Computers, Environment and Urban Systems xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Computers, Environment and Urban Systems

journal homepage: www.elsevier.com/locate/ceus

A comparison between the cost effectiveness of CCTV and improved street lighting as a means of crime reduction

Tony Lawson*, Robert Rogerson, Malcolm Barnacle

University of Strathclyde, Glasgow, United Kingdom

ARTICLE INFO

Keywords:
Cost effectiveness
Cellular automaton
CCTV
Improved street lighting

ABSTRACT

The effectiveness of CCTV and improved street lighting has been studied extensively in terms of their potential for reducing the number of crimes in a certain area. However, this does not take into account the cost of the interventions or the savings due to crime reduction. This paper presents a model, which takes the form of a cellular automaton to simulate the implementation of improved street lighting and CCTV cameras using a range of strategies. This permits an exploration of simulated options to find which is most cost effective and what the best strategy for implementation is. The results indicate that there are few situations where CCTV is more cost effective than improved street lighting as a way of reducing street crime. In addition, it is shown that the strategy of targeting locations with the highest crime rates, "hot spots", has the greatest potential for maximising the cost effectiveness of interventions.

1. Introduction

Situational crime prevention and interventions such as CCTV and improved street lighting are widely used as ways to deter crime. Research is extensive on this but as Cozens and Love (2015) recently note, approaches continually need to adapt with changing demographic patterns, lifestyles and technology. However, adding new approaches and responding to changing urban circumstances is costly for the agencies involved, and difficult choices have to be made between forms of crime prevention. Calls for more sophisticated cost-benefit analysis have been re-iterated by Welsh, Farrington, and Gowar (2015) and in particular, the need for more experimental and quasi-experimental designs to support such cost benefit analysis.

This paper contributes to the debate by developing a model that provides estimates for the effectiveness of CCTV and improved street lighting, quantified in terms of their economic benefits. It also contributes to policy by providing indications of how to use crime prevention measures most effectively, which are robust enough to be generalised into guidelines for designing future crime prevention schemes.

Our approach takes the form of a cellular automaton that will be described in some detail below. The model is used to simulate the implementation of improved street lighting and CCTV cameras using a range of strategies, taking the city of Glasgow as an example. With a population of just over 600,000 Glasgow is the most populous city in Scotland and has one of the highest crime rates in the UK. However, in line with a wider trend in advanced economies, and combined with local initiatives, crime has decreased significantly in recent years. Hence, while all cities have their own unique characteristics, Glasgow presents a suitable test case for modelling urban crime.

The computer simulations permit an exploration of options to find which technology is the most cost effective and what is the best strategy for its implementation. As there is no way to find the optimal strategy by analytical means, a simulation approach is utilised to search among a range of possible alternatives. While the simulations are hypothetical, the model is based on real data. It combines police data on street crimes in Glasgow from 2004 to 2013 with information on the cost per crime from the UK Home Office study of Dubourg, Hamed, and Thorns (2005) and updated estimates from (Home Office, 2011). This makes it possible to determine the total cost of street crime, both economically and socially, for a range of crime types. Next, estimates of the effectiveness of CCTV and improved street lighting, in terms of percentage reduction in crime, are derived from the meta-analyses of Welsh and Farrington (2008a, 2008b). These are used to determine the marginal change in the cost of crime under a range of intervention scenarios. The estimated cost of each intervention is then compared with the anticipated saving, due to the predicted reduction in crime, to obtain a measure of the cost effectiveness of each scheme. This makes it possible to answer questions that are more general such as, under what circumstances is CCTV more cost effective than improved street lighting and what is the best type of location for deploying these resources? Since there are significant areas of uncertainty at each stage of the process, a key feature of the model is

* Corresponding author at: 4/3 14 Haughview Terrace, Glasgow, United Kingdom.
E-mail address: tonylawson773@btinternet.com (T. Lawson).

http://dx.doi.org/10.1016/j.compenvurbsys.2017.09.008
Received 9 December 2016; Received in revised form 13 September 2017; Accepted 25 September 2017

its facility for bracketing each 'best estimate' with a range of values to determine the robustness of the answers to the questions above.

Our simulations show that:

1) There are few situations where installing CCTV is more cost effective than improving the street lighting.
2) Interventions are most cost effective when targeted at highly localised 'hotspots'.

This contributes to the debate on the cost effectiveness of these technologies, provides general guidelines for efficiently implementing crime reduction schemes and presents a modelling tool with the potential for assisting with the design of future interventions.

After this introduction, the paper unfolds as follows. First, the principles of the cellular automaton model are outlined. Then the data requirements for estimating the cost of street crime are discussed. Next, the operation of the model is described in more detail. The initial results from the 'best estimate' model are given next. Then the parameters are varied in a series of 'Monte Carlo' simulations to test the robustness of the results. The implications of the findings are discussed next and conclusions are drawn at the end.

2. Developing the model

The model used in this paper is based on the idea of a cellular automaton. A cellular automaton models a world in which space is represented as a uniform grid, time advances by steps and the laws of the world are represented by a uniform set of rules that are used to compute each cell's state from its own previous state and those of its close neighbours (Gilbert & Troitzsch, 2005). The unit of analysis in a cellular automaton is the individual unit or cell. Minimally, the cell has a location specified by one or more spatial coordinates. The cell may also have other characteristics, which range from a binary on/off indicator to a list of variables. The state of each cell must first be initialised and then it evolves over time according to a set of transition rules. Each cell takes account of its own state and optionally the state of nearby cells. When all cells have been processed, the cycle repeats for the next time step. Time is thus discrete but by simulating small time differences at each step, it is possible to create the impression of continuous evolution.

The agent-based modelling platform NetLogo has a grid of static cells known as patches. These provided a convenient basis for implementing the cellular automaton model. Each postcode in Glasgow was assigned to a spatial location using six-figure UK National Grid map coordinates. The locations of CCTV cameras and streetlights, obtained from Open Data Glasgow and Glasgow City Council respectively, already had x and y coordinates. NetLogo has input functions that were used to load the postcode data to the appropriate patch. There is also a high-level programming language that can efficiently manipulate the data and a graphical user interface where parameters can be set and simulations visualised on a grid. One of the key features of NetLogo for this project was the 'behaviour space' facility that automates the running of many simulations with a range of different parameters. This Monte Carlo method makes it possible to explore the input parameter space, with the results of each combination of parameters output to a spreadsheet. The final model provides a tool that can be adapted to different cities and so with appropriate data, contribute towards optimising the use of resources in any location. The next section describes the model in more detail.

2.1. Data requirements

In order to estimate the cost effectiveness of an intervention to reduce crime, it is necessary to have:

1) An estimate of the average cost of a crime; this can be disaggregated into a number of crime types;
2) Data on actual crimes occurring in a particular area over a specified period;
3) An indication of the effectiveness of CCTV and improved street lighting in terms of the number or percentage of crimes avoided;
4) A way of calculating the total cost of the intervention.

Each of these components is described below.

2.1.1. The unit cost of crime

Estimates for the unit cost of a range of crime types are taken from Dubourg et al. (2005) in conjunction with updated estimates from (Home Office, 2011). These British Home Office reports seem to be the most up to date and comprehensive study undertaken in the UK. They cover the full range of cost components, from precautions against crime, the physical and emotional impact of crime, the value of goods damaged or stolen, costs to the health system, police costs in investigating the crime, the cost of court proceedings and cost to the Prison Service due to any custodial sentence. The values for a range of crime types were obtained from Table 2.1 of Dubourg et al. (2005: 7) and Table 2A (Home Office, 2011: 9).

2.1.2. Crime data

In order to estimate the total cost of crime in a certain area over a specified period, it is necessary to multiply the unit cost of crime by the number of crimes taking place there. Data on street crime in Glasgow was obtained from Police Scotland via collaboration with Glasgow City Council through Community Safety Glasgow. The time window was 1 January 2004 to 31 December 2013 inclusive. Only crimes that occur outdoors are considered because it is assumed that the effect of CCTV and street lighting is negligible for indoor crime. In all, there were just over half a million street crime events over this period, which are observed as crimes at the point when the police refer them for further action by the prosecuting authority, which is known as the Procurator Fiscal in Scotland. Each record contains details of the date and time at which the offence occurred, the nature of the offence and its location at the level of the postcode. On average, a postcode covers about 1 ha.

There are several steps between a crime taking place and being observed in our dataset. First, it must be reported to the police. Next, the police have to record it as a crime. Then the crime must be solved or detected i.e. the offender is identified. This means that to estimate the actual cost of street crime, it is necessary to extrapolate from the dataset we have in order to estimate the true number of offences that actually took place.

2.1.3. Reporting and recording crime

For most types of crime, the multiplier up to the point of the police recording it was obtained from Table A1 in Home Office (2011: 8). For other types that were not available from the Home Office report, the rate of reporting to the police was taken from ONS (2012) and the rate of recording by the police was obtained separately from HMIC (2014: 64).

2.1.4. Detecting crime

The rate of detection of offences was taken from Table 2 of Smith, Taylor and Elkin (2013: 25). The percentages do not vary greatly from year to year and these values are from 2008/9, which corresponds to the middle years in our dataset.

2.2. Crime multiplier

The proportion of crime reaching the next stage of the process can be interpreted as a probability. If these are assumed to be independent events then the probability of a particular crime that occurs being detected, where it is observed in our dataset can, be obtained by multiplying the probability at each stage. Multiplying the number of crimes