupied + 2.76 2-persons - 0.707 C2 + 0.608 C4

Where C2 and C4 are the constant terms for districts 2 and 4 respectively.

The common descriptors across the two equations were the proportion of detached housing and the proportion of retired residents respectively. It is also noted, however, that the proportion of public sector renters actually showed a positive influence (fit 1) with fit 2 showing a similar effect, this time through owner occupiers producing a negative impact on yield. It should be noted, however, that those terms only retain that significance when all the other listed terms are present. It does not necessarily mean that public sector renters are actually better recyclers than the owner occupiers. It is also noted that only the constant terms for the worst performing district (C2) and the best performing district (C4) were actually significant.

The model fits to the observed data are shown in figures 8.1 and the residuals from those fits are shown in figure 8.2.

Figure 8.1. Model Fits to 5-District Round Data

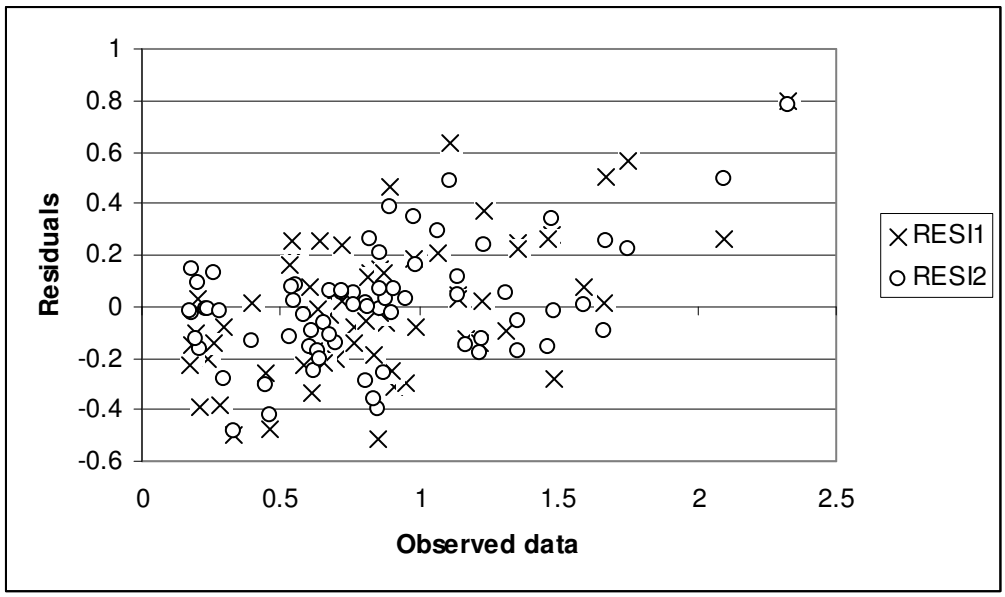


The two models show comparable goodnesses of fit to the observed data, with similar levels of scatter, though with a marginally 'tighter' distribution produced by the second model. Adjusted r-squared values were just under 0.7 (Fit 1) and just over 0.7 (Fit 2). It is seen that there is still much scatter even with the best-fitting models, which emphasizes that those models cannot explain all the observed variations. It should also be noted at this stage, that

the two reported models are not the only possible models that might apply. Other models (with similar goodness of fits) could also be derived, depending on different choices and sub-sets of the demographic variables that were considered in the regression..

Normally, in analyses such as these, the outliers of concern are considered to be those with standardized residuals (actual residual/ standard deviation) of greater than about 2. From the two analyses taken together, we found that 6 out of 70 rounds returned standardized residuals greater than 1.9. Those rounds are now considered further. Figures 8.3 a&b show the absolute differences in the demographic profiles of those rounds from the average profiles from across the whole 70 rounds.

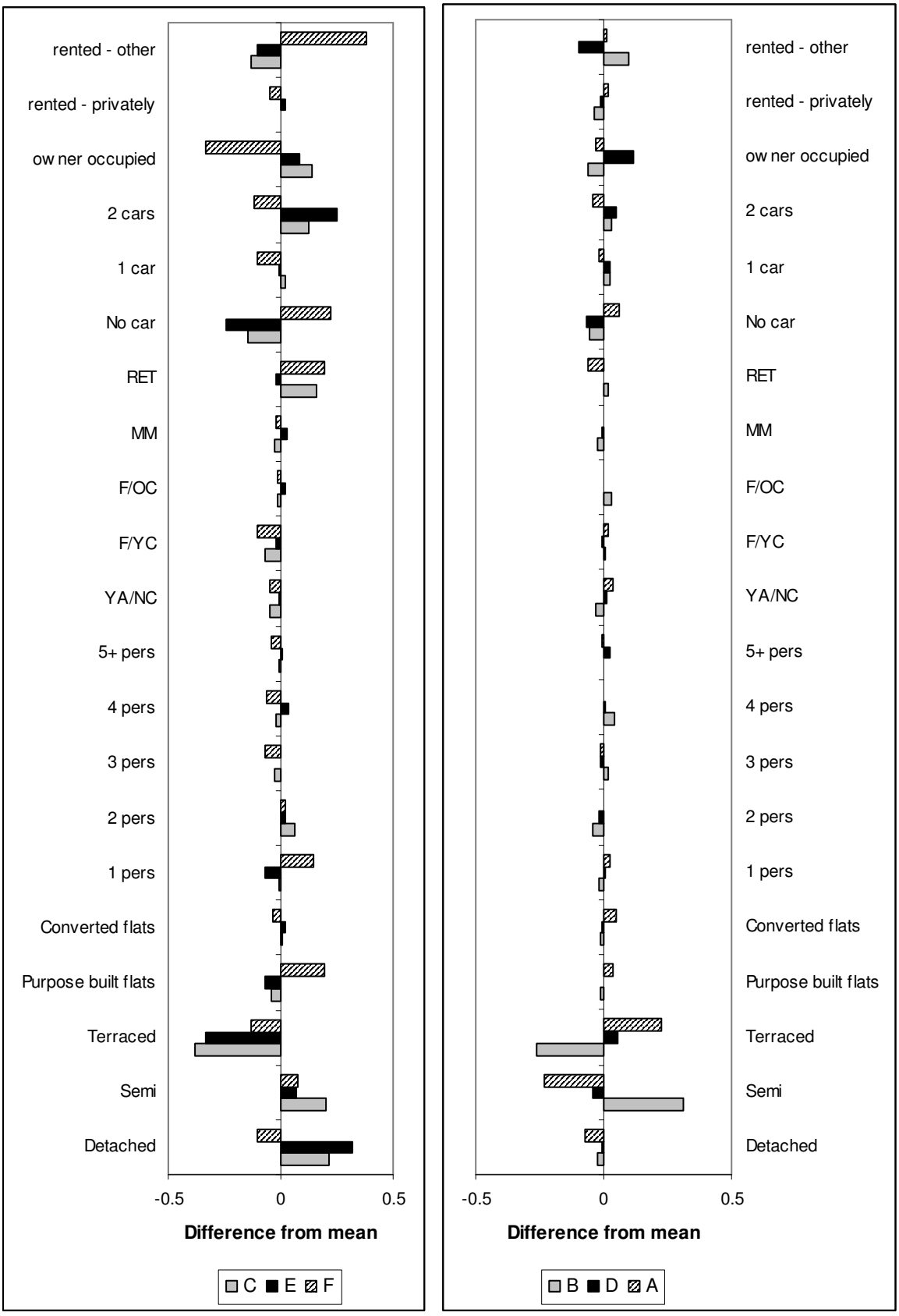
Figure 8.2. Residuals from Model Fits to 5-District Round Data



The demographic profiles of the six major outliers do not reveal anything other than marginal differences in the house hold sizes and family life-cycle stages of their residents compared to the 70 rounds taken as a whole. The major differences appear to be in housing type, tenure and car ownership. Rounds ‘C’ and ‘E’ were quite similar. They had much higher proportions of detached housing and lower proportions of terraced housing than average, and substantially higher levels of car ownership and owner-occupation. Both performed much better in reality than was predicted by the models. Round F, by contrast had very high proportions of flats, council tenants, single occupancy, and retired residents, with low levels of car ownership. This district also performed much better in reality than was predicted by the model. The common factor between all three was that they represented the extremes of the demographics of the five districts. It is not surprising, perhaps, that the model fit tails off at those extremes. The poor fit may be as much to do with the inadequacy of the model as it may be to do with any physical reason.

Rounds A, B, and D however do not show such extreme demographics, yet they too were poorly fitted by the model. The model significantly under-predicted the performances of rounds A and B, whilst round D was significantly over-predicted. The reasons for such poor fits remain unclear.

Figure 8.3 a&b. Differences in Demographic Profiles in Rounds with High Residuals in Model Fit compared to the Mean Demographic Profiles of all Rounds.



8.4 Conclusions

Overall, it can be concluded that whilst there appears to be a general pattern between observed performance variations and demographic profiles, the performances of individual neighbourhoods show much scatter around that general trend. A general demographic predictor can not explain all of the variance between neighbourhoods. Different demographic factors may take on different importances in different districts. However, like the whole district analyses that were presented in the previous section, the picture appears to be one of reasonable conformity across the majority of areas, but with a small number of outliers; those outliers tending to be areas with the more extreme demographic profiles. It may be concluded that simple linear models are the most appropriate models to use to explain demographic effects. More complex, non-linear models could potentially provide better fits at the extremes. However, there was insufficient data to test the efficacy of using such models.

9. TIME SERIES ANALYSIS

9.1 Introduction

This section considers the temporal changes in the individual collection round data over the last three years. The data sets that were used in the analyses were ‘as received’ from the local authority records. It should be noted that all the provisos about data quality, as discussed in section 8.1, also apply equally here. In addition, it should also be noted that one data set contained several missing or zero returns. Outside of bank holidays, the interpretation of such records is not always clear.

The main results reported in this section are based on time series supplied by the Boroughs of Wyre, Fylde and Burnley respectively. The Fylde and Wyre analyses were able to consider discrete time horizons at one month [or 4 week] intervals from the period April 1999 to March 2002 and beyond. The Burnley data set ran for 20 months The other data received contained much shorter time series or was at district level rather than round level.

Overall, the data sets were quite ‘noisy’ with considerable month to month variations. The interpretation of any significant temporal trends or discrete events from such raw data can be subject to much uncertainty as many different factors may be in play. To help facilitate a better overall interpretation, it becomes necessary to try to deconvolute the individual effects of some of the major factors. This was achieved through the statistical technique of decomposition. In the analyses reported here, the time series were decomposed into three factors: (i) an overall trend, (ii) seasonal effects, and (iii) residuals. The analyses sought to establish how coherent each of those factors was across different rounds within an authority, and as far as we were able, across different authorities as well. The final part of the analysis sought to investigate reasons for identified non-coherences.

9.2 Coherence amongst Collection Rounds

Within Authorities:

The initial analyses investigated whether the time series of the raw weight recovery data showed any correlations amongst individual rounds. Table 9.1 gives the results of the correlation analysis for Wyre and table 9.2 gives simplified results for Fylde. Table 9.1 shows values of the Pearson Correlation coefficient for each pair of rounds together with its associated p-value which determines whether the established correlation is statistically significant. The correlation coefficient itself takes a value from –1 (perfectly negatively correlated), through 0 (no correlation) to +1 (perfectly positively correlated). The shaded squares in table 9.1 show correlations that are statistically significant at the 95% confidence level, whilst in table 9.2 these are designated by single asterisks. Double asterisks show significances at 99% confidence.

The degrees of similarity amongst the different rounds can also be visualised through the dendrograms derived from cluster analysis of the 10 rounds (figures 9.1, Wyre).

Table 9.1. Correlation Matrix for Wyre (10 Rounds – 'A' to 'J')

	A	B	C	D	E	F	G	H	I
B	.050 .771								
C	-.020 .928	.158 .359							
D	-.043 .801	.025 .885	.128 .456						
E	-.264 .120	-.280 .098	.294 .082	.202 .236					
F	.139 .420	.263 .121	-0.068 .695	.017 .920	-.019 .912				
G	-.214 .211	.275 .105	.134 .435	.084 .627	-.129 .453	.230 .177			
H	.189 .268	.199 .245	-.179 .296	.078 .653	-.239 .160	-.195 .254	**.385** **.020**		
I	.292 .084	**.430** **.009**	-.131 .447	.077 .653	-.147 .391	.145 .399	**.359** **.031**	**.579** **.000**	
J	**.453** **.006**	.012 .943	=.216 .205	.063 .713	-.229 .179	.264 .120	.050 .772	.231 .174	**.506** **.002**

The correlation and cluster analyses both reveal reasonably strong similarities between rounds H, I and J with reasonably strong individual links between one or more of these areas and rounds A, B, and G. At the other extreme, rounds C, D and E form a second, rather weakly linked cluster.

Like Wyre, Fylde also showed some correspondences between different rounds, though no real pattern could be easily discerned. However, it is noted that substantially more of the round performances appeared to be unrelated rather than being related, suggesting that localised factors may dominate any pervasive factor acting over the whole district.

Figure 9.1. Cluster Analysis Results showing Similarities amongst Wyre Rounds

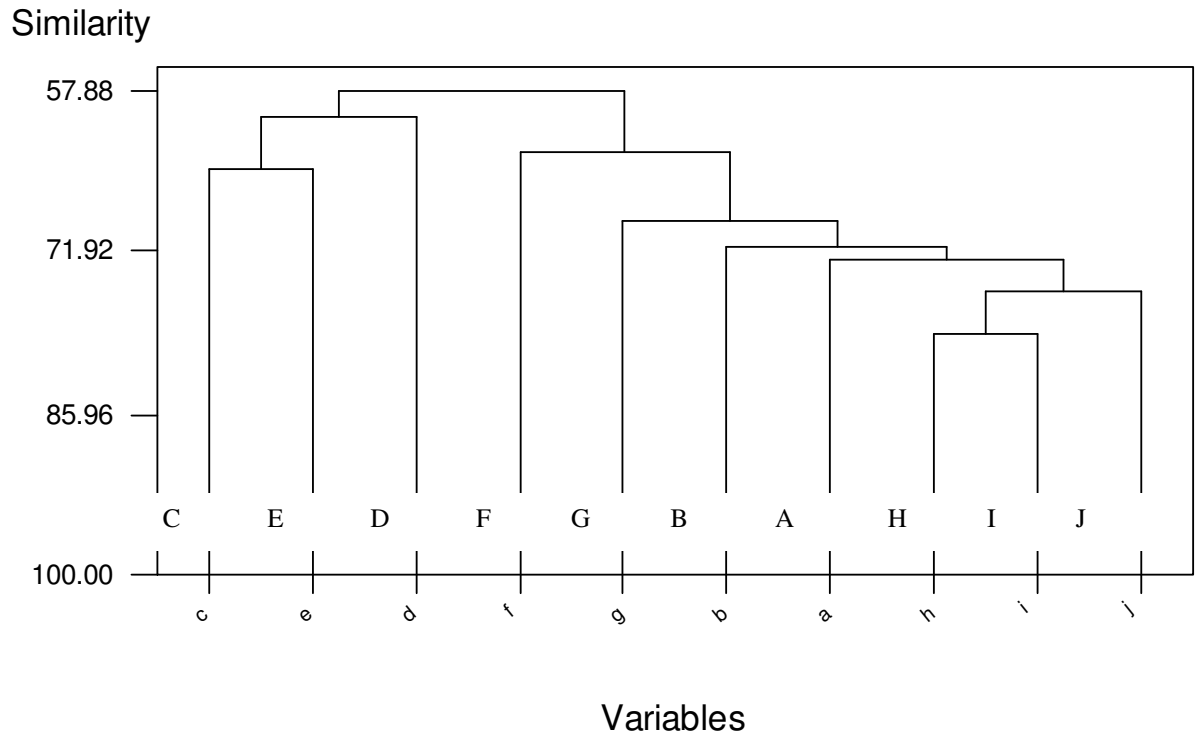


Table 9.3. Correlation Matrix for Fylde (20 Rounds – 'P1' to 'B4') – Note only bottom left entries in the matrix are shown.

	P1	P2	P3	P4	P5	Y1	Y2	Y3	Y4	Y5	G1	G2	G3	G4	G5	B1	B2	B3	B4
P2	**																		
P3																			
P4																			
P5																			
Y1	**				**														
Y2			*																
Y3							**												
Y4					**		**												
Y5																			
G1							*												
G2			*																
G3			**	**								*							
G4																			
G5	**				**	**													
B1	*										*		**		*				
B2			*	**											**	*			
B3										**									
B4													**				**	*	
B5																			

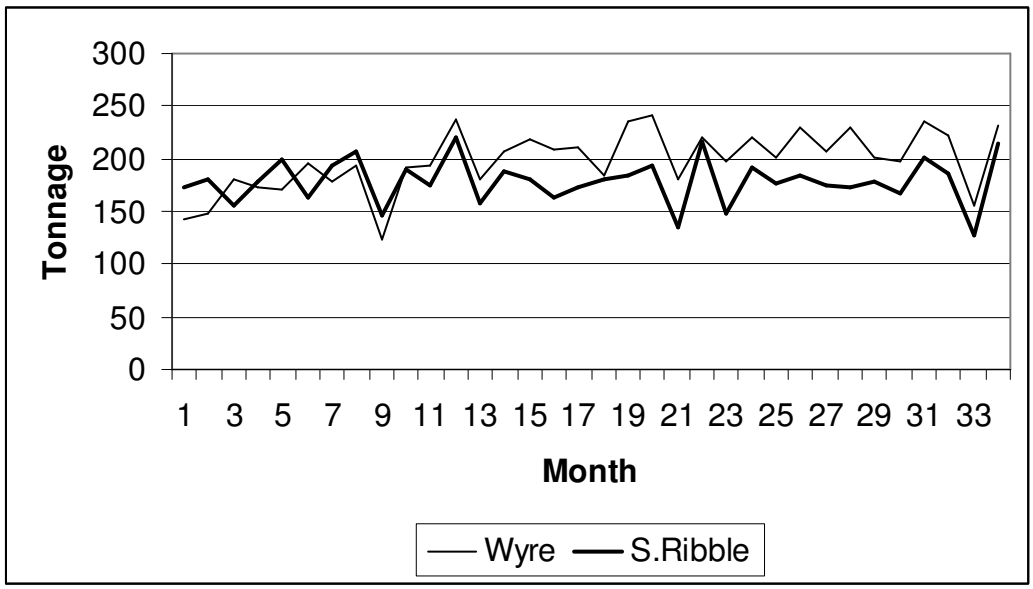
** Significant at 95%, significant at 90%

Between Authorities:

With the data available, it only proved possible to make one direct inter-authority comparison across the whole 3-year analysis period. This comparison was between Wyre and South Ribble. (A 3-year district-level time series had been supplied by South Ribble).

Unfortunately, it was not possible to directly compare Fylde with those authorities as well because of different base accounting periods for the data sets. The Wyre versus South Ribble comparison produced a strong correlation revealing quite similar monthly trends(Pearson correlation = 0.542, p= 0.001; figure 9.2). However, this single comparison is insufficient to enable any generalised conclusions to be drawn.

Figure 9.2. Comparison of Wyre and South Ribble Time Series



9.3 Decomposition Analysis

This technique is illustrated for the Wyre data set in figure 9.3. The illustration shown refers to Wyre Borough as a whole. The curves show the residuals from removing the constant linear trend, removing the monthly seasonal variations, and from removing both.

It is noticed, however, that the assumption that there may be a linear year-on-year average growth in tonnage collected may not be strictly valid. Inspection of the raw data shows that the growth experienced during 1999/00 and 2000/01 may now be levelling off. This would imply that recent marginal increases in participation and capture with time may not be sustainable into the future. Alternatively it could simply mean that there is now less paper in the system. In the late 1990s, newspaper and magazine paper consumption showed a year-on-year rise of some 2-3%. However 2001 saw a downturn in newspaper advertising (in the nationals at least), and paginations have consequently fallen a little. As national consumption figures for 2001/02 remain to be published, this hypothesis remains unverified.

The relative scales of the year-on-year trend are shown for Wyre in figure 9.4a, where it is noticed that one of the 10 collection rounds actually showed a reduction with time. The growth distribution by collection round for Fylde is shown in figure 9.4b. Here, 3 out of 20 rounds showed reducing yields with time. Most rounds in both districts, however, showed moderate increases with time, with the highest year-on-year changes reaching ip to 20% per annum. For the districts as a whole, Wyre showed an annual linear growth of 6.7%. Fylde 2.4%, and South Ribble –0.1% over the 3 year period. In Burnley (figure 9.4c), there was more variation amongst the individual rounds with more rounds showing [positive and

negative] changes in excess of 20%. Whilst it is not possible to identify reasons for the contrasting behaviours, it is noted that both Fylde and Wyre operate mature schemes that have been running for over 5 years, whilst the scheme in Burnley was a much more recent introduction. It could then be hypothesised that performance adjustments at round-level are more likely to happen in the early stages of a schemes history, with greater stability setting in with maturity.

Figure 9.3. Decomposition of Wyre Time Series

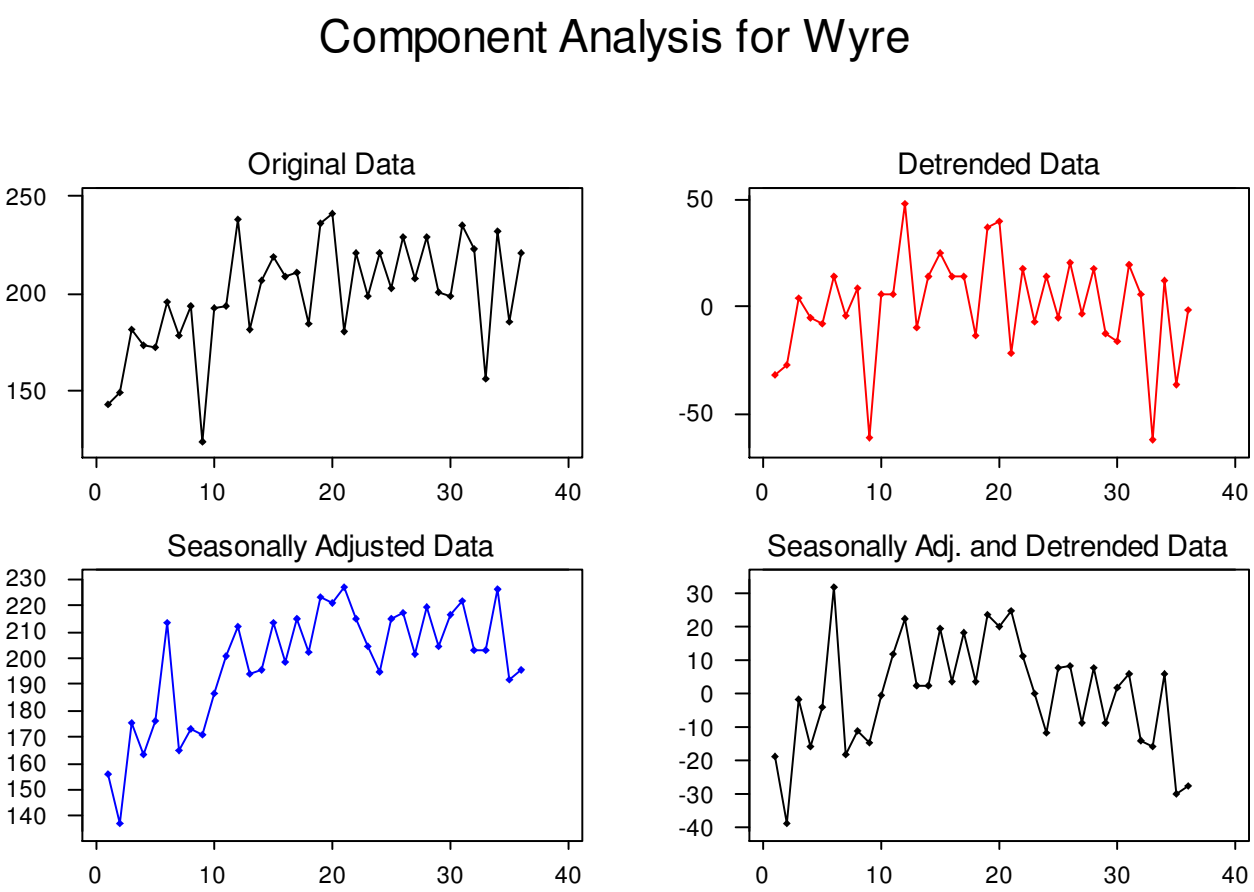


Figure 9.4a. Summary of Trends in Year-on-year Paper Collected in Wyre (10 Rounds)

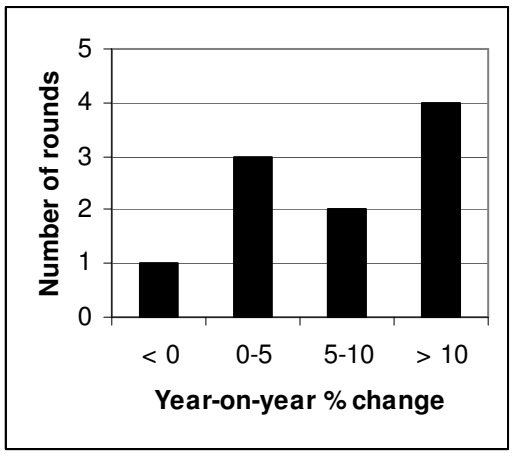


Figure 9.4b. Summary of Trends in Year-on-year Paper Collected in Fylde (20 Rounds)

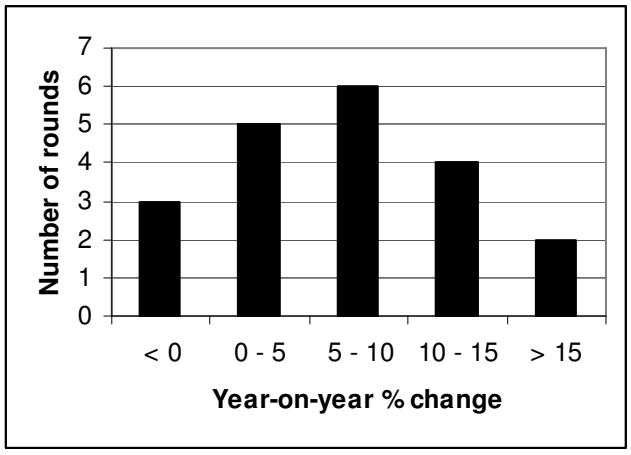
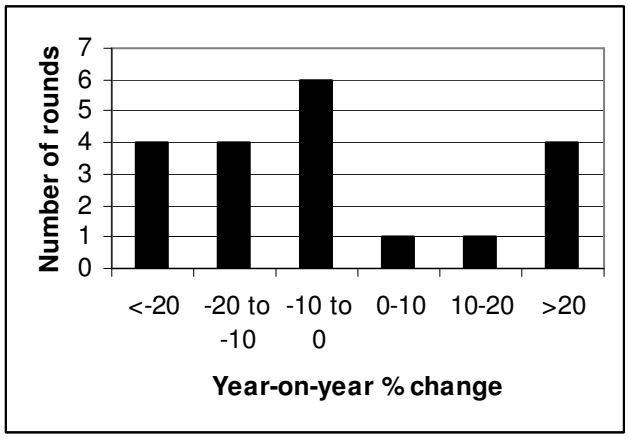


Figure 9.4c. Summary of Trends in Year-on-year Paper Collected in Burnley (20 Rounds)



The overall decomposition fits are shown for Wyre and Fylde at district level in figures 9.5a and 9.5b. The decomposition fit for the Wyre data set is particularly close across the whole time series, indicating that much the same seasonal variation may have happened over each of the three years. The fit to the Fylde data is less good, noticeably at the beginning of the data set and in the most recent data, where the January to March 2002 data is out of phase to that of 2000 and 2001. The Burnley time series was too short to permit any seasonal decomposition.

Figures 9.6 a-c show the decomposed seasonal indices for Wyre, South Ribble and Fylde respectively. The different accounting length in the Fylde should be noted when comparing its data with the other two districts.

Figure 9.5a Decomposition Fit for Wyre

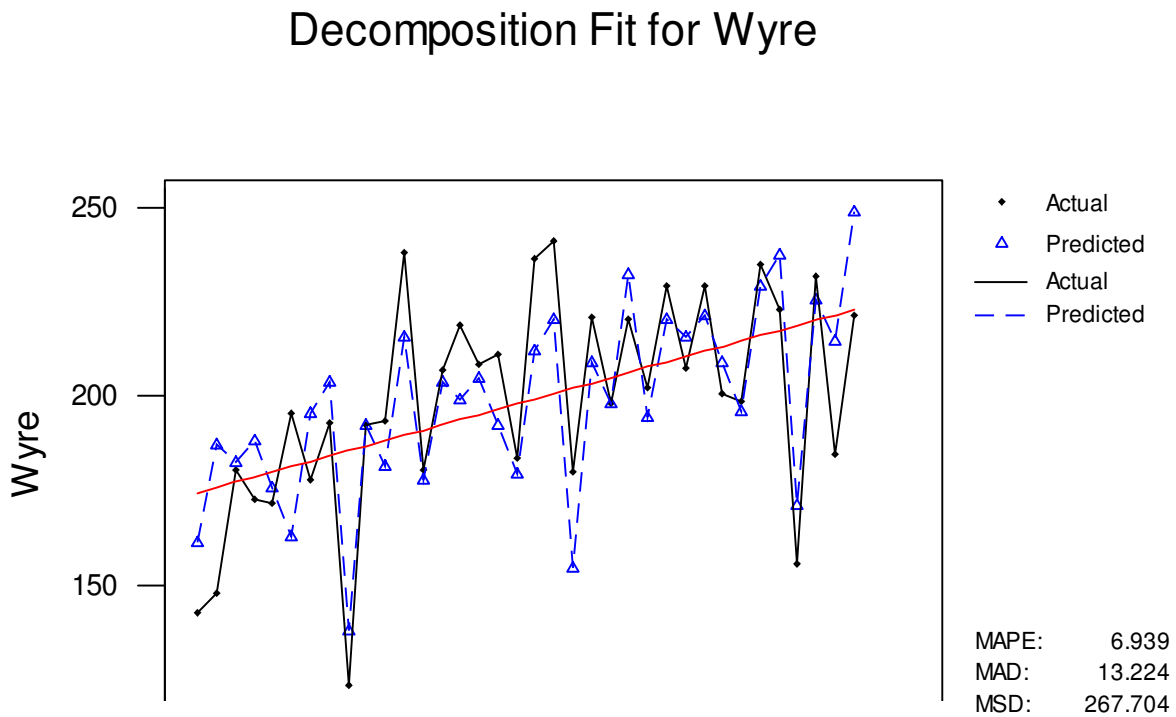
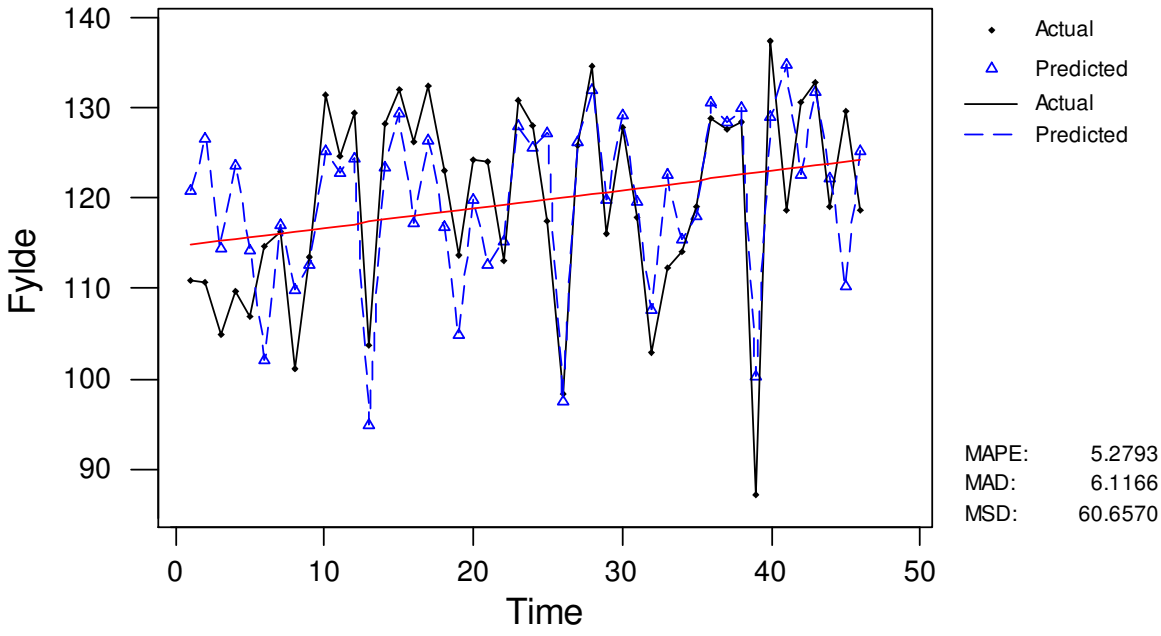
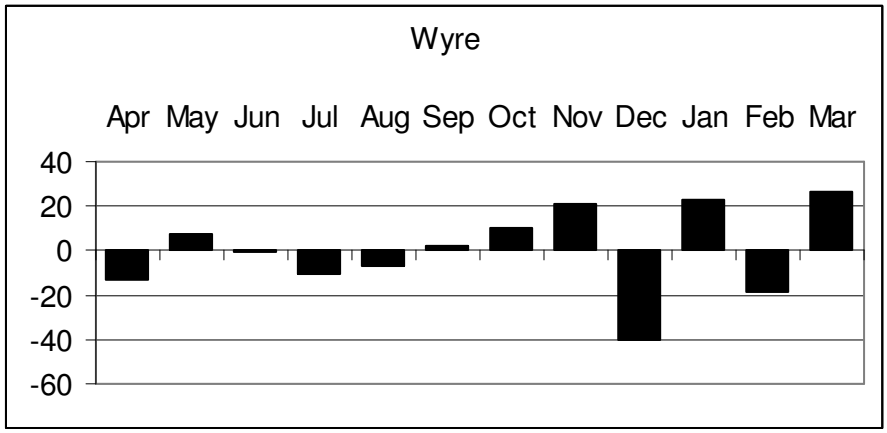
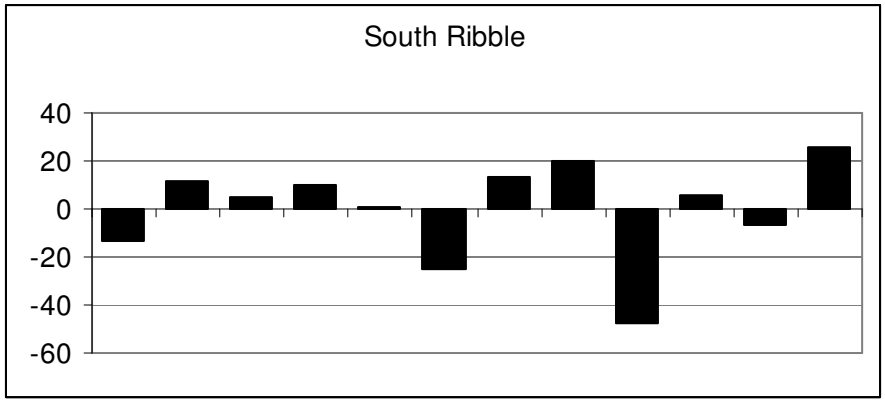


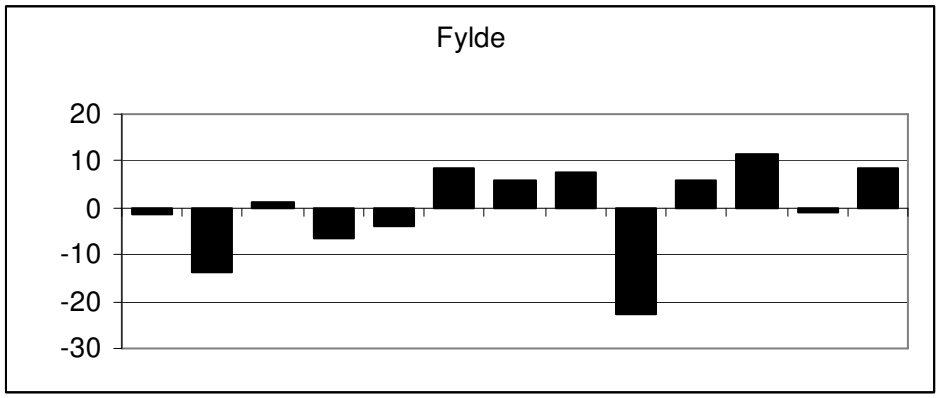
Figure 9.5b Decomposition Fit for Fylde



Figures 9.6 a-c. Seasonal Indices







Clearly all three data sets show a common December 'low' with corresponding elevated yields in October to November and also in January. The local seasonal indices for the rest of the year, however, show much less clear or coherent behaviours.

Before going on to analyse individual districts in more detail, it is worthwhile to reflect on the wider outcomes of the decomposition analyses. Firstly they have shown that some facets of seasonal variation have occurred over more than one district, and could be quite general. Secondly, they have shown that similar seasonal trends (with some differences) may occur year after year. Given that the past is known, we could then use the past data to help forecast the future. That possibility was tested was tested for the 3 districts. Firstly, the seasonal indices were developed for the first two years of each time series, and that data was extrapolated to provide the monthly forecasts for year 3. The results are shown in figure 9.7 a-d.

Figure 9.7a Decomposition for Wyre Years 1&2 with Forecast for year 3

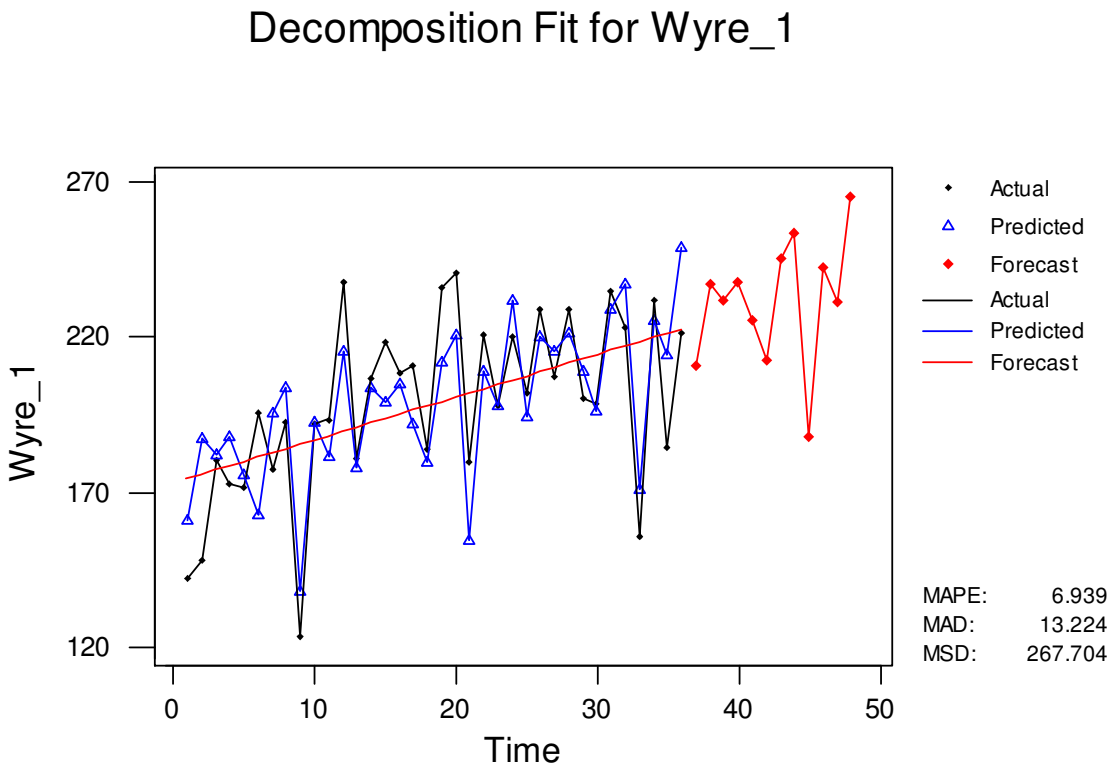
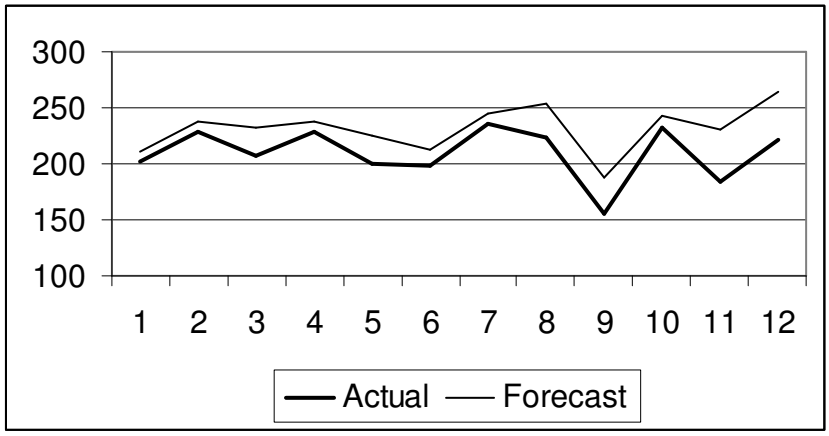


Figure 9.7b. Fit Between Forecast and Actual Tonnages (Wyre)



The correlations between forecasts and actuals were all high and statistically significant (Pearson correlation = 0. 806, p= 0.002; Wyre. Correlation = 0.751, p= 0.003; Fylde. Correlation = 0.725, p=0.018; South Ribble). The progressive deviation from the forecast in Wyre results from the over-estimation of the continuing year-on-year trend. The seasonal components however were very well predicted.

Figure 9.7c. Fit Between Forecast and Actual Tonnages (Fylde)

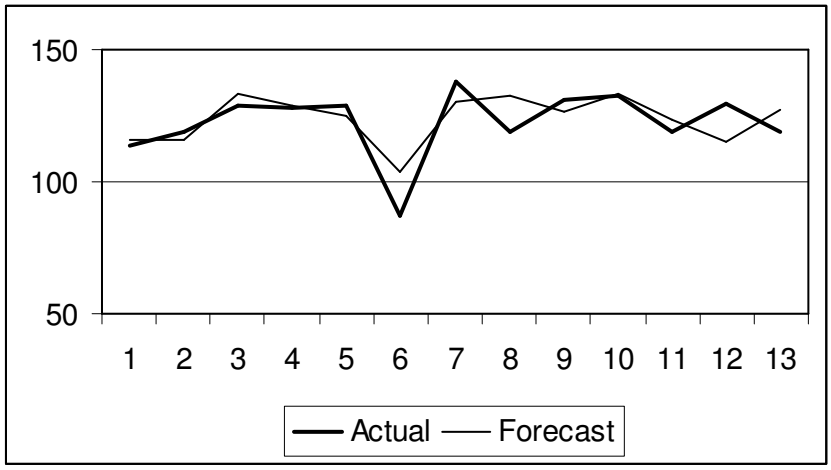
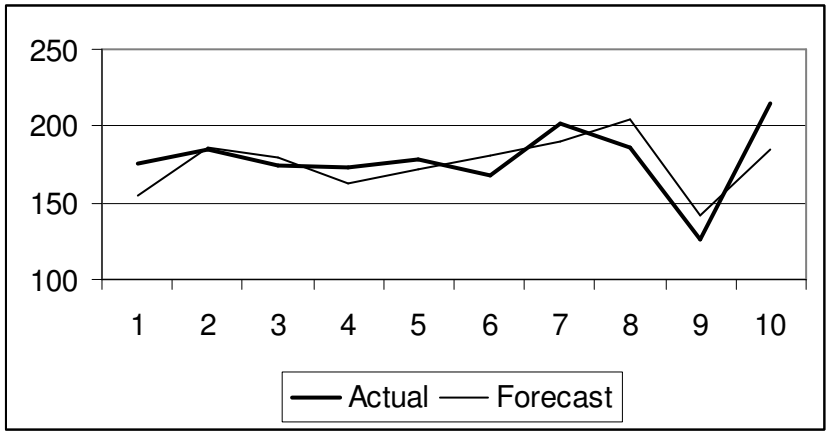


Figure 9.7d. Fit Between Forecast and Actual Tonnages (South Ribble)



Effectively these results add support to the notion introduced in section 2 of this report. "The past is the key to the future". Put another way, current performance may indeed provide a good predictor of future performance.

It should be noted, however, that all the above forecasts were made just using a simple linear trend model with seasonal decomposition. The assumption that the year-on-year 'trend' is actually linear is quite questionable. More sophisticated forecasting models do not necessarily rely on that assumption. Utilisation of more sophisticated models such as ARIMA (Autoregressive integrated moving average) could potentially improve the forward projections.

9.4 Investigation of Possible Factors Influencing Behavioural Differences between Rounds

The correlation analyses of section 9.2 identified two distinct clusters of behaviours in Wyre: Rounds C, D, & E, and rounds H, I, and J respectively. It was also found that these clusters also correlated with the three rounds showing the lowest year-on-year increases and the three with the highest year on-year increases (figure 9.4a). Whether those differences might be explained by demographic differences is now tested. The demographic profiles of each of the

six identified [outlier] rounds are compared to the corresponding profiles for the borough as a whole (figures 9.8 a&b). It is seen in these results that the largest distinguishing feature of the poor performers was the higher than average proportion of semi-detached houses and owner occupations in all three poorly-performing districts. The best performers were in many ways quite similar demographically. Slightly elevated proportions of detached housing, smaller household sizes and more older residents were common amongst these rounds. Whist no definite conclusions can be drawn, it could be hypothesised that demographic sectors outside the traditional recycling base (typified by semi-detached owner occupied housing) may now be catching up? Overall, for the borough as a whole, the effects are quite small. The best stepwise regression model for 1999/00, like its counterpart in 2001/02 only found one significant explanatory variable: 'The proportion of detached housing'. A significant change in the recycling base in Wyre over the last 3 years has not been proven.

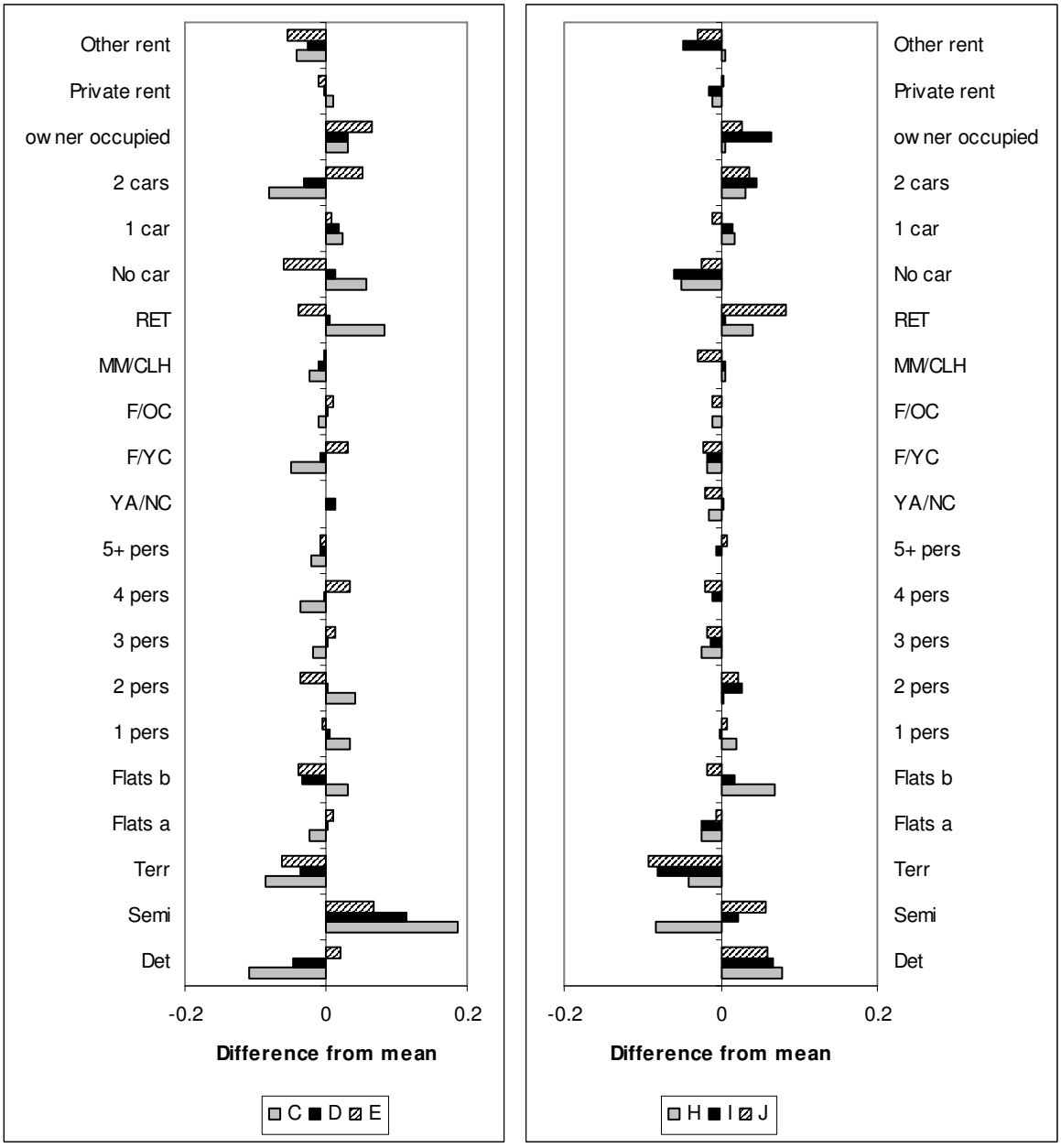
Much more pronounced effects were seen in Burnley. The demographic profiles of the four rounds showing the highest average improvements over the last 18 months are shown in figure 9.9b. Figure 9.9a shows the corresponding profiles for the four rounds with the largest decreases in yield over that period. Again. like figure 9.8, the demographic profiles are plotted in the form of differences from the district means. The results show that the most deteriorating rounds tend to have higher proportions of detached and, possibly, semi-detached housing, high car ownership, and higher than average levels of owner occupation. In contrast the highest improving rounds have lower than average proportions of detached housing, higher than average proportions of purpose-built flats, more single person households, low car ownership and high levels of public sector rented accommodation. These trends amplify what was seen in Wyre, with the yields from the traditional recycling base declining with time whilst that from the less traditional recyclers improved. Overall this shows that there may have been a progressive convergence of paper yields with time over the last 18 months, through demographic differences becoming eroded with time. This effect also shows as a much tighter distribution of yields across all the collection rounds during the more recent period (figure 9.10b). The effect was not apparent in the Wyre data (figure 9.10a).

Univariate regressions of demographic variables against the annual change in yield across all 20 rounds showed the following factors to be significant.

Table 9.4 Demographic Factors Correlated with Changes in Yield

Positively associated with increasing yield	Negatively associated with increasing yield
Purpose-built flats	Detached housing
Converted flats	Four person households
Single person households	One car
Five+ person households	Two cars
No car	Owner occupiers
Public sector rentals	

Figures 9.8 a&b. Differences in Demographic Profiles of Individual Rounds with Low Annual Growth and High Annual Growth compared with the District Mean (Wyre)



Figures 9.9 a&b. Differences in Demographic Profiles of Individual Rounds with Low Annual Growth and High Annual Growth compared with the District Mean (Burnley)

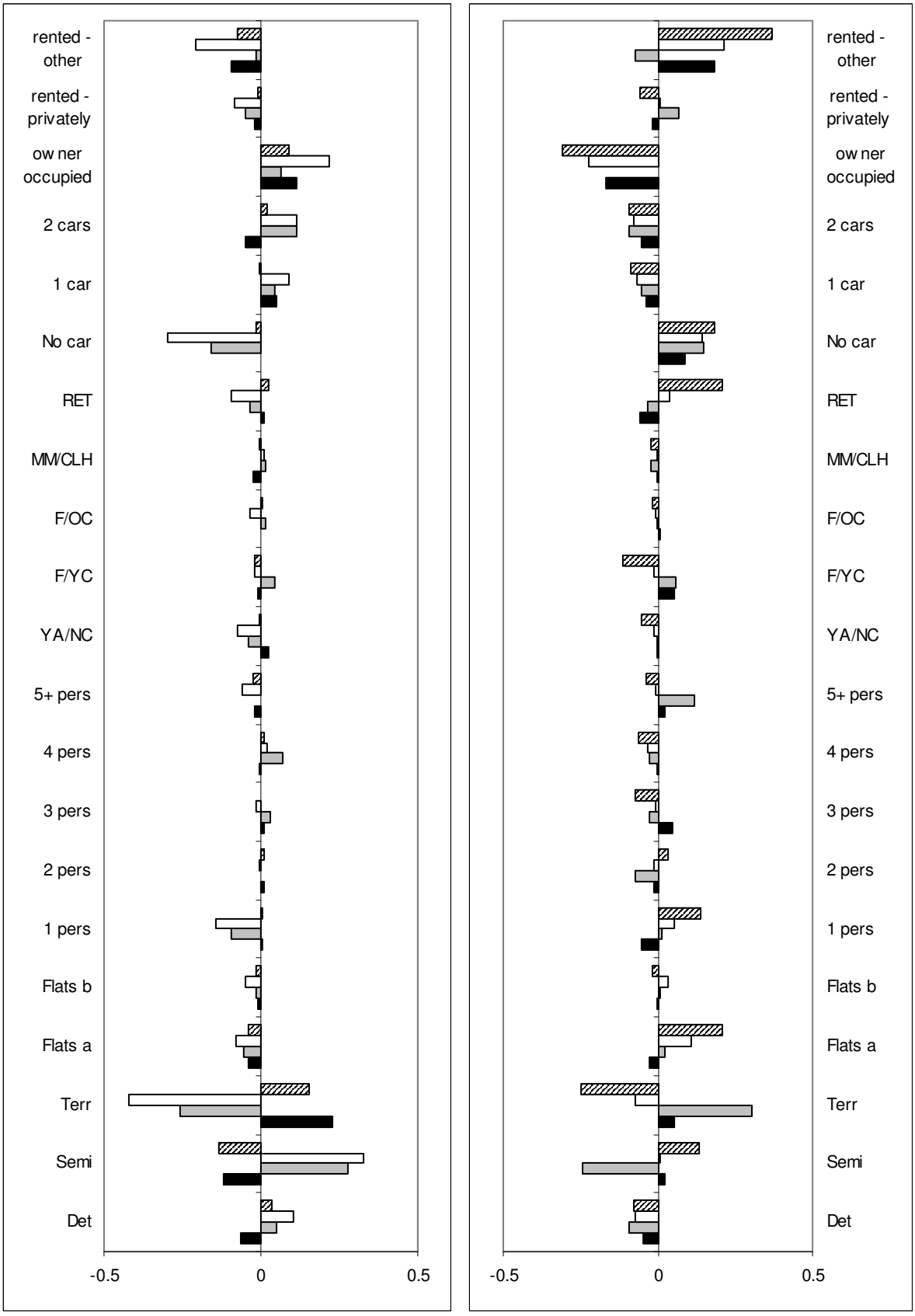


Figure 9.10a Yield Distribution by Year (Wyre)

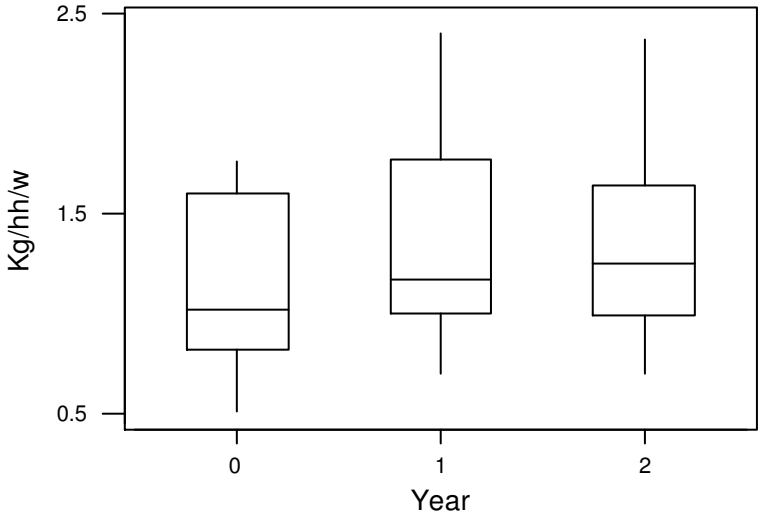
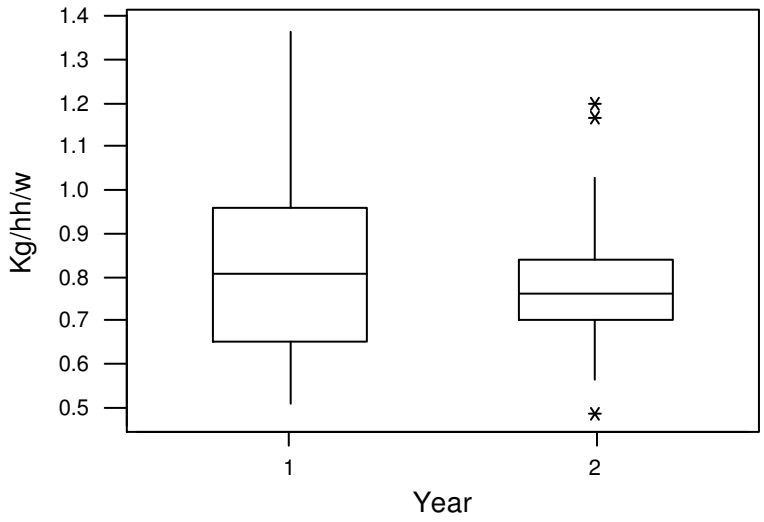


Figure 9.10b Yield Distribution by Year (Burnley)



9.5 Identification of Significant 'Events'

A final aim of the research was to identify the frequency of significant 'step' changes in performance that might be linked to real world events. However, it proved difficult to unambiguously identify such incidents of gross 'irreversible' change amongst any of the rounds studied. Only one possible gross event was identified in 50 rounds from 3 districts over three years. Smaller events, if they occurred, were lost in the noise and simply subsumed into the annual trends. Previous research by the author had identified an event which saw the collapse of participation in one village in Fylde (Tucker, 2001). The effects of that event were spread over a 6 month period, and were not paralleled in neighbouring communities. That

event did not show on the collection round statistics. It would appear that 'events', if they do occur, may be quite localised, with their effects being buffered at collection round level.

9.6 Conclusions

The results show that similar temporal trends in paper yields may be occurring amongst individual districts, with quite similar seasonal indices, but with some variations in their respective year-on-year trends. Future yields should be reasonably predictable from the past performances given a status quo in recycling provision and scheme promotion.

The yearly changes in yield tend to be relatively small (<6%) at district level, though much larger swings can be seen within the individual collections rounds of each district. It is conjectured that more variations could happen in relatively immature schemes before they settle down into more stable behavioural patterns. Whilst the analyses of the previous section showed that traditional demographic indicators may offer some explanation of the performance differences amongst rounds, the time series analyses provide some evidence that those differentials may be reducing.

Finally, it is stressed that the conclusions reached must be considered to be quite tentative due to the relatively small number of data sets upon which they were based, and because of possible limitations and uncertainties in those data.

10. DISCUSSION AND CONCLUSIONS

10.1 Programme Design

Kerbside recycling schemes across the UK can perform very differently even when those schemes outwardly appear quite similar. A similar picture is also painted in the US. Whilst 'more convenient' schemes tend on average to perform better than those perceived to be less convenient, the influence of scheme design parameters on performances are not straightforward. At their upper limit, different scheme designs can all perform equally well. Below that limit, however, there can be performance differentials associated with different design options. The most important parameter may be the type of recycling container supplied to the household, with rigid recycling containers (e.g. boxes and bins) generally outperforming both bags and 'no containment' schemes. Multi-material collections often outperform paper-only collections, in their paper yields as well as their overall yields. The number of materials collected appears positively related to scheme success, though schemes that collect high numbers of materials can be vulnerable to misunderstanding. Kerbside glass collections appear to be working reasonably well (or at least those that are reported are), and it is considered that best practice could well be likely to involve glass recovery within the kerbside collection. The design parameters with the weakest effects on performance (on average) are the frequency of collection and having a same day collection as the residual waste.

The importance of getting the container right should not be underestimated. That container forms the main interface between the public and the scheme. Experiencing problems with the container are one of the major causes of drop-out. The main container-related factors are:

- A sense of ownership (essentially having a container and the assurance that it will be returned intact after it is emptied);
- Storage considerations (outside storage generally being preferred except where there is a high risk of vandalism; also space requirements are important);
- Container size (it must be big enough for requirements, but not too large to handle or to generate false impressions of how much waste is wanted).

The best choice of container may ultimately be decided by market and safety considerations. This will demand a rigid container if glass is to be collected, and depending on how far BS EN643 is implemented may well demand a separate containment system for the paper fraction in order to minimise the risk of cross-contamination. A two container system for dry recyclate may also be forced through weight considerations. With fortnightly or longer collections, 10 Kg or more recyclate will be generated by many households.

However, it must be borne in mind that simply providing a box rather than a bag does not necessarily guarantee good performance. Some box schemes perform quite poorly.

10.2 Information, Education and Promotion

Here we need to consider three main classes of action:

(i) Generic large-scale, centrally-managed 'background' waste awareness campaigns such as "Doing your bit", "Rethink rubbish", "Slim your bin" etc.

The efficacy or cost benefits of such campaigns still remain to be proven. At this stage, they should not be relied upon to produce significant local improvements.

(ii) Local (County or District) reinforcement/ awareness-raising messages.

These campaigns may need to be fairly intensive to break through local ignorance, distrust, and apathy (as witnessed in Kensington and Chelsea). Regular, or follow on, interventions may then be needed to sustain any enhancements of performance into the longer term. Providing group feedback could provide one good strategy here for the maintaining contact and correcting problems.

Unfortunately, nobody has yet found an educational and promotional recipe or panacea that can be guaranteed to work. However, we are somewhat clearer as to what will not work. Rewards, and prizes, for example have never produced any long-term success, and they can be administratively burdensome as well. Yet, even today, they are being tried and, not surprisingly, they still do not work..

One major, and often overlooked, consideration, for successful promotion, is that the timing and point of delivery can be crucial. The message needs to be delivered when the recipient is susceptible to it. That timing is best when household waste management is high on the householder's personal agenda, else the message can get lost amongst other priorities. The optimum timing is when 'waste management considerations' are impacting directly on personal lifestyles. That often coincides with a time of change. This leads on to, what the author believes may be one of the most crucial elements in achieving good practice.

(iii) Promotions at times of managed change.

Whilst there are few common features amongst the successful case studies, the features that many of them do share is that: (i) they were built around managed changes to existing waste or recyclate collection regimes, and (ii) that change had been well promoted. It is believed that the two actions together may be synergistic to the overall success.

Overall, education and promotion may be necessary ingredients to achieving good performance, though they are not sufficient on their own to guarantee good performance.

10.3 Past Experiences, Spatial Coherence, and History

By and large recycling behaviours are quite stable. A recycler will generally continue to recycle into the future whilst a non-recycler will continue not to recycle, even through periods of pressure for behavioural change. Put simply, recycling can be dominated by habit.

The time series analyses showed good correspondences between successive years' recycling performances. Year-on-year changes in kerbside paper yield ranged from 0 to 6% at district level, straddling the estimated 2-3% yearly rise expected from an increasing paper consumption. At collection round level, the variations were much wider, ranging up to 20% or more growth per annum in some rounds. In one authority, the highest growths were associated with rounds containing high proportions of non-traditional recycling groups, with yields deteriorating in rounds with high proportions of traditional recyclers. This indicates that any past demographic dependences may now be being eroded.

The seasonal dependences of the paper yields showed a reasonable correspondence between years and broadly similar seasonal indices were found for all districts analysed. A simple extrapolation of the previous and current seasonal and growth trends to the following year was shown to be a good predictor of the following year's performance. Such forecasts could provide a useful baseline for monitoring purposes.

Significant events to disturb the status quo could be typified by fairly rapid 'irreversible' changes in the tonnages collected. Such changes could result from episodes of poor service, or be due to successful promotions. Only one such 'event' was identified amongst 50 collection rounds in a 3 year period. Such macro-events thus appear to be a minority happening. Actual events may be much more localised, and effectively buffered by the rest of the collection round or lost in the 'noise' of the system.

There was also evidence that similar, coherent behaviours may be occurring between different authorities. Also many coherences were found amongst the individual rounds collection rounds within an authority, though more rounds showed dissimilarities than showed similarities. Thus, whilst there may be a general pervasive factor behind the observed behaviours, specific local factors may significantly mask any effects.

10.4 Demographic Factors

The statistical analyses of kerbside newspaper, pamphlet and magazine yields across Lancashire and the North West of England provided some supporting evidence that areas containing the greater proportions of traditional recycling classes do still tend to recycle greater quantities of paper. The proportions of detached households, car ownership, and retired residents often correlated positively with the higher yields whereas the proportion of flats (especially converted flats), private sector rentals and younger adults often correlated negatively with yields. However no one model was found to apply to all districts, and no individual demographic variable was found to be equally significant within every district. Demographic models fitted simultaneously across the whole county also failed to provide any unique solution. Several different models all provided comparable fits. Furthermore, a significant proportion of the observed variance remained unexplained by every model, and the fits to around 10% of the collection rounds were particularly poor. Some, but not all, of those outliers were of relatively extreme demographics (e.g. very affluent, or a high proportion of younger residents, single householders, and private sector rented flats).

Many districts were found to be quite similar in terms of their demographic profiles, though like the individual collection rounds, there were also definite outliers. Those outliers often corresponded to the authorities with the best and worst paper yields.

As discussed above, there was some evidence that demographic factors may be becoming less important with time, however the generality of any such effect still needs to be confirmed.

10.5 Other Factors

The research was founded on the premise that if best practice in kerbside recycling behaviour could be predicted, the explanatory variables for that prediction must be easy and practical to obtain in order that those predictions could be practical use. The hypotheses were that programme design variables, demographic factors, and past histories might provide the bases for those predictors. In essence could they act as good proxies or surrogates for the attitudes that shape recycling behaviours. The results show that all three classes of variables do have some explanatory powers, though do not provide anything like a complete description. The plan of the research was to ‘fit’ the best models to take account of those factors, then to examine the residuals for any remaining trends, and see if any further explanatory variables might be identified The data sets, however, generally proved to be very noisy and it was difficult to identify any ‘definite features’ that could be definitely attributed to a definite physical cause. We must then accept ‘noise’ as being an intrinsic feature of the system. Whilst part of the noise may be attributable to temporal anomalies associated with local accounting practices, much of the noise has to be considered irrational or random in origin. It is noted that the *Integrated Household Waste Management Model* of the University of Paisley (Tucker, 2001) implicitly builds in a randomness across all of its model variables. This research gives further support for that underlying premise. Of course this does not necessarily mean than more of the observed variances will never be explained. To answer that question, more analyses need to be undertaken, based on larger data sets, with more potential explanatory factors being explored. Finally, as a cautionary note, it is stressed that whilst we glibly talk about attitudes being the real predictors of behaviours, it is noted that attitudinal research has also failed to explain the observed variations in recycling behaviour. Whilst

some attitudes have been identified as important, many behaviours still appears quite irrational.

10.6 Best Practice?

So what does all this tell us about best practice? First, there appears to be one overriding and sobering fact: "You have got what you have got, and tomorrow you will probably get again what you got yesterday!" … unless you can engineer something quite dramatic! Clearly, some areas of the community are making significant year-on-year improvements in recycling performance (whilst some other areas are dropping down) though such effects are quite localised and substantially diluted in the borough-wide figures. So how do you stimulate better performance across the whole district? There is no evidence that awareness, education and promotion on their own can provide any answer. Even the most highly intensive, personal contact campaigns only added a few percentage points to their borough-wide recycling rates. Making recycling easier, more convenient, and 'more attractive' provides a second route towards better practice. Yet the supposed 'optimum' programme design variables do not always return best performance. But when you put the facilities change and promotion and education together…..?

A second point is in the significant 'natural' changes that may be occurring at neighbourhood levels. These local 'ups' and 'downs' can balance out over a whole district and be lost in the district-wide statistics. Good practice will be in sustaining the 'ups' whilst preventing the 'downs'. Localised actions may well provide the best management solutions here. However, before that can be done, it becomes essential to understand the local pictures in more detail. In this respect it is important to routinely monitor performances at those local levels. Good practice has to take a bottom-up approach. Individual households, streets and neighbourhoods remain the most important variables in the community.

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APPENDIX A: ILLUSTRATION OF THE EVOLUTION OF A STEPWISE REGRESSION EQUATION

Step	1	2	3	4	5	6	7
No constant							
4 pers	5.70	3.87	2.01	2.45	0.96		
T-Value	17.12	7.82	2.82	3.35	1.08		
P-Value	0.000	0.000	0.006	0.001	0.283		
Det		2.14	3.03	3.12	3.05	3.34	3.08
T-Value		4.57	5.98	6.27	6.41	8.53	7.90
P-Value		0.000	0.000	0.000	0.000	0.000	0.000
rento			0.97	0.99	0.73	0.83	1.27
T-Value			3.43	3.57	2.62	3.14	4.13
P-Value			0.001	0.001	0.011	0.003	0.000
Flats b				-2.1	-4.2	-4.4	-4.6
T-Value				-1.99	-3.32	-3.57	-3.83
P-Value				0.051	0.001	0.001	0.000
RET					1.17	1.45	1.82
T-Value					2.74	4.32	5.14
P-Value					0.008	0.000	0.000
Flats a							-2.07
T-Value							-2.54
P-Value							0.013

Step	8	9	10	11
No constant				
4 pers				
T-Value				
P-Value				
Det	3.29	3.00	1.75	2.14
T-Value	8.06	6.85	3.35	3.74
P-Value	0.000	0.000	0.001	0.000
rento	1.28	1.86	2.46	2.42
T-Value	4.21	4.14	5.59	5.54
P-Value	0.000	0.000	0.000	0.000
Flats b	-4.6	-4.3	-3.0	-2.7
T-Value	-3.89	-3.68	-2.67	-2.41
P-Value	0.000	0.000	0.010	0.019
RET	2.19	3.15	3.81	4.13
T-Value	5.19	4.56	5.83	6.10
P-Value	0.000	0.000	0.000	0.000
Flats a	-2.20	-2.37	-2.53	-2.47
T-Value	-2.71	-2.95	-3.44	-3.39
P-Value	0.009	0.004	0.001	0.001
Semi	-0.45	-0.70	-1.31	-1.31
T-Value	-1.57	-2.19	-3.93	-3.97
P-Value	0.122	0.032	0.000	0.000
No car		-0.86	-2.30	-1.88
T-Value		-1.74	-3.86	-2.91
P-Value		0.087	0.000	0.005
F/OC			8.7	13.8
T-Value			3.71	3.48
P-Value			0.000	0.001
MM/CLH				-2.1
T-Value				-1.58
P-Value				0.118