Crime as a local public bad, neighbourhood observation and reporting

Siddhartha Bandyopadhyay† Kalyan Chatterjee‡

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Abstract

We examine the effects of giving incentives for people to report crime on crime rates. In particular, we look at what happens when the costs of reporting are negligible and the cost of being interrogated by the police are high in a rational choice model of crime and crime reporting. Perverse equilibria where everyone reports or no one reports (and thus reports have no informational value) emerge. This happens both in a model where police make rational inferences about crime based on reports as well as in a model where police investigate according to fixed rules operating under a fixed budget. Importantly, generating more reports about crime could actually increase equilibrium crime rates. This occurs via a resource thinning effect caused by "too many" reports. Hence, from a policy perspective increasing incentives for neighbours to report suspicious activities may prove to be counterproductive. We also show how different ways of profiling certain groups of people can either increase or decrease crime rates in the profiled group.

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1 Introduction

In the last few years, the idea has once again surfaced that private citizens should be encouraged to report on "suspicious" activities in their neighbourhood, presumably because

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†Department of Economics, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK.

‡Department of Economics, The Pennsylvania State University, University Park, Pa. 16802, USA.
neighbours are in the best position to detect incipient criminal activity and are likely to be most severely affected by such activity. The former US Attorney-General, John Ashcroft, had in fact proposed a formal programme, Operation TIPS (Terrorism Information and Prevention System), to encourage such reporting, though this programme was eventually not approved by Congress. A recent report in the Washington Post (excerpted in the Manchester Guardian Weekly of Nov. 26-Dec.3, 2004) notes that in Moscow, the city council has actually passed a law to create "public order councils" in neighbourhoods, who would be "keeping an eye on the people next door". 1

The examples above all pertain to spatial neighbourhoods but the issue is more general than this. Potential whistleblowers in corporations are able to observe signals indicating possible crimes among their co-workers. Tax authorities encourage reporting from individuals about potential violators they might suspect. As in other models invoking a spatial metaphor, a wider variety of contexts is actually covered by the analysis.

The rationale for providing incentives to individuals to report suspicious activities has to do, presumably, with the free rider problem and with the limited resources available to the police making it impossible for them to discover crime everywhere without help. Thus, the authorities provide various incentives which lower the cost of reporting for citizens who notice something suspicious. This paper seeks to show that perverse and unintended consequences could follow in equilibrium from such incentives, well-intentioned though they could be.

Proposals to have neighbours informing on each other have naturally raised concerns about civil liberties and the right to privacy. However, our, more prosaic, concern here is about the effectiveness of such neighbourhood surveillance in the absence of any appropriate standards of what constitutes suspicious behaviour. In a news item on CNN (November 17, 2001), it was reported that a truck that kicked up a cloud of dust was thought to be men of Middle East descent spraying the road. The same item also reported that in Rhode Island, the FBI arrested a man who admitted that he sent an anthrax letter to a friend as a joke. The Holland Sentinel Online of July 8, 2003, mentions a bank robber who phoned in a bomb threat at a mall to divert police attention from a bank heist several miles away. The prevalence of deliberate hoaxes has led, for example, to the "Anti-hoax terrorism legislation of 2003" in the US, which seeks to cover false reports that could not be prosecuted under current law.

Of course, all this does not imply that such neighbourhood reporting does not have its uses. The net effectiveness of encouraging such reporting could be positive or negative and

1In Malaysia SMS reports have been encouraged, they allow the reporter to stay anonymous and saves him the cost of police interrogation, having to appear as a witness in the future etc. (see http://www.cellular-news.com/story/9986.shtml).
this is still an open question, one on which this paper could shed some light.

We study these issues using a model where a finite number of agents is located on a circle, so that each agent has two neighbours. Each agent derives a private benefit from committing a crime, which is private information. However, each agent (we shall often not distinguish between an agent and the site where he is located) also emits a signal, which his two neighbours observe. The distribution of such signals depends on whether a crime is being committed at a site or not, but a signal does not perfectly reveal whether something nefarious is being carried out. Each neighbour observes the signal and independently (of the other neighbour) decides whether to make a report or not, given the cost of reporting.

In the first model in this paper, police observe who reported on which site and implement an optimal investigation strategy. There is a cost of investigating a site, which we assume to be (weakly) increasing in the number of reports, and a cost of being investigated. If an investigation is made and a crime has indeed been committed, the criminal is apprehended and removed. If the criminal is apprehended, the criminal’s neighbours gets positive payoffs in having the criminal removed from their neighbourhood. Thus, crime in our framework is any undesirable activity that has the property that it particularly affects people in the immediate vicinity, who are also the people most likely to observe it.\(^2\)

In the second model, we assume that the police follows simple rules of investigation; investigate every site if there is one report or, alternatively, if there are two reports. There is a fixed budget, which is spread out over the sites being investigated. In both models, we make an assumption about the investigating strategy (a random one) followed by the police if there are no reports or "too few" reports i.e. the police budget constraint is slack in some sense.

We consider perfect Bayesian equilibrium crime rates, reporting and investigation strategies in these two environments.\(^3\) In particular, we examine whether lowering the costs of reporting could actually increase criminal activities by thinning the resources of law enforcement over investigating a greater number of potential criminals, thereby reducing conviction rates and hence expected penalties from committing crime. Finally, we look at what happens if certain groups are profiled. We look at two ways in which profiling works: one way to think of profiling is that people report on the basis of not just the signals they receive

\(^2\)It is possible, of course, that the crime does not specifically affect only the neighbours. The actual victims of the crime could well be different from those who observe it being committed. This would reduce the private benefit obtained by having a criminal removed from the neighbourhood and thereby reduce the incentive to report.

\(^3\)The crime rate is the ex ante probability that an agent will commit a crime. Since all sites are ex ante identical, this probability is the same for all sites in symmetric equilibrium. Of course, if reports are informative, the probability that a crime has actually been committed, given reports, could differ across sites.
but also on the basis of some observable characteristic, another way to model this is that the police condition their investigation decision not just on the reports but also on this observable characteristic. In the first case, crime rates in the profiled group actually goes up while in the second it goes down. The first effect arises because of the noise introduced into the report by the possible misinterpretation of innocent activities as suspicious. The second raises the crime rate in the non-profiled part of the population and therefore has ambiguous effects.

Our main results are as follows:

1. In both our models, a low but positive reporting cost could lead to every site being reported; in the optimal investigation model every site could be reported twice. Therefore lowering the cost of reporting might lead to a larger number of reports than socially optimal. The pure strategy equilibria with all sites being reported have non-informative reports.

2. There is also an equilibrium with no reports in the optimal investigation model. The ex ante probability of crime when no one reports is bounded above by the ex ante crime rate when everyone reports. In both cases, reports do not have any informational content.

3. We model profiling by observable characteristics in two different ways. The first approach is to assume that the profiled group is given "priority for investigation" by the police and hence the cost of investigating a report on a member of such a group is lower. This leads to a higher probability of crime in the non-profiled group. More interestingly, we can also conceive of profiling as a lower ability by the potential reporter to distinguish suspicious from innocent activities by a profiled group member. This leads to more reporting of the profiled group members and also a higher posterior probability of crime in the profiled group.

4. In the fixed budget model, there is no equilibrium with no reports and none with everyone reporting, though as pointed out above, there could be an equilibrium with every site being reported.

5. There could be an equilibrium where exactly one site has a crime but all $N$ sites get reported on, through a kind of "contagion" effect. Thus statements about the certainty that crime has been committed in the neighbourhood from trusted public figures (without information about where it has actually occurred) could lead to everyone reporting.
Increasing the number of reports needed to trigger an investigation could lead to no one reporting and a high crime rate. More generally, there is a public good element to reporting, agents do not take into account that their report may increase or lower the probability of crime elsewhere, hence we get overreporting or underreporting.

Thus the message we get is that the relation between crime and incentives from crime reporting is fairly complex and incentives for crime reporting may in fact lead to an increase in crime. Hence, the policy of encouraging increased vigilance about neighbours needs re-examination not just from the angle of intruding on the privacy of people but also in terms of its effectiveness in crime prevention.4

2 Related literature

There is a large literature on crime starting from the seminal work by Becker (1968) who first analysed crime as an economic decision. Since then there have been several papers extending Becker’s work and developing several aspects of crime and crime fighting policies. Becker’s model has been modified in different directions. The ones most relevant for us are those which generate multiplicity. Several papers have generated multiple equilibria starting from Sah (1991) where similar economies could reach different equilibrium crime rates with a fixed level of resources devoted to law enforcement. The variation in these papers often arise from the channel through which multiplicity arises and most of them have a general equilibrium flavour. Examples include Fender (1998) and Burdett, Lagos and Wright (2003). This has some empirical support as well. In particular, the issue of wide variation in crime rates has been addressed using a neighbourhood structure by Glaeser, Sacerdote and Scheinkman (1996). They work out the effect that neighbours have on behaviour; having criminal neighbours induces people to commit crime. While we have not studied dynamics in this paper, we can generate multiplicity in a neighbourhood structure where everyone behaves completely rationally. In terms of the broad debate on public vs. private enforcement of law (see the classification and discussion in Polinsky and Shavell (2000) and references therein), our model falls somewhere in between. While enforcement is by a public law enforcement authority, the selection of the sites to investigate depends on neighbourhood reports.

4There are of course associated general equilibrium effects as an increased spending on prevention of potential terrorist activities reduces the resources to spend on other criminal activities thereby encouraging such activities. As noted in a recent article in the New York Times ‘the war on terrorism is also depleting law enforcement resources’ and several states have seen an increase in crime rates. We wish to concentrate, however, on the more striking issue that having to act on an increased number of potential threats following increased vigilance may not, even after a budget increase, decrease such activities. (The NYT June 7, 2003 ‘As Budgets Shrink, Cities See an Impact on Criminal Justice’ by Fox Butterfield.)
We should mention that so far we have not come across any paper in the crime literature with this explicit neighbourhood structure; nor did we find any work which looks at the effect of offering incentives to report crime on crime levels. A recent paper by Eeckhout, Persico and Todd (2005) studies optimal policing with commitment and shows that announcing random ‘crackdowns’ can be optimal. Even though the paper does not look at crime reporting, allowing the police to credibly announce that all reports may not be investigated with equal intensity (as they do) may lead to potentially interesting results in our framework. We discuss this further in the section on profiling and in the conclusion. In terms of modelling, mention may be made of some similarity that this paper has with auditing models (see for example Reinganum and Wilde (1986)). There are, of course, many papers using a local observation approach in other fields (e.g. Ellison (1993), Eshel, Samuelson and Shaked (1998), Chatterjee and Xu (2004)), though the agents are not fully rational in most of these papers (an exception is Xue (2003)).

In summary, while several papers on crime generate multiplicity, we believe our paper is the first to look at the effects of crime reporting on crime, looking at how this (act of reporting) interacts with the decision to commit crime and can perversely affect crime.

3 The model and notation

3.1 Agents and sites

There are a finite number $N \geq 3$ of people$^5$, each located at a single site on a circle. Agent $i \in N$ learns the value $x_i \in [0, 1]$. $^6$, where $x_i$ denotes person $i$’s private benefit from crime and the $x_i$ are realisations of i.i.d random variables with common cdf $G(\cdot)$. Each agent $i$ decides whether or not to commit a crime i.e. each agent chooses $d_i \in [0, 1]$ where $d_i$ denotes the probability of committing a crime. The site agent $i$ is on emits a signal $s_i$ seen by the neighbours on either side, with the intensity depending on whether agent $i$ has committed a crime or not. Let $F_0$ and $F_1$ be the probability distributions of the signal emitted from a site conditional on no crime and on crime, respectively. The probability distributions are all assumed to be absolutely continuous and the ratio $\frac{f_1(s)}{f_0(s)}$ is increasing in $s$ (where $f_0$ and $f_1$ are the respective densities). The monotone likelihood ratio property implies first-order stochastic dominance, so the higher (more intense) the signal, the more likely it is that a

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$^5$Typically, we think of $N$ as large, though this is not used in any proofs.

$^6$The lower bound of the support might be negative rather than 0, in which case there will be some expected proportion of the population who would never commit a crime. While it is possible to incorporate such an assumption into the model, it would necessitate considering some special cases that we are able to ignore here which would detract from the main focus of our analysis.
crime is being committed.

After observing signals emitted by her neighbours, an agent has to decide whether to report a site or not. The agent incurs a cost of reporting $\eta$ per report (so $2\eta$ for two reports) and also, if she has been reported herself and is investigated, a cost of being investigated of $\gamma$. The reporting decision is denoted $\rho_i \in [0, 1]^2$ where $\rho_i = (\rho_{i-1}, \rho_{i+1})$ denotes the reporting probabilities on $i - 1$ and $i + 1$. These will depend on whether $d_i = 1$ or 0 and on the signals $s_{i-1}$ and $s_{i+1}$. We assume that Player $i$ does not observe her own signal $s_i$.

The cost of a crime at site $i$ is 1 to each of agents $i - 1$ and $i + 1$. If the police apprehends the criminal, each neighbour saves the cost of the crime. Thus, the net benefit of apprehending a criminal to the two neighbours is 2. The apprehended criminal incurs a penalty $\theta > 1$. The way we interpret this is as follows. Removing a criminal prevents future crime and hence benefits the neighbours. Since, we have a static model, this is a reduced form of representing the payoffs to the neighbours. Alternately, we could have interpreted $d_i$ as denoting the probability of planning a crime and, of course, preventing this gives the neighbours a benefit. In that case, the agent, if apprehended, does not enjoy the fruits of the crime. This would change the payoffs and equilibrium characterisation slightly but the qualitative results remain unaffected. In considering whether to investigate a site the police consider only the welfare of the neighbours, the criminal’s disutility from apprehension is not considered.

3.2 The police

The police is modelled here as separate from the agents. This means that we rule out any nexus between the police and the community as well as any benefits that may accrue to the police from having crime reduced if the police also lived in the neighbourhood. This makes the model tractable and serves as a good approximation for communities where such interaction is minimal. However, the police play a crucial role and indeed the two models in this paper differ primarily with respect to the assumptions made about the behaviour of the police. In the first model, the police observe the reports and decide whether or not to investigate. The police chooses whether or not to investigate depending on how many reports there are from a site and how many reports there are about the site. Let $\ell, m \in \{0, 1, 2\} \times \{0, 1, 2\}$ be used to denote the number of reports on site $i$ and the number of reports emanating from site $i$. Thus an investigation strategy is denoted by $\omega : \{\{0, 1, 2\} \times \{0, 1, 2\}\}^N \rightarrow [0, 1]^N$. Let $C(r)$ be the cost of investigating a site if reports have been received about $r$ sites. We assume that

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7 As we are looking at the effects of reducing the cost of reporting, we think of $\eta$ as typically "small", perhaps even close to 0. (The penalty for false or misleading reports, which could increase $\eta$, is not practicable here because the signal $s$ is noisy. Moreover, it would increase the cost of reporting in expected terms).

8 The reporting decision is made after the actual decision to commit crime or not, so even though $d_i$ denotes the probability of crime, it takes on values 0 or 1 in any actual realisation of play.
$C(r)$ is either flat or increasing in $r$ with $C(0) = 0$ and $C(N) \leq 2$.  The assumption that $C(.)$ is increasing in $r$ sharpens some of our results in the first model. The intuition behind this assumption is that more reports tax the limited resources of a police department, even if they are not investigated. This can happen because each member of the police force has to spend a certain amount of effort handling the procedural formalities associated with filing reports and, given diminishing returns to effort, the cost of undertaking the effort necessary for investigation increases the more the effort spent on proper collation of the reports.\footnote{Cost could be convex in effort. We do not mean to imply procedural formalities are unimportant. Proper collation of reports is essential for accurate investigation. Also, adding a fixed cost per site actually investigated does not change the results.}

In the second model, another view is taken of resource constraints. Here we assume there is a \textit{fixed budget} of effort $e$ and if $r$ sites are reported then the probability of investigation is $\frac{r}{r}$. The difference between the two models is essentially, therefore, one of interpretation of how tight a resource constraint is. The first model also captures the scenario where the police are unable to commit to an investigation strategy, hence they investigate ex post depending on whether social cost exceeds social benefit, rather than maximise ex ante social welfare. The fixed budget may be interpreted as a scenario where the police are able to commit to expending a certain amount of resource, though that is not optimally chosen in this case.

In both models, there is an issue of what the police does if the number of reports is "too small". In the first model, this arises if there are no sites reported. In this case, an (endogenously determined) number of sites is randomly chosen for investigation. In the second model, if $e > r$, the remaining $N - r$ sites are investigated with a probability $\frac{e - r}{N}$ and the $r$ sites reported are investigated with probability 1.

### 3.3 Timing of events

At the beginning of the game, $t = 0$, the $x_i$ are realised-the value of $x_i$ is revealed only to agent $i$. Each agent $i$ then decides whether or not to commit a crime, that is he chooses $d_i$. Given $d_i$, a signal $s_i$ is generated and observed by $i - 1$ and $i + 1$. Each player $i$ then chooses whether or not to report, $\rho_i$. Given all the reports, the police decides on investigation $\omega_i$. If a criminal is caught, the criminal is removed and penalised. If agent $i$ has chosen $d_i = 1$, he obtains the benefit $x_i$. The various costs are paid when incurred. The game ends after the penalties and benefits have been obtained.

\footnote{$C(N) \leq 2$ ensures that if expected crime rate is 1, every site should be investigated. That in turn ensures that the crime rate is bounded away from 1.}
4 Perfect Bayesian Equilibria of the optimal investigation model.

In this model the police investigate each report based on an optimal investigation strategy as described in the previous section. We solve for the symmetric Perfect Bayesian Equilibria of this game\textsuperscript{11}. The following conditions are needed for the equilibria we describe. (1) $\theta > 1$ and (2) $C(N) \leq 2$. Condition (1) is needed, otherwise we could have positive crime even when all sites are investigated and condition (2), as discussed, ensures that crime rate $u$ is bounded away from 1.

4.1 The optimal investigation decision for the police

Suppose that $r > 0$ sites have been reported to the police\textsuperscript{12}. Let $u_{tm}^i$ be the conditional probability that a crime has been committed at site $i$, given $\ell$ reports on site $i$ and $m$ reports from site $i$. (This refers to the police’s belief and the same notation is used to describe beliefs on and off the equilibrium path.)

If $r = 0$, the police investigates a random number of sites. Let $u_{00}^i$ be the probability that a site has a criminal given no reports about it or from it. Moreover, this probability does not depend on $i$, since we are considering symmetric equilibrium strategies. If the police randomly generates $r'$ reports to investigate, the procedural formalities must be completed for these $r'$ sites, so that the cost of investigation is $C(r')$ per site.

\textbf{Lemma 1} The police investigation policy is as follows: If $2u_{tm}^i > C(r)$, set $\omega = 1$. If $2u_{tm}^i < C(r)$, set $\omega = 0$. If $2u_{tm}^i = C(r)$, set $\omega \in [0, 1]$.

\textbf{Proof.} This is clearly true, given the costs and benefits of investigation of a site, with 2 being the total benefit from apprehending and removing a criminal. ■

4.2 The reporting decision

Given the police investigation decision, we now consider the equilibrium reporting decision by the agents.

\textbf{Lemma 2} If $s_i > s_i'$ and neither agent $i-1$ or $i+1$ reports at $s_i$, neither will report at $s_i'$;

\textsuperscript{11}For a formal definition of Perfect Bayesian equilibrium see Fudenberg and Tirole (1991). Our analysis incorporates sequential rationality according to beliefs updated using Bayes’ rule whenever possible.

\textsuperscript{12}We assume here that if there are any reports, these are the only sites that are investigated. It is only if no sites are reported that a random number of reports is generated.
Proof. The statement follows from the monotone likelihood ratio property on the distributions of signals, since a lower signal is evidence of a lower probability that the site emitting the signal has committed a crime. ■

A general characterisation of mixed strategy equilibria does not yield any new insights in this model; there is a version of the free rider problem, but the problem is not very acute given that our attention is on the case where the cost of reporting $\eta$ is close to 0, either as a feature of the environment or because of policies designed to encourage reporting on neighbours.

A partial characterisation of how the relative magnitude of $\eta, \gamma$ and $\theta$ and its interaction with the investigation and reporting strategies put restrictions on what inferences are compatible in equilibrium is provided in a working paper version. Here, we summarise the effects of increased reporting. Suppose $i-1$ reports $i$. There are two effects of reporting. First, it stochastically increases the number of reports and therefore reduces the probability of investigation, given that the cost of an individual investigation goes up in $r$. Second, it potentially changes the prior of the police, who might infer that $i-1$ is more likely to be a criminal if he reports $i$ or vice versa. If the effects work in the same direction or the first effect dominates, then reporting is more beneficial for criminals (who have more to lose if investigated) than for non-criminals. Hence, a report should be informative about the reporter, who is more likely to be a criminal. If the second effect dominates and works in the opposite direction from the first, then not reporting should be better for the criminal. This would however imply that reporting should work in the same direction as the reduced probability of investigation. Thus, the belief that the act of reporting or not reporting is informative about the reporter is not far-fetched. This also provides some justification for using these beliefs for out-of-equilibrium actions in the equilibria discussed in the next two subsections. In the next subsection, we shall discuss the case where everyone reports and the subsection after that discusses the case where no one reports.

4.3 Equilibrium where everyone reports

Proposition 1 There exists an equilibrium (for $\eta \leq \gamma\{1 - [G^{-1}(1 - C(N)/2)]/\theta]\}$ such that all $i$ report for $s_{i+1}$ (and $s_{i-1}$) $\geq \underline{s} = 0; d_i = 1$ if $x_i \geq \underline{x}$ with $1 - G(\underline{x}) = u_0 = C(N)/2$, and $\underline{x} = \theta \omega_{22}$. If some site $i$ does not report, the agent at that site is believed to have committed a crime with probability 1 and is investigated with probability 1, other investigation probabilities being unaffected. If site $i$ is not reported on by at least one neighbour, that site is not investigated.$^{13}$

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$^{13}$As stated here, only reported sites will be investigated. We can replace this with the assumption made in later results where a minimum number of reports is generated randomly, without changing the result,
Proof. The investigation strategy is clearly optimal, from Lemma 1, since the reports are uninformative (there are reports for every value of \( s \)) and the police is indifferent between investigating and not investigating, so that any probability of investigation is optimal. Given that \( \omega_{22} \) is chosen, the payoff of an agent is \( x_i - \theta \omega_{22} - \gamma \omega_{22} - \eta \) if she commits a crime and \( -\gamma \omega_{22} - \eta \) if she does not commit a crime, hence the condition. We have to check that the reporting strategy for a player is also optimal given what other players are expected to do. If an agent \( i \) deviates and does not report, her payoff will be \(-\gamma\) if she has not committed a crime and \( x_i - (\gamma + \theta) \) if she has committed a crime. Therefore, she will choose to report (given \( d = 0 \)) if \(-\gamma \omega_{22} - \eta \geq -\gamma\). But we know that the equilibrium condition gives us \( \omega_{22} = \left[ G^{-1}(1 - C(N)/2) \right] / \theta \), so substitution yields

\[
\left[ G^{-1}(1 - C(N)/2) \right] \gamma / \theta \leq \gamma - \eta
\]

or

\[
\gamma \{ 1 - \left[ G^{-1}(1 - C(N)/2) \right] / \theta \} \geq \eta.
\]

This gives the requisite bound on the reporting cost for this to be an equilibrium. The above condition is also sufficient for \( d = 1 \), since the cost of being investigated is higher for the agent who has committed a crime. \(^{14}\)

Remark 1 Consider a case where both the criminal and the non-criminal adopt a (pure) reporting strategy of reporting for sure if \( s_i \geq \bar{s} > 0 \) and not reporting otherwise. In this case, a site \( i \) would either have two reports (if \( s_i \geq \bar{s} \)) or none. Thus if one report is seen, this is off the equilibrium path and beliefs must be specified accordingly. If the criminal and non-criminal adopt different pure reporting strategies, that is, the value of \( \bar{s} \) depends on whether the reporting site has committed a crime itself or not, then the beliefs if only one report is observed are given by Bayes’ theorem. In the first case, it is clear that a deviation has taken place but it is not clear by whom. (Namely, is it the agent who reports her neighbour the deviator or the agent who does not report?) If the police response is to investigate both players \( i - 1 \) and \( i + 1 \) with probability 1, then such a deviation will be deterred. However, a belief that justifies this appears to be incompatible with "no signalling what a player does not know", one of the conditions constraining beliefs off the equilibrium path in Fudenberg and Tirole, since the player who deviates (say, \( i - 1 \)) does not know whether \( i + 1 \) has committed a crime or not and the \( x_i \) are independent draws for all \( i \).

since it involves two or more deviations to bring this about.

\(^{14}\)Note, that we require that the deviator is investigated with a higher probability for this proposition (and the next) to hold. The deviator being investigated with probability 1 simplifies the algebra. Indeed, for small \( \eta \) if the deviator was investigated with the same probability but a neighbouring site with a lowered probability, the equilibrium would still exist (for slightly different configurations of \( \gamma \) and \( \eta \).)
4.4 Equilibrium with no agent reporting

The previous section has shown that when reporting costs are small enough, there is an equilibrium where a report is completely uninformative about whether a crime has been committed or not. We now consider the polar opposite case, where there are no reports and consider the conditions under which this could be an equilibrium. (This too has non-informative reporting.)

This crucially depends on how the police responds (on the equilibrium path) to no reports about any site. It is clear that if the police does not investigate without reports, there will be a probability 1 of crime at every site and this cannot be an equilibrium. We therefore adopt the assumption that $r^\prime$ pseudo-reports are randomly generated by the police in this event.

**Proposition 2** There exists a continuum of equilibria with $r = 0$, that is no one reports. On the equilibrium path, the police choose $r^\prime$ pseudo-reports, where $r^\prime$ is sufficiently high. The crime rate in any equilibrium is given by $u = C(r^\prime)/2$. The police choose site $i$ with probability $\frac{r^\prime}{N}$ and investigate a chosen site $i$ with probability $\omega \in [0, 1]$; if any agent $i$ does report, the police investigate the reporter with probability 1, justified by the belief that $x_i = 1$. The site reported on is investigated with an unchanged probability $\frac{r^\prime}{N}$, If the number of sites reported is more than $r^\prime$, the police adopt the optimal investigation strategy under the belief that the probability of crime at a reported site is unchanged from the ex ante probability and at a reporting site is 1.

**Proof.** The maximum probability of being investigated for site $i$ is $\frac{r^\prime}{N}$, for a given $r^\prime$. The net expected benefit from crime for site $i$ is at least max $\{ x_i - \theta \frac{r^\prime}{N}, 0 \}$. The ex ante probability of crime is therefore at least $1 - G[(\theta) \frac{r^\prime}{N}]$. Given the assumption about the probability distribution $G$, this is decreasing in $r^\prime$. The cost $C(r^\prime)$ is increasing in $r^\prime$. Given that $C(0) = 0$, as assumed, there is a $r^{\prime*}$ such that

$$1 - G[(\theta) \frac{r^{\prime*}}{N}] = C(r^{\prime*})/2.$$  

15This is the minimal "crime rate" possible in this kind of equilibrium. For values of $r^\prime$ above this a value $\omega$ is chosen so that

$$1 - G[(\theta) \frac{r^\prime}{N}\omega] = C(r^\prime)/2.$$  

Clearly, the police will not deviate from the investigating strategy. If $r^\prime < r^{\prime*}$, it should increase $r^\prime$. Once $r^\prime$ is high enough, it should follow the investigation strategy because it is

15It is, of course, trivial to modify this to take into account the fact that $r^\prime$ is an integer.
optimal. For the agent at site $i$, deviating to report instead of remaining quiet will give a payoff of $-\gamma - \eta$ while remaining quiet will give a payoff of $-\gamma \frac{\tilde{r}}{N}$ (for a non-criminal). Clearly the deviation is unprofitable for all values of $\eta$. The benefit obtained by reporting is 0, because whether a site is investigated or not does not depend on whether it is reported based on the out-of-equilibrium beliefs.

Remark 2 Note that the "crime rate" in the no reporting equilibria can take on values between $C(r^*)/2$ to $C(N)/2$. Here we have assumed that generating reports is costless for the police-only the investigation is costly. If the act of choosing sites randomly figures in the police’s preferences, so that lexicographically fewer sites investigated were preferable to more the "crime rate" would be at its lower bound and therefore strictly less than in the equilibrium of Proposition 1.

4.5 Summary of this section

We have shown in this section that if reporting costs are sufficiently low, reports can be completely uninformative about whether there has been crime or not. An equilibrium in which no one reports has at most the same crime rate as one in which everyone reports, and, given that agents save on reporting costs in the second equilibrium, is better for society.

5 Equilibria of the model with a fixed budget

We now consider our second model. The main difference with the earlier model is that now the only rational decision-makers are the agents around the circle. The police is assumed to behave according to pre-set rules by which to expend a fixed budget for investigations. The main motivation for this section is to be more realistic about the kinds of pressures that determine the actions of actual law enforcement authorities. It might be argued that police do work with a fixed budget and reports need to be investigated if the budget so allows.

We keep the same notation as in the previous section for the crime and the reporting decisions and for the agents. The police now have a fixed budget to investigate $e$ sites and this is spent as follows:

1. If there are $r$ reports and $r \geq e$, then from the reported sites $e$ randomly chosen sites are investigated.

2. If there are fewer reports than $e$, then all reports are investigated with probability 1 and $e - r$ of the remaining $N - r$ sites are randomly chosen for investigation.
3. An agent’s probability of being investigated depends on the total number of sites reported on and on \( e \) and, conditional on these, is unaffected by whether she herself reports or not.

4. A single report is sufficient to get the reported site "on the list". The police does not condition its investigation decision on the number of reports about a site. (We briefly consider what happens when the police need two reports to investigate in Sec 5.1)

We first show that the no reporting equilibria of Proposition 2 are no longer equilibria of this model for sufficiently small \( \eta \).

**Lemma 3** For sufficiently small \( \eta \), any equilibrium in the fixed budget model must have a positive probability of reporting with \( 1 < e < N \).

**Proof.** Suppose not, so that there is an equilibrium in which no site reports with positive probability, i.e. \( \bar{s} = 1 \). The probability that any site is investigated in the candidate equilibrium is \( \xi \). Now suppose that Player \( i - 1 \) observes a high signal \( s \) from site \( i \); assume that \( d_{i-1} = 0 \). If \( i - 1 \) reports, her payoff is

\[
u(s) \cdot \frac{1 - \eta - \gamma e - 1}{N - 1}.
\]

If she does not report, her payoff is

\[-\gamma \frac{e}{N} + \frac{u(s) e}{N}.
\]

The difference between these two expressions is

\[
u(s) \left( \frac{N - e}{N} \right) + \gamma \left( \frac{N - e}{N(N - 1)} \right) - \eta = \frac{N - e}{N} (\nu(s) + \frac{\gamma}{N - 1}) - \eta.
\]

The sign of this expression depends upon \( \nu(s) \) and \( e \) as well as the costs \( \eta \) and \( \gamma \). For given values of \( e, N \) we can find an upper bound for \( \eta \) such that this condition holds for sufficiently high \( \nu(s) \).

**Remark 3** Note that if \( e \) is small the condition for a profitable deviation is met for more values of \( \eta \). If a non-criminal has a profitable deviation from this candidate equilibrium, so does a criminal.

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We now check whether everyone reporting can be an equilibrium with a fixed police budget.

**Lemma 4** There is no equilibrium in this fixed budget model where everyone reports both neighbours for any $\eta > 0$.

**Proof.** The equilibrium probability of investigation is now $\frac{\xi}{N}$. Suppose that Player $i - 1$ deviates and does not report for some value of $s_i$. The probability of investigation is unchanged for all sites, since every site has at least one report on it. Thus both the benefits and the costs from this investigation probability will remain the same, and the only effect will be that $i - 1$ saves $\eta$, the cost of reporting. □

We now consider other possible equilibria.

**Proposition 3** There exists an (asymmetric) equilibrium for small enough reporting costs such that every site $i$ is reported on for all values of $s_i$.

**Proof.** We already saw that, given the rules for police investigation, both neighbours will not report a site with probability 1. If every site is reported on, the investigation probability for each site is $\frac{\xi}{N}$. Suppose that Player $i - 1$ (with $d_{i-1} = 0$) reports Player $i$ in the candidate equilibrium. If Player $i - 1$ decides not to report for a signal $s_i$, her gain will be $\eta$, the reporting cost. The loss from not reporting will be $u(s_i) \cdot \frac{\xi}{N} + (\gamma)(\frac{\xi}{N} - \frac{\xi}{N})$. The loss will outweigh the gain for all values of $s$ if $\eta \leq (\gamma)\frac{\xi}{N(N-1)}$. Since the police investigation strategy is fixed, the site $i - 1$ will not attract further investigation as a result of not reporting so this is sufficient. □

For higher reporting costs, we can construct a mixed-strategy equilibrium as follows. Let $q(s_i)$ be the probability that a non-criminal at site $i - 1$ reports a site $i$ based on a signal $s_i$. Given the payoffs, it is easy to see that if a non-criminal is randomising (between reporting and not reporting a site) for a given signal, the criminal will report the site with probability 1. Let $p = u.1 + (1 - u)q(s_i)$ denote the unconditional probability that a site $i$ which emits a signal $s_i$ is reported by $i - 1$ and $u$ is the unconditional probability that site $i - 1$ has a criminal. Let $\Delta \omega(i - 1) = E_r(\omega(k) - \omega(k + 1))$ where $k$ is the random number of sites other than $i$ that have been reported and $\omega(i) = E_r(\omega(r))$, $r$ being the total number of reports. The distribution of $r$ depends on the distribution of signals and on the reporting strategies followed. The net gain to $i - 1$ from reporting site $i$ is the benefit of site $i$ being investigated, $(u(s_i) \cdot \Delta \omega(i))$ and the decreased expected cost of being interrogated $(\gamma \Delta \omega(i - 1))$ net of the loss because of decreased probability of site $i - 1$ being investigated $(u(s_{i-2}) \cdot \Delta \omega(i - 2))$. We formalise this as follows.
Proposition 4 The following constitutes a mixed strategy equilibrium for the game with a fixed budget, with the notation above.

(i) Given the signal $s_i, s_{i-2}$ if $d_{i-1} = 0$, $i - 1$ reports with a probability $q$ and if $d_{i-1} = 1$, with probability 1 such that

$$1 - p = \frac{\eta}{u(s_i)\Delta \omega(i) + \gamma \Delta \omega(i - 1) - u(s_{i-2}) \Delta \omega(i - 2)}$$

so long as $p \in [0, 1]$. Thus, $p$ is the probability of a site being reported that makes the non-criminal indifferent between reporting and not reporting. If $q(s)$ is the probability with which a non-criminal reports for a signal of $s$, then $p(s) = u.1 + (1 - u).q(s)$.

(ii) Given the reporting strategies, the decision on whether to commit a crime or not is obtained for Player $i$ by the following expression

$$\max\{x_i - \theta \omega(i) - \eta(d_i = 1), -\eta(d_i = 0)\}.$$

with $\eta(d_i)$ being the expected reporting cost given the optimal reporting strategy$^{16}$

Proof. The value of $p$ above is chosen by $i - 1$ (through choosing $q$) to keep the non-criminal at $i + 1$ indifferent between reporting and not reporting given a signal $s_i$. This is seen by multiplying the left hand side by the denominator which gives us the incremental benefit of reporting (i.e. benefit of reporting multiplied by the probability $1 - p$ that the site was not reported). Notice that as $s$ increases (i.e. for higher values of the signal), $p$ goes up (as $q$ goes up) so that $1 - p$ (the probability of a site not being reported) goes down to make sure that the left hand side of the equation adjusts as $u(s_i)\Delta \omega(i) + \gamma \Delta \omega(i - 1)$ increases with $s$. At this value of $p$, the criminal at site $i + 1$ strictly prefers to report because of the "red herring" effect i.e. because of the lowered probability of apprehension. Hence the denominator in the expression would have an additional term $\theta \Delta \omega(i - 1)$. Given these reporting strategies, it is clear that the decision on whether to commit a crime or not will be given by the expression in (ii) i.e. the maximum of the net benefits of committing or not committing crime. Notice that the expected reporting cost $\eta$ depends on the decision to commit crime as that influences the probability that the agent will report and hence incur the cost.

Remark 4 Note that if there is a bound $\bar{s} > 0$ such that the non-criminal does not report a site below $\bar{s}$, the criminal will continue to report. Since the police does not base its decision on whether to investigate on whether a person has reported or not, this strategy does not affect the probability that the reporting site will be investigated. Since the probability of investigation

$^{16}$Of course, $\eta$ will depend on the probability of reporting given the signal and the a priori distribution of the signal itself.
is always positive, the crime rate is never 1. We denote by $u_{\text{max}}$ the maximum crime rate. Obtaining a report about a site is informative about crime at that site in this setting.

We conclude this subsection with an example of what can happen if $\gamma$, the cost of being investigated is high, and is in fact $> e$. This is by no means outside the bounds of possibility, given the disruptions caused in the lives of those who have been "objects of interest" in recent investigations, as well as for those who have been incarcerated and eventually released without having been charged.

This is a sort of contagion equilibrium, where everyone reports because for low enough costs the private benefit of reporting is greater than the cost of lowered apprehension probability in sites with a high probability of criminal activity (i.e. where stronger signals are emitted). We illustrate this with an example, which is a special case of our setup, to emphasise the point. The example uses the neighbourhood structure of our model. Whilst this result holds with one report being sufficient to cause investigation, it also holds without indifferences if both neighbours need to report a site to get it on the list.

Example 1 Consider a case where criminal activity can be perfectly observed by the neighbours. Further let $\gamma \Delta \omega(i - 1) \gamma > \Delta \omega(i)$ to make the cost of interrogation sufficiently high and let $\eta = 0$. Let everyone hold the belief that there is one criminal in society. Further assume that a crime has been committed at site $i$. We now show that it is indeed optimal for every site to be reported. Clearly, site $i$ will be reported on and in turn the criminal in $i$ will report $i - 1$ and $i + 1$ to reduce her apprehension probability. If $\gamma \Delta \omega(i - 1) \gamma > \Delta \omega(i)$, the agents in $i - 1$ and $i + 1$ will report $i - 2$ and $i + 2$. Now, all agents from $i - 2$ and $i + 2$ onwards do not know the location of crime but they can infer that criminals of neighbours will report both neighbours. Hence, for any positive probability $\alpha$ of being reported, they gain $\alpha \gamma \Delta (\omega) > 0$ from reporting their neighbours. This is true for any agent other than $i - 1$ and $i + 1$. Hence, everyone reports. Finally, note that any agent commits crime as long as $x_i \geq e N \theta$. So this particular realisation will have agent $i$ receiving an $x_i \geq e N \theta$ and everyone receiving $x_i \leq e N \theta$.

5.1 Two reports

One way in which the police might try to condition investigation is by paying more heed to a site if both neighbours report it. At an extreme the police may decide to investigate only if two reports are made about the site. With common signals, this may be a way to get around

\[17\text{ Here, } \eta = 0 \text{ ensures that we do not need to worry about co ordination issues about which neighbour will report which site as both neighbours can report a site in equilibrium. The analysis however goes through for "small" } \eta \text{ except that we have to adopt a convention about which neighbour reports which site.}\]
the free rider problem. However, with conditionally independent signals, this may also be thought of as trying to investigate crime where the probability is higher.\textsuperscript{18} We now consider equilibria when the police follow a rule of investigating a site only if both the neighbours on either side report it. Clearly, this will imply that in all pure strategy equilibria, either a site will not be reported or both neighbours will report a site. Thus, we get the following lemma

\textbf{Lemma 5} In all pure strategy equilibria, with a fixed budget and two reports necessary for investigation, as long as $\eta > 0$, either a site will have two reports or 0 report about it

\textbf{Proof.} Suppose a site has 1 report, then the site will not be investigated but will lead to a cost of $\eta$ for the reporter. Clearly, by deviating he saves the cost. \hfill $\blacksquare$

\textbf{Remark 5} This of course implies that criminals and non-criminals must be using the same cutoff value of the signal as, otherwise, there would exist values of the signal for which a criminal or non-criminal would report a site but not both, contradicting the above lemma.

Further, we note that this may not necessarily encourage reporting as there exists an equilibrium when no one reports; since clearly deviation by one neighbour is not optimal, the site will not be investigated and only the cost of reporting is borne by the reporter. The following lemma states this

\textbf{Lemma 6} There exists an equilibrium when sites are investigated only if two reports are made about it such that no one reports and $u = u_{\text{max}}$

\textbf{Proof.} Given that no one makes a report, unilateral deviation only incurs a costs of reporting as police investigate only if there are two reports. Clearly with no investigation apprehension probability is $\frac{\epsilon}{N}$. Hence, $u = u_{\text{max}}$. \hfill $\blacksquare$

Other symmetric equilibria, which are informative, of course exist. At low costs for instance, there exists an equilibrium where everyone reports. This is analogous to proposition 3 except that this is a symmetric equilibrium. This is because reports are investigated only if both neighbours make reports. The following proposition formalises this.

\textbf{Proposition 5} There exists a symmetric equilibrium for small enough reporting costs such that every site $i$ is reported on for all values of $s_i$.

\textbf{Proof.} Similar to proposition 3. \hfill $\blacksquare$

\textsuperscript{18}In fact, the probability is higher even with common signals in a mixed strategy equilibrium where $p(s)$ is increasing in $s$. 

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Remark 6  Note that the social cost is higher, as the net cost of reporting is \( \eta N > \eta \frac{N}{2} \) which is the total cost to the agents when only one report is needed to get the police to investigate.

Of course, with two reports the social cost is necessarily bigger for pure strategy equilibria. In fact, we can characterise for every \( \eta \) a cutoff strategy, i.e. if the signal \( s > s' \) both neighbours will report a site, otherwise not. The following proposition characterises all equilibria where both neighbours report.

Proposition 6  For every \( \eta \) there exists a value of the signal such that both neighbours report for sure i.e. \( \rho_{i-1} = 1 \) if \( s_i \geq s \), \( \rho_{i-1} = 0 \) otherwise. The corresponding decision to commit crime is given by

\[
\max\{x_i - \theta \omega(i) - \eta(d_i = 1), -\eta(d_i = 0)\}.
\]

with \( \eta(d_i) \) being the expected reporting cost given the optimal reporting strategy.

Proof. Consider any \( \eta \), then as long as \( u(s).\Delta \omega(i) + \gamma \Delta \omega(i - 1) > \eta \), both neighbours find it in their interest to report. The second part of the proposition is analogous to proposition 4. □

These describe the pure strategy equilibria of the fixed budget model where two reports are needed to trigger investigation. There exists a mixed strategy equilibrium of the model as well. The difference between the mixed strategy equilibrium of the fixed budget model with one report is that calculation of the benefit of reporting is different. With the same notation, let \( p = u + (1-u)q(s) \). The following constitutes a mixed strategy equilibrium.

Proposition 7  (i) Given the signal \( s_i \), if \( d_{i-1} = 0 \), \( i-1 \) reports with a probability \( q \) and if \( d_{i-1} = 1 \), with probability 1 such that

\[
p = \frac{\eta}{u(s).\Delta \omega(i) + \gamma \Delta \omega(i - 1) - u(s_{i-2}).\Delta \omega(i - 2)}
\]

so long as \( p \in [0,1] \). Thus, \( p \) is the probability of a site being reported that makes the non-criminal indifferent between reporting and not reporting. If \( q(s) \) is the probability with which a non-criminal reports for a signal of \( s \), then \( p(s) = u(s).1 + (1-u(s)).q(s) \).

(ii) Given the reporting strategies, the decision on whether to commit a crime or not is obtained for Player \( i \) by the following expression

\[
\max\{x_i - \theta \omega(i) - \eta(d_i = 1), -\eta(d_i = 0)\}.
\]

with \( \eta(d_i) \) being the expected reporting cost given the optimal reporting strategy
Proof. The proof is similar. Importantly, note that now if the non-criminal reports the benefit is given by \( pu(s) \Delta \omega(i) + \gamma \Delta \omega(i - 1) = \eta \) since if he reports, the expected benefit occurs only if the other neighbour reports the site.

6 Profiling

One of the more visible features of the policy of encouraging untrained individuals to report suspicious activities has been the importance given to observable characteristics by those reporting, such as race, age or gender. In similar vein, police often pay more attention to this observable characteristic in deciding whether to chase up reports or not. We show in this section that the two ways in which profiling can occur has quite different consequences for crime rates.

We use a simpler version of our model to address the consequences of taking these observable characteristics into account. The main simplifications are the following: the private benefit of crime can take on a high or low value and the signals emitted can be high or low. Specifically, we assume that \( x_i, s_i \in \{0, 1\} \) for all \( i \). There is an observable characteristic \( A \) which can take on values \( A_0 \) and \( A_1 \). What this means is that agents could assign different probabilities to the random variable \( x \) based on whether \( A \) is \( A_0 \) or \( A_1 \). Denote \( P(x = 1 \mid A_j) = a_j, j \in \{0, 1\} \). We assume \( a_0 = a_1 \), so as to make the effects more stark.

Given the value of \( x_i \) agent \( i \) chooses \( d_i \in [0, 1] \). As before, a signal \( s_i \) with the monotone likelihood property is emitted. Specifically, we assume that if \( d_i = 1, s_i = 1 \) and if \( d_i = 0, s_i = 0 \) with probability \( \xi \) and \( s_i = 1 \) with a probability \( 1 - \xi \). We further simplify by assuming that the signal is seen only by \( i - 1 \), so that we can ignore the free rider problem.

There are various different ways to model profiling. The first, is to model the police as paying more attention to reports about a particular group. While this could occur for various reasons, we shall adopt a relatively weak assumption, namely that there is no difference in the probabilities of crime perceived by the citizens but the cost \( c_0 \) incurred to investigate reports about group \( A_0 \) is lower than the cost \( c_1 \) incurred to investigate a report about group \( A_1 \). Thus the cost for investigating any reports on \( A_0 \) individuals will be \( c_0 \) and the cost of investigating \( A_1 \) individuals will be \( c_1 \). The way we rationalise this assumption is to think of the police having incurred a fixed cost of investigating the profiled group (perhaps because

\[19\]We have had the well-known instance in the UK of a Brazilian being described as "Asian-looking" by an eyewitness, who then discovered other suspicious features about him, such as the fact he was wearing a coat because he felt cold.

\[20\]We could have adopted stronger behavioural assumptions, for example that a signal of 1 from a member of group \( A_0 \) is reported and investigated with probability 1 but the consequences of this are relatively easy to see and they are incompatible with any kind of equilibrium behaviour.
that group has been more crime prone in the past and so the police have already gathered some preliminary information on that group when making this fixed investment) so that the variable cost of investigating is lower.\footnote{An alternate way to interpret this is as a very special case of our assumption that cost of investigation is weakly increasing in number of reports. Assuming that reports about the profiled category have priority, here it is increasing in priority classes. If the value of \(c_1\) could depend on the actual number of reports of individuals from \(A_0\), there might be an incentive for someone from group \(A_1\) to report on a neighbour from \(A_0\) to reduce the probability of investigation when \(A_1\) individuals are investigated. We ignore this last effect.}

We can calculate the posterior probabilities of crime, given the priors and the value of the signal. Denote by \(\alpha_j\) the probability with which an agent of group \(j\) will commit crime conditional on getting a signal of 1. Note that if \(s_i = 0\), \(u_j = 0\), regardless of \(i\) or \(j\). If \(s_i = 1\), Denote by \(d_{ij}(1)\) the decision to commit crime and by \(d_{ij}(0)\) the decision not to commit crime by individual \(i\) in group \(j\). We can calculate the following probabilities.

\[
P(d_i = 1 | \text{\(i\) is in group \(0\)}) \text{ is given by:} \quad u_0 = \frac{a_0 \alpha_0}{a_0 \alpha_0 + (1 - a_0 \alpha_0)(1 - \xi)}
\]

Similarly, \(P(d_i = 1 | \text{\(i\) is in group \(1\)})\) is given by

\[
u_1 = \frac{a_1 \alpha_1}{a_1 \alpha_1 + (1 - a_1 \alpha_1)(1 - \xi)}
\]

We now characterise the unique equilibrium in this set up.

**Proposition 8** If \(a_j > \frac{\xi}{\theta} > \eta\), the following behavioural strategy profile \((d_{ij}(1), d_{ij}(0), \rho_j(1), \rho_j(0), \omega_j)\) constitutes the unique Perfect Bayesian equilibrium of the profiling game.

(i) \(d_{ij}(1)\) is chosen so as to make \(u_j = \frac{\xi}{\theta}\), using the Bayes’ Theorem calculations above.

(ii) \(\frac{1}{\gamma + \theta} = \rho_j \omega_j\),

(iii) \(-\eta + \omega_j u_j = 0\).

(iv) \(d_{ij}(0) = 0, \rho_j(0) = 0\).

**Proof.** We suppress the subscript \(j\) for \(d_{ij}\) in what follows, assuming agent \(i\) is of type \(A_j\). Since there are no agent-specific inferences here, we shall suppress the dependence of \(\rho\) and \(\omega\) on \(i\).

First, we consider the reporting decision. We note that no player will have an effect on his own probability of being investigated by his choice of whether or not to report. Therefore, if the report observed on \(i\) is \(s_i = 0\), the agent at \(i - 1\) obtains a net benefit from reporting of \(-\eta\), since there is no effect on \(\omega\) and since the posterior probability of crime at site \(i\) given a signal of 0 is 0. Therefore, in equilibrium, a signal \(s_i = 0\) will not be reported.

Consider a signal \(s_i = 1\) with site \(i\) being of type \(A_j\). Then the agent \(i - 1\) will report if
\[-\eta + \omega_j u_j \geq 0.\] (1)

Second, we look at the investigation decision. The police will investigate a report on \(A_j\) if
\[2u_j \geq c_j.\] (2)

Suppose \(u_j > \frac{c_j}{2}\). Then \(\omega_j = 1\) and reporting takes place (of \(s_i = 1\)) if \(u_j \geq \eta\). If \(u_j < \frac{c_j}{2}\), \(\omega_j = 0\). If \(u_j = \frac{c_j}{2}\), \(\omega_j \epsilon [0, 1]\).

The third part is the decision on whether to commit crime or not. So long as \(\omega_j > 0\), the agents \(i\) with \(x_i = 0\) will strictly prefer \(d_i = 0\) (no crime) because of the positive cost of being investigated and penalised. Of course if \(\omega_j = 0\), \(d_i(0) \epsilon [0, 1]\). Suppose \(a_j > \frac{c_j}{2}\). Then agent \(i\) chooses
\[d_i = 1\text{ if } 1 - (\gamma + \theta)\rho_j \omega_j \geq -\gamma(1 - \xi)\rho_j \omega_j,\] (3)
\[d_i = 0\text{ otherwise and } d_i \epsilon [0, 1]\text{ if equality holds above.}\]

This can be simplified as \(d_i = 1\) if
\[1 \geq \rho_j \omega_j (\gamma \xi + \theta).\] (4)

Consider possible pure (behavioural) strategy equilibria.
(i) \(d_i(1) = 1, \rho_j(1) = 1, \omega_j = 1\). Since \(\theta > 1\), this cannot be an equilibrium for the agent deciding to commit crime.
(ii) \(d_i(1) = 1, \rho_j(1) = 0, \omega_j = 0\). This can be an equilibrium only if \(a_j < \frac{c_j}{2}\), as previously pointed out. If \(\omega_j = 0, \rho_j\) must be 0 in equilibrium because of positive reporting cost. The combination \(\rho_j = 0, \omega_j = 1\) is also clearly not in equilibrium unless \(\frac{c_j}{2} \leq a_j < \eta\). If \(a_j > \eta\) and \(u_j < \eta\), the choice of \(d_i\) is not a best response \((d_i(1) = 1\) would be).
(iii) \(d_i(1) = 0, \rho_j(1) = 1, \omega_j = 1\). Here clearly \(\omega_j = 1\) is not a best response given the proposed equilibrium strategies.
(iv) \(d_i(1) = 0, \rho_j(1) = 0, \omega_j = 0\). This is clearly not a best response for agent \(i\).

The only pure strategy equilibria possible are therefore for the case of \(a_j \leq \max\{\eta, \frac{c_j}{2}\}\).

We now consider mixed strategy equilibria.

\(^{22}\)If this is not true, \(s_i = 1\) will never be reported and everyone who has \(x_i = 1\) will commit a crime (and the others will be indifferent).

\(^{23}\)As expected, the lower \(\xi\) is, the more attractive crime is.
For $\omega_j$ to be in $(0,1)$, from (2),
\[ u_j = \frac{c_j}{2} \]  
(5)
This implies that agent $i$ with $x_i = 1$ must be using $\alpha_j \in (0,1)$, since we are considering $a_j > \max\{\eta, \frac{c_j}{2}\}$. This implies from (4) that
\[ \frac{1}{\gamma \xi + \theta} = \rho_j \omega_j. \]  
(6)
We can also restrict ourselves to considering the case where $\frac{c_i}{2} > \eta$.\(^{24}\) Then the mixed strategy equilibrium is given by (5),(6) and
\[ -\eta + \omega_j u_j = 0. \]  
(7)

7. The key aspect of this that $A_0$ is “profiled” as high priority for investigation and this makes $c_1 > c_0$. Therefore $u_1$, the posterior probability of crime, is higher for the non-priority group $A_1$, from (7), the probability of investigation is lower and from (6) the reporting probability is higher! Note that in this section, we have not used the dependence of $c_1$ on the number of individuals of type $A_0$ reported. As mentioned earlier, this gives an additional incentive for type $A_1$ to report on type $A_0$ neighbours, though we can’t specify exactly what happens in equilibrium.

A second way to think of profiling is to allow for more reports to emanate about the profiled group. This could happen as a result of receiving ‘incorrect’ signals about the profiled group more frequently. The parameter in the model of this section that corresponds best with the informal stories of individuals of a particular type being treated with suspicion is $\xi$. Recall this is the probability that a signal of 0 is correctly perceived. If, as seems natural, members of the profiled group are more likely to have innocent activity misinterpreted as criminal then $\xi_0$ is small. i.e. the signal is uninformative. From (3), $\rho_0 \omega_0$ will be relatively high and members of the profiled group will be reported more often. However, the posterior probability of a crime given a report will remain at $\frac{c_0}{2}$ in equilibrium. This will increase $\alpha_0$, so in this case more of the profiled group will actually commit crime given the biased misreading of the signal. This, as we see stands in stark contrast to the result in Proposition 8 in this section. Hence, the police viewing one group as more worthy of investigation leads to a different impact on crime rate than the case where the bias comes from the citizens who

\(^{24}\) If not, we could have an interior value of $\omega_j$ and a value of $\rho_j = 0$. But if $\rho_j = 0$, $d_i = 1$ would be a profitable deviation for agent $i$.

Alternatively, If $\frac{c_i}{2} \leq \eta = u_j$, $\omega_j = 1$, $\rho_j$ is given by (6) would constitute an equilibrium.
The effect of welfare on removing the cost difference between investigating groups is indeterminate and depends on the proportion of each type and what each type does in equilibrium. This is consistent with what Eeckhout, Persico and Todd (2005) find in their model of an optimal crackdown.

7 Future work and concluding remarks

We have constructed a simple model of crime reporting, where only neighbours of criminals can observe crime, to examine the impact of encouraging neighbours to report crime on crime rates. In particular, we focus on the scenario where costs of reporting are close to zero and analyse the effect of removing the so-called free-rider problem. It turns out that since the public good element still remains, overreporting could take place as each agent does not take into account the negative effect of her report on the informativeness of other reports. What is striking is the prevalence of a number of equilibria where reporting is completely uninformative. We have also discussed the issue of profiling. One way which we have modelled this is as priority given to investigating individuals of a given set of observable characteristics and shown that this leads to the posterior probability of crime being higher in the non-profiled group. More interestingly, we have shown that if we conceive of profiling as a lower ability by the potential reporter to distinguish suspicious from innocent activities by a profiled group member, this leads to more reporting of the profiled group members and also a higher posterior probability of crime in the profiled group.

A brief discussion about the empirical relevance of our model seems in order. There is little documented evidence in the crime literature or crime statistics on the consequences on encouraging people to report each other. Widely practised in Soviet Union, East Germany and several erstwhile communist countries, the secrecy surrounding their practices do not allow us to get a clear picture of how successful this was in curbing subversive activities. There is a flavour of what such reporting could lead to during the McCarthy era where people were asked to report on their colleague’s political beliefs. The following incident serves to highlight the chain reactions of inducing people to report (a bit like our contagion example). Larry Parks agreed to give evidence to the House Un-American Activities Committee (HUAC)…[who] insisted that Parks answered all the questions asked. The HUAC had a private session and two days later it was leaked to the newspapers that Parks had named names. Leo Townsend, Isobel Lennart, Roy Huggins, Richard Collins, Lee J. Cobb, Budd Schulberg and Elia Kazan, afraid they would go to prison, were also willing to name people
who had been members of left-wing groups.25 While law enforcement chased these people, it is quite plausible that people genuinely pursuing subversive activities were having a field day. Present day efforts to encourage anonymous ordinary citizens to alert the police to undesirable activities may have similar effects.26 These seem to suggest that our all-report, high crime equilibrium has some parallels in the real world. Also, as noted in the introduction, many reports emanate from people who have criminal backgrounds, which is consistent with the prediction of our model.

Several extensions arise naturally from this work. One interpretation of the profiling section is that the police lower the (marginal) cost of investigation by investing a fixed cost in profiling a certain group. This has a flavour of committing to crack down on a certain group (even when ex ante crime rates do not differ across groups) a la Eeckhout, Persico and Todd (2005), such ‘crackdowns’ may or may not be effective depending on the distribution of costs of investigating with and without profiling. However, in stark contrast when citizens report the profiled group more frequently, it leads to higher crime rates in the profiled group.

An issue we have touched on, but which needs more investigation, is the general equilibrium effect associated with trying to lower crime of any one type leading to increases in other types of crime (the so called ‘displacement effect’). This is implicitly captured in our optimal investigation model in terms of the increased cost of having to chase more reports, which can be interpreted as the opportunity cost of having less to spend on other types of crimes, but a fuller formalisation of this is left for future work. We also do not tackle the related and interesting issue of whether a neighbourhood watch programme can bring down crime by increasing the accuracy of reports. This is of course of particular interest as a major issue in reporting is to develop a standard of what could constitute a suspicious activity. Presumably in a successful neighbourhood watch programme the police will invest in training citizens in being able to infer what are suspicious activities. This would be formally equivalent to increasing the accuracy of the signal. Hence, it would be interesting to see what kind of equilibria emerge in such an environment. Another interesting question is whether clustering or dispersion of criminals across sites can lead to different crime rates by leading to different actual number of sites reported. Hence, even for an identical distribution of $x_i$, whether the high $x_i$ are in neighbouring sites or far away can matter in the actual number of criminals in any period. A dynamic extension can thus look at the long run path of crime starting from a

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25 See, for example the website below from which the lines are taken
http://www.spartacus.schoolnet.co.uk/USAmccarthyism.htm

26 A recent police investigation at Art Car Museum, an avant-garde gallery in Houston, on the basis of a phone call is just one of the several "red herrings" that law enforcement is chasing in what many have dubbed as the New McCarthyism (see Matthew Rothschild’s articles in the Progressive http://www.progressive.org/0901/roth0102.html for several more illustrations ).
particular realisation of $x_i$, which should yield interesting results. These, along with a more thorough investigation of empirical evidence, remain for future research.
References


Eeckhout, Jan, Nicola Persico and Petra Todd (2005), ‘A Rational Theory of Random Crackdowns’ working paper


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