Have new street lighting schemes reduced crime in London?

Paul R Marchant

Abstract

Crime counts published by the Home Office for the Metropolitan Police Crime and Disorder Reduction Partnership areas have been collated across the years 2003-2009. The crime counts over time have been modelled taking into account the 'multilevel' (years within areas) nature of the data. The key variable of interest, as a predictor of within-area change of crime, is the proportion of a Core Investment Period of new Private Finance Initiative street lighting which had been completed up to the given time point as a predictor of within area change of crime. The final model gave a 95% confidence interval for the multiplier by which the number of crimes is increased of (0.87, 1.11), for a fully implemented lighting programme, consistent with zero effect.

Introduction

Light at night can be seen as a way to reduce crime and this is one of the justifications for increasing street lighting, e.g. Leeds City Council (2004). This view has been supported by the published results of some experimental studies; e.g. Welsh and Farrington (2008). However reviews of experimental work can suffer from weaknesses, such as publication bias (e.g. Section 16.1.1 Higgins, Green 2009). The issue of the impact of lighting on public safety is contentious, Marchant (2005, 2010).

In this work observations, relating to changes in recorded crime in areas of London while new lighting is introduced, are examined. The data includes areas which have no new lighting as well as those that do. Where lighting is introduced, it is started at different times and proceeds at different rates. A statistical model which is consistent with the data is developed to attempt to find evidence that the new lighting has affected the amount of crime.

The data

The data are a combination from two sources; one on the numbers of recorded crimes and the other on the extent of the introduction of new street lighting programmes in corresponding areas.

The number of crimes is obtained from 'Crime in England and Wales' the annual Home Office publication of Police recorded crime. In this publication the number of crimes is given for each of the Crime and Disorder Reduction Partnerships (CDRPs) covering all of England and Wales for the period 1 April to 31 March. (There are approximately 370 CDRPs.) The crime counts have been collated for all years between 2003 and 2009. (In this work the convention adopted is that the year, say 2003, indicates the end point of the 'crime year', 1 April 2002 to 31 March 2003.)

In this work only the London Metropolitan Police Force Area is considered as information on lighting here could be clearly allocated to individual CDRP areas. (Elsewhere this was not always the case).

Six (out of 32) CDRPs of the Metropolitan Police Force Area had PFI lighting schemes which started within the time frame of this study.

All 7 years were matched by their CDRP name record. The 6 key offences recorded are:

1. Violence against the person
2. Sexual offences
3. Robbery
4. Burglary of a dwelling
5. Theft of a motor vehicle
6. Theft from a motor vehicle

From these recorded offences the total number of offences recorded for each year was calculated and this was the response variable used in the analysis.

The other data set used held the start and end dates of the 'Core Investment Period (CIP)' of street lighting replacement, in which brighter, whiter lighting is installed; often to replace the older orange Low Pressure Sodium (LPS) lights. The CIP period is when the new lights are gradually installed until completion. This data was supplied (private communication) by Jens Reike & Paul Foskett of the Department for Transport, which is the part of government responsible for the Private Finance Initiative (PFI) new lighting programme. The proportion of the way through the CIP, at the middle of each crime year, was derived by linear interpolation from the start and end dates.

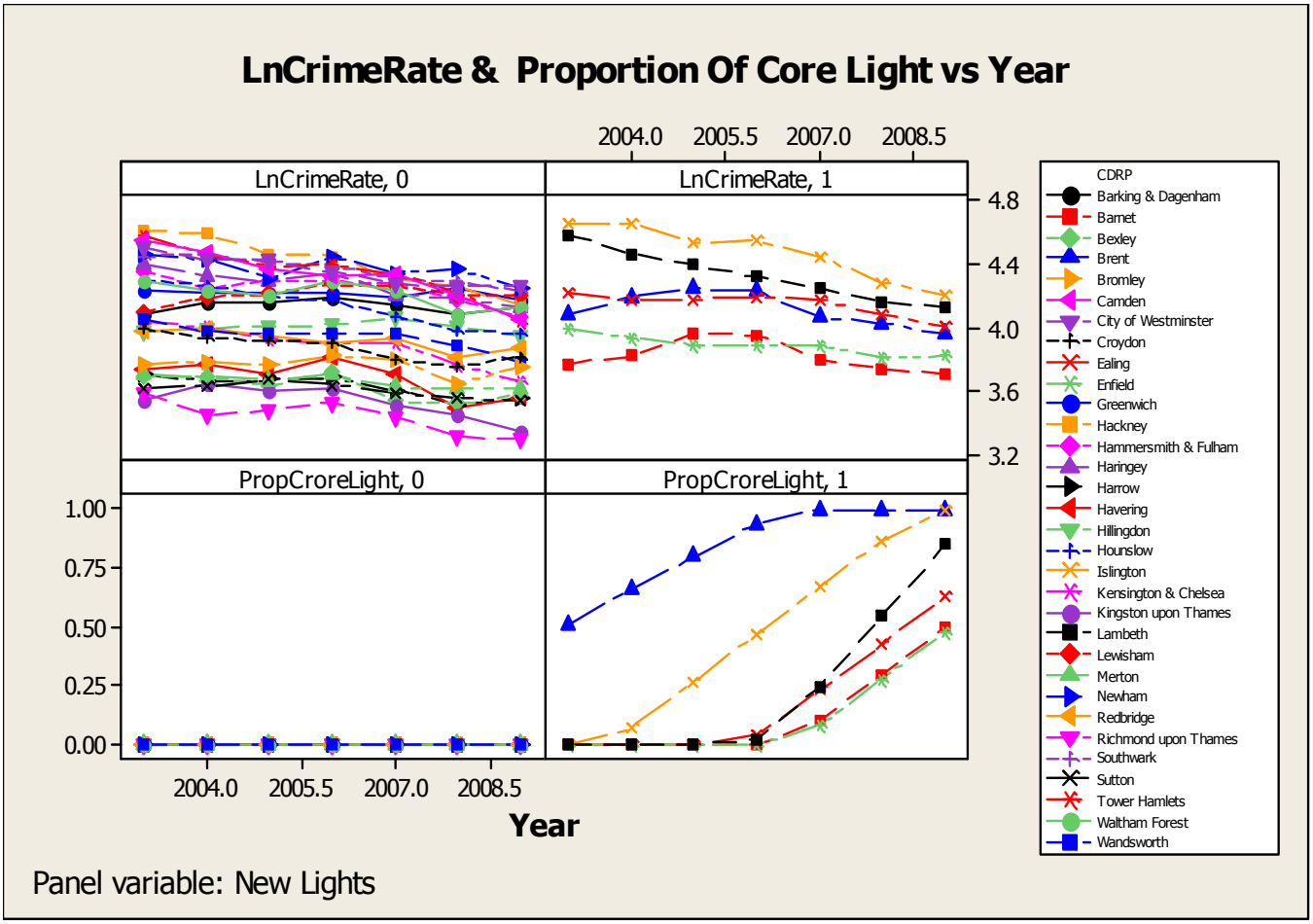
The aim of this work is to see if a change in crime level is detectable as new lights are installed.

The start and end dates of the Core Investment Period for the six areas receiving some new lighting are.

CDRP Area	Start of CIP	End of CIP
Brent	Mar-1999	Mar-2006
Islington	Jun-2003	Jun-2008
Ealing	Aug-2005	Aug-2010
Lambeth	Dec-2005	Apr-2009
Barnet	Apr-2006	Apr-2011
Enfield	May-2006	May-2011

The total crime recorded in each year, separated by those areas receiving some new lights and those receiving none, is shown below.

The display shows the natural log of the crime rate for the years and the proportion of the Core Lighting Programme completed in each local authority. The proportion of the Core Lighting Programme completed is of course zero for those not having a Lighting Programme as seen in the lower left hand panel.



The analysis

The aim of the analysis was to create a well fitting statistical model of number of crimes that incorporated the time variation across the seven years, also including the proportion of CIP, lighting change, completed within each of the seven years. The model construction took account of the multilevel structure: the number of crimes in each year (7 of these) nested within CDRP areas (32 of these). There were no missing values in the Metropolitan Police Area crime data.

A series of increasingly complex multilevel linear models, (Goldstein 2003) incorporating a Normal distribution disturbance term was developed using the MLwiN multilevel modelling software (Rasbash et al 2009). In the work the total crime count was transformed by taking its natural logarithm in order to achieve homoscedasticity and normality of residuals.

The first model had no predictor variables added; just an intercept term random at the 2 levels. This partitions the variability into that between years within CDRP, level 1 indicated by i, level 1 and variation between CDRPs, level 2 indicated by j, level 2. Residuals e_{ij} from level 1and u_{0j} from level 2 are both taken to be Normally distributed with mean = 0 and a variance σ^2 appropriate to each level.

$Ln\ (Y) = \beta_0 + u_{0j} + e_{ij}$

β_0 = Grand Mean
level 2 residual $u_{0j} \sim N(0, \sigma_{u0}^2)$
level 1 residual $e_{0ij} \sim N(0, \sigma_e^2)$

The coefficients and standard errors can be seen in the first numeric column of Table 1 in the Appendix.
The estimated variance relating to between areas is larger (0.1333) than that within areas, across time, (0.0103) indicating that the areas are very different in the number of crimes recorded. This would be reduced by utilising crime rate or by having the population as a predictor in the model, rather than simply using the number of crimes. However the interest is the within area change and how this relates to lighting change. This is now developed. The issue of using crime rate instead is revisited later.

The model was then extended to include the time trend across the 7 years and a quadratic time trend was found to be sufficient, i.e. higher order terms did not improve the fit. The model equation is given below. In the adequately fitting quadratic model the intercept and linear term were 'random' but the squared term did not need to be as the variance of the putative random quadratic term was small. It was therefore kept as 'fixed'. Note that the time/occasion variable was centred on 2006, the middle year, so that the intercept is interpreted as relating to that year.

$Ln\ (Y) = \beta_0 + u_{0j} + (\beta_1 + u_{1j})t + \beta_2\ t^2 + e_{ij}$

$u_{0j} \sim N(0, \sigma_{u0}^2)$
$u_{1j} \sim N(0, \sigma_{u1}^2)$
with a covariance between u_{0j} and u_{1j}

$e_{0ij} \sim N(0, \sigma_e^2)$

The results are shown in the second numeric column of Table 1.
Incorporating a time trend reduced the within area residual variance considerably.

The effect of lighting was then incorporated as another term in the linear model. Simply adding the proportion of the way through the CIP gave a very small point estimate for the effect of lighting, with a standard error indicating that the size of effect is consistent with zero. The estimates of the other parameters in the model are very little changed. See the third numeric column of Table 1.

However it is more informative to partition the lighting (X_{ij}) between the 2 levels: year (i), level 1; area (j), level 2.

$X_{ij} = <X._j> - <X._j> + X_{ij}$

Where $<X._j>$ = mean CIP progress made by CDRP area j within the years 2003 to 2009

So $X_{ij} = <X._j> + (X_{ij} - <X._j>)$

The first term above is the mean of the proportion of CIP lighting within a CDRP area over the 7-year period, whereas the second (bracketed) term is the deviation of the proportion of CIP lighting for a given year from this mean.

When the two terms from partitioning were entered into the model instead of the one, un-partitioned simple proportion of the way through the CIP, it gave only a small drop in the deviance (-twice log likelihood) statistic. (The deviance is a measure of model explanation with smaller values corresponding to more explanation.) However the partitioned model enabled interpretation of the two parts of the effect lighting. See the fourth numeric column of Table 1 for the results.

The year to year within CDRP effect of change of lighting from its mean value is small with a considerably larger standard error. The point estimate of the coefficient is -0.018 indicating that for a completed programme of relighting crime would decrease by 1.8% but the standard error says that this estimate is not statistically significant. The point estimate of the effect of mean CDRP lighting level is larger than the within area lighting effect. It has a positive value suggesting that those areas which have progressed further into relighting tend to be those with higher crime counts. However the between area effect is not much bigger than its standard error and is thus consistent with zero. Diagnostic checks of model fit, such as residual plots, were seen to be satisfactory.

To check further these results, the model was re-estimated using Markov Chain Monte Carlo (MCMC) computation (using a chain length of 250000). (See Browne 2009). The MCMC method does not rely on the approximations of Maximum Likelihood Estimation (MLE) used

above and so allows more accurate results, at the expense of a lot more computation. However the MCMC results are very similar to those MLE as expected for a large sample with a Normal disturbance term. See the fifth numeric column of Table 1 for the results.

The key within CDRP-area occasion coefficient is -0.016 with a standard error of 0.061 for MCMC as opposed to -0.018 with a standard error of 0.058 for MLE. MCMC gave a central 95% interval (-0.135, 0.106) for the within CDRP-area lighting effect. Converting this, by exponentiating to give the multiplier by which the number of crimes is increased, yields (0.87, 1.11) for a fully implemented lighting programme. That is: the interval for the estimate spans a reduction of 13% to a rise of 11% in crime.

Further analysis

It might be argued that it is important that the size of the resident population is included and this can be done using the log estimate of population, for the year 2004, for each CDRP area as a predictor of log number of crimes. However, when this is done, (although reducing the deviance of the fitted model) the coefficient giving the effect of lighting within area remains very similar to its previous value and it is the lighting effect which is the focus of interest. Again a similar result is obtained when the log crime rate, log(number of crimes per inhabitant), is modelled. If reliable year on year population figures for each area were available, adding these to the model could be valuable. However, the current work did not have estimates of the population of the areas for every year.

Discussion

It would be very useful to have data on crime and lighting which is more fine-grained, geographically and temporally, in order to obtain better estimates of lighting effect, e.g. month by month at street level.

It should be recognised that interpolating from the CIP start and end dates will only give an approximation to the true proportion of replacement lighting for each year. Similarly police recorded crime will only be an approximation to the true level of crime because of some measurement error. (Note police recorded crime is a measure which has also been often used to estimate the effect of street lighting on crime in experiments.) However it is anticipated that the approximate nature of the measures used will not obviously give rise to bias in a particular direction in assessing the effect of lighting on crime.

Also it would be useful to have other relevant predictors of crime, which vary over time and place, (such as perhaps a measure of policing strength) to see what impact these might have in conjunction with the amount of lighting.

However the conclusion of the current research is; no evidence that street lighting has a great beneficial effect on crime is observed, estimating as it does a plausible range of effect from a 13% reduction to an 11% rise. The upper range of the confidence interval would indicate lighting making matters worse.

The strength of the work presented is that it is based on data from a large scale 'roll out' and as such will not suffer from limitations that can occur in experimental work.

In this work just total crime has been modelled but further work is planned for examining the relationship for different crime types.

The method outlined in this work could similarly be used for the assessment of the effect of lighting on road traffic accidents. Furthermore, the method could also be used to assess the effect of programmes, other than lighting, during 'roll out', to see if the claimed benefits of a programme are being realised.

Conclusion

The current study, based on the Metropolitan Police Area of London which comprises 32 local authority-areas (CDRPs) 6 of which had PFI new lighting schemes in progress, finds no good evidence for lighting benefit in reducing total crime. It estimates the range (95% confidence interval) for the expected effect of a fully implemented programme of new street lighting to span from a 13% reduction to an 11% rise in crime.

Acknowledgements

Thanks are expressed to Jens Reike & Paul Foskett of the Department for Transport for supplying the data on the dates for the new street lighting projects. Also, thanks go to the staff at Centre for Multilevel Modelling at Bristol University, particularly Kelvyn Jones and George Leckie, for useful discussions. Similarly thanks go to my associate Paul Baxter of the Division of Biostatistics at the University of Leeds.

References

Browne WJ (2009) *MCMC estimation in MLwiN Version 2.13* Centre for Multilevel Modelling, University of Bristol

Goldstein H (2003) *Multilevel Statistical Models*.(3rd edn) Arnold, London

Higgins JPT, Green S (eds) (2009) *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.0.2. The Cochrane Collaboration www.cochrane-handbook.org.

Leeds City Council (2004) *Outline Business Case for PFI Credits to the DfT: Street Lighting Scheme*, revised July 2004.

Marchant, PR (2005) *Evaluating area-wide crime-reduction measures*. Significance 2 63-65

Marchant, PR (2010) *What is the contribution of street lighting to keeping us safe? An investigation into a policy.* Radical Statistics 102 32-42

Rasbash J, Steele F, Browne, WJ and Goldstein H (2009) *A User's Guide to MLwiN, v2.10*. Centre for Multilevel Modelling, University of Bristol.

Rasbash J, Charlton C and Pillinger R (2009) *Manual Supplement to MLwiN v2.10*, Centre for Multilevel Modelling, University of Bristol.

Welsh B, Farrington D (2008) *Effects of improved street lighting on crime,* Campbell Collaboration Review.

Walker A, Flatley J, Kershaw C et al (eds) (2009) *Crime in England and Wales* http://rds.homeoffice.gov.uk/rds/crimeew0809.html

Paul Marchant

Leeds Metropolitan University
Leeds LS6 3QS
p.marchant@leedsmet.ac.uk

Appendix

Table 1 Model Comparison Table: Coefficients and their (Standard Errors)

	Base model 2-level No Predictors	Accounting for time trend	+ Proportion of CIP	CIP Partitioned: between CDRP & within CDRP	CIP Partitioned: between CDRP & within CDRP by MCMC
Response	Log(NCrime)	Log(NCrime)	Log(NCrime)	Log(NCrime)	Log(NCrime)
Fixed part β					
Constant	9.4543 (0.0649)	9.47620 (0.06500)	9.47606 (0.06504)	9.44384 (0.06678)	9.44704 (0.07319)
Year-2006		-0.03499 (0.00411)	-0.03505 (0.00428)	-0.03462 (0.00424)	-0.03463 (0.00450)
$(\text{Year-2006})^2$		-0.00548 (0.00087)	-0.00549 (0.00089)	-0.00542 (0.00089)	-0.00542 (0.00091)
PropOfCIPDone			0.00288 (0.05617)		
MeanCDRP_CIP				0.51392 (0.36295)	0.48085 (0.38595)
ChangeInCIP				-0.01803 (0.05773)	-0.01594 (0.06128)
Random part					
Level: CDRP					
Var (u_{0j}) Constant	0.1333 (0.0337)	0.13452 (0.03370)	0.13442 (0.03368)	0.12544 (0.03144)	0.14672 (0.03990)
Var (u_{1j}) Year-2006		0.00047 (0.00014)	0.00047 (0.00014)	0.00046 (0.00013)	0.00053 (0.00016)
Cov (Constant Year-2006)		-0.00160 (0.00153)	-0.00162 (0.00154)	-0.00121 (0.00146)	-0.00140 (0.00179)
Level: Occasion					
Var (e_{0ij})	0.0103 (0.0011)	0.00203 (0.00023)	0.00203 (0.00023)	0.00204 (0.00023)	0.00210 (0.00024)
units – CDRP	32	32	32	32	32
units – Year	224	224	224	224	224