Environmental Sciences

An investigation into ‘fly-tipping’ in the Borough of Slough

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ABSTRACT

Fly-tipping is the unlawful deposit of waste in an unauthorised location. Recorded incidents of fly-tipping in the UK have increased in recent years after nearly a decade of decline. In 2014/15 UK Local Authorities spent £50 million clearing fly-tipped waste from public land. Fly-tipping is relevant from an environmental justice perspective as certain communities appear to be disproportionately burdened by fly-tipping. In an attempt to assist local authorities in tackling fly-tipping the UK Department for the Environment, food and Rural Affairs introduced the Fly-capture database in 2004 for the recording of local authority data on fly-tipping. However, there remains a paucity of research concerning fly-tipping in the UK and the drivers and possible solutions are poorly understood. This investigation focused on the borough of Slough; examining how rates of fly-tipping reported to the Local Authority varied geographically and over time between 2010 and 2015. The rate of fly-tipping increased over the period studied, with monthly variability appearing irregular and lacking in seasonality. Statistically significant correlations were found between the rate of fly-tipping and multiple deprivations scores ($r = 0.67$ at 95% CI) and the % of resident population in privately rented accommodation ($r = 0.46$ at 95% CI). The implication of these findings are discussed and recommendations for improving the Local Authority response are made.

INTRODUCTION

Fly-tipping is defined as the illegal depositing of waste in an unauthorised location. Fly-tipping is a criminal offence in the UK by virtue of Section 33 of the Environmental Protection Act 1990 and is punishable by an unlimited fine or up to five years imprisonment if convicted in the Crown Court *(HMSO, 1990)*. Local Authorities (LAs) share responsibility for the enforcement of this statute with the Environment Agency.

Fly-tipping is a 'catch-all' terminology conventionally used to describe offences wide ranging in their extent; from deposits of single sacks of household rubbish to industrial scale tipping of tonnes of commercial waste. The House of Commons Environmental Audit Committee in 2003 expressed concern that the term fly-tipping underplays the severity of an offence that has a profound impact on the environment and society (Papworth and Thompson, 2009).

In 2013/2014 English Local Authorities (LAs) dealt with 852,000 cases of fly-tipping. This represented a significant increase of 20% compared with the previous year (Priestly, Bennet and Pratt, 2016). There was a further 5.6% increase in 2014/2015 with local authorities reporting 900,000. The estimated cost to English Local of clearing this fly-tipped waste Authorities was £50 million (DEFRA 2015).

The apparent increase in fly-tipping is a major cause for concern for LAs in the UK as they are legally obliged to keep public land within their jurisdiction free from litter and refuse and are therefore unable to avoid the costs associated with the collection and disposal of fly-tipped waste. However the impact of fly-tipping is not merely financial. It is postulated that fly-tipping impacts more widely on the environment, the economy and society.

The natural response of LAs and the Environment Agency to dealing with fly-tipping is to regulate and enforce, and both organisations have a range of enforcement tools at their disposal (Webb 2006). However, for a variety of reasons criminal convictions for fly-tipping are relatively few than 1% of the cases reported in 2014/15 resulted in a criminal conviction (DEFRA, 2015). Furthermore there is a paucity of evidence concerning the effectiveness of enforcement and other

interventions in tackling fly-tipping and other environmental offences such as littering.

If fly-tipping is to be tackled effectively, a more proactive evidence based approach is required, involving careful examination of the factors which drive people to illegally dump waste, so that local strategies can be devised, implemented and assessed for their efficacy. However the current lack of good quality research in the area of fly-tipping is likely to undermine this approach and a far larger and better quality evidence base is required.

Aims and objectives of study

The overall aim of this study is to contribute to the reduction of fly-tipping in Slough by the fulfilment of the following objectives:

1. To briefly explore DEFRA fly-capture data for Slough to provide context to the Slough fly-tipping problem.
2. To examine temporal patterns in fly-tipping in Slough and explore any emerging trends.
3. To map cases of fly-tipping reported to and recorded by Slough Borough Council
4. To use the mapped data to identify fly-tipping 'hotspots' within the borough of Slough
5. To explore the relationships between the levels of fly-tipping in particular neighbourhoods in Slough with the socio-economic characteristics of those neighbourhoods.
6. To critically assess the quality of the available data on fly-tipping in Slough and suggest ways in which its accuracy, reliability and therefore usefulness could be improved.

It was the original intention of the researcher to analyse data sets from 2 other Local Authorities and to compare their results with those of Slough Borough Council. Freedom of information requests were made to the Local Authorities in question but it was perceived that the cost of responding would be excessive so the request were refused under section 12 of the Freedom of Act. As such the

objectives of the research were amended but the overall aim of the project remained the same.

LITERATURE REVIEW

The Impacts of fly-tipping

Financial

Local Authorities are obliged under Section 89 of the Environmental Protection Act 1990 to as far as is reasonably practicable, keep specified public land in their area clear of litter and refuse (DEFRA, 2006). The cost of fulfilling this obligation is funded through Council Tax.

For legal, political and practical reasons it is not possible to increase council tax revenue in response to a sudden requirement for more frequent cleansing of public land As such money must be diverted from other LA services to cover the additional collection and disposal costs of arising from increases in the level of fly-tipping on public land (reference).

The impact on LA resources is not restricted to clearance and disposal costs. Under section 79 of the Environmental Protection Act 1990, Local Authorities are duty bound to both c*ause its area to be inspected from time to time to detect statutory nuisance'* and '*where a complaint of a statutory nuisance is made to it by a person living within its area, to take such steps as are reasonably practicable to investigate the complaint*' (HMSO, 1990).

Statutory nuisances can include *'any accumulation or deposit which is prejudicial to health or a nuisance'* and the duties described above extend to any land or property within the LA area; not just land maintainable at Public Expense.

The concept of 'nuisance' is not explicitly defined in statute but has evolved through case law, so the determination of whether a deposit is likely to cause a nuisance or not requires at least a basic investigation by an appropriately trained officer (Jenkins, 2006); an investigation which of course has to be resourced. This is

perhaps a hidden cost to Local authorities that does not appear to be reflected in the literature or in government publications concerning fly-tipping.

Environmental Impacts:

The ecological impact of fly-tipping will depend very much on the type, scale and location of the deposit and a great deal of literature is available concerning effects arising from the improper disposal of specific categories of products; particularly in the developing world where municipal waste management services are patchy or non- existent (Minh et al 2006)

A detailed discussion is beyond the scope of this study but the literature highlights the following effects; contamination of soil and water by heavy metals, PCBS and Dioxins (Lemanowicz et al, 2016; Mazza et al, 2015) physical injury to wildlife (Williams and Simmons 1996 and 1999) (Williams and Deakin 2007) and air pollution arising from the combustion of fly-tipped waste either by spontaneous combustion or arson (Horner 1993).

Perhaps the most discernible environmental impact of fly-tipping is its aesthetic effect. Accumulations of waste and litter make an area look dirty and un-cared for (Webb et. al 2016); they can also cause nuisance odours and provide food and harbourage for rodents and other pests of public health significance (Traweger et al 2006; Della et al 2010).

Wider societal impacts:

Many of the impacts of fly-tipping are perhaps quite obvious and, given the collection of the correct data, relatively easy to measure. But fly-tipping has been linked with wider, perhaps more abstract effects.

Studies have suggested that the presence of fly-tipping and other 'social incivilities', like littering, graffiti and fly-posting in an area; encourage the commission of more serious offences such as theft, vandalism and violent crime. This phenomenon was described in 1982 by Wilson and Kelling as the 'broken window effect' (Brown, Perkins, Brown, 2004; Jenkins, 2015, Pitner, Yu, Brown, 2012). The theory is not without its detractors, and the cause-effect relationship is no doubt questionable,

but there is some evidence of its applicability to litter and fly-tipping in the UK (Webb et al 2006),

There is also evidence that the visible presence of 'small scale' crime or anti-social behaviour creates a perception amongst individuals that there is a more general crime problem in their area making them feel less safe, less trusting and consequently; the community in which they live less cohesive (Innes 2004; Webb et al 2006). A person's fear of crime and perception of their community has been shown to be negatively associated with health and wellbeing and this association is strongest amongst already socially isolated groups (Lorenc et al, 2013)

Moreover, it has been postulated that fly-tipping disproportionately effects the most deprived communities (Pellow 2004, Jenkins 2015) and discourages inward investment (Encams 2003).

Overall the evidence for the inclusion of fly-tipping in discussions about social and environmental justice are strong and the justifications for tackling the problem go beyond mere aesthetics and economics. Tackling fly-tipping can contribute to breaking the downward cycle of social and environmental degradation that plagues some communities already faced with a catalogue of disadvantages and help to improve environmental equality

Drivers for fly-tipping

The reason behind individuals' decisions to deposit waste are likely to vary. For example the factors driving a householder to fly-tip an excess sack of domestic waste are unlikely to be the same factors influencing a contractor to dump large quantities of commercial waste.

The literature does however indicate the existence of relationships between levels of illegal dumping and certain socio-economic and geographic variables, from which hypotheses about possible drivers can be inferred and explored.

One potential factor is the cost of legitimate waste disposal. A number of studies have examined the effect of 'pay per unit' schemes on the levels of illegal dumping of household waste and highlighted a positive relationship between the cost of the

schemes and the levels of illegal dumping (Kelleher, Kim and Chang, 2008; Miranda and Bynum, 2002; Kinnaman and Fullerton, 2000)

The collection of household waste in the UK is free at the point of collection so it is perhaps reasonable to suggest that cost is likely to be less important when considering drivers for the fly-tipping of household waste in the UK. However, LA's are able to charge for the collection of bulky items i.e. any items that don't fit into a cylindrical container of dimensions 750 millimetres by 1000mms (Hodson and Williams 2011)

Qualitative evidence obtained by Hodson and Williams in 2011 suggests that the cost of legitimate disposal does influence the levels of fly-tipping of this type of waste.

The argument that the cost of legitimate disposal is strongly influential might be bolstered by the findings of Hodson and Williams (2011) and Masamuto and Takeuchi (2011), of a negative relationship between affluence and levels of illegal dumping within a particular area. However, a population's affluence may determine or be determined by many other demographic characteristics which have in turn been advanced as possible drivers for fly-tipping, including population density, levels of education and car ownership, predominant housing and tenure type, and land use type (Hodson and Williams in 2011).

It is in the case of commercial fly-tipping where cost of legitimate disposal is perhaps most significant. Webb et al (2006) conducted interviews with commercial waste handlers and producers and individuals who had previously been prosecuted for fly-tipping (2006). Cost of legitimate disposal was consistently mentioned as a factor in the offender's decision to fly-tip. The cost saving, or in some cases money making potential of fly-tipping was perceived as worth the risk when balanced against the perceived risk of being caught and prosecuted; and the low level fine they would receive if convicted (Webb et al 2006).

The importance of enforcement has been highlighted in other studies relating to illegal dumping. Sigman (1999) Shinkuma and Managi (2012) point to a negative relationship

between the enforcement of anti- dumping laws and the levels of illegal dumping. While Ichinose and Yamamoto (2011) found that in Japan increasing the level of penalty for dumping, reduces the frequency of illegal dumping incidents.

However, there is little available evidence about the effectiveness of enforcement in deterring fly-tipping in the UK. Local Authorities in the UK spent £17.6 million on fly-tipping enforcement in 2014/15; this represented an increase on the previous year (DEFRA, 2015). There is no absolute statutory obligation to take enforcement action against fly-tippers; only to remove the waste or deal with Statutory Nuisance. Which begs the question, what is the justification for such expenditure? And furthermore, if the justification for taking enforcement action is that it is a means of reducing fly-tipping in the long term; on what evidence do local authorities base this assumption?

It seems logical to suppose that increasing enforcement activity will increase both the actual and perceived risk of an offender being apprehended and that consequently levels of offending will fall, but various studies on enforcement, question this common supposition. For example Parker (2006) discussed the failure of enforcement to ensure regulatory compliance by failing to alter business' moral perceptions of the regulation being enforced. Another study by Wilson (2006) examined the effect of additional law enforcement on offending. He found that the deterrent effect was not equitable across all crime types, with additional enforcement having a greater effect on the levels of more serious and violent offences than on 'minor' offences.

Other possible covariates for fly-tipping include Housing tenure and type. In their study concerning the county of Hampshire, Hodsman and Williams (2011) uncovered a relationship between the proportion of rented accommodation in an area and levels of fly-tipping. This particular relationship might be particularly relevant to the study area included in this research, as Slough has higher than the UK average (mean) levels of rented accommodation (SBC, 2016) and a link between housing Tenure and the rate of other crimes in Slough has already been postulated (Higgins and Jarman, 2015).

As well as the cost of legitimate disposal, the convenience and ease of disposal have been suggested as important. Both qualitative (Webb 2006) and quantitative research (Ichinose and Yamamoto 2011) indicate that the availability of legitimate waste management facilities affect the amount of illegal dumping of waste.

One important factor yet to be mentioned is the increasing amount of waste generated by the population. It seems intuitive that an increase in the total amount of waste generated will result in increased levels of fly-tipping. This finding has been confirmed by amongst others Sedova (2016) and is an important consideration when examining the relationship between fly-tipping rates and other variables.

Fly-Capture Database

In an attempt to help LAs and the Environment Agency tackle fly-tipping DEFRA introduced the 'Fly-capture Database' in 2004. Fly-capture was a web based system used to collate data from LAs on the incidence of fly-tipping in their area; as well as information about the type, size and location of fly-tips.

Fly-capture was also used to record the number and type of actions taken by Local Authorities to reduce fly-tipping (Priestley, Bennet and Pratt 2016). The database closed in 2015 and the same data is now recorded through WasteDataFlow, another web based system for recording data on municipal waste (Priestley, Bennet and Pratt 2016).

To ensure consistency in reporting between local authorities DEFRA issued technical guidance on what constitutes fly-tipping for reporting purposes but stressed that the restricted definition was only to be applied in relation to fly-capture, not for example, when deciding whether an offence has been committed.

The bar chart in **Figure 1** shows a steady downward trend in the number of fly-tips reported to fly-capture between 2007 and 2013 and increase from 2013 -2015. This reversal in trend was quite extensively reported in the media (Rawstorne, 2016) However, DEFRA advised caution in the interpretation of the recent increase, stating that many local authorities qualified their data returns with possible explanations for the increases including the introduction of new technologies for reporting and recording fly-tipping data (DEFRA, 2015).

But in reality, all of the data collected by fly-capture must be interpreted with caution. The application of inconsistent definitions of fly-tipping between local authorities is recognised as a significant problem. For example 'side waste' (that is waste left by householders for collection other than in a LA receptacle) can be 'fly-tipping' but it is not consistently treated as such by local authorities (Webb 2006; Priestly, Bennet and Pratt, 2016).

Furthermore, fly-capture only included data concerning fly-tips on public land, therefore a proportion of fly-tips i.e. those occurring on private land, which have been demonstrated to cause considerable economic damage to landowners are not reflected in the fly-capture statistics.

Finally, the fly- capture records contain only aggregated data (Webb 2006). For example, the total number of fly tips on highways, the total number of construction waste fly-tips. This limits the analytical possibilities of the data, as subtle relationships for example between type of waste, location, and volume cannot be explored.

Nevertheless, fly- capture data is not without value as it can provide context to locally gathered data, highlight trends which can be explored more thoroughly through qualitative and quantitative research and guide local authorities and central government in prioritising interventions. Perhaps one of the most important headline statistics from fly-capture is the persistently large contribution of household waste to the total number of fly-tips each year; illustrated in **figure 2.**

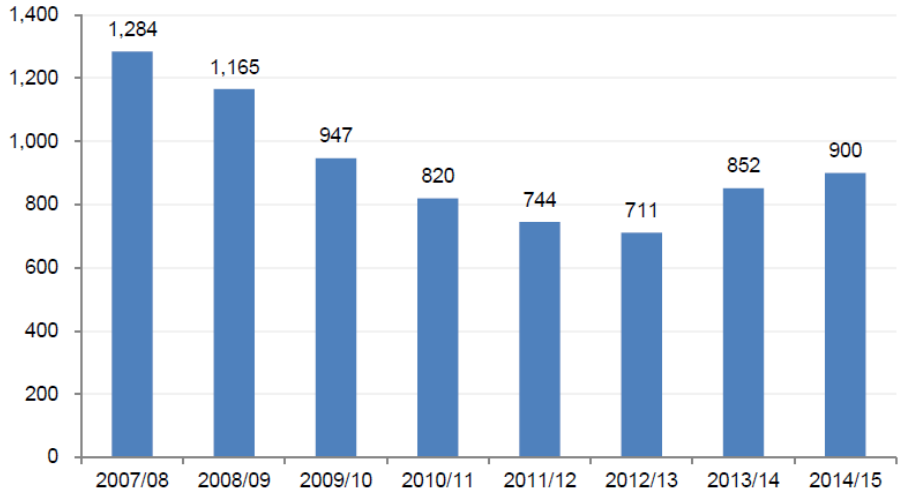


Figure 1: *The bar chart shows the trend in the number of fly-tipping incidents in England reported to Fly-capture between 2007 and 2015. Source: DEFRA/ Government Statistical Service Available at:* *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/469566/Flycapture_201415_Statistical_release_FINAL.pdf*

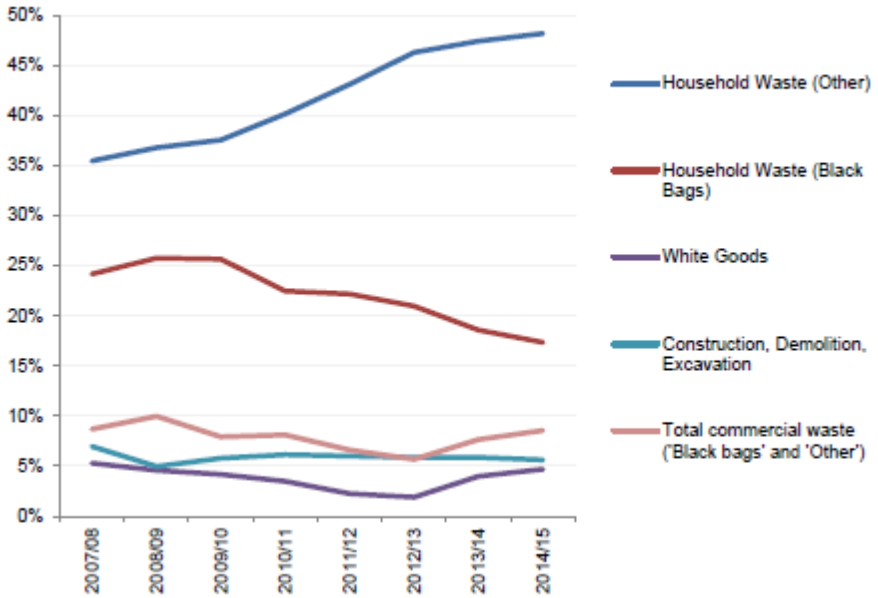


Figure 2*: Time-series showing the number of fly-tipping incidents in England as a proportion of total incidents. Source: Source: DEFRA/ Government Statistical Service Available at:* *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/469566/Flycapture_201415_Statistical_release_FINAL.pdf*

Profile of Study Area- Slough, Berkshire

Slough is a unitary authority in the County of Berkshire in the South East of England, lying approximately 30Km West of London. The latest estimates for Slough suggest a population of 144600 (ONS, 2015)

Slough is an economically vibrant town. The UK and European headquarters of a number of major multinational companies are based in the town. A recent Employment Impact Study published estimated that at least one quarter of the residents in Slough are dependent on income from Heathrow which only a few miles from the town (Parsons Brinckerhoff and Berkeley Hanover Consulting, 2013).

Despite the buoyant economy in Slough, levels of inactivity amongst Slough residents was above the UK average in 2015 and levels of deprivation increased between 2010 and 2015 relative to the rest of England (SBC, 2016). Five neighbourhoods in Slough are in the 10-20% most deprived category in UK.

At the time of the last census Slough had the most diverse population in the UK outside London. A school census in 2012 recorded over 150 languages spoken.

In 2015 Slough Borough Council launched its 5 year plan which was updated in 2016 (SBC, 2016[2]). The plan contains a number of objectives including encouraging investment, reducing crime, improving the image of the town and increasing community cohesion (SBC, 2016[2]). The evidence explored in the preceding literature review suggests that reducing fly-tipping in Slough could potentially contribute to the achievement of 'Five Year Plan' objectives.

Waste collection Services in Slough

Households in Slough are provided with two bins for the storage of their household waste each of 270 litres capacity; one for mixed recyclables and the other for non-recyclable waste. On request residents can obtain an additional 270 litre capacity bin for their green waste (SBC, 2015)

Slough Borough Council charge a fee of £30.75 for the collection of up to 5 bulky waste items. A reduced fee is applied for households where the sole occupants are

pensioners or are registered disabled. A commercial collection and disposal fee is charged to landlords of privately rented accommodation. It is perhaps important to note, especially considering the importance of convenience as a driver for fly-tipping in the literature, that payment for this service must be made up front but can only be made by cash, cheque or postal order (SBC, 2015).

Officers from Slough Borough Council's Neighbourhood Services section are responsible for recording an investigating cases of fly-tipping and other environmental crime. They are also charged with dealing with land owners who persistently fail to clear waste from their land, through the service of legal notices.

Records pertaining to fly-tipping are entered onto the 'Civica Community Protection database' where officers are required to add details of their investigations.

A proportion of reported fly-tipping cases are referred directly to Slough's Waste Collection Contractor (WCC) Service Level Agreements between the WCC and the LA dictate how quickly the WCC must remove fly-tipping from public land. Many fly-tips are removed before a thorough investigation into the source of the tip are carried out.

METHOD

Data collection

Fly-tipping-data

The variable chosen to represent the extent of fly-tipping in Slough was the 'fly-tipping rate per 1000 population'. The volume of waste fly-tipped is therefore not accounted for in this study.

Fly-tipping data was obtained from two sources. Slough Borough Council's Civica Public Protection Database. This database is used to record all reports of fly-tipping by members of the public, and by patrolling local authority officers.

Entries in the database are coded according to category and type. There are multiple 'type' codes used to record fly-tipping. The database contains within it a report generating function which was used to create Excel spreadsheets listing all entries coded with a 'fly-tipping' type code between April 2010 and March 2015.

The second set of data came from Slough Borough Council's Waste Collection contractor (WCC). The WCC often collects fly-tipped waste before it is reported to Slough Borough Council so for completeness, a Freedom of Information Request was made to The Environmental Services Department at Slough Borough Council for data concerning all fly-tips collected by the WCC, by date and location between April 2004 (to coincide with the launch of Fly-capture) and March 2015.

Unfortunately, the WCC was only able to provide data as far back as April 2010. This restricted the overall scope of this study.

The fly-tipping data from both sources were extensively searched for duplicates and for wrongly coded reports i.e. those cases that were coded as fly-tipping but actually related to, for example fly-posting. These reports were removed from the list.

It is important to note that the strict criteria applied by DEFRA for inclusion in reporting to 'Fly-capture' was not applied in this study. The justification for this approach is examined in the discussion section of this report.

Annual and monthly total fly-tipping *counts* were established for each year of the study and using population data, annual and monthly fly-tipping *rates* were calculated per 1000 population.

Population data

Population data was obtained from the Neighbourhood Statistics pages of the Office for National Statistics (ONS) Website. This website allows the user to tailor spreadsheets of data covering a range of geographical and administrative areas.

At the Local Authority level, Mid-Year Population Estimates were available up to Jun 2014. As no population estimate was available for 2015, the mean annual population growth for the preceding 3 years was used to estimate a mid-year population for 2015.

To allow for changes in population to be fully accounted for this study required the calculation of monthly fly-tipping rates and therefore monthly population estimates. These were calculated as follows:

Pop'n of Month X= Pop'n of month X-1 + (annual population change/12)

(This of course assumes a steady increase in population throughout the year)

The mid- year population estimate was used to calculate annual rates. Mid- year was taken to be October for the purpose of this study.

Deprivation and other Demographic data

Deprivation is multi-faceted and subjective and can therefore be measured using a variety of indicators. The index of multiple deprivation (IMD) is the Governments standard measure of deprivation at the local level (DCLG, 2015). IMD provide a single deprivation score for a population based on six indicators weighted according to their perceived significance; income, employment, education and training, housing, access to services and health and disability.

IMD scores are available via the ONS website at the Lower Layer Super Output Area (LSOA). Super Output areas are geographical areas designed for the compilation and publication of statistics (ONS, 2016). This research used the 2010 LSOA IMD scores for Slough as these were the most recently published at the time of commencement of this study, and their publication coincided with the beginning of the period studied.
All other demographic data was obtained via the ONS neighbourhood Statistics which were based on the results of the 2011 census.

Data Analysis

Temporal variability

Data was recorded, presented and analysed using Microsoft Excel® and the data analysis and presentation tools contained within it.

In order to decide the most appropriate statistics to use to describe the data, histograms were created to establish the distribution of the data. Mean and standard deviations were calculated using the appropriate functions in Microsoft Excel.

Time Series plots of monthly fly-tipping rates were created using Excel, and examined for trend and seasonality. Time series can generally be decomposed into 3 elements:

1. Trend- the long term movement of the series
2. Seasonality- systematic patterns that occur at regular and predictable intervals

3. Irregularities/residuals- random unpredictable fluctuations which might arise from a range of sources

In a time series the 'signal' for each component can be obscured by the other components In order to detect the trend the data was 'smoothed' by the calculation of 12 month moving averages followed by the centred moving means. The centred moving means were plotted, and a linear regression model applied.

A subseries plot was created to establish whether the data possessed any seasonality. This was further explored by 'de-trending' the data and plotting the differences in the rate of fly-tipping between each consecutive month.

Mapping and spatial variability

Sorted fly-tipping data was mapped by postcode using Pitney Bowes Spectral Spatial Analyst Software.

Note: Some geographical information was missing from the 2010/11 and 2014/2015 datasets and consequently the data had to be excluded from this part of the analysis.

Many of the fly-tipping reports contained only references to a street. So during the data sorting process, a large number of post-codes had to be entered manually. Where the reports made reference to a specific nearby address or landmark the post code of this address or landmark was used to record the location of the fly-tip. Where the report only specified a street name, the postcode for the middle address in the street was used. Post codes were obtained via either the Civica Community Protection Database, or if this was not possible the web based Royal Mail Post Code finder (Royal Mail, 2016).

Due to access restrictions in effect on the mapping system Slough Borough Council's Mapping Officer was asked to upload the sorted data onto the system.

From the mapped data it was possible to establish annual fly-tipping rates per unit of population in each LSOA. An overall mean annual fly-tipping rate for each LSOA

for the the middle 3 years of the data set was calculated using the 2012 mid-year population estimates.

Scatter Plots comparing the LSOA mean annual fly-tipping rates with the relevant IMD scores were created. A trend line was generated according to the 'least squares' method and its corresponding equation and correlation coefficient generated.

The correlation coefficient, denoted by R is a measure of the strength and direction of a linear relationship between two variables. Values range from –1, a perfect negative correlation, to 0 signifying no correlation to 1, a perfect positive correlation. The residual is the vertical distance between each data point and the trend line. The value of each residual is a measure of how much the observed Y value differs from the predicted Y value generated by the trend line and its corresponding equation. The residual values were used to identify outliers.

The distribution of the residuals was used to assess the applicability of the linear regression model.

Though the use of LSOAs allows for subtle analysis of the data, day to day Slough Borough Council presents much of its data on the basis of electoral ward (personal communication, 2015) To maximise the usefulness of this research, fly-tipping rates for each electoral ward were calculated and comparisons drawn.

Note: following the 2011 census 2 of the LSOAs were divided up and 4 new LSOA areas were created. At the commencement of this project IMD scores were not available for the newly created LSOAs and the new boundaries were not available on the mapping database. The fly-tipping rates for the two LSOAs were therefore excluded from the regression analysis. However, as the LSOA boundary changes did not affect the overall ward boundaries, the data was included in the calculation of the electoral ward fly-tipping rates.

RESULTS

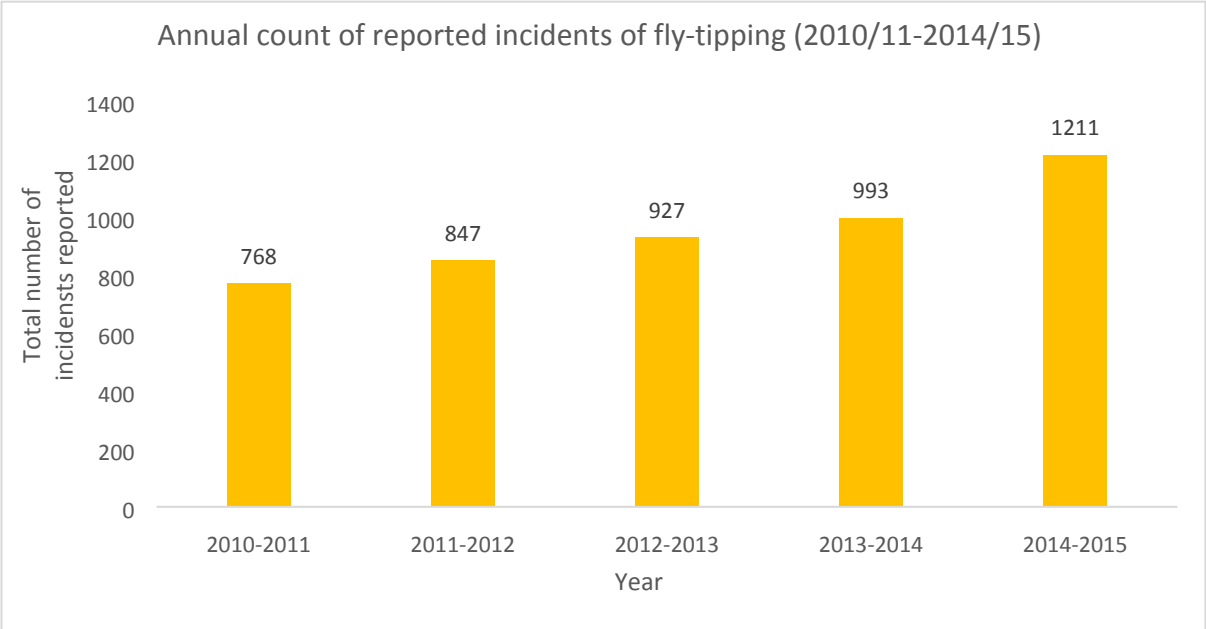


***Figure 3**: Bar chart showing total annual count of fly-tipping incidents between 2010/11 and 2014/15*

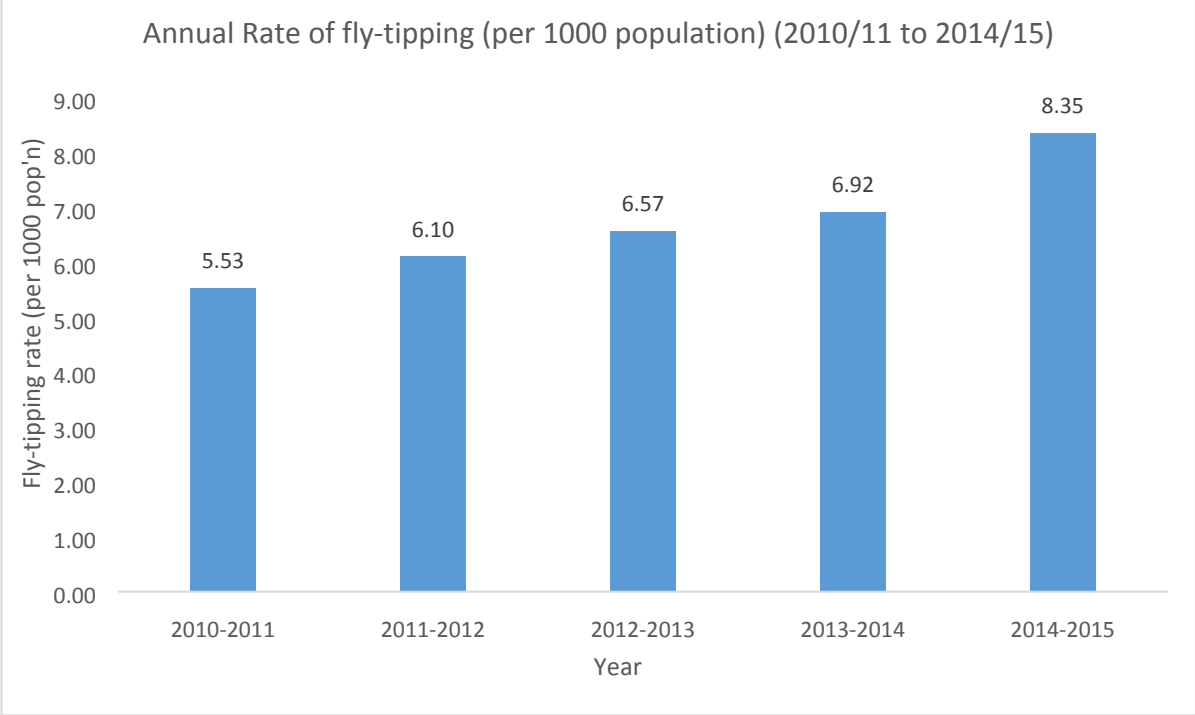


***Figure 4**: Annual rate of fly-tipping per 1000 population between 2010/11 and 2014/15*

Figures 3 and 4 show the annual total counts and annual rates of fly-tipping (per 1000 of population) respectively. They are virtually identical in their appearance.

Never-the-less to ensure consistency fly-tipping rates are use predominantly for the remainder of this study.

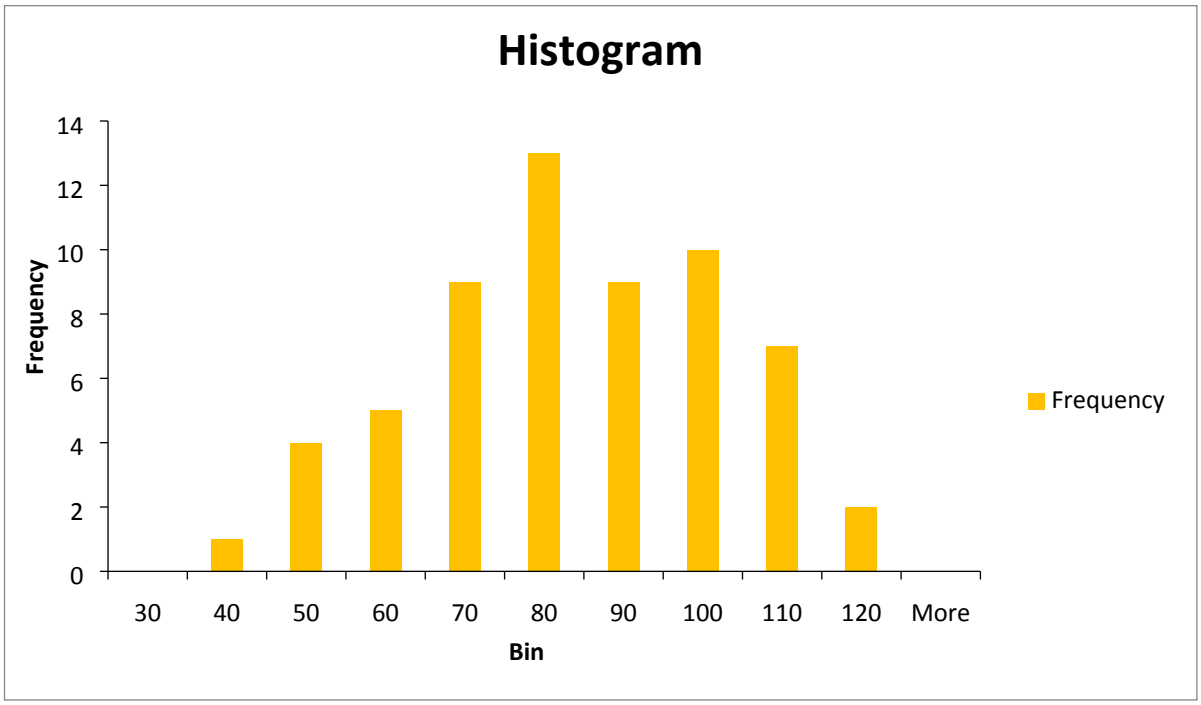


***Figure 5**: Histogram showing distribution of monthly fly-tipping counts.*

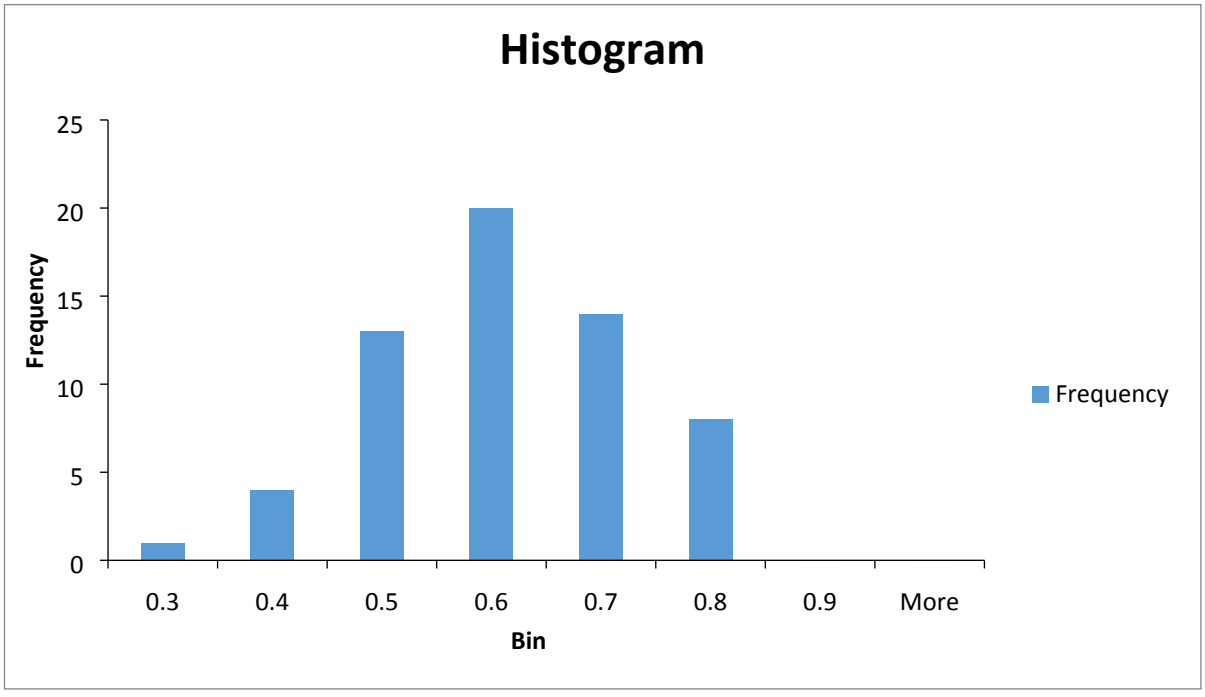


***Figure 6**: Histogram showing distribution of monthly fly-tipping rates (per 1000 population).*

The histograms pictured in **figures 5 and 6** both fit the 'bell shaped curve' of a Normal distribution well. This is important as it determines the type of statistics

that can be applied to the dataset and allows some simple but useful conclusions to be drawn.

Year	Rates	Mean	Std Dev	Mean +/- SD	
2010-2011	5.53	6.70	0.95	- 1 SD	4.80
2011-2012	6.10			+1 SD	5.75
2012-2013	6.57				
2013-2014	6.92			- 2 SD	6.92
2014-2015	8.35			+ 2 SD	8.59

Figure 7 *Table showing the mean and standard deviation for the annual rates of fly-tipping between 2010/11 and 2014/15*

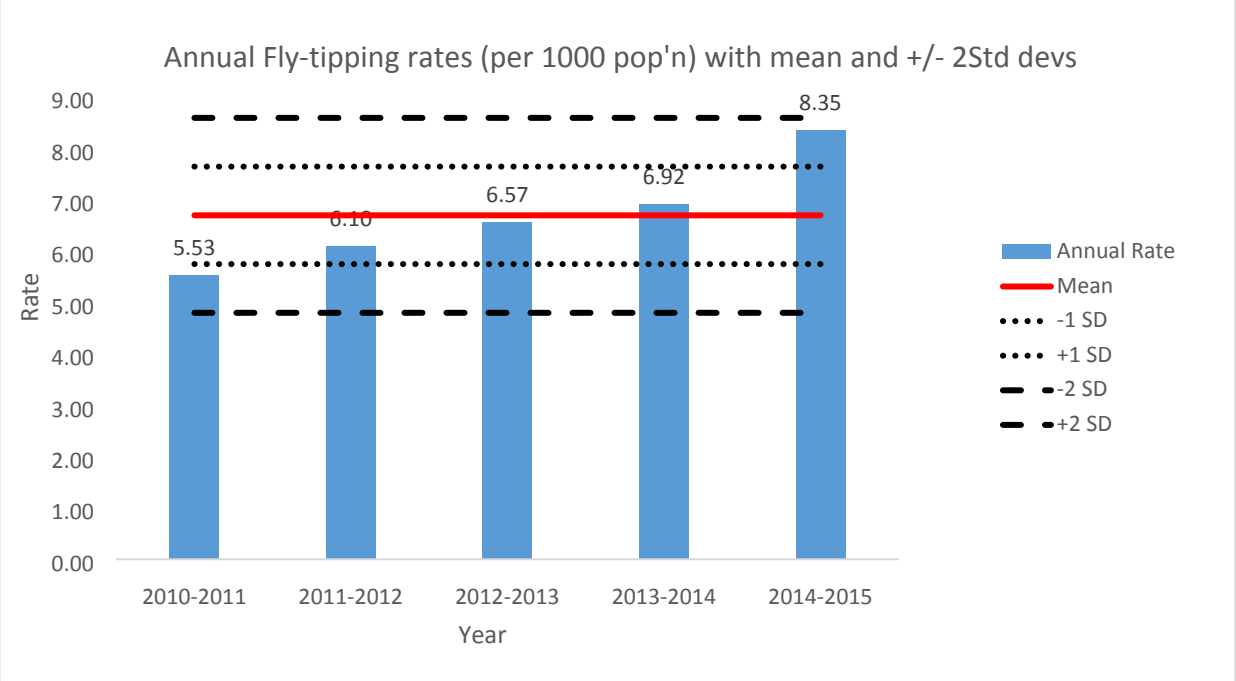


Figure 8 *Annual fly-tipping rates and associated mean and standard deviations from table in figure 6.*

The table and graphs depicted in **figures 7 and 8** illustrate that the individual annual fly-tipping rates do not vary hugely from the mean annual fly-tipping rate for the period studied. The graph clearly illustrates that 3 of the 4 years studied have fly-tipping rates within 1 standard deviation of the mean and all, have rates within 2 standard deviations of the mean. As such, it is perhaps reasonable to say that despite the obvious step increase in fly-tipping throughout the period studied, the

variability is quite small when considering the data set as a whole. Another way of examining the data would be to calculate the % difference from year to year.

Year	Rates	% increase
2010-2011	5.53	
2011-2012	6.10	10.29
2012-2013	6.57	7.66
2013-2014	6.92	5.28
2014-2015	8.35	20.69

***Figure 9**: Table of % changes in fly-tipping rates between each financial year*

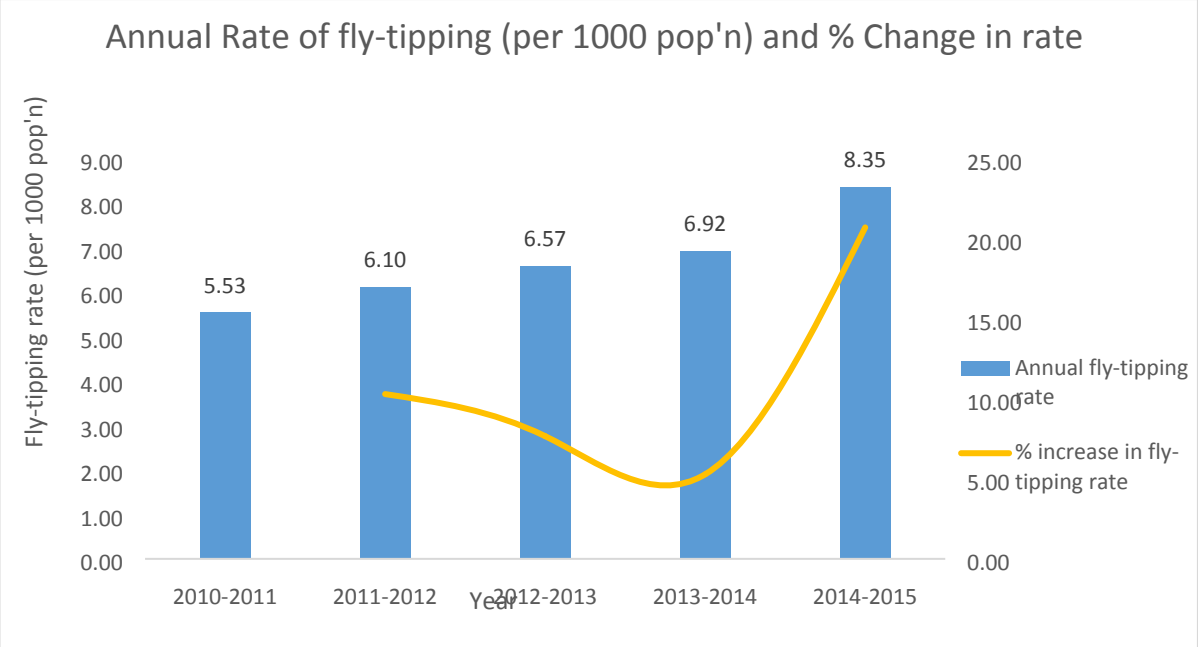


Figure 10 Annual rate of fly tipping and % change in rate each year

Figures 9 and 10 together show the percentage change in the rate of fly-tipping between each year studied. Although the fly-tipping rates are increasing between 2010/11 and 2013/14 the difference between each year is getting smaller, suggesting the rate of increase is slowing. However, between 2013/14 and 2014/15 there is a sudden increase in the percentage change.

In order to further explore the change in fly-tipping rates over the study period a basic time series plot of monthly fly-tipping rates was created.

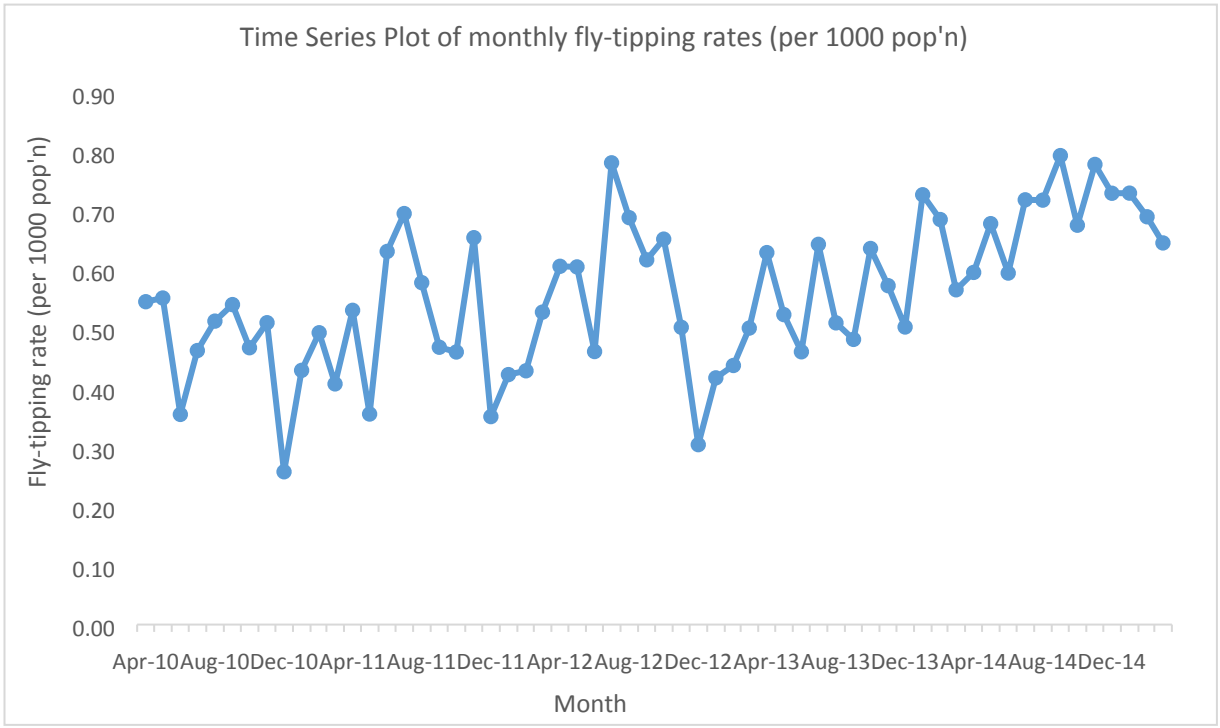


***Figure 11**: Time series plot of monthly fly-tipping rates*

As discussed in the methods section, time series can be decomposed into trend, seasonality and irregular components. A simple visual inspection of the time series plot in **figure 11** indicates a small positive trend, and considerable random variability. A slight seasonal effect may be present; note the position of the points for December in each year however further analysis is required to separate the data into its component parts.

As explained in the methods section the data was 'smoothed' using 12 month moving averages and centred moving means. The centred moving means and associated regression line are plotted alongside the monthly fly-tipping rates in **Figure 12. (**As the time intervals for the time series are evenly spaced, for simplicity months have been replaced with numbers in the X axis).

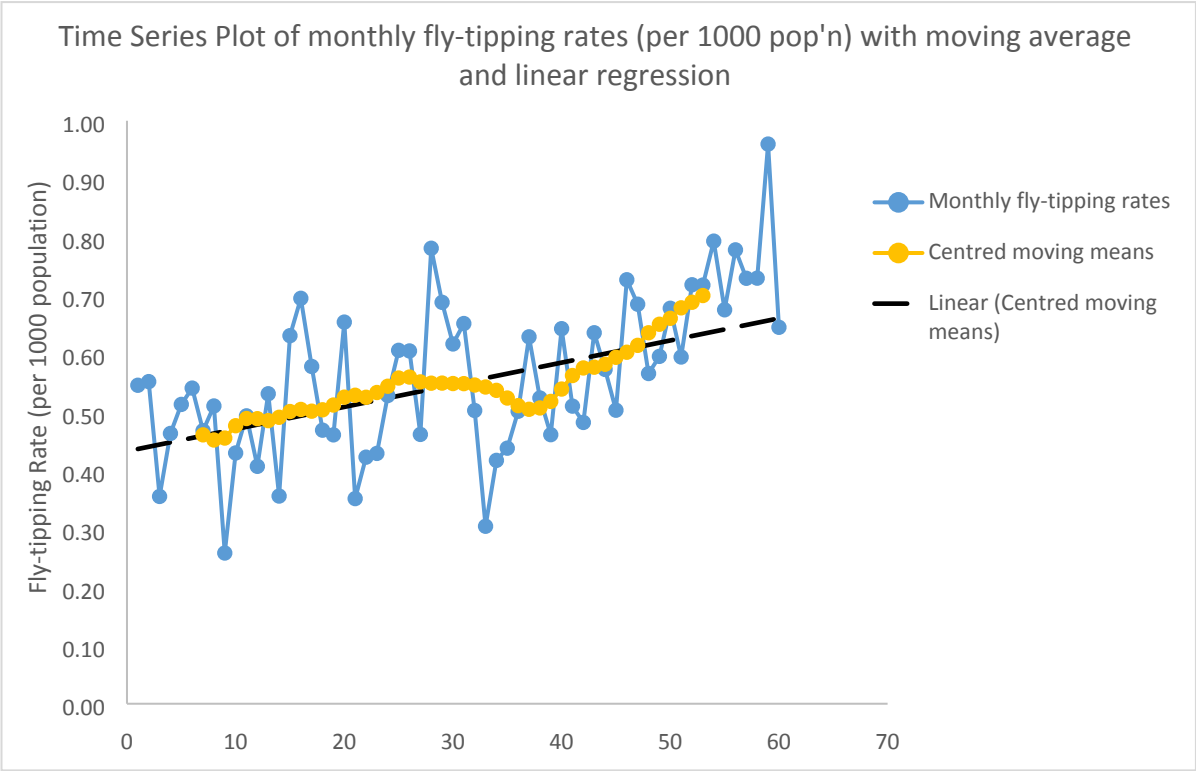


Figure 12: *Shows the centred moving means for the fly-tipping rates with regression line and corresponding equation.*

The R^2 and r values for the regression line in **figure 12** indicate a strong trend in fly-tipping over the period studied, confirming the conclusion drawn from the initial examination of figure 8. The linear model fits the early part of the data relatively well but it is clear that it cannot fully explain the trend in the data. As such, it would be unwise to make predictions of future fly-tipping based on a linear model. Further investigations into the most appropriate statistical model for the dataset are beyond the scope of this research.

In order to establish if there is indeed a seasonal component to the data, a simple seasonal subseries plot was created and is shown in **figure 13**.

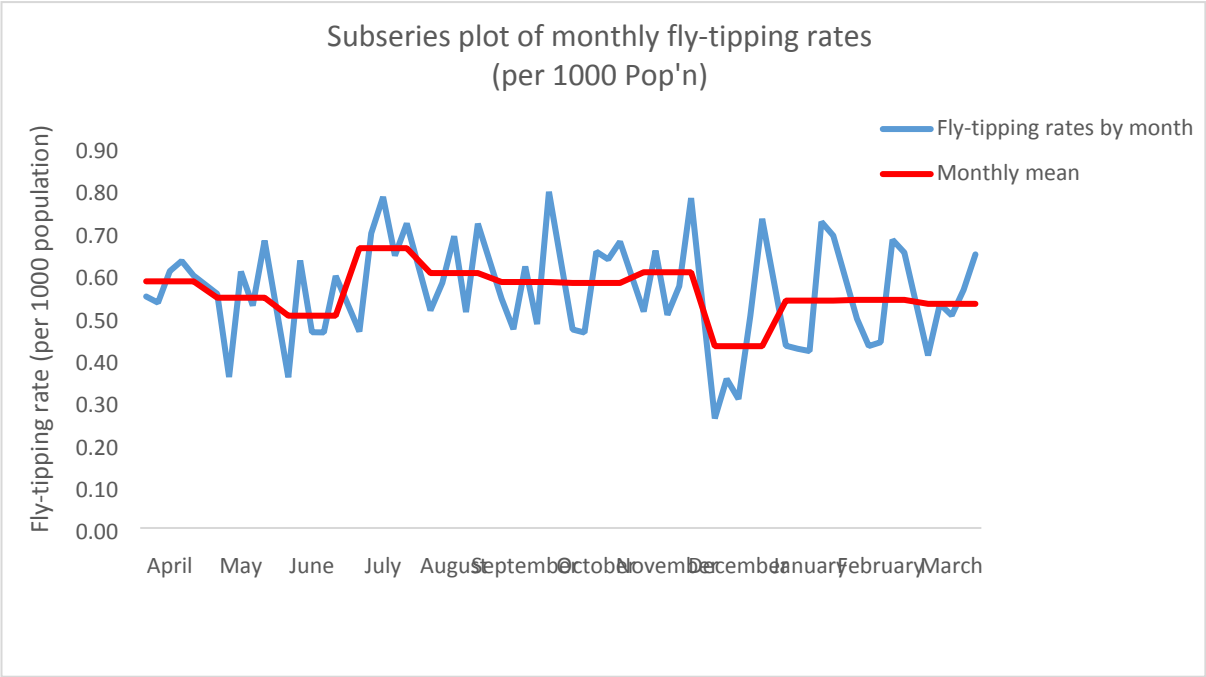


Figure 13: *Subseries plot. Fly-tipping rates for the same month from each year are grouped together. The solid red line represent the means of each month.*

Figure 13 shows that with the exception of July and December, the means for the equivalent months in each year of the study, hover between 0.5 and 0.6 fly-tipping incidents per month per 1000 population. This might support the existence of seasonal effect associated with July and December but of course, as already evidenced there is a positive trend in the data set, and simply comparing the means does not take account of this. So the data was 'de-trended' by simply calculating the differences between each consecutive monthly fly-tipping rate. The differences were then plotted against time.

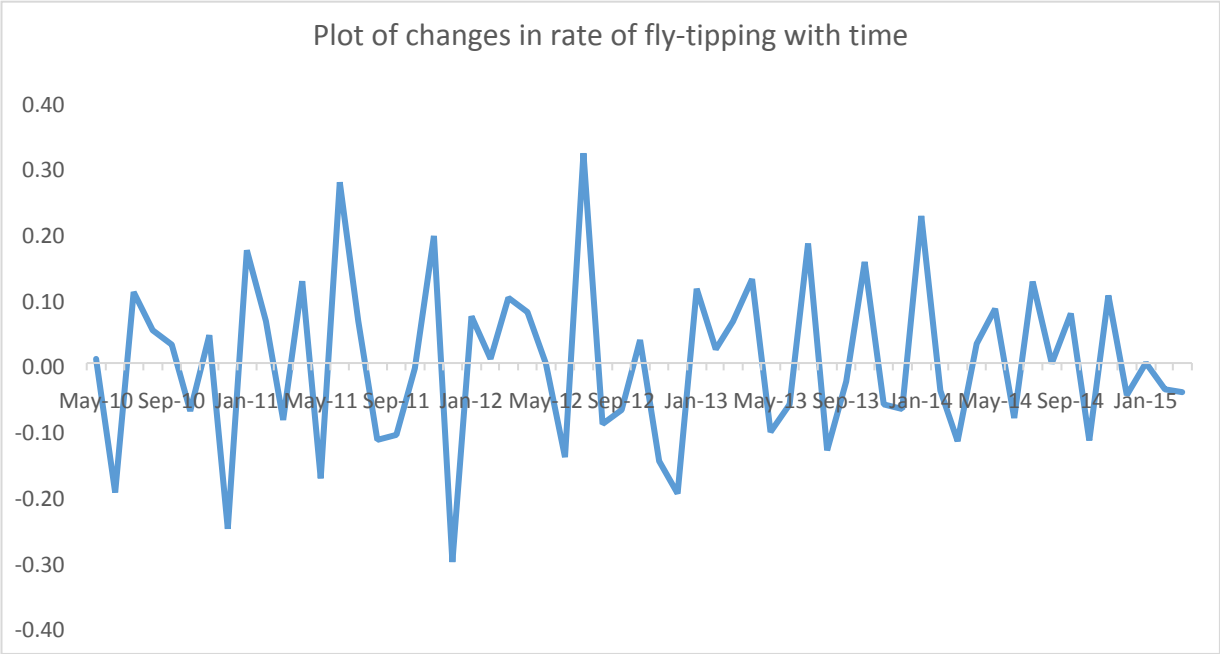


***Figure 14**: Plot of the differences in fly-tipping rates between consecutive months*

Though the de-trended data continues to show some obvious peaks in the early part of the series for July, and troughs for December the effects appear neither pronounced in their magnitude nor persistent in frequency and it is concluded that there is insufficient evidence in this dataset to conclude that a seasonal effect exists. A larger dataset with more data points would reveal if a persistent seasonal effect does exist.

DEFRA reporting rate and Slough Borough Council figures

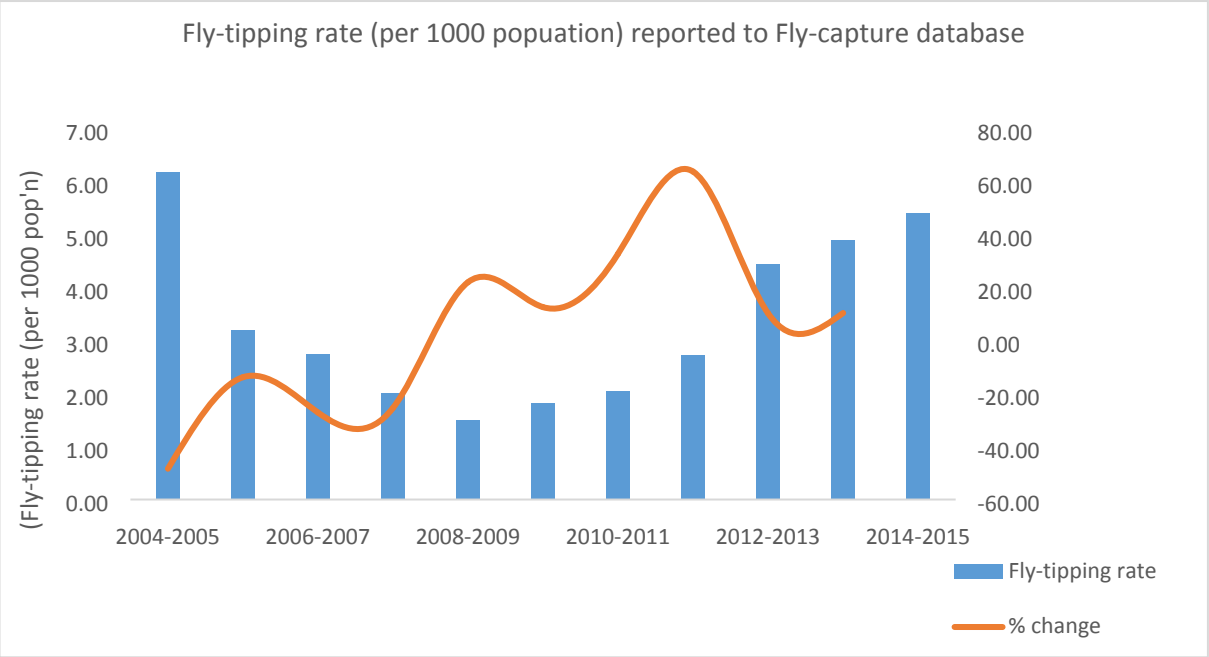


***Figure 15**: Bar Chart showing the annual rates of fly-tipping in Slough reported to the Environment Agency and extracted from the Fly-capture database. The line graph shows the % change in fly-tipping rate (Y axis on the right)*

The graph in **figure 15** shows the annual rate of fly-tipping as reported to DEFRA by Slough Borough Council via the web based fly-capture database since its conception in 2004. The graph concurs with the trend observed in previous figures of an increase in the rate of fly-tipping between 2010 and 2015 However, the inter-annual changes show a different pattern with the greatest increase being observed between 2011/12 and 2012/2013.

Year	Annual Fly-tipping count (Slough data)	Annual Fly-tipping Count (DEFRA data)	% of total cases reported to DEFRA
2010-2011	768	282	36.7
2011-2012	847	382	45.1
2012-2013	927	630	68.0
2013-2014	993	700	70.5
2014-2015	1211	781	64.5

***Figure 16**: Table showing the annual fly-tipping counts contained with Slough Borough Council's data and the annual counts according to DEFRA Fly-capture data (extracted from the fly-capture database). The third column shows the proportion of the fly-tipping reports to Slough Borough Council which are also reported to DEFRA for inclusion in fly-capture.*

Geographic Variation in the Rate of fly-tipping in Slough

In order to establish how the rate of fly-tipping varies across the borough of Slough, approximate locations of each reported incident were mapped. The points on **Figure 17** are indicative of the locations of individual fly-tipping incidents over three, of the five years of the study 2011/12, 2012/13 and 2013/14. The remaining two years of data were excluded as explained in METHODS.

There is clearly huge variability in the locations of the incidents and there are no obvious 'hotspots'. However there are clearly areas from where there are few or no reported incidents.

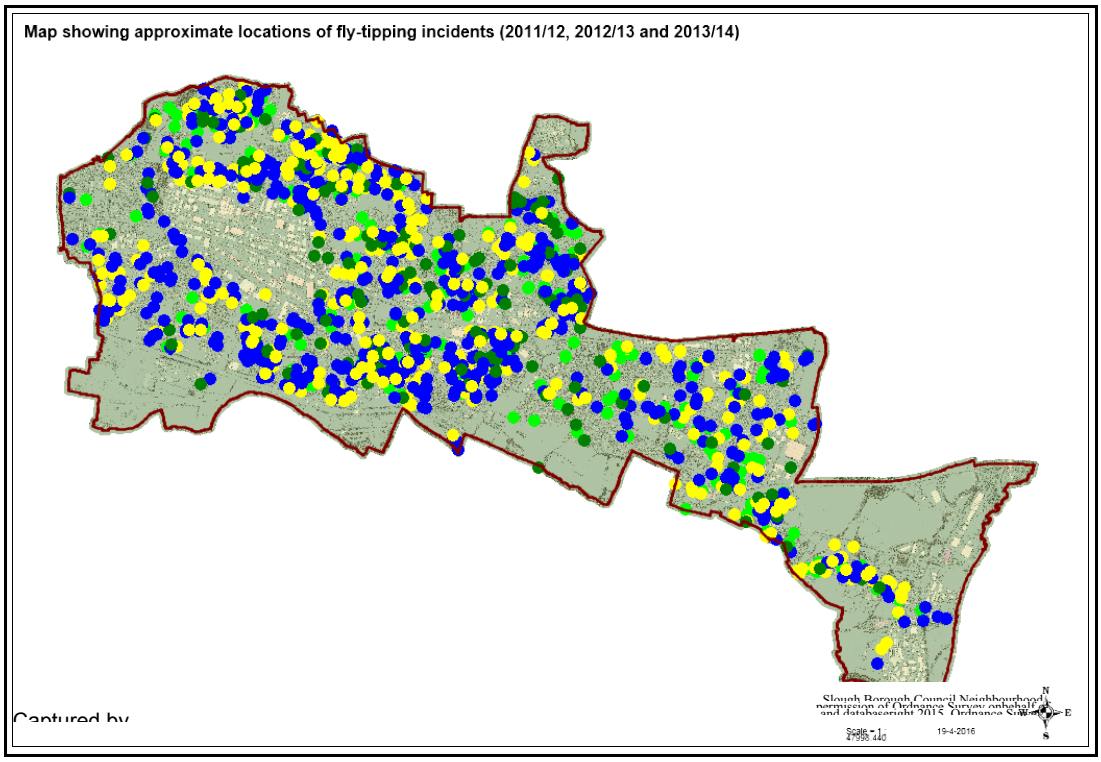


Figure 17: *map of fly-tipping incidents (each dot represents an incident of fly-tipping)*

Figure 18 shows the 2010 LSOA boundaries in Slough. Each LSOA is shaded according to its deprivation score at the time of the 2010 Census. The map was created using census data already mapped onto the Spectrum Spatial Analyst

programme and was not created specifically for this study. **Figure 19 shows** the pre 2014 electoral ward boundaries

The mapped fly-tipping data points within each LSOA area and ward area for each year were counted and annual mean LSOA, and annual mean electoral ward fly-tipping rates were calculated.

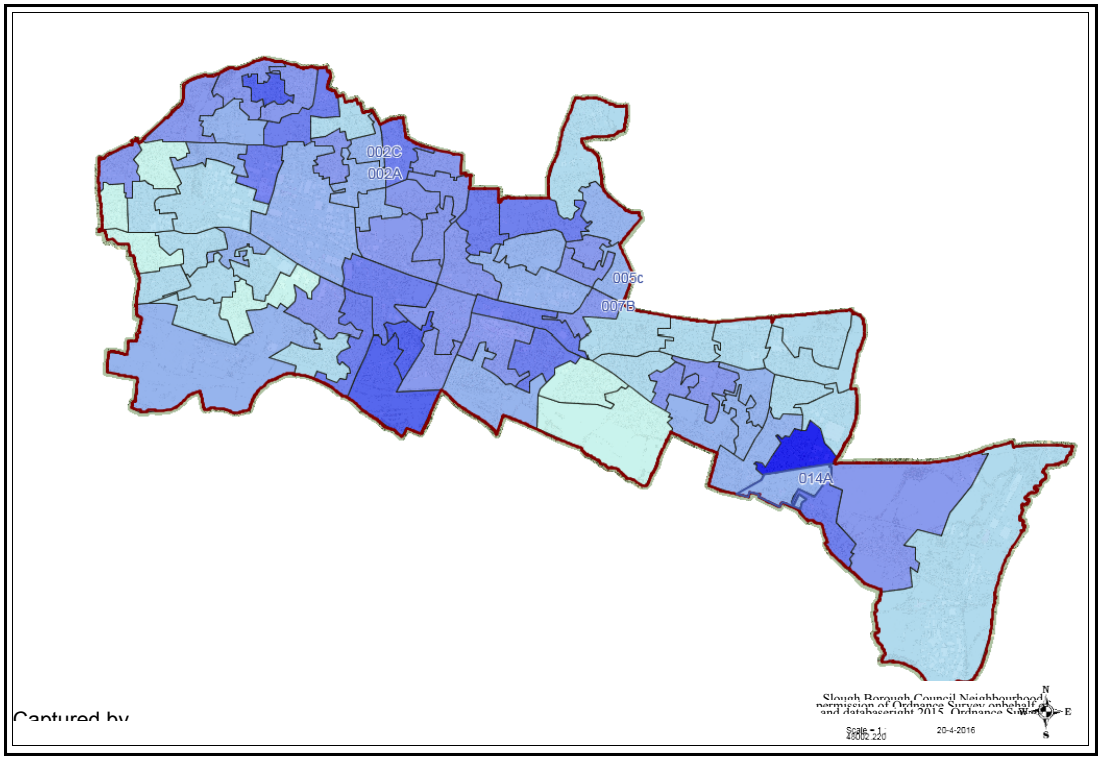
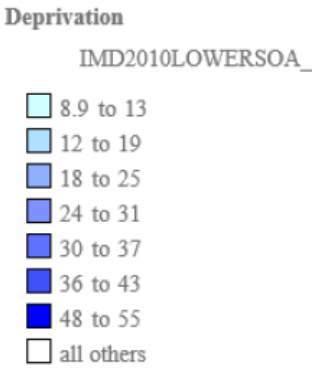


Figure 18: *Map showing Lower Super Output Area boundaries in Slough. The Location of the outliers referred to later in this study are shown. Areas are shaded according to their IMD score range. (See legend)*



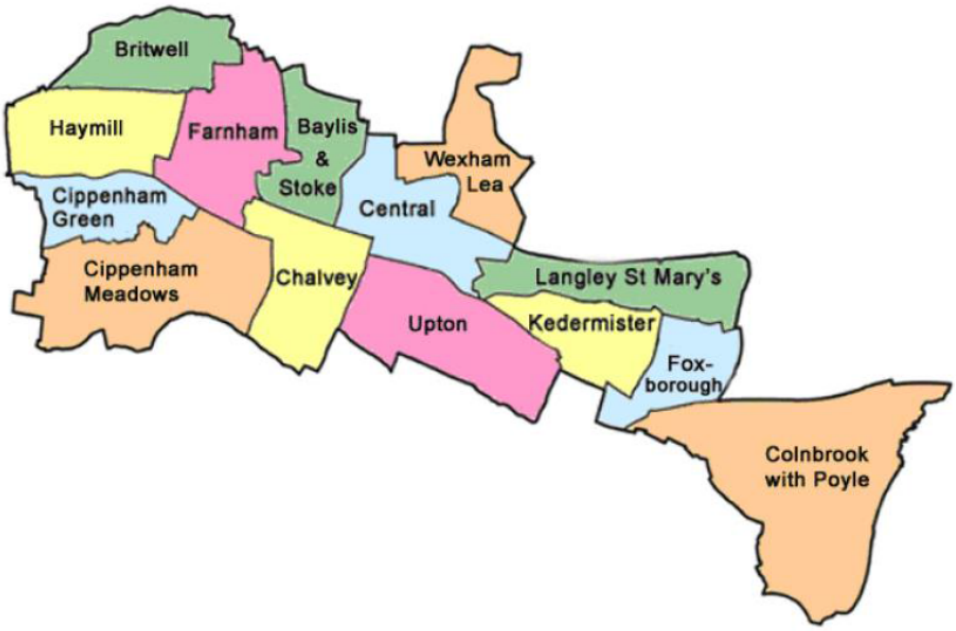


Figure 19 *Map of Slough Borough denoting electoral ward boundaries*

Figures 20 and 21 show the total number of fly-tips and rate of fly-tipping per 1000 population in each electoral ward in Slough between 2011/12 and 2013/14 Note the difference in ranking between the two charts.

In both figures the wards are ranked from most to least affected (left to right). The disparity between the 3 most and 3 least affected wards is clear, there are approximately 6 more fly-tipping incidents per head of the population per year in Central, Farnham and Colnbrook and Poyle than there are in Langley St Mary's, Cippenham Green and Haymill.

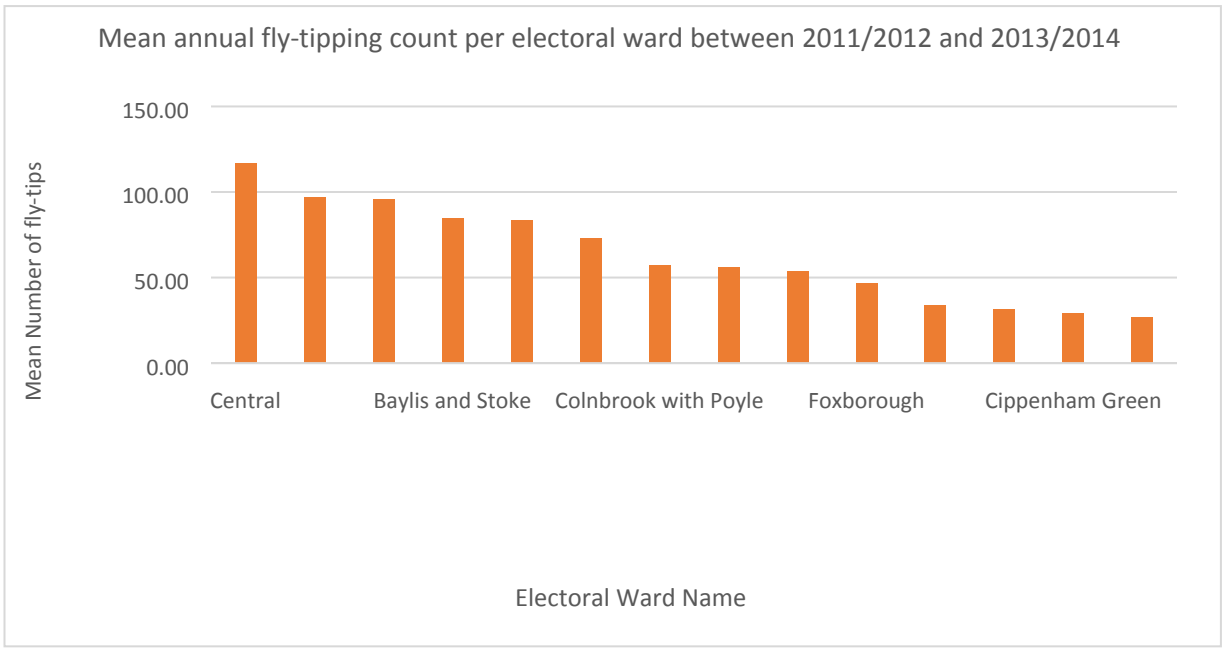


***Figure 20**: Bar chart showing the mean annual number of fly-tips per electoral ward in Slough between 2011/12 and 2013/14.*

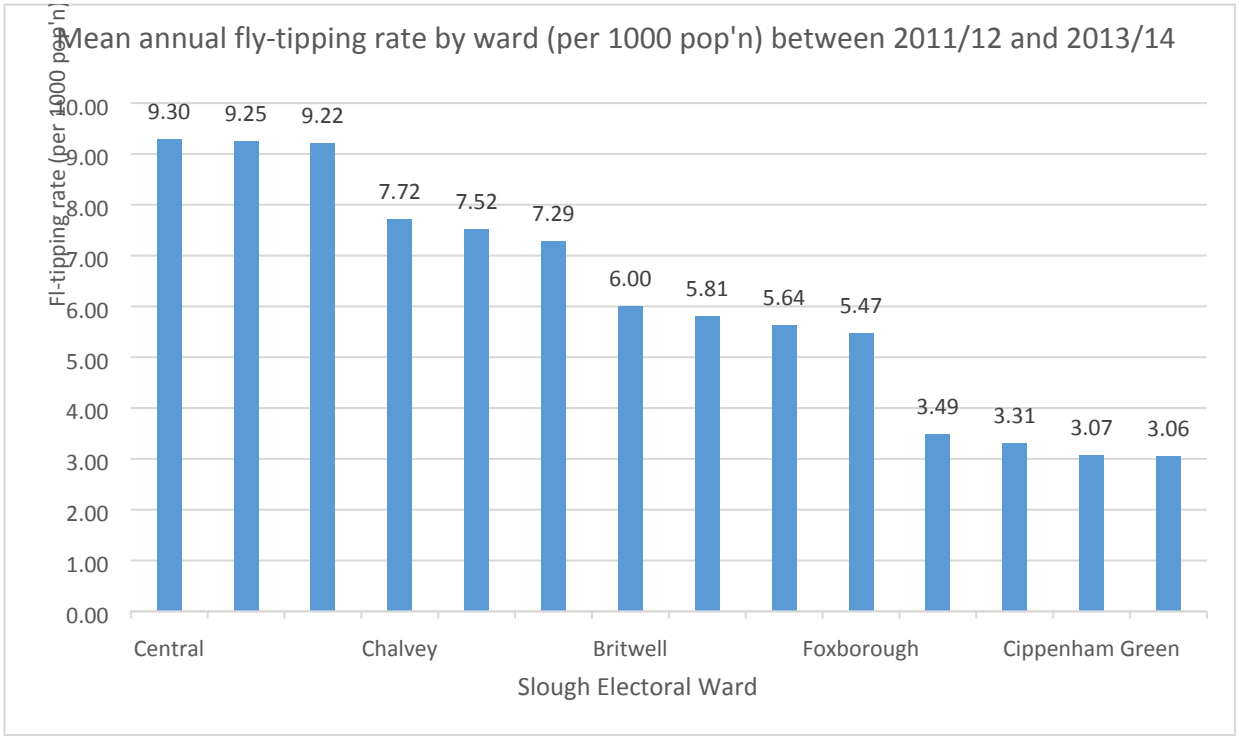


***Figure 21:** Bar chart showing mean annual fly-tipping rate per electoral ward in Slough between 2011/12 and 2013/14.*

Fly-tipping rates and Index of deprivation scores in Slough

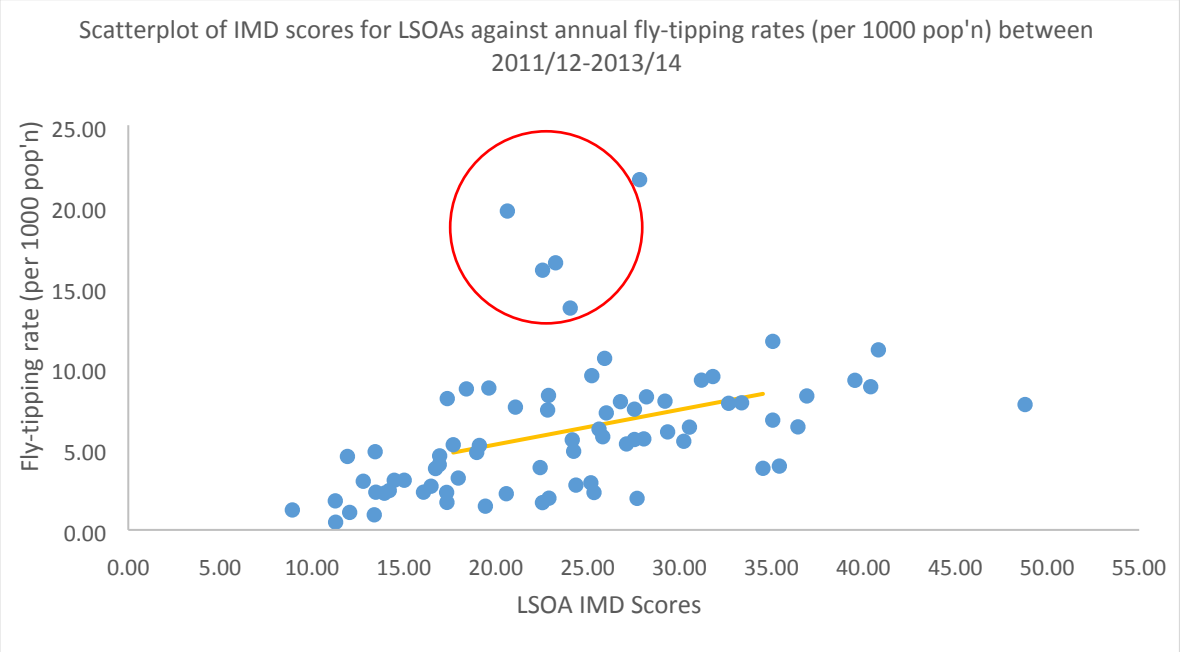


Figure 22; *Scatter plot of the index of Multiple Deprivation scores for each Lower Super Output Area (2011 Census data) in Slough against the mean annual rate of fly-tipping between 2011/12 and 2013/14.*

The scatter plot of LSOA ward IMD scores against fly-tipping rate and associated regression line and R^2 value are shown in **figure 22**. Pearson Correlation Coefficient *(or r value)* was calculated using the regression analysis tool in Excel®. The r value, indicated on the chart indicates a weak positive relationship between LSOA's IMD score and the rate of fly-tipping in Slough during the period studied.

Appendix 1 contains the summary output from the regression model. The P value indicates that the relationship is significant at the 95% confidence level. However for the regression model to fit the data, the distribution of the residuals must be normal so the presence of the outliers (circled in red on figure 22 and listed in the table in figure 23), cast doubt on the applicability of the linear model.

LSOA	IMD score	Rate	Predicted Y	Residual
002A	22.54	16.04	5.82	10.22
002C	24.04	13.70	6.15	7.56
005C	20.63	19.70	5.41	14.29
007B	27.82	21.64	6.96	14.68
014A	23.25	16.50	5.98	10.52

Figure 23: *Shows the fly-tipping rate, IMD score, predicted value for Y and residual values generated by the trend-line for 5 of the LSOAs.*

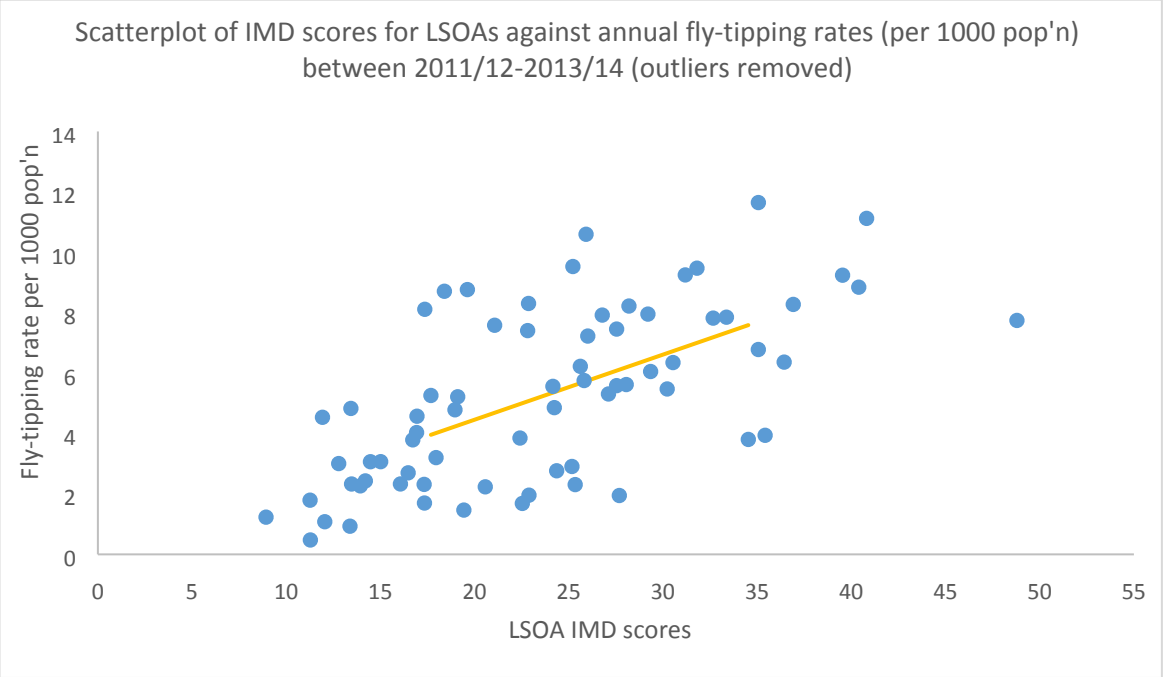


Figure 24: *Scatterplot of fly-tipping rate per 1000 population (outliers listed in figure 23 have been removed from the dataset)*

As an 'experiment' a second scatter plot was created with the outliers removed.

It is immediately clear from **Figure 24** that without the outliers the observed relationship between the variables is far stronger, with a correlation coefficient of **r=0.6** indicating a moderately strong linear relationship. The F and P values in the summary output contained in **Appendix 1**, again indicate statistical significance for this result at the 95% confidence level.

To further test the applicability of the linear regression model in the absence of the outliers a histogram of the residuals from the regression in figure 24 was constructed. The acceptance of the linear regression model first requires the residuals to have a normal distribution. The histogram in **Figure 25**, is broadly bell shaped, indicating a Normal distribution.

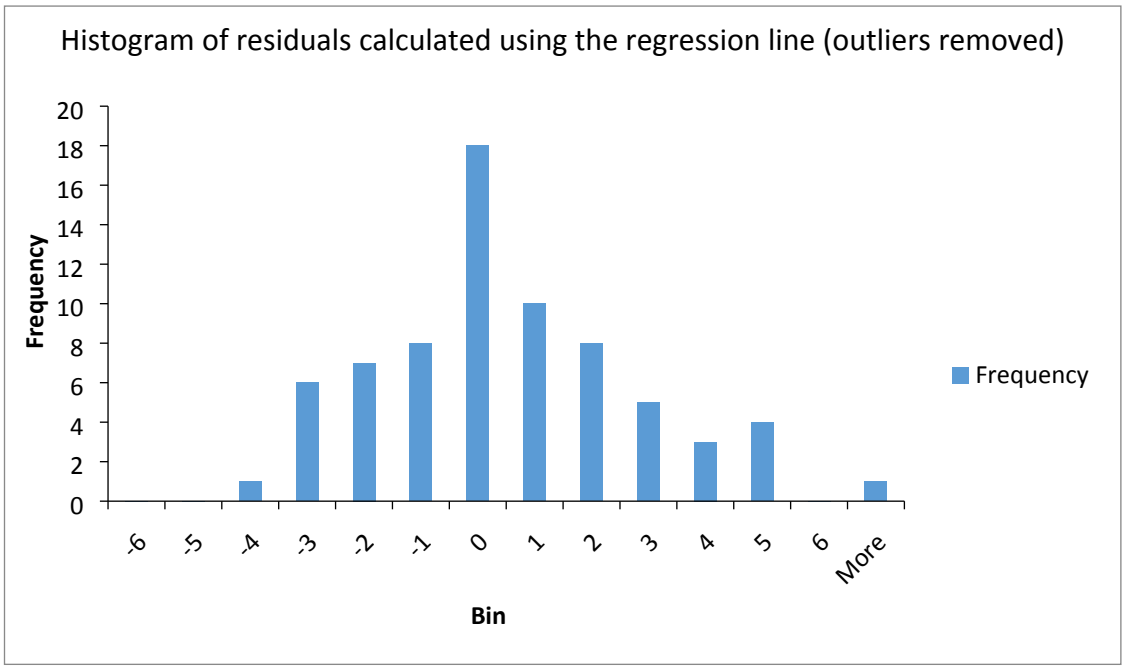


Figure 25: *Histogram of residuals generated by regression line in figure 24*

The second condition that must be satisfied for the linear regression model to be accepted, is homescedasticity (Rumsey). This was tested through plotting the residual values for each LSOA against the LSOA IMD scores. For the linear regression model to be accepted the residual plot must be unstructured with roughly equal variance across the values for X i.e. no clusters at points along the axis. The spread of the points along the axis in **Figure 26** seems unstructured, and the variance does not appear to change either negatively or positively along the X axis. Again the presence of outliers is acknowledged.

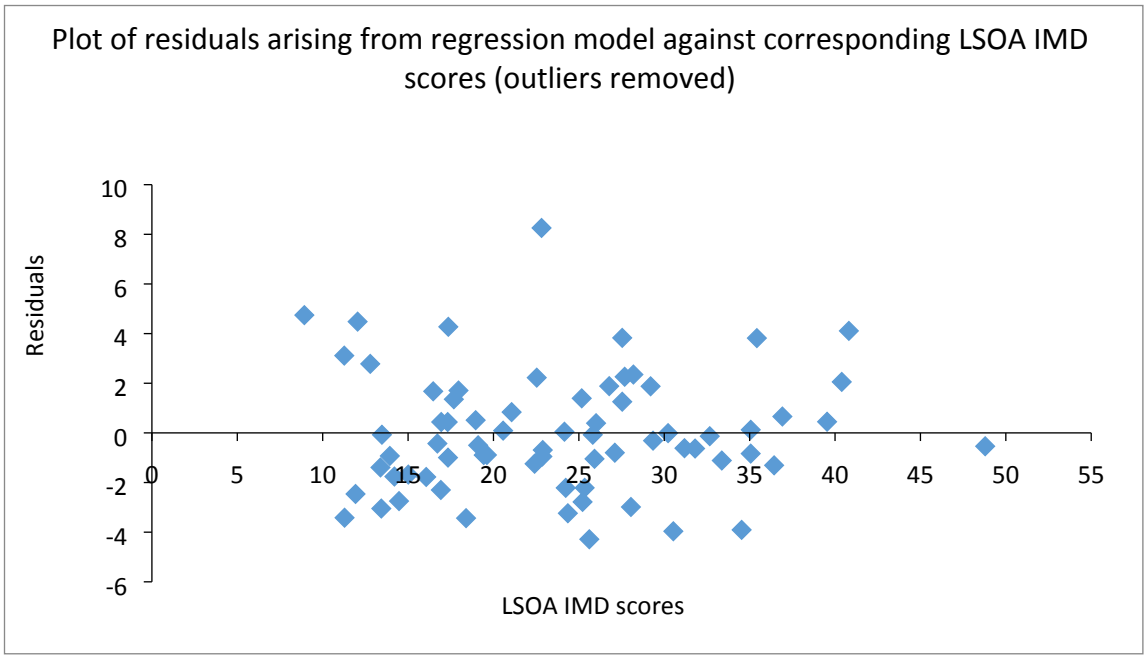


Figure 26: *Scatter plot of residuals against corresponding values on X axis*

Figures 25 and 26 provide further support of a positive correlation between IMD scores and fly-tipping rates in Slough if the outlier LSOAs are excluded from the analysis.

Fly-tipping rates and population density

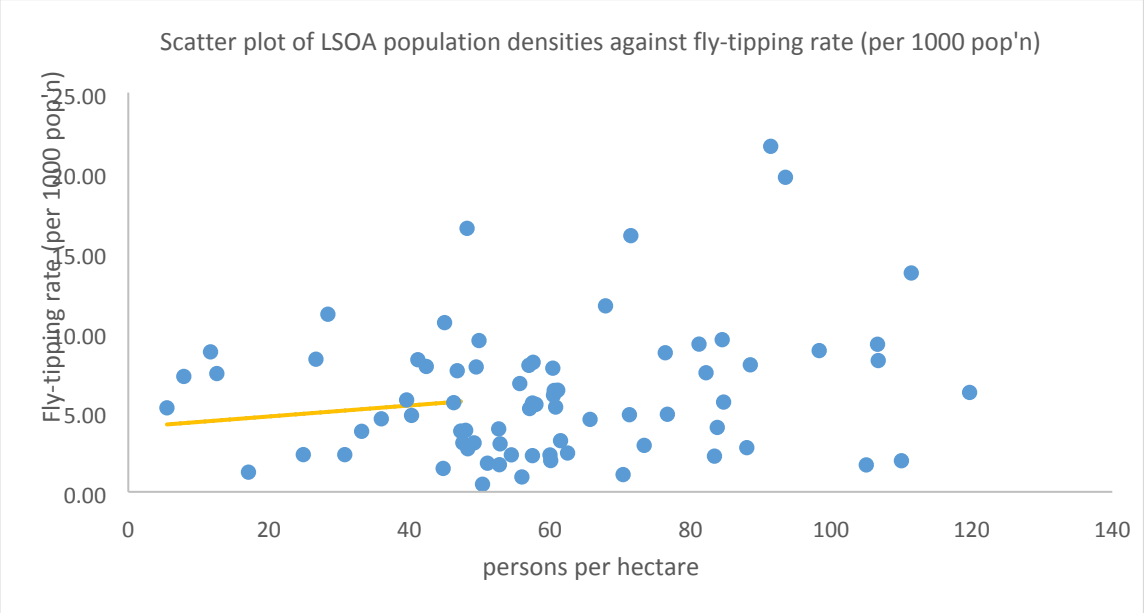


***Figure 23**: Scatter plot LSOA's population density against fly-tipping rate.*

It is immediately obvious from the scatter plot that there is little correlation between the two variables. The data points are spread across the graph with no obvious trend or pattern the R Squared and corresponding correlation co-efficient confirm the lack of correlation as such further analysis of the model would be counter-intuitive.

The same procedure as above was used to explore variation in Fly-tipping rates with a number of other socio-demographic factors which were identified through the literature review as possible covariates with fly-tipping rates

Regression analyses were performed and only one of the variables showed any correlation with fly-tipping rates in Slough. **Figure 28** shows the r values generated from regression analyses. The P and F values are only shown in relation to variable '% of the usual resident population in the LSOA living in privately rented accommodation'. Implications of this finding are examined in DISCUSSION section.

Variable	R value (pearsons correlation coefficient)	P value	F value
% of households in LSOA living in an apartment flat or maisonette (2011 Census data)	0.22		
% of people in LSOA living in an apartment flat or maisonette (2011 Census data)	0.19		
% of households with no access to car or van (2011 census data)	0.27		
% of resident population living in privately rented accomodation (2011 census data)	0.46	2.74E-05	2.74E-05
% of resident population living in social rented housing (2011 census data)	0.04		
% of resident population living in social rented Council Housing (2011 census data)	0.04		

Figure 24: *Table showing r values for regression of fly tipping rates with different socio-economic variables. P and F values are only shown where a correlation was observed*

DISCUSSION

Variation in fly-tipping rates over time

This study clearly reveals that overall, fly-tipping rates in Slough increased between April 2010 and March 2015. The variability across the period of study, illustrated by figure 7, may appear quite small, and the changes between 2010/11 and 2013/2014 may seem of limited significance from a practical perspective. But consider the step change in the rate of fly-tipping from 2013/2014 to 2014/15. This equated to a 20% increase on the previous year and is likely to have put considerable pressure on Local Authority resources.

Moreover, the increase appears to have occurred quite abruptly, following three or four years of slowing growth in the fly-tipping rate. Such increases in fly-tipping are likely to be problematic for LAs, which find it difficult to respond to sudden pressures; by for example recruiting more staff to investigate fly-tipping. The effects of a 20% change in the rate of fly-tipping in Slough are likely to have been; a far less timely response to fly-tipping complaints, delays in waste being cleared and consequently a deterioration in environmental quality. Perhaps some qualitative analysis of the local community or Local Authority officers would reveal if these consequences did indeed come to pass.

Of course, an increase in the fly-tipping rate as calculated in this study does not necessarily equate to an increase in the actual amount of waste unlawfully deposited in the borough. Firstly, the fly-tipping rate will be strongly influenced by the reporting rate; this is not accounted for in this study.

Secondly, this research was based on a count of fly-tipping cases, and as such the volume of waste dumped is not considered here.

Accounting for the volume of waste in any study in Slough would be problematic because fly-tipped waste and legitimately disposed of waste are collected and transported in the same vehicle and are weighed together at the waste management site. Also, not all fly-tipped waste is collected by the LA contractors. Private landowners are responsible for clearing their own land and are free to transfer the waste to any lawful waste carrier or management site.

In any case, from a local authority perspective the number of fly-tips (transformed to rate) was an appropriate parameter for this research, as the burden of fly-tipping on the local authority, results not just from the cost of disposing of the waste, but also from costs associated with collection and the handling and investigation of fly-tipping reports.

This study highlights the need for more consistent and longer term data gathering on fly-tipping. The time series plots and subsequent analysis in figures **11, 12 and 13** elucidated a certain amount of information about the trends and patterns in the rate of fly-tipping in Slough over the study period. For example, it provided further evidence of a positive trend in the rate fly-tipping in Slough and highlighted possible seasonal peaks and troughs; though these were far from convincing.

It seems from the limited time period studied, that intra-annual variability in fly-tipping rate is dominated by the irregular component; short term unpredictable fluctuations resulting from any number of random factors. It is likely that much of the variability arises from the inconsistent way fly-tipping data is recorded.

Longer term studies would help reveal if this is a true reflection of reality or if there are indeed seasonal patterns. Identifying seasonal patterns is important to the Local Authority as it can guide the allocation of resources. .

Furthermore, longer term data would allow the researcher to establish whether the linear model fits the trend, or whether some other model is appropriate. Finding the correct model may even allow the accurate forecasting of future fly-tipping rates and how those rates might respond to external factors e.g. increases in the cost of legitimate disposal, increases in enforcement activity. In addition, it would improve the ability of the local authority to assess the long term effectiveness of any anti-fly-tipping intervention. In both cases it is crucial that avoidable irregular variability arising from errors in the processing of fly-tipping data are eliminated (as far as is reasonable), so that the trends and seasonality components are not obscured.

Comparison with Fly-capture data

As already discussed this study does not use DEFRA's fly-capture definition of fly-tipping as criteria for inclusion in this study. The justification being that restricting the study to merely those cases falling within the fly-capture definition would underestimate the effect fly-tipping has on the LA and the community. Every report of 'fly-tipping' or 'illegal deposit of waste' requires a response from the Local Authority and therefore there is resource impact in every case; though it is acknowledged that the magnitude of the impact will vary considerably.

It was deemed a useful exercise to calculate the proportion of the total number of cases recorded as 'fly-tipping' by Slough Borough Council that were also reported to DEFRA via the fly-capture database.

The disparity between the data-sets is presented in **Figure 16**. It would be beneficial to explore the source of the disparity further by drilling down into the detail of the cases that were not reported to DEFRA. It might be that the disparity represents serious errors in the collection of data by the LA, alternatively it could represent the proportion of fly-tips reported to the LA that have occurred on private land, as these are not reportable to DEFRA; in which case the disparity would provide a useful tool. In either case there clearly exists potential for further analysis

Spatial variation in fly-tipping rates in Slough

This part of the analysis perhaps poses more questions than it answers. This study sought to determine whether a relationship exists between levels of deprivation and the fly-tipping rates in the Borough of Slough. It can be stated with reasonable confidence that a weak to moderate positive correlation does exist between the variables. However, there are a number of areas within the borough (see table in figure 23) which 'buck the trend' and these areas cast doubt on the strength of the relationship and point to the existence of other explanations for the variation.

It is of course possible that the outliers resulted from some sort of measurement error which artificially inflated the fly-tipping rates in those LSOAs. If this is the case then the scatter plot and corresponding regression analyses in **Figure 24** indicate that the positive correlation may in fact be stronger, with greater levels of

confidence in the existence of a genuine relationship between the rate of fly-tipping and deprivation in Slough as measured by IMS score.

In any case the link between deprivation and fly-tipping in Slough should be a cause for concern for the LA. As stated previously, improving 'community cohesion' is a key objective of Slough Borough Council's five year plan (Slough Borough Council, 2015). Disparities in environmental quality between neighbourhoods are likely to undermine the achievement of this objective and as the studies discussed in the literature review suggest, the presence of 'social incivilities' like fly-tipping may even exacerbate inequality and deprivation, by reducing inward investment and encouraging crime and anti-social behaviour. There is therefore a clear need to address the problem of fly-tipping in Slough if the Borough is to become a more equitable place.

However this poses the question why does the relationship between fly-tipping and deprivation exist? Which of the underlying measures of deprivation, i.e. household income, housing, level of education etc. is the most significant factor in the determining the positive correlation between rates of fly-tipping and deprivation. Also, a discussion must be had about whether living in a deprived area makes a person more likely to fly-tip, or whether fly-tipping is simply more likely to be carried out in a deprived area, irrespective of who is doing it.

One suggestion made in the limited number of studies on fly-tipping is that population density, which is often a covariate with deprivation is also a driver for fly-tipping the hypothesis being that those living in highly dense areas are most likely to live in flats, apartments and smaller properties where space for the storage of waste is limited. Indeed Hodson and Williams (2011) found such a relationship in their study. This study used the same indicator of density (persons per hectare) and but the scatter plot in figure 27 indicates is no evidence of a correlation between population density and the rate of fly-tipping is Slough.

However, Slough covers a relatively small geographic area and although there are variations in the type of accommodation, the urban nature of the borough means that the range of population densities is likely to be lower than in other studies which compared data collected from different local authorities. It is perhaps not

surprising then that no correlation was observed between the two variables in Slough.

Regression analyses were run for a number of other variables and only the proportion of privately rented accommodation showed any correlation with the rate of fly-tipping in Slough. This is an interesting finding, especially considering the recent findings discussed in the literature review about housing tenure and crime. Of course, as with deprivation the correlation is only weak to moderate and the finding must be interpreted with caution but the relationship is a cause for concern. Slough already has higher than UK average levels of privately rented accommodation and the sector is rapidly expanding. If the relationship is a genuine one then increases in the proportion of privately rented accommodation in Slough could also result in the levels of fly-tipping.

Fly-tipping 'hot-spots' in Slough

As already discussed there are several neighbourhoods within Slough which appear from this study to be disproportionately burdened by fly-tipping. Their locations are marked on **Figure 18**. Further detailed analysis of the data for those areas is required to establish whether the very high levels of reported fly-tipping genuinely reflect high levels of actual fly-tipping or whether they are a consequence of higher levels of reporting or some other measurement error.

Such a measurement error might arise for example, from the inconsistent application of the term 'fly-tipping' between those recording the fly-tipping data. It would be reasonable to suppose that repeated 'over- recording' of fly-tipping in one neighbourhood is a possibility in Slough, especially given that officers responsible for responding to and dealing with reports of fly-tipping in the borough, work consistently in the same neighbourhoods. Never the less the possibility that the areas are genuine fly-tipping 'hotspots' has to be considered.

Predictably four of the five LSOA with the highest rates of reported fly-tipping are within the 3 worst affected electoral wards as shown as demonstrated in maps in figures **18 and 19** by the bar charts **Figures 20 and 21**.

It would reasonable to begin any analysis of these 'hotspots' with a search for any common geographic or sociodemographic characteristics, but of course the rate of fly-tipping in each area could be high for any number of reasons and those reasons may differ from area to area.

Sources of error and methodological weaknesses

The results of research and data analysis should be interpreted with caution in any circumstance, but the apparent lack of consistency in the way fly-tipping data is recorded in Slough advocates an even greater level of prudence than is normal.

As was found by Webb in his 2006 study across the UK, the data held by Slough is of varying quality, as evidenced by the requirement to omit some data from parts of the analysis in this research. The fly-tipping records are plagued with omissions concerning for example, details about the type of waste deposited in each fly-tip; which makes the detection of duplicate records and the subtle analysis of relationships difficult. As stated in the method, every effort was made to remove duplicate and miscoded records but a proportion are likely to have remained in the dataset and this will of course have influenced the analysis.

Another major weakness affecting the reliability of this study is the lack of consideration made to the relationship between fly-tipping rates and the total amount of waste generated per person in the borough over the study period.

As stated in the literature review, a number of papers have demonstrated the positive correlation between the total amount of waste generated and the amount of illegal dumping in an area. Any investigation into the relationship between the rate of fly-tipping in an area and its demographic characteristics, should first take account of any variability arising from changes in the total amount of waste generated. Assuming the existence of a positive correlation between total waste generated and fly-tipping rates, the residual variation can then be plotted against the various demographic variables.

However, data on total waste generated was not available for the geographic areas used for this study. In fact the only data available in Slough related to the total amounts of municipal waste collected and disposed of at the Local Authority level.

As any conclusions drawn about possible relationships (or lack of them) between variables in this study are therefore unlikely to be very reliable.

The choice of variables in this study is also likely to be a source of in accuracy and unreliability; including the rate of fly-tipping per head of the population. Firstly this rate is based on population estimates that may or may not be accurate but perhaps more importantly the variable is based on the number of cases of fly-tipping reported to Slough Borough Council and the number of cases reported may not truly reflect the actual amount of fly-tipping. Duplication has already been discussed, but there is also the matter of reporting rates.

Clearly the propensity to report offences like fly-tipping will vary from person to person according to numerous factors. Accounting for this variable in future studies would rely on the calculation of a reporting rate for each of the areas studied. In fact establishing reporting rates by comparing the number of actual tips with those reported in a would be a very useful but very challenging project as the researcher would need to establish as precisely as possible to true number of fly-tipping incidents in a given area, over a particular timescale.

Finally, this study covers only a very limited period of time. A study covering a far longer period of time would provide much more analysis, providing the quality of the data is sound, particularly in relation to the time-series analysis.

CONCLUSIONS AND RECCOMMENDATIONS

It is clear that poor quality data recording, as well as lack of appropriate data at the local level has prevented the drawing of firm conclusions from this research.

It has however, provided confirmation of a recent upsurge in reported fly-tipping rates and identified 3 ‘hotspot’ areas requiring further detailed analysis.

The study has also identified positive correlations between fly- tipping rates and: a) deprivation as measured by the IMD scores for LSOAs and b) the % of usual resident

population living in privately rented accommodation at the LSOA level. The discussion provides some context for these findings and warns caution about their interpretation.

The findings overall suggest a number of things that Slough Borough Council could do to ensure they target their increasingly limited resources in an efficient manner and improve their response to fly-tipping in their jurisdiction:

1. Overhaul the way fly-tipping is recorded. The numerous codes and descriptions available to those responsible for inputting data are confusing and the interpretation of fly-tipping is inconsistent. To ensure consistency in reporting a 'Slough fly-tipping definition' should be created and all relevant staff should be provided with training on the definition and when and when not to use it. The DEFRA fly-capture definition could be utilised but this is likely to be too restrictive. There must be a means of easily extracting the fly-capture data for reporting purposes.
2. A project should be devised to establish whether the elevated rates of fly-tipping in the 'hotspot' areas are the result of genuinely elevated levels of fly-tipping or other factors like reporting rates and/or errors in recording. If the 'hotspot' areas are genuinely disproportionately burdened by fly-tipping, detailed analysis of the type of waste being deposited should be carried out so that interventions to tackle the problem can be devised.
3. All counter fly-tipping interventions should be assessed for the efficacy; the time series analysis might provide a means of doing this; and time taken to investigate fly-tips should be properly recorded for cost- benefit analysis purposes. At present many investigations are carried out but few result in enforcement action. Furthermore, there is no evidence concerning the effectiveness of enforcement in deterring fly-tipping. The most cost effective method of dealing with fly-tipping might simply be to collect the dumped waste as quickly as possible to avoid the occurrence of nuisance and the 'broken window effect'; though there may be ethical/moral reasons why this option is not appropriate.

4. Finally, the possible link between the prevalence of privately rented accommodation and fly-tipping rates should be explored further. It may be that targeting interventions towards private landlords will help to tackle fly-tipping in Slough in the future.

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APPENDIX 1

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.424718							
R Square	0.180385							
Adjusted R Squa	0.169158							
Standard Error	3.82107							
Observations	75							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	234.5766	234.6	16.1	0.0001459			
Residual	73	1065.842	14.6					
Total	74	1300.418						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.97	1.35	0.72	0.47	-1.72	3.66	-1.72	3.66
IMD_SCORE	0.22	0.05	4.01	0.00	0.11	0.32	0.11	0.32

Summary output from regression model of mean annual fly-tipping rates against IMD Scores in Slough.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.6455							
R Square	0.41666							
Adjusted R Square	0.40809							
Standard Error	2.19382							
Observations	70							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	233.765	233.765	48.571	1.611E-09			
Residual	68	327.273	4.81284					
Total	69	561.038						
	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.15	0.78	0.19	0.85	-1.41	1.70	-1.41	1.70
IMD_SCORE	0.22	0.03	6.97	0.00	0.15	0.28	0.15	0.28

Summary output from regression model of mean annual fly-tipping rates against IMD Scores in Slough with outliers removed