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**ARE “GANGSTAS” PEACOCKS?
THE HANDICAP PRINCIPLE AND ILLICIT MARKETS**

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Are “Gangstas” Peacocks? The Handicap Principle and Illicit Markets*

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Abstract

Criminals who wear gang colors are acting in a surprisingly brazen way which must increase the probability of being caught and punished by the police. In our model this brazen behavior is a solution to an enforcement problem. The central idea is that less able criminals see lower gains from continued participation in crime because they will be caught and punished more often. Lower future gains imply that reputational concerns will be less effective at enforcing honesty. Only dealing with brazen criminals will become a good way to avoid dealing with incompetent criminal, because they cannot afford to mimic the brazen behavior. The principle is similar to the selection for a handicap in evolutionary biology.

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1 Introduction

Why do criminals sometimes act in such a brazen way? If what you are doing is illegal, then why would you ever draw more attention to yourself? However there is plenty of evidence that criminals, especially gangs, do exactly that. In particular, they wear their gang's colors in a way that is highly visible.¹ In this paper we will suggest that the purpose of such brazen actions is to signal competence. The explanation will be similar in style to the handicap principle in Biology.

The handicap principle in Biology is best exemplified by the mating behavior of the peacock. The females select the males with the biggest brightest tail and the males display their tail in order to attract the females. The big bright tail is surely a survival disadvantage. Being bright, it increases the probability that the peacock is seen by predators; being big, it slows down the peacock when he tries to evade the predators who spotted the bright tail.

It turns out that this survival disadvantage is precisely the reason the females select for the big bright tail. A male who displays himself with his big bright tail has the survival disadvantage and is still here despite it. This must be good news about his other hidden qualities which would promote his survival: he must be strong and fast. A male peacock with the handicap of a big bright tail has been tested and has passed (with flying colors). A male peacock with no such tail has not been tested.²

The model we will build will show how gang colors can operate as a signal for criminals in a very similar way. Gang colors or other brazen behavior will act as a handicap for a criminal. If they are still willing to commit crimes when they have this handicap, then they must be good at evading the police. Why do criminals want to cooperate with other criminals only if they are good at evading the police? The most obvious reason would be fear of the risk of being caught by "transmission". That is fear that the other criminal's incompetence will lead to your conviction.

However there is a conceptual difficulty here that means it cannot be that simple. Suppose that criminal i is competent and criminal j is incompetent. Further suppose that when they are engaged in some collaborative illegal enterprise, if the police catch i they also get sufficient evidence to implicate j and vice versa. The over the course of this collaboration the probability the police catch and punish i must be the same as the probability they catch and punish j . So if j is so incompetent that i would prefer not to collaborate with him at all, j must also prefer not to collaborate with i . So a competent criminal should not have to worry about incompetent criminals trying to work with him. If they are so incompetent that the competent criminal does not want to work with them, they won't want to work with him either.³

¹Jankowski (1991); Ferrell (1995); Miller (1995); Bjerregaard (2002); Auerswald et al. (2004) all provide evidence of the wearing of colors by gangs and the knowledge that extra police attention is one of the costs that accompanies it.

²See Zahavi (1975, 1977); Grafen (1990).

³Provided of course both groups of criminals find the punishment imposed equally arduous and face

In our model, the desire to avoid trading with incompetent criminals is a direct result of how that incompetence affects their behavior. In short we will show that competent criminals have a greater expected value from the future criminal opportunities ahead of them and so will care more about their reputation for honesty among other criminals. This greater concern for their reputation means that they will behave honestly while less competent criminals might well cheat their trading partners. This is the source of the desire to avoid trading with incompetent criminals. In order to expand on this more fully, we must explain an economic problem that criminals feel most acutely - the problem of trust.

1.1 The Problem of Trust

Most of economic thought assumes that people can make agreements and be bound to them. In short we assume that contracts are enforced. However this isn't necessarily the case in all times and places. Any economic transaction will present at least one party the opportunity to cheat the other. Sellers can sell substandard goods, and buyers can perpetually claim that the check is in the post. In the overworld courts do exist, but they might well be too slow, or too expensive to provide effective redress.^{4,5}

In reality several institutions have evolved over time in order to overcome the problem of trust and allow trade to take place. The most obvious example is the court system (Cooter and Rubinfeld, 1989). However reputational concerns are also of paramount importance.⁶ These are typically modelled as there being some probability that people you trade with tomorrow will hear of your actions today. This provides the incentive to forego self-regarding actions today in order to ensure that there are future opportunities to trade. The model built here has similar features. However, we are interested in the way in which signalling can supplement that reputational mechanism and make it work better.

Gambetta (1993) has highlighted how the mafia represent a solution to the problem of trust in criminal markets and explored the consequences of contract enforcement being supplied through a private market. Our concern here will be with less violent reputa-

the same outside options. It might be that incompetent criminals have worse outside options and so are more desperate to commit a particular crime at this point in time. This would mean that they will accept the higher probability of being caught while their competent collaborator would not.

⁴An example of slow moving courts comes from India, where it has been reported (Dixit, 2004, p.3) that it will take 324 years to clear the backlog before the courts, provided no new cases are filed.

⁵The regulations surrounding the fees that lawyers can charge in loser pays jurisdictions in the USA allows us to estimate the financial cost of going to court. According to the Laffey Matrix (<http://www.laffeymatrix.com/see.html>), a lawyer eleven years out of law school should expect to charge \$582 per hour. Transposing this figure to an own paying jurisdiction, this means that one should not pursue a legal claim up to \$9,000 unless you believe the lawyer can resolve it inside of two working days.

⁶In the historical context, see Hirshleifer and Rassmusen (1989); Milgrom et al. (1990); Greif (1989, 1993). More theoretical treatments are in Kandori (1992*b,a*); Ellison (1994); Okuno-Fujiwara and Postlewaite (1995); Harrington (1995), and modern applications can be found in Bernstein (1992); Dixit (2003, 2004); Bowles and Gintis (2004).

tional mechanisms for maintaining trust. Our leading example will be the market for illegal narcotics. These are often sold by criminal gangs who sometimes wear gang colors drawing more attention to themselves than would seem to be necessary. In these markets, the sellers have ample opportunity to cheat the buyers by reducing the purity of the narcotics they sell, the buyers have few opportunities to cheat the sellers. Furthermore the buyers are weaker than the sellers and have no capacity to inflict any punishments of their own, neither do they have the resources to seek help from any mafia type institution to police the sellers.

We suppose that sellers are heterogeneous in terms of the probability that they will be caught and punished by the police. We further suppose that their honest behavior towards buyers is maintained by a reputational mechanism. However each future sale is worth less to the incompetent sellers than it is to the competent sellers. This means that for some intermediate levels of effectiveness of the reputational mechanism, the incompetent sellers will find it optimal to cheat buyers while the competent criminals find it optimal to trade honestly. We assume that the criminal justice system is not interested in punishing buyers.

For buyers, it would be very helpful to know whether the seller you are trading with is competent or incompetent. You would not want to trade with the latter for fear of being cheated. However information like this may well be private information. The difficulties of such asymmetric information can be resolved by signalling and screening. Buyers can condition their purchase decision on whether the seller has done something blatant. Incompetent sellers would not find it profitable to use the signal and cheat, but competent sellers still find it profitable to signal and trade cooperatively.⁷

Finally, bear in mind that the reason such a signal works is that it raises the expected cost of selling by raising the expected costs of the criminal justice system to the seller. This is a cost that can be borne by competent sellers but not by incompetent sellers. There is another way to raise the expected costs of the criminal justice system which is by increasing the penalty faced if caught. Sometimes mechanisms might actually be available to sellers which would do exactly that. For example, suppose that society finds the selling of drugs near schools even more harmful than simply selling drugs and so imposes harsher penalties when the activity is conducted near a school. Then sellers might be able to signal their competence by only selling their drugs near schools. The policy might actually encourage precisely the behavior we were trying to discourage.

The next section outlines the model. Section 3 examines the circumstances under which universal cooperation can be maintained. Section 4 considers under what conditions an equilibrium exists in which competent traders play cooperatively, but incompetent traders cheat their trading partners. Section 5 examines the circumstances under which a signalling equilibrium can exist. Section 6 examines the policy implications under a similar model in which signalling is achieved by criminals taking actions which increase the criminal penalties they would face if caught. Section 7 concludes.

⁷For a fuller discussion of the diverse range of signals deployed by criminals, see Gambetta (2009).

2 The Model

We imagine two equally large populations of buyers and sellers of an illicit good. At the beginning of each period, the buyers and sellers are randomly assigned to pairs containing one buyer and one seller. In those pairs, they then play a trust game where the buyer decides whether or not to buy drugs from the seller (B for Buy or D for Don't Buy) and the seller decides whether or not to dilute or 'cut' the drugs, (C for Cut or P for Pure).

The payoff matrix is shown in Table 1. We assume that $S > M > 0$ and that $H > 0 > L$.

		Buyer	
		B	D
Seller	P	H	0
	C	L	0
		M	0
		S	0

Table 1: We assume that $S > M > 0$ and that $H > 0 > L$.

Note that in the only Nash equilibrium of this game the seller plays C and the buyer plays D. This outcome is strictly pareto dominated by the strategy profile where the buyer buys and the seller sells pure drugs. They need to use a reputational mechanism to try and achieve the Pareto optimal outcome of {P,B}. However, because this trade is illegal, there is a bit more to the story.

2.1 Sanctions

Broadly speaking, there are two different kinds of sanctions that Sellers will face in the model. They face criminal sanctions if they are *caught* by the police. They face reputational sanctions if they are *observed* by the buyers selling cut drugs. The linguistic distinction is important. I refer to sellers as having been *caught* if the police catch them, I refer to the sellers as being *observed* if they cheat and that cheating incident becomes common knowledge, costing them their reputation.

2.1.1 Social Sanctions

Whenever a seller plays C and the buyer plays B, there is a probability π that all of the buyers find out about it. Their betrayal then becomes common knowledge throughout the community of buyers and sellers. The buyer in question is somehow able to get enough people to know about the incident and pass that information on.

When it becomes common knowledge that a seller has betrayed a buyer, the buyers permanently ostracize the seller and no buyer will buy from an ostracized seller. Historical examples of this kind of punishment are plentiful. Offenders used to be placed in the town stocks or forced to wear a “scarlet letter”. More recently there is a similar opportunity to name and shame poor quality suppliers on eBay, Amazon and other online markets. Bernstein (1992) reports a similar means of punishment in the diamond trade.

When trade in the good in question is illegal, messages denouncing rogue traders must be discreet. This is why the information about a player cheating leaks to the rest of the community only probabilistically. As in the telephone game, the message can become distorted and mutate to the point where it is incomprehensible and useless. Buyers in this market cannot communicate as clearly as the diamond traders observed by Bernstein (1992) by sticking a photograph on the bulletin board. So reputational mechanisms cannot work so flawlessly.

2.1.2 Criminal Sanctions

For simplicity, we will assume that buyers are not subject to criminal sanctions. Their crime is so petty that the police and the courts choose simply to ignore it unless it can lead them to “bigger fish”. However the justice system is interested in punishing the sellers. We will assume that the law regards their crime as a midemeanour and punishes them either through fines; community service; or through short prison sentences. Should they be caught, some penalty is paid by the seller, but they are otherwise free to continue trading in the next period. Let the disutility from being caught and facing criminal sanctions be denoted by P . We assume that this cost, if experienced with certainty, would wipe out the gains from any trade the seller could have been engaged in, $P > S$.

An alternative to this model would assume long prison sentences that removed criminals from the population. We will examine this possibility later. However, the tendency in modern penology towards greater use of non-custodial sentences means that consideration of such penalties may well be more relevant.

2.2 Competent and Incompetent Sellers

Let the probability that a particular seller, i is caught by the police when engaged in a trade be γ_i . If i is type 1, the competent type, we say that $\gamma_i = \gamma_1$. If i is type 2, the incompetent type, then we say that $\gamma_i = \gamma_2 > \gamma_1$. The difference is simply that the competent criminals are better at systematically covering their tracks.

2.3 Births and Deaths

The population of sellers is not static. In each period, there is some probability, $1 - \delta$ that a seller will leave the population, either due to death or retirement. This probability

is independent of history and of type. So the survival probability for all sellers is δ .

When a seller leaves the population, they are instantly replaced by a new seller. With probability α , the new seller is of the competent type, but with probability $1 - \alpha$ the new trader is incompetent.

2.4 Notation

It will be convenient when considering the sellers to consider their payoffs net of the possibility of being caught and punished. For a type i seller, the net expected payoff should the buyer buy when they have kept their merchandise pure is $M_i = M - \gamma_i P$ and should the buyer buy when the seller has cut their merchandise, the seller will expect $S_i = S - \gamma_i P$.

So net of criminal sanctions, the game being played has a payoff matrix shown in Table 2. We assume that $S_i > M_i > 0$ and continue to assume that $H > 0 > L$.

		Buyer	
		B	D
Seller	P	M_i	0
	C	S_i	0

Table 2: We assume that $S_i > M_i > 0$ and that $H > 0 > L$.

3 Universal Cooperation

We will now examine under what circumstances we can maintain universal cooperation as an equilibrium profile. By universal cooperation, we mean that buyers always buy provided the seller has not been ostracized and sellers always sell pure merchandise, so never get ostracized. Ostracised sellers if they ever existed (which on the equilibrium path they don't) and if a buyer ever bought from them (which never happens on the equilibrium path) would play C because they do not expect to have another trading opportunity anyway.

So both sides of the market are doing what the other side would like to see them doing and the outcome is Pareto optimal.

Proposition 1 *There is a minimum probability, $\pi_U(\delta)$ such that if the probability of observing someone selling impure drugs is $\pi > \pi_U(\delta)$, then an equilibrium exists in which*

buyers always buy and sellers of all types choose to sell pure drugs. That minimum probability is given by

$$\pi_U(\delta) = \left(\frac{1-\delta}{\delta}\right) \left(\frac{S-M}{M_2}\right). \quad (3.1)$$

Provided the survival probability is large enough,

$$\delta > \delta_U^* = \frac{S-M}{S_2}, \quad (3.2)$$

this critical level of π will be less than 1.

Proof. First consider the incentives of buyers. If the sellers are following the proposed strategy, then buying from a non-ostracized seller will get a payoff of H and not buying gets a payoff of 0. Since $H > 0$ by assumption, it is always in the interests of the buyers to buy from non-ostracized sellers given the strategy of the sellers.

Next consider the incentives for a seller. The continuation value from continuing to supply pure merchandise is $V_i^P = M_i + \delta V_i^P$, hence $V_i^P = M_i / (1 - \delta)$. A single period deviation from P to C will get $S_i + \delta(1 - \pi)V_i^P$. The deviation will not be profitable provided that

$$\begin{aligned} M_i + \delta V_i^P &> S_i + \delta(1 - \pi)V_i^P, \\ M_i &> S_i - \delta\pi V_i^P, \\ \delta\pi V_i^P &> S_i - M_i, \\ \pi &> \left(\frac{1-\delta}{\delta}\right) \left(\frac{S-M}{M_i}\right). \end{aligned} \quad (3.3)$$

So maintaining provision of pure merchandise as an equilibrium strategy for all players requires that

$$\pi > \left(\frac{1-\delta}{\delta}\right) \max\left\{\frac{S-M}{M_1}, \frac{S-M}{M_2}\right\}.$$

Suppose that $(S-M)/M_1 > (S-M)/M_2$. That would imply that $M_2 > M_1$ and so $\gamma_1 > \gamma_2$, which is a contradiction. So our requirement to maintain the universal cooperation equilibrium collapses to

$$\pi > \pi_U(\delta) = \left(\frac{1-\delta}{\delta}\right) \left(\frac{S-M}{M_2}\right). \quad (3.1)$$

Remembering that π is a probability and so must be such that $\pi \in [0, 1]$, we also require that $\pi_U(\delta) < 1$.⁸ This requires that

$$\begin{aligned} (1-\delta)(S-M) &< \delta M_2, \\ \delta(S-M+M_2) &> S-M, \\ \delta &> \delta_U^* = \frac{S-M}{S_2}. \end{aligned} \quad (3.2)$$

⁸ $\pi_U(\delta) > 0$ is trivial.

This completes the proof. ■

Proposition 1 places a minimum value on the probability of being observed cheating to maintain an equilibrium in which all sellers trade honestly. This minimum value is a decreasing function of the survival probability, δ , because lost future income is less of a disincentive when a future is less likely.⁹

The region in which the equilibrium exists is shown in Figure 1. It has been drawn in $\alpha - \pi$ space, the reasons for which will become clear shortly. This shows the region of parameter space in which the equilibrium will exist, which is the space between $\pi_U(\delta)$ and $\pi = 1$.

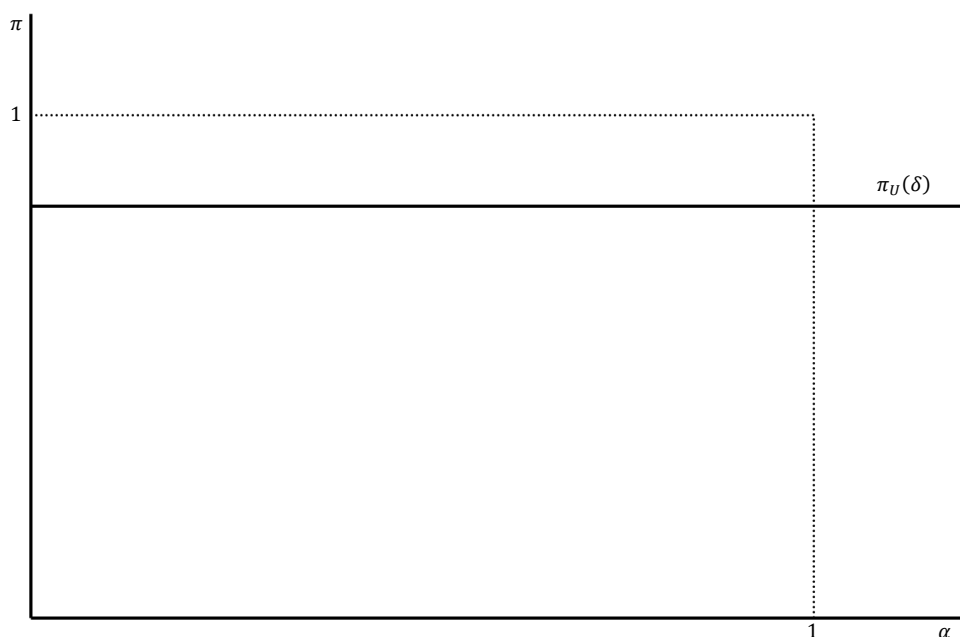


Figure 1: The region of full cooperation.

With a little rearranging we can say a bit more about $\pi_U(\delta)$, which can be written as

$$\pi_U(\delta) = \frac{S - M}{\delta M_2 / (1 - \delta)}. \quad (3.4)$$

⁹To demonstrate that $\pi_U(\delta)$ is indeed decreasing in δ , consider $\pi_U(\delta) = \left(\frac{1-\delta}{\delta}\right) \left(\frac{S-M}{M_2}\right)$, $\Rightarrow \pi'_U(\delta) = \left(\frac{S-M}{M_2}\right) \left(\frac{-\delta-(1-\delta)}{\delta^2}\right) = -\frac{1}{\delta^2} \left(\frac{S-M}{M_2}\right) < 0$.

The numerator here is the temptation to any seller to cheat the buyer in any one period. Such cheating will result in a payoff that is $S - M$ higher than it otherwise would be. The denominator is the net present value of future payoff that will be foregone if the incompetent seller cheats and is observed. If the seller is to trade honestly, the probability of being observed cheating must be greater than this ratio. The greater the temptation to cheat, the higher the probability of being observed must be in order to prevent sellers from cheating. The greater are future expected payoffs from trading, the lower the probability of losing them needs to be in order to keep sellers honest.

The government can exercise some influence over the denominator of (3.4). It might be able to increase the strength of criminal penalties or the probability that incompetent criminals will be caught, and so reduce the net present value of future criminal activity. This will make it harder for criminal markets to function as criminals will need to develop better mechanisms for policing themselves.

Also consider the minimum level of patience to maintain universal cooperation. While $\delta_U^* = (S - M) / S_2$ is its most economical representation, the most economically illuminating representation is perhaps

$$\delta_U^* = \frac{S - M}{(S - M) + M_2} \in (0, 1).$$

So $\delta > \delta_U^*$ can be rearranged to a requirement that $\delta M_2 / (1 - \delta) > S - M$. This requires that the net present value of future payoffs risked by cheating is greater than the temptation to cheat. So what is at stake must be greater than the temptation to cheat.

4 Type Contingent Honesty

By type contingent honesty we mean that sellers' behavior is contingent on their type. Competent sellers sell pure drugs but incompetent sellers play cut the purity of their wares. The strategy of the buyers is actually the same as in the universal cooperation equilibrium in that they buy from non-ostracized sellers and don't buy from ostracized sellers. So in this case the reputational mechanism is not sufficiently strong to maintain the cooperation of all sellers. Specifically we will examine whether the following strategy profile can be an equilibrium:

- Buyers buy only from people who have not been ostracized.
- Competent sellers always sell pure merchandise.
- Incompetent sellers always sell cut merchandise.

To check whether the decision of the buyer is optimal, we will need to know the distribution of the sellers. On the equilibrium path, how many sellers are

- competent and ostracized;

- competent and non-ostracized;
- incompetent and ostracized; or
- incompetent and non-ostracized.

The population distribution will depend on the strategy being pursued. To find the steady state population distribution, we need to consider the flows into and out of each population given the strategy profile.

Let θ_1 denote the proportion of sellers who are not ostracized and of the competent type. Let θ_{2a} denote the proportion of sellers who are not ostracized and are of the incompetent type. Let θ_{2b} denote the proportion of sellers who have been ostracized and are of the incompetent type. Since competent sellers always play P, they are not ostracized under the proposed strategy profile. So it must be that $\theta_1 + \theta_{2a} + \theta_{2b} = 1$.

The expected payoff of the buyer depends on the distribution of types of sellers. The more competent sellers and the fewer incompetent sellers, the higher the expected payoff from buying. Furthermore the greater the proportion of incompetent sellers who have been found out and ostracized, the higher the expected payoff to the buyer from buying. The higher the expected payoff from buying, the more likely the buyer will buy from a non-ostracized seller of unknown type.

In each period a proportion of each sub-population, $1 - \delta$ flows out of the population. Further, $\alpha(1 - \delta)$ of the population enter as competent traders and $(1 - \alpha)(1 - \delta)$ of the population enter as non-ostracized incompetent sellers. There is an additional flow of $\pi\delta\theta_{2a}$ from the incompetent non-ostracized sub-population to the incompetent ostracized sub-population, the result of cheating traders being observed and ostracized. These population flows are shown in Figure 2.

To find the steady state population frequencies we simply determine the flows such that inflow equates to outflow for each sub-population. Then

$$\begin{aligned}\theta_1 &= \alpha, \\ \theta_{2a} &= \frac{(1 - \delta)(1 - \alpha)}{1 - \delta + \delta\pi}, \\ \theta_{2b} &= \frac{\delta\pi(1 - \alpha)}{1 - \delta + \delta\pi}.\end{aligned}$$

If someone meets a seller who is ostracized, they know they are of the incompetent type. If someone meets a seller who has not been ostracized, they cannot know the seller's type with certainty. Let the probability that a seller is competent given they are not ostracized be denoted by $\theta_{1|N}$. Similarly let the probability of incompetence given a trader is not ostracized be denoted $\theta_{2|N}$. Then by Bayes' Rule:

$$\theta_{1|N} = \frac{\theta_1}{\theta_1 + \theta_{2a}}, \tag{4.1}$$

$$\theta_{2|N} = \frac{\theta_{2a}}{\theta_1 + \theta_{2a}}. \tag{4.2}$$

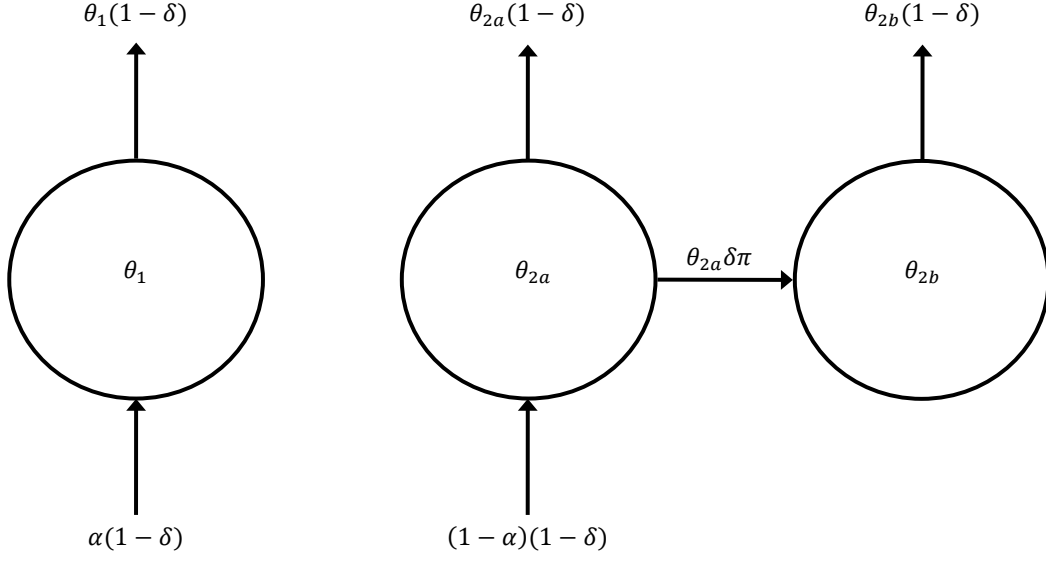


Figure 2: Population flows when incompetent traders betray.

We can now state the following proposition,

Proposition 2 *There exists an intermediate range for π , the probability that a seller of cut drugs is observed and a minimum population proportion of competent traders such that if π lies inside this intermediate range and α is greater than this minimum value, then there exists an equilibrium in which the buyer buys from any non-ostracized seller, the competent sellers sell pure drugs and the incompetent sellers cut the purity of their drugs.*

The intermediate range for π is given by

$$\pi_C^-(\delta) < \pi < \min\{\pi_U(\delta), 1\}, \quad (4.3)$$

which overlaps with the probability space $\pi \in (0, 1)$ provided that,

$$\delta > \delta_C^* = \frac{S - M}{S_1}. \quad (4.4)$$

The minimum level of α is given by

$$\alpha > \alpha_C^*(\delta, \pi) = \frac{-(1 - \delta)L}{(1 - \delta + \delta\pi)H - (1 - \delta)L} \in (0, 1). \quad (4.5)$$

Proof. First consider the continuation values from the candidate strategy profile for the sellers and consider whether they have any profitable single-period deviation. Consider the competent seller, her continuation value from the proposed strategy profile will be $V_1^P = M_1/(1 - \delta)$. A single period deviation from providing pure merchandise will get her $S_1 + \delta(1 - \pi)V_1^P$. She has no incentive to deviate provided that

$$\begin{aligned} M_1 + \delta V_1^P &> S_1 + \delta(1 - \pi)V_1^P, \\ \delta \pi V_1^P &> S - M, \\ \pi &> \pi_C^-(\delta) = \left(\frac{1 - \delta}{\delta}\right) \left(\frac{S - M}{M_1}\right). \end{aligned} \quad (4.6)$$

Similarly, the continuation value from the proposed profile for the incompetent seller is $V_2^C = S_2 + \delta(1 - \pi)V_2^C$, which implies $V_2^C = S_2/(1 - \delta + \delta\pi)$. A single period deviation would earn $M_2 + \delta V_2^C$. The deviation is not profitable provided that

$$\begin{aligned} S_2 + \delta(1 - \pi)V_2^C &> M_2 + \delta V_2^C, \\ \delta \pi V_2^C &< S - M, \\ \pi &< \pi_U(\delta) = \left(\frac{1 - \delta}{\delta}\right) \left(\frac{S - M}{M_2}\right). \end{aligned} \quad (4.7)$$

A seller who has already been ostracized does not expect to get another trading opportunity whatever action he takes when he meets a buyer. So there is nothing to stop him from playing C.

By combining (4.6) and (4.7), we can see that π must be inside a suitable range:

$$\pi_C^-(\delta) < \pi < \pi_U(\delta). \quad (4.3)$$

We have already shown that $\pi_C^-(\delta) < \pi_U(\delta)$ in the proof of Proposition 1.

In order for the minimum value of π to be less than unity and so something that can be satisfied by a probability, we need

$$\begin{aligned} (1 - \delta)(S - M) &< \delta M_1, \\ \delta(S - M + M_1) &> S - M, \\ \delta &> \delta_C^* = \frac{S - M}{S_1}. \end{aligned} \quad (4.4)$$

Now consider the payoff for the buyer. Upon meeting a seller who has been ostracized they know that seller will cut their merchandise and so the payoff from buying will be $L < 0$. So they have no profitable deviation to buying in this situation.

Upon meeting a seller who is not ostracized they will believe that the seller is competent and will sell pure merchandise with probability $\theta_{1|N}$. They will believe that the seller is incompetent and will sell cut merchandise with probability $\theta_{2|N}$. So the expected

payoff from buying will be $\theta_{1|N}H + \theta_{2|N}L$. There will be no profitable deviation for the buyer provided this expected value is positive,

$$\begin{aligned} \frac{\theta_1}{\theta_1 + \theta_{2a}}H + \frac{\theta_{2a}}{\theta_1 + \theta_{2a}}L &> 0, \\ \theta_1H + \theta_{2a}L &> 0, \\ \alpha H + \frac{(1-\delta)(1-\alpha)}{1-\delta+\delta\pi}L &> 0, \\ \alpha(1-\delta+\delta\pi)H - \alpha(1-\delta)L &> -(1-\delta)L, \end{aligned}$$

which gives the required

$$\alpha > \alpha_C^*(\delta, \pi) = \frac{-(1-\delta)L}{(1-\delta+\delta\pi)H - (1-\delta)L} \in (0, 1). \quad (4.5)$$

This completes the proof. ■

The two conditions in (4.3) place minimum and maximum values on the probability of being observed cheating and being ostracized should a seller cut their merchandise. The minimum cut off ensures that the competent traders will find it better to trade honestly. The maximum cut off ensures that the incompetent traders will find it better trade dishonestly. We should note that the maximum value of π to maintain the conditional cooperation equilibrium is the same as the minimum value of π to maintain the universal cooperation equilibrium. This ensures that the two equilibria will never co-exist. We might regard (from the point of view of the market participants) the conditional cooperation equilibrium as a second best solution, available only when the first best solution is unobtainable.

In terms of how we should interpret these conditions, their interpretation and the relevance of the various parameters is exactly the same as for (3.1) in the unconditional cooperation equilibrium.

The condition in (4.4) ensures that sellers are sufficiently likely to survive from one period to the next that a probability of being observed cheating less than unity is sufficient to ensure that competent criminals prefer to sell pure merchandise. This is similar to the requirement from (3.2) in Proposition 1 and it has a similar interpretation, both in terms of how the critical value will respond the parameters and the trade off that it represents.

The condition in (4.5) is new. This is needed to ensure that the buyers still prefer to buy from a seller who has not yet been ostracized rather than not buy. In order for this to be the case, the probability that they are competent and so will sell pure merchandise needs to be sufficiently high. This is why there is a minimum level of α , the probability that an entering seller is competent.

Importantly, α_C^* is falling in π . This is because as the probability that a cheating seller is observed and ostracized increases, incompetent traders who have not been ostracized become less likely to spend any significant amount of time in that state. It will take less

time for them to be found out and ostracized by the buyers. This increases the proportion of the incompetent sellers who have been ostracized and reduces the proportion of the incompetent sellers who have not (yet) been ostracized. So incompetent sellers become a smaller proportion of the non-ostracized sellers. This makes buyers, *ceteris paribus*, more likely to buy from a non-ostracized trader.

We can also see from (4.5) that the greater is the benefit to a buyer who actually buys from the seller playing P, the lower the value of α at which the buyer is willing to buy, $d\alpha_C^*/dH < 0$. Similarly, the greater is the dis-benefit to a buyer who actually buys from a seller who plays C (the more negative is L), the greater the proportion of sellers in the population who must be competent in order for the buyer to want to buy, $d\alpha_C^*/dL < 0$.

We can show the region where the conditional cooperation equilibrium is possible in $\alpha - \pi$ space as we did for universal cooperation. This is shown in Figure 3. The conditional cooperation equilibrium can be supported by the parameter values that are inbetween the $\pi_C^+(\delta)$ and the $\pi_C^-(\delta)$ schedules and to the right of the $\alpha_C^*(\delta, \pi)$ schedule. So some cooperation can be maintained for levels of π that are much lower than the level required to maintain universal cooperation. However this relies on there being a sufficient density of competent criminals that buyers are still comfortable buying even though they cannot be sure that the seller is selling pure merchandise.

The economic reasons why competent criminals trade honestly while incwith strategy Pwith strategy P incompetent criminals are deceitful are important. For competent criminals, there are high expected future rewards to continued selling. This is because of the low probability of being caught. For incompetent criminals, the expected rewards are much lower because in each period they face a higher probability of being caught and punished by the police. These lower expected future rewards mean that the future is less valuable to the incompetent criminals than to the competent criminals. So the reputation that allows the seller to continue trading is less valuable to the incompetent seller than to the competent seller. Therefore the incompetent seller is willing to take greater risks with that reputation for the same immediate reward.

Buyers do not want to deal with incompetent criminals precisely because of the greater chance of being betrayed. The possibility that an incompetent criminal being caught could lead to your being caught is irrelevant in this context. The old saying goes that it is better to trust a fool than a knave. The fool's incompetence may be painful at times but the knave will almost certainly betray you. Here we have turned that logic on its head. The fool will betray you precisely because their foolishness means that they expect lower future returns and so care less about their good name.

5 A Signalling Equilibrium

We now consider the possibility of signalling where the competent sellers deliberately do something to draw attention to themselves. Wearing gang colors is the leading motivation we will use. However we have to remember that there are other things they could do.

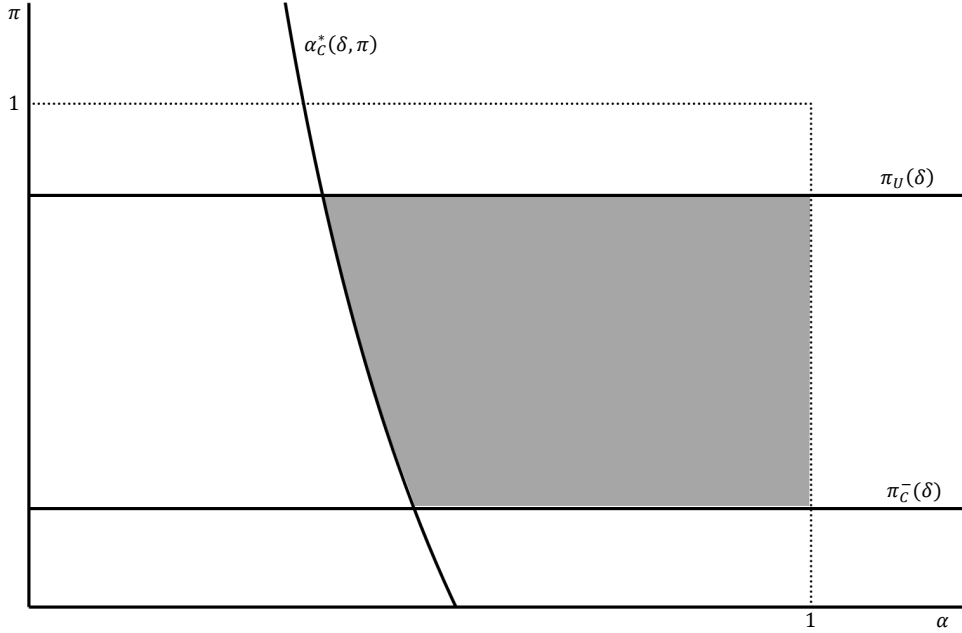


Figure 3: The conditional cooperation equilibrium is possible in the region bounded by $\alpha_C^*(\delta, \pi) \leq \alpha \leq 1$ and $\pi_C^-(\delta) < \pi < \pi_U(\delta)$.

Simply acting like a criminal with a particular gait, attitude, or manner of carrying oneself might well be enough for the purposes of the signal. In order to incorporate this into our model we introduce a new parameter, ω which denotes the strength of the signal. The signal increases the probability that seller i is caught by the police to $\min\{\gamma_i + \omega, 1\}$.¹⁰

We then consider the following candidate strategy profile for an equilibrium. Competent sellers adopt the signal and sell pure drugs (strategy P). Incompetent sellers do not adopt the signal and sell cut merchandise (strategy C). Buyers will buy only from sellers who have adopted the signal, otherwise they will not buy. This leads us to the following proposition

Proposition 3 *There exists a minimum level of π , $\pi_S(\delta, \omega)$ and an intermediate range for the signal strength ω such that if $\pi > \pi_S(\delta, \omega)$ and ω is inside this intermediate range; then there exists a signalling equilibrium in which buyers only buy from signalling sellers, competent sellers signal and sell pure drugs, and incompetent sellers do not signal and*

¹⁰In what follows, we will simply assume that $\omega < 1 - \gamma_2$ to avoid the tedious complications this raises.

cut the purity of the drugs they offer.

The minimum level of π is given by

$$\pi > \pi_S(\delta, \omega) = \left(\frac{1 - \delta}{\delta} \right) \left(\frac{S - M}{M_1 - \omega P} \right). \quad (5.1)$$

This condition can be satisfied provided that

$$\delta > \delta_S^* = \frac{S - M}{S_1 - \omega P}. \quad (5.2)$$

The intermediate range for the signal strength is given by

$$\frac{S_2}{P} < \omega < \frac{M_1}{P}. \quad (5.3)$$

Signals exist which can be inside this range provided that

$$\gamma_2 - \gamma_1 > \frac{S - M}{P}. \quad (5.4)$$

Before proving the proposition, we shall examine what these conditions mean.

The condition in (5.1) is required to ensure that competent sellers are sufficiently motivated by the potential loss of their reputation to ensure that they guard their reputation. It fulfills a similar function, and has a similar interpretation to the condition (3.1) in Proposition 1. The condition in (5.2) similarly ensures that the competent criminals will have sufficient care for the future that they care about their future payoffs. This does fulfill the same function and has the same interpretation as the condition (3.2) from Proposition 1.

The conditions in (5.3) ensure that the signal is strong enough that incompetent sellers are not tempted to signal and sell cut merchandise. It simultaneously ensures that the signal is not too strong to prevent the competent sellers from selling pure merchandise profitably. Where ω takes the smallest value consistent with (5.3) we have the most efficient possible equilibrium.¹¹ We will find this useful when considering the extent to which the signalling equilibrium outcomes allows improvements on the conditional cooperation outcomes.¹²

The condition in (5.4) ensures that signal strengths exist which can satisfy (5.3). It ensures that the weakest signal that can disincentivise the incompetent trader from

¹¹Although in this model, the only choice of the seller concerning the signal is whether to signal or not, we could also imagine a similar model in which the signal strength was a choice of the seller. In that case, this minimum signal would constitute a Riley equilibrium, following Riley (1975) which is the most efficient signalling equilibrium because it minimises the size of the signal to the smallest level consistent with maintaining the equilibrium and so minimises the signalling cost. In a slight abuse of terminology we will refer to this minimum signal strength case as a Riley equilibrium.

¹²From the perspective of the market participants.

trading dishonestly is weaker than the strongest signal that will not disincentivise the competent trader from trading honestly.

Proof. First consider the strategy for the buyers. Given the strategies of the other players, buying when matched with a signalling seller will pay $H > 0$ and so must be optimal. Similarly buying when faced with a non-signalling seller will pay $L < 0$ and so cannot constitute a profitable deviation. So there is no profitable deviation for the buyer.

Next consider the competent seller. The continuation value of signalling and selling pure merchandise is $V_1^S = M_1 - \omega P + \delta V_1^S$, or $V_1^S = (M_1 - \omega P) / (1 - \delta)$. A single period deviation to signalling and selling cut merchandise will pay $S_1 - \omega P + \delta(1 - \pi)V_1^S$. So selling cut merchandise will not constitute a profitable deviation provided that

$$\begin{aligned} M_1 - \omega P + \delta V_1^S &> S_1 - \omega P + \delta(1 - \pi)V_1^S, \\ \delta \pi V_1^S &> S - M, \\ \pi > \pi_S(\delta, \omega) &= \left(\frac{1 - \delta}{\delta} \right) \left(\frac{S - M}{M_1 - \omega P} \right). \end{aligned} \quad (5.1)$$

In order to ensure that this can be satisfied by a probability, we need to ensure that $\pi_S(\delta, \omega) < 1$, which implies that

$$\begin{aligned} (1 - \delta)(S - M) &< \delta(M_1 - \omega P), \\ \delta(M_1 + S - M - \omega P) &> S - M, \end{aligned}$$

which requires that

$$\delta > \delta_S^* = \frac{S - M}{S_1 - \omega P}. \quad (5.2)$$

The competent seller also has the option of not signalling. As a single period deviation, this would earn $0 + \delta V_1^S$ given the strategies of all other players. This would not be a profitable deviation provided that

$$\begin{aligned} 0 + \delta V_1^S &< M_1 - \omega P + \delta V_1^S, \\ \omega &< \frac{M_1}{P}. \end{aligned} \quad (5.5)$$

Next consider the incompetent seller. The continuation value to his strategy is $V_2^S = 0$ given the strategy of all other players. The most profitable single period deviation would be to signal and sell cut merchandise. This would earn $S_2 - \omega P + \delta(1 - \pi)V_2^S = S_2 - \omega P$. It would not be a profitable deviation provided that

$$\begin{aligned} S_2 - \omega P &< 0, \\ \omega &> \frac{S_2}{P}. \end{aligned} \quad (5.6)$$

The two conditions, (5.5) and (5.6) combined give (5.3).

Finally we need to ensure that the maximum value of ω in (5.5) is greater than the minimum value of ω in (5.6). This requires that

$$\begin{aligned}
 S_2/P &< M_1/P, \\
 S - \gamma_2 P &< M - \gamma_1 P, \\
 (\gamma_2 - \gamma_1) P &> S - M, \\
 \gamma_2 - \gamma_1 &> \frac{S - M}{P}.
 \end{aligned}
 \tag{5.4}$$

This completes the proof. ■

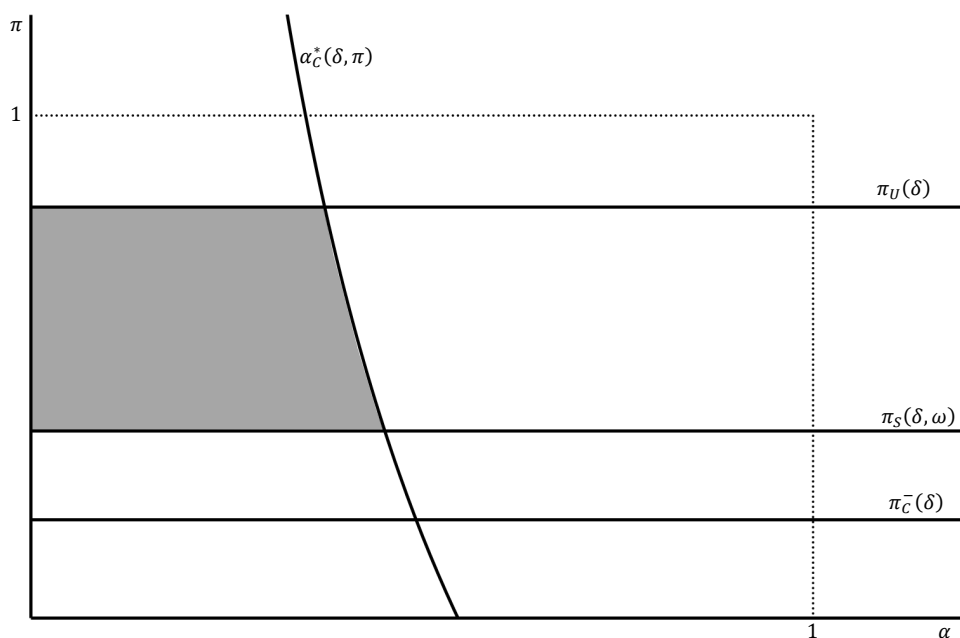


Figure 4: In this example, the signalling equilibrium exists for all parameter values such that $\pi > \pi_S(\delta, \omega)$. However the shaded area shows where the signalling equilibrium is available and no other pure strategy equilibrium involving trade is available. This is the region of expanded trade opportunities generated by the signal.

We can see the region where the equilibrium applies in $\alpha - \pi$ space in Figure 4. The signalling equilibrium is available for all sets of parameter values above the line $\pi_S(\delta, \omega)$, however the shaded area is where no equilibrium calling for buyers to buy was available

before but the signalling equilibrium is available now. In this shaded region, no equilibrium calling for buyers to buy was available before because although the competent sellers would have cooperated, there were not enough of them to make it worthwhile for the buyers to buy. The only way buyers will buy in this region is if they are certain of the type of their trading partner and the signalling equilibrium allows them to be sufficiently certain. Under what circumstances will the signalling equilibrium expand the parameter range for which cooperative outcomes can be maintained?

5.1 Expanding the Range of Cooperation

When does the signalling equilibrium expand the range of parameters for which some honest trading can be maintained? In order to consider this question, it helps to restrict consideration to the case of the Riley equilibrium which minimises the signalling costs and so will maximise the region of parameters for which the signalling equilibrium can be maintained. We will therefore restrict attention in what follows to the case where $\omega = S_2/P$. We will also assume that all the conditions for the signalling equilibrium in Proposition 3 hold.

We can then assert the following proposition.

Proposition 4 *If the signalling equilibrium exists, then it will increase the parameter range for which some trade is possible as a pure strategy equilibrium outcome if and only if*

$$\gamma_2 - \gamma_1 > S_2/P. \quad (5.7)$$

Proof. We know from (4.5) that $\alpha_C^*(\delta, \pi)|_{\pi=1} \in (0, 1)$. So between $\pi_C^-(\delta)$ and $\pi_U(\delta)$ there is always a region where the conditional cooperation equilibrium cannot be maintained because an unknown seller is insufficiently likely to be competent from the point of view of the buyer. So in order to ensure that the signalling equilibrium does indeed increase the parameter range for which trade can take place, it is necessary and sufficient for $\pi_S(\delta, \omega)|_{\omega=S_2/P} < \pi_U(\delta)$. We evaluate at $\omega = S_2/P$ because this is the minimum signalling cost that is consistent with excluding the incompetent sellers.

$$\begin{aligned} \left(\frac{1-\delta}{\delta}\right) \left(\frac{S-M}{M_1-S_2}\right) &< \left(\frac{1-\delta}{\delta}\right) \left(\frac{S-M}{M_2}\right), \\ M_2 &< M_1 - S_2, \\ M - \gamma_2 P &< M - \gamma_1 P - S + \gamma_2 P, \\ (\gamma_2 - \gamma_1) P &> S - \gamma_2 P, \\ \gamma_2 - \gamma_1 &> S_2/P. \end{aligned} \quad (5.7)$$

This completes the proof. ■

The significance of (5.7) is that it requires the competent and incompetent traders to be sufficiently different that the smallest possible signal, S_2/P is less than the difference

between the two types in terms of the probability of being caught. Indeed, if the types were not this different, then a signalling competent seller would be as likely (or more) to be caught as a non-signalling incompetent seller. If it were possible to get the signalling competent seller to trade honestly, it would also be possible to get the non-signalling incompetent seller to trade honestly. So why have a signalling equilibrium when the universal cooperation equilibrium is also possible?

The requirement on the type difference to ensure the signalling equilibrium adds options in (5.7) will be a more stringent one than the requirement to ensure the signalling equilibrium exists in (5.4). Mathematically, assuming otherwise leads to the conclusion that $M_2 < 0$ contradicting one of our assumptions. Economically, this is because ensuring that the equilibrium exists is to require that $\pi_S(\delta, \omega) < 1$, whereas ensuring that it is productive in the sense that it creates trading equilibria where none existed before is requiring that $\pi_S(\delta, \omega) < \pi_U(\delta)$, which will typically be a more stringent requirement.

5.2 Improving Welfare

In this discussion, we will restrict attention to a comparison of the conditional cooperation equilibrium and the signalling equilibrium where both are available.

In terms of welfare, the buyers always prefer the signalling equilibrium to the conditional cooperation equilibrium. Under conditional cooperation, the buyers get cheated from time to time, which is costly. Under the signalling equilibrium, this does not happen and the buyers do not pay the cost of the signal. However the sellers (of both types) will always prefer the conditional cooperation equilibrium since they do not bear any cost of being cheated and would have to pay the signalling cost or be barred from trade under the signalling equilibrium. When is the signalling equilibrium welfare superior to the conditional cooperation equilibrium? In other words, when do the benefits to the buyers outweigh the costs to the sellers?

Normalising the population size to 1, then under the conditional cooperation equilibrium,

- there are θ_1 trades which involve the seller supplying pure merchandise and the buyer buying;
- there are θ_{2a} trades that involve the seller supplying cut merchandise and the buyer buying; and
- there are θ_{2b} trades that involve the seller supplying cut merchandise and the buyer not buying.

The first of these trades generates expected welfare of $M_1 + H$, the second generates welfare of $S_2 + L$ and the third generates no welfare. So the total welfare generated in each period in the conditional cooperation equilibrium is

$$W_C = \alpha(M_1 + H) + \frac{(1 - \delta)(1 - \alpha)}{1 - \delta + \delta\pi}(S_2 + L). \quad (5.8)$$

By contrast under the signalling equilibrium, only α trades take place and in each of them the seller signals and sells pure merchandise while the buyer buys. These meetings generate welfare of $M_1 - \omega P + H$. In all other meetings the buyer does not buy. So welfare under the signalling equilibrium is

$$W_S = \alpha (M_1 - \omega P + H). \quad (5.9)$$

The signalling cost is clearly increasing in the level of the signal. Let us therefore consider the case of the Riley equilibrium with the minimum signal level, $\omega = S_2/P$. In that case,

$$W_S = \alpha (M_1 - S_2 + H). \quad (5.10)$$

Now we need to consider where the society of criminals might be better off in the signalling equilibrium rather than the conditional cooperation equilibrium. This will be the case where $W_S > W_C$,

$$\begin{aligned} \alpha (M_1 - S_2 + H) &> \alpha (M_1 + H) + \frac{(1 - \delta)(1 - \alpha)}{1 - \delta + \delta\pi} (S_2 + L), \\ \Rightarrow \underbrace{\frac{(1 - \delta)(1 - \alpha)}{1 - \delta + \delta\pi} (-L)}_{\text{Cost of being cheated}} &> \underbrace{\alpha S_2}_{\text{Signalling cost}} + \underbrace{\frac{(1 - \delta)(1 - \alpha)}{1 - \delta + \delta\pi} S_2}_{\text{Foregone cheating}}. \end{aligned} \quad (5.11)$$

Expression (5.11) shows when the signalling equilibrium is better than the conditional cooperation equilibrium in terms of total payoffs. The term on the left hand side is the cost of occasionally being cheated in the conditional cooperation equilibrium felt by the buyers. The first term on the right hand side is the signalling cost in the signalling equilibrium paid by the competent sellers. The final term is the benefit the incompetent sellers derive from occasionally being able to cheat the buyers in the conditional cooperation equilibrium, this might be seen as an opportunity cost of being in the signalling equilibrium rather than the conditional cooperation equilibrium since it is the benefit the incompetent sellers would derive from the other possible equilibrium. So (5.11) is requiring the benefits of the signalling equilibrium to exceed the costs of the conditional cooperation equilibrium.

We can rearrange (5.11) in a way that might be more useful for comparisons in $\alpha - \pi$ space.

$$\begin{aligned} (1 - \delta)(1 - \alpha)(-L) &> (1 - \delta + \delta\pi)\alpha S_2 + (1 - \delta)(1 - \alpha)S_2, \\ \alpha(1 - \delta + \delta\pi)S_2 &< (1 - \alpha)(1 - \delta)(-L - S_2), \end{aligned} \quad (5.12)$$

which becomes

$$\alpha < \alpha_P^*(\delta, \pi) = \frac{(1 - \delta)(-L - S_2)}{\delta\pi S_2 + (1 - \delta)(-L)}. \quad (5.13)$$

The condition in (5.13) places a ceiling on the value of α for which the signalling equilibrium is welfare superior to conditional cooperation. The lower is α , the less costly is the signalling equilibrium in terms of the signalling cost paid by competent sellers. Lower values of α will also tend to increase the frequency with which buyers will be cheated by incompetent sellers in the conditional cooperation equilibrium.

This critical level of α will be positive provided that $-L - S_2 > 0$, requiring the cost to the buyers of being cheated by incompetent sellers to be greater than the benefit derived by those incompetent sellers from cheating the buyers. In other words, the trades that the signalling equilibrium prevents must not be socially beneficial. The maximum level of α such that the signalling equilibrium is welfare-superior to the conditional cooperation equilibrium depends on how socially costly these trades are. The maximum level of α also depends on π and δ as they will exert some influence on the equilibrium frequency of non-ostracized incompetent sellers in the conditional cooperation equilibrium.

The question then becomes whether the welfare-superiority of the signalling equilibrium is consistent with the existence of the conditional cooperation equilibrium. In order for this to be the case, we will need $\alpha_P^* > \alpha_C^*$ at some point where it is also the case that $\pi \in [\pi_S, \pi_U]$. What are the implications of $\alpha_P^* > \alpha_C^*$, and are any of them inconsistent with $\pi \in [\pi_S, \pi_U]$?

$$\frac{(1 - \delta)(-L - S_2)}{\delta\pi S_2 + (1 - \delta)(-L)} > \frac{-(1 - \delta)L}{(1 - \delta + \delta\pi)H - (1 - \delta)L},$$

$$((1 - \delta + \delta\pi)H - (1 - \delta)L)(-L - S_2) > (\delta\pi S_2 + (1 - \delta)(-L))(-L),$$

multiplying out and cancelling terms, this becomes

$$(1 - \delta + \delta\pi)H(-L - S_2) + (1 - \delta)L^2 + (1 - \delta)LS_2 > -\delta\pi LS_2 + (1 - \delta)L^2,$$

$$(1 - \delta + \delta\pi)H(-L - S_2) + (1 - \delta)LS_2 > -\delta\pi LS_2,$$

$$(1 - \delta + \delta\pi)H(-L - S_2) > (1 - \delta + \delta\pi)(-L)S_2.$$

This is actually independent of δ and of π .

$$-HL - HS_2 > -LS_2,$$

$$(H - L)S_2 < -HL,$$

$$S_2 < \frac{-HL}{H - L}. \tag{5.14}$$

Interestingly, this condition is independent of δ and of π . Intuitively this is because in both critical values of α : δ and π matter for the same reason, because of their influence on the equilibrium distribution of the type of seller in each of the equilibria. Otherwise the requirements of (5.14) are much as we would expect. It is most likely that the signalling equilibrium constitutes a welfare improvement where the signalling cost, S_2 is low and the benefits and costs to the buyers from honest dealing and cheating respectively by the sellers are large (high H and high $-L$).¹³

¹³It is simple to show that $\frac{d}{dH} \left(\frac{-HL}{H-L} \right) > 0$ and $\frac{d}{d(-L)} \left(\frac{-HL}{H-L} \right) > 0$.

Figure 5 shows the $\alpha_P^*(\delta, \pi)$ schedule for a parameterised example. We can see that for this example, there is a region where both the signalling equilibrium and the conditional cooperation equilibria are possible but the signalling equilibrium provides more social welfare than conditional cooperation. This is shown by the fact that $\alpha_P^* < \alpha_C^*$ and the relevant region is shaded.

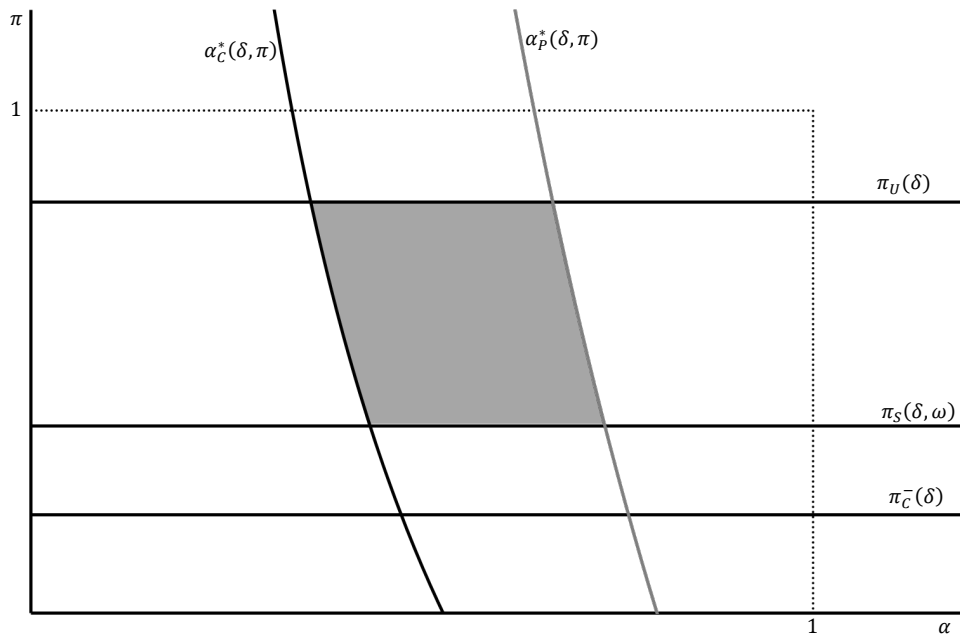


Figure 5: When the signalling equilibrium provides more social welfare than conditional cooperation.

5.3 Comparison of the two separating equilibria

At this point it is worth pausing to consider the two separating equilibria we have discovered in more depth. In the type-contingent cooperation equilibrium, the lower expected value of potential future trades for the incompetent seller meant that they valued those future trading opportunities less and so were willing to expose them to greater risk than their competent counterparts would for the same immediate gain.

In the signalling equilibrium the lower expected gain from any trade for the incompetent seller in this particular period means that they are unwilling to endure the same entry costs to trading in terms of the additional expected punishment disutility due to the

signal. So the two types of seller separate for different reasons in the two equilibria. In the type-contingent cooperation equilibrium, they separate because of the difference in expected future gains. In the signalling equilibrium, they separate because of different current gains.

At first sight, the signalling equilibrium we have described here may appear to be signalling without the Spence-Mirrlees condition on marginal costs. However, such a condition does exist on the marginal benefits of signalling. The *opportunity cost* of not signalling for the competent seller is greater than the *opportunity cost* of not signalling for the incompetent seller. In that respect, this is similar to the Hoppe et al. (2009) model of assortative matching in marriage markets.

6 Raising the Cost

The signalling equilibrium described in the previous section worked because it raised the expected cost for the sellers of participating in the criminal market. Only the competent sellers had a sufficiently large marginal benefit from participation to continue to sell drugs. However, raising the probability of being caught is not the only way to raise the expected cost of participation. One might also increase the penalty if caught. Let ΔP denote the increase in the criminal penalty for dealing drugs if the crime is committed in a manner society finds particularly egregious, dealing outside a school for example. In such situations stiffer penalties may actually be counter-productive. The reason is that criminals may use the increased cost of trade as a signal which supplements their reputational mechanisms for ensuring trust.

To show this we will state and prove the following proposition,

Proposition 5 *There exists a minimum level of π , $\pi'_S(\delta, \Delta P)$, and an intermediate range of ΔP , such that if $\pi > \pi'_S(\delta, \Delta P)$ and ΔP is inside the intermediate range, then there exists a signalling equilibrium in which competent sellers sell pure drugs outside a school, incompetent sellers try to sell cut drugs some distance from the school, and buyers will only buy from sellers who are near a school.*

The minimum level of π is

$$\pi'_S(\delta, \Delta P) = \left(\frac{1 - \delta}{\delta} \right) \left(\frac{S - M}{M_1 - \gamma_1 \Delta P} \right), \quad (6.1)$$

which will be less than 1 and so satisfied by some probability provided that

$$\delta > \delta'_S = \frac{S - M}{S_1 - \gamma_1 \Delta P}. \quad (6.2)$$

The intermediate range for the strength of the extra penalties is

$$\frac{S_2}{\gamma_2} < \Delta P < \frac{M_1}{\gamma_1}, \quad (6.3)$$

which is a non-empty range provided that

$$\frac{\gamma_1}{\gamma_2} < \frac{M}{S}. \quad (6.4)$$

Proof. Given the strategies of the sellers, the strategy specified for the buyers is trivially a best response, so we will consider the strategies for the sellers.

The competent seller has a continuation value from continuing with the specified strategy of $V_1 = M_1 - \gamma_1 \Delta P + \delta V_1 = (M_1 - \gamma_1 \Delta P) / (1 - \delta)$. A single period deviation to cutting the purity will pay $S_1 - \gamma_1 \Delta P + \delta (1 - \pi) V_1$. This will not be a profitable deviation provided that

$$\begin{aligned} M_1 - \gamma_1 \Delta P + \delta V_1 &> S_1 - \gamma_1 \Delta P + \delta (1 - \pi) V_1, \\ \delta \pi V_1 &> S - M, \\ \delta \pi \left(\frac{M_1 - \gamma_1 \Delta P}{1 - \delta} \right) &> S - M, \end{aligned} \quad (6.5)$$

which becomes

$$\pi > \pi'_S(\delta, \Delta P) = \left(\frac{1 - \delta}{\delta} \right) \left(\frac{S - M}{M_1 - \gamma_1 \Delta P} \right). \quad (6.1)$$

In order for (6.1) to be satisfied by a probability, this critical value must be less than 1, which will be the case when

$$\begin{aligned} (1 - \delta)(S - M) &< \delta(M_1 - \gamma_1 \Delta P), \\ \delta(M_1 - \gamma_1 \Delta P + S - M) &> S - M, \\ \delta > \delta'_S &= \frac{S - M}{S_1 - \gamma_1 \Delta P}. \end{aligned} \quad (6.2)$$

A single period deviation to not signalling by not trading outside the school will get $0 + \delta V_1$, which is not a profitable deviation provided that

$$\begin{aligned} M_1 - \gamma_1 \Delta P &> 0, \\ \Delta P &< \frac{M_1}{\gamma_1}. \end{aligned} \quad (6.6)$$

Similarly, the incompetent seller will get a continuation value of $V_2 = 0$ given the strategy profile. The best possible single period deviation would be to trading outside the school but continuing to sell drugs of cut purity. This will give a payoff of $S_2 - \gamma_2 \Delta P$ which will not be a profitable deviation provided that

$$\begin{aligned} S_2 - \gamma_2 \Delta P &< 0, \\ \Delta P &> \frac{S_2}{\gamma_2}. \end{aligned} \quad (6.7)$$

The condition (6.3) is simply the combination of conditions (6.6) and (6.7). In order to ensure that the range is non-empty, we need to ensure that the minimum value for the extra penalty set out in (6.7) is less than the maximum value for the extra penalty set out in (6.6). This means that

$$\begin{aligned} \frac{S_2}{\gamma_2} &< \frac{M_1}{\gamma_1}, \\ \frac{S - \gamma_2 P}{\gamma_2} &< \frac{M - \gamma_1 P}{\gamma_1}, \\ \frac{S}{\gamma_2} &< \frac{M}{\gamma_1}, \\ \frac{\gamma_1}{\gamma_2} &< \frac{M}{S}. \end{aligned} \tag{6.4}$$

This completes the proof. ■

This is very similar to the signalling equilibrium calculated in the previous section. Provided there is sufficient type difference, the equilibrium will exist for all values of π that are large enough, independent of the value of α . Similar to the previous section we could then calculate conditions under which the signalling equilibrium will expand the range of parameters for which a trading equilibrium will exist and the conditions under which the signalling equilibrium might constitute an improvement on type-contingent cooperation equilibria. These calculations are omitted here as the economic content will be very similar to the previous section.

However what we do intend to highlight are the implications for policy makers of these conclusions. If policy makers are concerned about drug dealers plying their trade near schools, passing a law to impose tougher penalties on those who do may be counter-productive and actually encourage the kind of behavior one is aiming to stop.

7 Conclusion

We have shown how signalling can explain the presence of blatant or flagrant actions by otherwise competent criminals. By being blatant in that way one signals that one is competent. Competence is valuable from the point of view of customers, even if the customers themselves face no criminal sanctions if the breach of society's laws is discovered. The value of competence is that competent criminals have brighter futures and as such care more about preserving the option of future trading opportunities. So competent criminals will be more protective of their reputations and will be more likely to trade honestly.

Under the right circumstances, reputational mechanisms might be sufficient to keep all criminals selling their wares honestly. However they might not. In these circumstances, provided the reputational mechanism is still sufficient to keep competent criminals honest, there might be an equilibrium where competent criminals sell their wares honestly and

incompetent criminals sell sub-standard merchandise. However in order for this to be the case, there must be a sufficiently high concentration of competent criminals in the market so that when a buyer buys, they are sufficiently likely to be buying from a competent criminal who won't have any incentive to cheat.

This might be quite restrictive on the range of parameters for which criminal trade is possible. However we can expand the range of parameter values for which trading occurs by introducing a signal. The signal makes it harder to secure the cooperation of competent sellers, but it also makes it unprofitable for incompetent sellers to enter the market and cheat buyers. This eliminates the restriction on the population density of competent traders that is needed to bring about honest trading.

The model allows us to make some predictions about the environments in which criminals signal by behaving in a flagrant fashion and the environments in which there will be no signalling. One environment that favors the emergence of signalling is where the reputational mechanism is moderately effective (sufficient to ensure the cooperation of competent types, but not incompetent types), and competent traders are relatively rare. The sale of drugs to the final consumers by street gangs offers an example. Unfortunately, there has been very little empirical work to date on the patterns that determine whether gangs choose to adopt gang colors or not. Most research has focussed on the reliability of using gang colors to identify gang members. So this suggests one potential avenue for future empirical research.

Our result furthermore questions one of the basic assumptions about the economics of crime which first appeared in Becker (1968). Becker postulated that the supply of offences an individual would be willing to commit would be decreasing in the probability of getting caught. While this is certainly an appropriate assumption for a general equilibrium model of crime, our model highlights some micro-level features of criminal markets which bring it open to question. In our model, increasing the probability of getting caught can increase the supply of offences because the way in which the probability is increased reassures potential trading partners. Potential trading partners might have feared that a seller was incompetent and so too likely to cheat. By deliberately increasing his own chance of getting caught the seller sends a signal that less competent sellers would not be able to imitate.

Finally recall that we built this model imagining that sellers who are caught by the police simply pay a fine or are forced to endure community service or a short prison sentence. Even if caught by the police, they are still available for trade in the next period. Our key qualitative conclusions will be robust to this assumption. If captured sellers were incarcerated and replaced in that period, then whether a seller is going to sell pure drugs or cut the purity of his drugs is still going to be determined by a cut-off in terms of the effectiveness of the reputational mechanism. Meaning that they will sell pure drugs if and only if the probability of being observed selling cut drugs and ostracized is greater than a certain cut-off. That cut-off will still be higher for incompetent individuals than for competent individuals. When inbetween the two cut-offs, there will be a critical population density of competent sellers which will be sufficient to make the buyers willing

to buy. Provided we imagine some disutility from going to prison which makes it worse than simply not trading in every period, then there will also be a signaling equilibrium which will allow us to get some honest trade going between competent sellers and buyers while incompetent sellers are unable to profitably imitate the signal.

Whilst we must acknowledge the possibility that social phenomena such as gang colors may well be “over-determined” and have multiple rather than singular causes, that should not blind us to the significance of this result. Gang colors as discussed here has stood for a multitude of criminal actions and patterns which might seem, on the face of it to draw more attention to criminals than is good for them. We might just as well have talked about excessively louche jewellery or particular ways of decorating cars; or simply walking and talking like a criminal. Once we realise that criminals may be deliberately attracting extra attention, the question of the optimal response by the police becomes an open one. They might be more effective at reducing crime if they ignore the extra information that criminals give off. If they do not target the “low-hanging fruit” then they might be more successful at injecting mistrust among criminals and disrupting illicit markets. Rules of evidence and police procedure that seem to restrict the police to fighting crime with one hand tied behind their back might actually serve to allow criminals to disrupt their own trade more effectively than the police can on their own.

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