Recruitment to Organised Crime

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Abstract

Organised crime is unique within the underground economy. Unlike individual criminals, criminal organisations can substitute between a variety of inputs; chiefly violence and labour. This paper considers the effect of several popular anti-crime policies in such an environment. Using a standard framework, I find that certain policies may cause the organisation to reduce its membership in favour of more intense violence. Others may lead to increases in membership. Consequently, policies designed to reduce the social loss suffered as a result of criminal activities may actually increase it. Results prove robust to differences in hiring practices on the part of the criminal organisation.

Keywords: Organised crime; Crime policy; Occupational choice.

JEL: J24, J28, K42

1 Introduction

Over recent years, a myriad of policies have been suggested to tackle youth involvement in crime. The reason for this is simple: crime inflicts a cost upon society. Recent estimates (Cohen and Piquero 2009) place the average present value to society of saving one high-risk eighteen year-old from a life of crime between $2.6 million and $5.3 million. Over the last decade, estimates of these costs have increased substantially. In an earlier study employing a similar approach (Cohen 1998), the headline cost was between $1.7

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million and \$2.3 million. Admittedly, a large proportion of the increase is the result of improvements in measurement techniques. Nevertheless, crime is much more costly than hitherto imagined. The individual involved suffers from foregone education, likely drug use, and potential punishment. Wider society is forced to invest in security, pay for public prosecution and incarceration, and suffer from victimisation and the fear of crime. The recent intensification of research into these policies is therefore unsurprising.

All of the policies put forward are based upon the same argument: increasing the opportunity cost of crime reduces its amount and intensity. In turn, this reduces the social cost of crime. Broadly speaking, this appears sound. However, in one special case - that of organised crime - it may fail. Criminal organisations are proactive. They can respond to new policies, counteracting their effects by adjusting their inputs and the wages they offer. Under certain conditions, discussed herein, the social cost of crime may even increase.

How large is the problem? Wage data from a Chicago gang (Levitt and Venkatesh 2000) suggest that the cost of youths joining criminal organisations may be towards the top end of Cohen and Piquero's estimates. They report that the gang studied valued the lives of its members at somewhere between \$8,000 and \$500,000. Even the upper estimate is only 10% of the average value of a human life in the literature, suggesting an average loss to society of around \$4.5 million. A recent survey (Egley and Howell 2011) estimated that there are 28,100 gangs active in the US, employing some 731,000 individuals. Combined with Cohen and Piquero's estimates, the annual cost of youth involvement in organised crime may be as high as \$465 billion in the US, or 3% of US GDP (Bureau of Economic Analysis 2011)[1].

This paper develops a simple framework in which to study a criminal organisation's likely reaction to the implementation of policy. A profit-maximising gang has two available inputs, labour and violence, which it uses to produce outputs ranging from prostitution and drug dealing, to people trafficking and protection. Heterogeneous youths grow up in the gang's neighbourhood. During their early years, they have the opportunity to acquire criminal skills. They then decide where to seek employment. If they join the formal economy, they are paid a flat wage. If instead they opt for a criminal career, they join the neighbourhood gang. By joining the gang, they are required to inflict violence. The exact amount of violence, and the form of compensation provided, depends upon the gang's ability to discriminate between youths with different abilities. At its most basic, the gang will offer a flat wage, and require all youths to inflict the same amount

[1]Cohen and Piquero use a constant 2% discount rate. Author's estimates are based upon youths being active from age 18 to 26 and use 2009 US nominal GDP.

of violence. A discriminating gang, on the other hand, may offer a range of different wages, each associated with a different level of violence.

When a policy is introduced that affects the youths' incentives, the gang's reaction depends upon how variation of inputs affect profits. If violence and size are complementary in the profit function, any policy that aims to reduce the incentive to join the gang also reduces the amount of violence the gang employs, unequivocally lowering the social loss from crime. If, on the other hand, violence and size are profit substitutes, a variety of outcomes may arise. Falling size may cause the gang to substitute towards violence or vice versa. Perversely, this could increase the social cost of crime. Policies are therefore most effective when they not only reduce gang membership, but also hamper the gang's ability to intensify violence.

1.1 Criminal Organisations as Firms

Two approaches are often employed when considering the activities of organised crime, reflecting two different literatures. Those considering the origins of criminal organisations (for example Gambetta 1996, Skaperdas and Syropoulos 1997 or Dixit 2007) think of them as pseudo-states, filling the void left by weak law enforcement. This literature views a local monopoly over violence as the defining characteristics of organised crime. Conversely, it is through the lens of a profit-maximising firm that established criminal organisations are most successfully analysed (for example Garoupa 2000, Chang, Lu, and Chen 2005 or Kugler, Verdier, and Zenou 2005). This paper adopts the second approach, whilst incorporating elements of the first.

Some tailoring of the standard theory of the firm apparatus is necessary. Criminal organisations are not regular firms; their property rights are not protected by statute. Moreover, their activities are under constant (violent) threat from law enforcement agencies, as well as competitors. As such, their factors of production are slightly different. The economic and criminological literatures point to two inputs being common to all flavours of criminal organisation: number of members and violence.

As with all firms, labour is critical for criminal organisations. In addition to its traditional role in production (Chang, Lu, and Chen 2005), there are several economies of scale that a larger organisation is able to take advantage of. Transactions within illegal markets are fraught with risk. Trading partners are prone to cheating one another. There is a constant threat from undercover police officers. These risks lead to a reduction in trade (Cook, Ludwig, Venkatesh, and Braga 2007) giving rise to the usual inefficiencies (from the criminal organisation's perspective, at least). Large criminal organisations can internalise a lot of these transactions. By vouching for its members, and inflicting severe punishments on those who renege, a criminal organisation enables individuals to trade with one another in safety. They also make it harder for police to infiltrate them by being more self-sufficient.

Sah 1991 notes that larger criminal organisations can also stretch police resources. As the number of members increases, the probability than any one individual will be arrested may diminish. Consequently, larger organisations suffer proportionally less from police disruption.

Violence is the other key component of criminal enterprises. At first pass, the reasons seem obvious. Firms operating a protection racket must be willing and able to use violence against those who disrupt their clients' businesses (Gambetta 1996, Dixit 2007). As protection often evolves into extortion, violence may also be required to ensure that clients continue to pay their fees (Garoupa 2000). Violence (equally, the threat of violence) can thus be seen as a direct input into the criminal organisation's production function.

Violence is equally important as a mechanism for reducing disruption to the organisation's other operations. As it is impossible for the organisation to operate in isolation, numerous stakeholders will, over time, gain information that could implicate it in various illegal activities. Violence is used to ensure that the cost of informing the police is prohibitively high.

Of these stakeholders, the ones with the greatest potential to harm the organisation are its members. Baccara and Bar-Isaac 2008 consider the problem of information diffusion within a network design framework. Where the threat of violence is credible, and sufficient to prevent members implicating the organisation, a hierarchical structure proves to be optimal. Information is passed throughout the organisation efficiently. Organisations, such as terrorist groups, who cannot rely on their members not to share information, are forced into a much less efficient cell structure. The use of extreme violence against members-turned-informants is well documented, particularly with regard to the Italian Mafia's code of secrecy; the *omertà* (see, for example, Gambetta 1996, Paoli 2003, Raab 2006). Similarly, violence may be employed to prevent residents of the organisation's territory (where its activities are profuse) from interfering, or cooperating with law enforcers.

Finally, criminal organisations use violence to protect their local monopolies from competitors. Silverman 2004 provides a relevant economic analysis, admittedly in a broader economics of crime context. He shows that there is an incentive for individuals to develop a reputation for violence, even if they are not inherently violent. By doing so, only those with a genuine predilection for violence will stand up to them. Similarly, criminal organisations may develop a reputation for violence to deter rivals.

Employing these inputs, criminal organisations' output is varied. They tend to be active in a variety of markets, from drugs and prostitution to protection and smuggling. Irrespective of which market(s) the organisation is operating in, size and violence are revenue complements. Members of more violent groups suffer less disruption, enjoy stronger monopolies, and may even be able to extort higher revenues. In other words, the aggregate marginal revenue product of labour is increasing in violence, and vice versa.

Criminal organisations' costs, on the other hand, are primarily wages paid to their members. Whilst the organisation's leaders dictate the extent of violence employed, it is the foot soldiers that face the cost of implementing it during the commission of their crimes. Levitt and Venkatesh 2000 show that, over a four-year period, members of drug-selling gang in Chicago had a 25% chance of dying. Over the same period, they also suffered an average of two non-fatal injuries (ranging from gunshots and knife wounds to beatings). In order to attract and retain members, wages must incorporate compensation for the violence they are forced to inflict. This provides an incentive for criminal organisations to substitute between size and violence. By increasing the amount of violence it requires its members to employ, the organisation's wage bill grows substantially, as each member must be compensated. In this sense, the marginal cost of size is also increasing in violence, and vice versa.

Whether violence and size are profit complements or substitutes depends upon which effect dominates. When the gang's size increase, the marginal revenue it derives from violence also increases. For example, with more members, the gang is able to extort money more successfully from its neighbourhood. This provides an incentive to increase violence. However, any increase in violence requires that the gang compensate its members. With a larger gang, more members need to be compensated. As such, an increase in size also increases the marginal cost of violence. Whether violence's profitability increases when size increases clearly depends upon whether marginal revenue or marginal cost increases more. This will play a key role in determining the effectiveness of policy.

1.2 Opportunities in a Criminal Neighbourhood

Youths growing up within a criminal organisation's territory face several difficulties when seeking work in the primary labour market. Such neighbourhoods tend to develop reputations for criminal activity. If this leads employers to engage in discrimination, and reduce their expectations regarding prospective employees' productivity from that neighbourhood, finding a job could be more challenging (Verdier and Zenou 2004). In turn, poor prospects provide less incentive to acquire human capital, creating a self-fulfilling prophecy (Lundberg and Startz 1983). Austen-Smith and Fryer 2005 suggest that this may be compounded by peer pressure. Attempting to gain a good education can be interpreted as a negative signal by a youth's peer group. This provides a further disincentive to acquire the skills necessary to seek employment. Combined, these two effects can lead to situations where the opportunities open to youths from such a neighbourhood are severely limited in the primary labour market.

In sharp contrast, opportunities abound in the informal economy. Success in this industry requires the acquisition of a different set of skills. Youths must develop an acceptance of, and willingness to use, violence. Ballester, Calvó-Armengol, and Zenou 2010 explore the acquisition of criminal skill in a network. As no schools offer certificates in intimidation (to this author's knowledge), they suggest that youths may acquire such skills through a mixture of trial and error (juvenile crime), and observing others' mistakes. This second channel - learning from others' mistakes - can cause of a great deal of heterogeneity in youths' intrinsic ability to acquire criminal skills. In their analysis, Ballester *et al* suggest that youths who feature centrally in a juvenile network will find skill acquisition far easier. They can observe others more easily, suffering less from trial and error. Once they have joined the criminal organisation, they will find inflicting violence far less costly as a result.

There is a broad range of criminological evidence in support of a learning process by which individuals become accustomed to using violence. Various works by Athens (summarised in Rhodes 2001) identify a common process of 'violentization' undergone by a large sample of prisoners incarcerated for violent crime. During this process, individuals are first desensitised to violence, before learning (through positive reinforcement) that it is an appropriate response to minor provocations. Juvenile gangs play an important role in this system. Esbensen and Lynskey 2001 interviewed fourteen year-olds in the US who claimed to be members of a juvenile gang. Of those, 25% claimed to have shot at someone. FBI statistics back up this claim. 80% of gang murders in 2009 were attributed to juvenile gangs (Federal Bureau of Investigation 2010). This is not merely a US phenomenon, however. Esbensen and Weerman 2005 conducted a similar study in The Netherlands. They found that members of a juvenile gang were four times more likely to be involved in violence than those not involved in a gang. Similarly, Salagaev *et al* 2005 found that Russian gang youths were seven times more likely to use violence to appropriate money or other goods. Whilst a proportion of these results may be attributed to bravado, they nevertheless indicate an acceptance of violence as a means to an end.

1.3 Policies Designed to Tackle Organised Crime

Since the inception of the economics of crime, economists have been suggesting policies to reduce criminal activity. In Becker's breakthrough paper of 1968, he proposed that a relatively cheap way to reduce crime was to simply increase the fine incurred when caught. Since then, an abundance of policies have been put forward, each aiming to manipulate the incentives of would-be criminals. This paper considers four broad categories:

1. Increasing the severity of punishment;
2. increasing arrest and conviction rates;
3. primary labour market policies; and
4. prevention of juvenile crime.

The idea of increasing the severity of punishment dates back to Becker. By increasing the size of fine, the expected payoff to committing crime is reduced, given a constant arrest rate. This reduces the incentive to become involved in crime, relative to staying honest. Related to this is increasing arrest and conviction rates. At first pass, the effects should be equivalent. Certainly, Burdett, Lagos, and Wright 2004 find that, in addition to reducing the incentive to commit crime, both policies increase average wages and reduce inequality. However, when we turn our attention to organised crime, this equivalence begins to break down. Increasing arrest rates reduces the number of members available for the organisation to utilise. This, in turn, will impact upon the wages they are willing to offer, and even their optimal levels of violence. Whilst increasing the length of prison terms may have similar effects, other increases in severity may not.

Primary labour market policies cover an extremely broad range of suggestions, all aiming to increase the wage paid in the formal economy. A by-product of this is a fall in crime. Two cases stand out, however, for their direct targeting of high-risk youths. The now famous Perry Preschool Programme (see Parks 2000), focused on poor black preschool children with low IQs in the 1960s. Participants attended preschool classes for 2.5 hours per day, five days per week. The preschool teachers also engaged with parents, visiting them for a further 1.5 hours each week. Participants were tracked over forty years, creating a reasonably comprehensive data set on their educational, employment and criminal outcomes. Recent analysis, whilst downgrading previous measures of success, still suggest that the project yielded an internal rate of return of 7%-10% (Heckman, Moon, Pinto, Savelyev, and Yavitz 2010). The second example relates to a range of case studies by the Education Innovation Laboratory at Harvard University. The Harlem Children's Zone in New York combines an intensive education programme with access to community services (Dobbie and Fryer 2011). EdLabs are also involved in numerous projects across the US aimed at high school students (Fryer 2010). For example, the Paper Project in Chicago targets ninth and tenth grade students. The organisers pay the students for passing their classes. They can earn up to $2,000 per year, with 50% payable upon graduation from high school.

Prevention of juvenile crime increases the cost of acquiring criminal skills, and is at the heart of the arguments put forward by Ballester, Calvó-Armengol, and Zenou 2010. By disrupting juvenile networks, the authorities are able to increase the cost of acquiring criminal skills. Youths are forced to learn in isolation, and are unable to learn from other mistakes. They are thus less likely to join criminal organisations, as they will find inflicting violence to be too costly.

Each policy works by reducing a criminal organisation's demand for members and/or violence. If size and violence are complementary in the profit function, a reduction in one creates an incentive to reduce the other. Conversely, if they are substitutes, it creates an incentive to increase the other. Under certain conditions, this countervailing effect may actually cause net increases in the demand for size or violence, increasing the loss suffered by society at the hands of organised crime. It is this mechanism that the rest of the paper is devoted to investigating.

The remainder of the paper proceeds as follows. In the next section, I introduce a model of recruitment to organised crime, outline the subgame perfect equilibrium, and discusses some useful assumptions. Having done this, section 3 discusses the likely impact of policy under various conditions, and highlights where policies may have unintended consequences. Section 4 extends the analysis, discussing a situation in which the gang can offer a range of jobs to youths. Section 5 considers the effects of policy in this more complicated setting. Finally, section 6 concludes.

2 A Simple Model of Recruitment to Organised Crime

I present a model of organised crime recruitment. The economic environment, hereafter referred to as the *neighbourhood*, consists of two sectors: the *primary labour market*[2] and *the gang*[3]. A mass N of heterogeneous youths grow up in the neighbourhood. After investing in appropriate skills, they decide where to seek employment. Whilst the primary labour market is passive, the gang acts as a simple monopsonist employer of criminals in the neighbourhood. Gang leaders adjust their approach to recruitment in order to maximise the gang's profits.

The gang's revenue, be it from drug sales or extortion, prostitution or people trafficking, depends primarily upon two characteristics: the size of its membership and the degree of violence it employs. I denote these by $M \geq 0$ and $V \geq 0$ respectively. Its revenue stream is given by a black box function[4], $R(V, M)$. Revenue is subject to positive but diminishing marginal returns and constant returns to scale. Moreover, there is some degree of complementarity between violence and size, insofar as $R(0, M) = R(V, 0) = 0$ for all $V, M \geq 0$. The gang is *simple*, insofar as it cannot distinguish between youths. All members inflict the same amount of violence, V, and receive the same wage, $g \geq 0$. Its profits are therefore given by:

$$\Pi(V, M) \equiv R(V, M) - gM \tag{1}$$

Gang leaders choose the degree of violence the gang employs, and the wage it offers its members in order to maximise (1). These choices become common knowledge, and are announced prior to any decisions made by youths.

Youths vary in their intrinsic criminal ability, denoted by σ and distributed exponentially with parameter $\lambda > 0$. Youths simultaneously make two decisions. Firstly, they choose how much criminal skill to acquire. They then decide which sector to work in. Acquiring criminal skill is a costly process. However, those with a higher criminal ability find it easier than those with a lower ability. Denoting the amount of criminal skill acquired by youth i by c_i, the cost of acquiring criminal skill is given by $\kappa C\left(\frac{c_i}{\sigma_i}\right)$. $C(\cdot)$ is a strictly increasing and convex function. $\kappa > 0$ reflects the fact that policy can

[2] This terminology follows Huang, Laing, and Wang 2004, who develop a similar model of predation.

[3] Whilst the terminology used refers to a street gang, the model presented is equally relevant to alternative forms of organised crime.

[4] The black box nature of revenue (as opposed to production) is purely for notational ease. One can think about it as an indirect revenue function: the one resulting from the optimal allocation of inputs across the wide range of activities the gang engages in. Kugler *et al* 2005 consider a more structured approach, decomposing revenue into the number of crimes committed, and the booty collected from each crime.

influence how easy it is to acquire criminal skills.

For simplicity, the primary labour market pays an exogenously given flat wage rate, $w \geq 0$. One can consider this wage to be net of any cost of education, as well as incorporating the probability of unemployment. The gang also pays a flat wage, $g \geq 0$. However, as discussed in the introduction, being involved in the gang is a dangerous affair. There is a possibility of arrest and conviction. Following Becker 1968, arrest occurs with probability p, resulting in a fine of size f and wages being withheld[5]. Moreover, gangs are violent enterprises. Whilst the gang leaders choose the level of violence the gang is known for, it is the members who must bear the cost of inflicting that violence. It is at this point that acquiring criminal skill pays off. By investing effort in learning to be a criminal, youths become desensitised to violence. So, whilst all gang members suffer disutility from having to engage in violence, those who have acquired large amounts of criminal capital suffer less. In particular, each youth suffer disutility $-\frac{V}{c_i}$. I assume that arrests are always made after a crime has been committed. Since youths inflict violence during their crimes, they therefore suffer this disutility irrespective of whether they are subsequently arrested. The payoff from joining the gang is therefore:

$$(1-p)\,g - pf - \frac{V}{c_i} - \kappa C\left(\frac{c_i}{\sigma_i}\right) \tag{2}$$

2.1 Equilibrium with a Simple Gang

The model yields a subgame perfect equilibrium. The gang announces its choices of V and g to maximise profits. Youths then acquire criminal skills and choose a career, conditional on the announced V and g, as well as their criminal ability, σ. As per usual, the equilibrium is found by backwards induction.

2.1.1 Youth Decisions

Taking the announced level of violence and gang wage as given, a youth with criminal ability σ_i faces the following utility maximisation problem:

$$\max_{j\in\{0,1\},c\geqslant 0}\left\{(1-j)\,w + j\left[(1-p)\,g - pf - \frac{V}{c}\right] - \kappa C\left(\frac{c}{\sigma_i}\right)\right\} \tag{3}$$

where $j \in \{0,1\}$ takes value one when the youth chooses to join the gang and zero otherwise.

[5] This is a simplification. In reality, there is some evidence to suggest that criminal organisations pay members' families whilst they are incarcerated. However, as they are unable to take advantage of other membership benefits, their gang wage does go down.

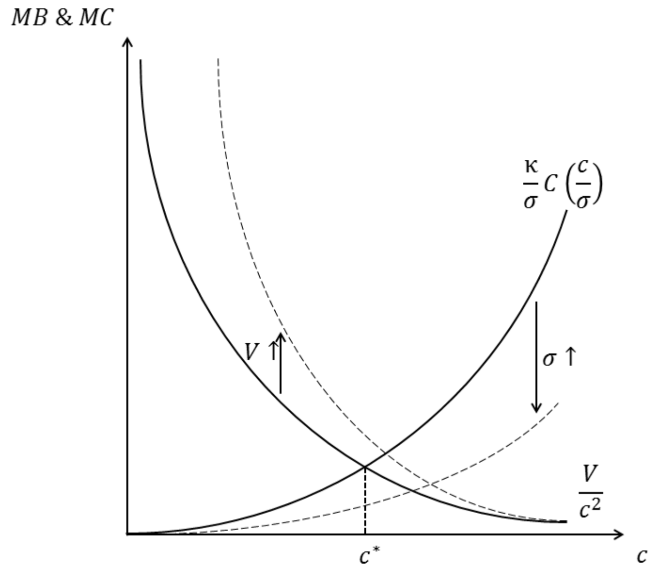

Figure 1: A σ-ability youth's choice of criminal skill.

Consider first the choice of criminal skill, conditional upon career choice. If the youth chooses to join the primary labour market, criminal skill is of no use to them. They consequently do not incur the cost of acquiring it, and select $c_i^* = 0$. Conversely, if they decide to join the gang, they choose $c^*\left(\sigma_i, V; \boldsymbol{\phi}\right)$ satisfying:

$$\frac{V}{c^*\left(\sigma_i, V; \boldsymbol{\phi}\right)^2} \equiv \frac{\kappa}{\sigma_i} C'\left(\frac{c^*\left(\sigma_i, V; \boldsymbol{\phi}\right)}{\sigma_i}\right) \tag{4}$$

where $\boldsymbol{\phi}$ is a vector of exogenous policy parameters. Equation (4) is represented in Figure 1. The resulting $c^*\left(\sigma_i, V; \boldsymbol{\phi}\right)$ is strictly positive, and increasing in both the level of violence employed by the gang and the criminal ability of the youth. More violence increases the marginal benefit of acquiring criminal skills, whereas increasing criminal ability reduces the marginal cost.

Given youths' choice of criminal skill, it is straightforward to show that the payoff to joining the gang is strictly increasing in criminal ability. Consider a youth with ability $\sigma' > 0$. Suppose that they join the gang, and acquire the optimal amount of criminal skill, $c^*\left(\sigma', V; \boldsymbol{\phi}\right)$. Now consider a youth with ability $\sigma'' > \sigma'$. If this youth joins the gang and acquires $c^*\left(\sigma', V; \boldsymbol{\phi}\right)$ criminal skill, they enjoy the same wage and suffer the same disutility from violence. However, since they have higher criminal ability, the cost of acquiring $c^*\left(\sigma', V; \boldsymbol{\phi}\right)$ is lower. They can therefore guarantee themselves of a strictly higher payoff than the youth with criminal ability σ'. Conversely, the payoff from joining the primary labour market, w, is independent of a youth's criminal ability.

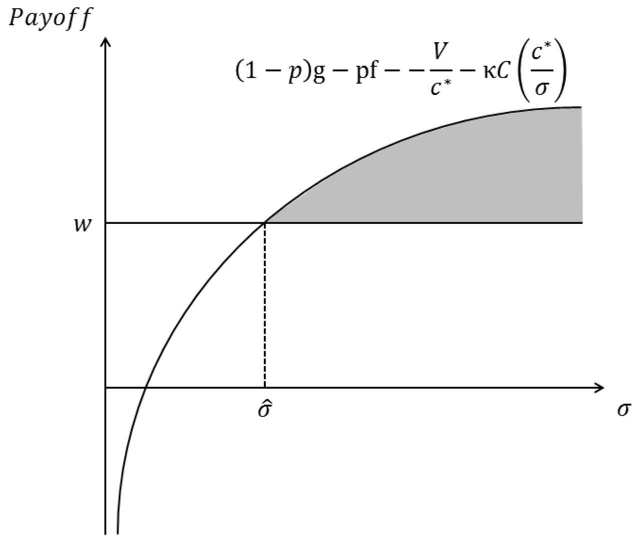

Figure 2: Youths' Payoffs from Gang Membership versus the Primary Labour Market

We can therefore conclude that there exists some $\widehat{\sigma}$ such that a youth will join the gang if and only if $\sigma_i \geq \widehat{\sigma}\left(V, g; \boldsymbol{\phi}\right)$. $\widehat{\sigma}$ is defined by:

$$(1-p)\, g - pf - \frac{V}{c^*\left(\widehat{\sigma}, V; \boldsymbol{\phi}\right)} - \kappa C\left(\frac{c^*\left(\widehat{\sigma}, V; \boldsymbol{\phi}\right)}{\widehat{\sigma}}\right) \equiv w \tag{5}$$

We call the youth with ability $\hat{\sigma}$ the *marginal youth*. Since all youths with ability above $\widehat{\sigma}$ join the gang, its size will be given by $M = N\left(1-p\right) e^{-\lambda\widehat{\sigma}}$. A proportion $e^{-\lambda\widehat{\sigma}}$ of the mass N youths join the gang. However, a proportion p are arrested and convicted, making them unproductive.

Youths' career choices are represented by Figure 2. An increase in the wage offered by the primary labour market increases the opportunity cost of joining the gang, raising the ability of the marginal youth. Similarly, increases in the conviction rate, severity of punishment, the degree of violence employed by the gang, or the cost of acquiring criminal skill reduces the payoff from joining the gang. Once again, this raises the ability of the marginal youth and, by extension, lowers the gang's size. The shaded area represents the surplus accruing to gang members. Since the gang is a single price monopsonist in this setting, all gang members receive a positive surplus through membership. Moreover, since the cost of violence decreases with criminal ability, higher ability youths receive a larger surplus than those with lower ability. We will revisit this in Section 4, where the gang is able to reclaim some (but not all) of this surplus by offering a menu of jobs with differing wages and associated levels of violence. For the moment, note that this does not imply that organised crime generates a social surplus. It simply suggests that those who join the gang are better off doing so in equilibrium. As noted in the introduction, gang activity have a tendency to supress formal wages and reduce the incentive to invest in formal human capital. Thus it may be the case that, were the gang not present, youths could guarantee themselves an even higher payoff in the primary labour market.

2.1.2 Gang Leader Decisions

During the exposition of the model, the gang leadership's profit maximisation problem was described as a decision regarding the degree of violence it expected gang members to engage in, V, and a wage rate it offered members, g. As a result of these decisions, some membership size, M, was induced. It turns out that a computationally easier way to view the gang leadership's problem is to think about them choosing the degree of violence, and then compensating gang members sufficiently to induce a chosen gang size. The extent of the compensation is derived as follows. In order to acquire gang size of precisely M, it is necessary that the marginal youth have criminal ability:

$$\hat{\sigma} = \frac{\ln N + \ln(1-p) - \ln M}{\lambda} \tag{6}$$

This youth must therefore be indifferent between the gang and the primary labour market. In order to ensure this with degree of violence V, the gang must offer a wage:

$$g(V, M; \boldsymbol{\phi}) \equiv \frac{w + pf}{1-p} + \frac{V}{\hat{c}(1-p)} + \frac{\kappa}{1-p} C\left(\frac{\lambda \hat{c}}{\ln N + \ln(1-p) - \ln M}\right) \tag{7}$$

where $\hat{c}(V, M; \boldsymbol{\phi})$ is the criminal skill of the marginal youth, defined implicitly by:

$$\frac{V}{\hat{c}(V, M; \boldsymbol{\phi})^2} \equiv \frac{\lambda \kappa}{\ln N + \ln(1-p) - \ln M} C'\left(\frac{\lambda \hat{c}(V, M; \boldsymbol{\phi})}{\ln N + \ln(1-p) - \ln M}\right) \tag{8}$$

The gang leadership's profit maximisation problem thus becomes:

$$\left(\hat{V}(\boldsymbol{\phi}), \widehat{M}(\boldsymbol{\phi})\right) = \underset{V \geq 0, M \in [0,N]}{\arg\max} \left\{R(V, M) - g(V, M; \boldsymbol{\phi}) M\right\} \tag{9}$$

Before continuing to outline the solution to (9), it is expedient to discuss an issue alluded to in the introduction. When violence increases, the marginal revenue product of size increases. Gang members face less disruption, a stronger monopoly, and may even be able to extort higher prices. Concurrently, however, the marginal cost of labour also increases. Each member is being forced to engage in more violence, increasing the loss they suffer as a result. The gang must offer additional compensation according to (7), in order to prevent those with relatively low criminal ability from opting to join the primary labour market instead. These two effects counteract one another, and consequently, the net effect on the marginal profit generate by size is unclear. Determining which effect dominates is not only helpful when describing the equilibrium, but proves to have important implications for the impact of policy in this environment. It is straightforward to show that:

$$\Pi_{VM} = \frac{1}{M\hat{c}(1-p)}\left[\eta - \left(1 + \frac{1}{\lambda\hat{\sigma}}\frac{1+\varepsilon}{2+\varepsilon}\right)\right] \tag{10}$$

where $\eta = \frac{MR_{VM}(V,M)}{R_V(V,M)} > 0$ is the cross elasticity of the marginal revenue product of violence with respect to labour, and $\varepsilon = \frac{\frac{\hat{c}}{\hat{\sigma}}C''\left(\frac{\hat{c}}{\hat{\sigma}}\right)}{C'\left(\frac{\hat{c}}{\hat{\sigma}}\right)}$ is the elasticity of the marginal cost of acquiring criminal skills with respect to $\frac{\hat{c}}{\hat{\sigma}}$. Clearly, η represents the relative increase in marginal revenue product of violence. The second term in parenthesis in (10) reflects the relative increase in the wage the gang offers. As the degree of violence increases, the amount of compensation required increases. However, this effect is tempered by the fact that youths invest in more criminal capital.

These terms depend upon the functional forms of $R(\cdot,\cdot)$ and $C(\cdot)$ respectively. It is therefore helpful to make one of two assumptions:

Assumption 1 (Complements) *The marginal revenue product of size is sufficiently elastic with respect to violence to ensure that Π_{VM} is always positive.*

Assumption 2 (Substitutes) *The marginal revenue product of size is sufficiently inelastic with respect to violence to ensure that Π_{VM} is always negative.*

These assumptions are illustrated in Figure 3. When η is large relative to M, the marginal cost of compensating youths for increasing amounts of violence is relatively small compared to the increase in marginal revenue. As such, Assumption 1 holds. In particular, if $\eta > 1 + \frac{1}{\lambda\hat{\sigma}}$, then the revenue effect always dominates the cost effect, irrespective of the functional form of $C(\cdot)$. Conversely, if η is small relative to M, the opposite is true. If $\eta < 1 + \frac{1}{2\lambda\hat{\sigma}}$, the relative increase in marginal revenue is insufficient to compensate for the relative increase in marginal cost, irrespective of the functional form of $C(\cdot)$. For η in between these two values, the situation is less clear, and the convexity of the criminal skill cost function becomes important.

We are now in a position to outline the gang leaders' choices.

Proposition 1 (Profit Maximisation) *Suppose that $\eta > 1$, and that either Assumption 1 or Assumption 2 holds. Then the gang leadership's profit maximisation problem given by (9) has a unique solution, with $\hat{V}(\boldsymbol{\phi}) > 0$ and $0 < \widehat{M}(\boldsymbol{\phi}) < N$.*

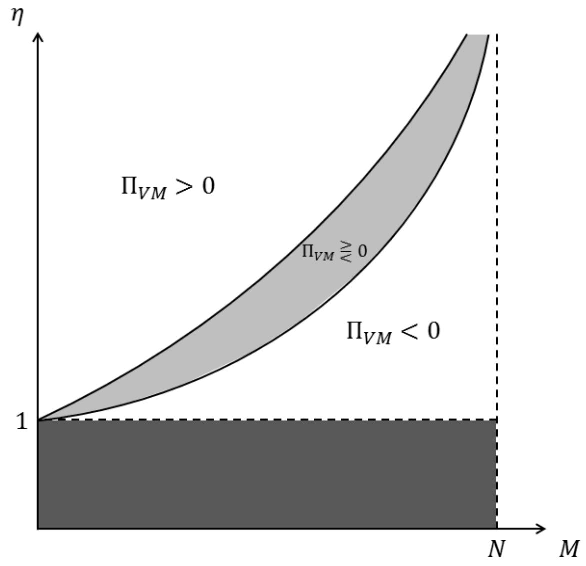

Figure 3: The range of values over which Assumption 1 and Assumption 2 hold.

Proof. See appendix A. ■

Requiring that $\eta > 1$ serves two purposes and is sufficient to ensure a maximum exists under both Assumptions 1 and 2. The marginal revenue product of violence declines as violence increases. However, as the gang requires greater feats of violence from its members, each youth optimally invests more heavily in acquiring criminal skills. As a result, each marginal increase in violence, dV, has a smaller impact upon the cost youths bear from inflicting violence, $\frac{dV}{c^*}$, since c^* is larger. Consequently, the gang must increase its compensation for inflicting violence by smaller amounts as violence increases: the marginal cost of violence is also decreasing. In order for a maximum to exist, we require that marginal revenue decline faster than the marginal cost. A sufficient condition for ensuring this is that $\eta > \frac{1}{2}$.

Under Assumption 1, $\eta > \frac{1}{2}$ guarantees that a unique maximum exists. Unfortunately, if violence and size are substitutes, the incentive to substitute may be strong enough to move the gang towards one of the extremes (high violence, tiny membership or vice versa). To counteract this, we require that a decline in violence reduces the marginal revenue product of size sufficiently as to admit interior maximum. This, in turn, requires the slightly stronger condition that $\eta > 1$.

Assumptions 1 and 2 are not necessary, but are sufficient to ensure uniqueness of the equilibrium. To see this, consider the restricted factor demand functions, $\widetilde{V}(M, \phi)$ and $\widetilde{M}(V, \phi)$. These are derived directly from the first order conditions (below), and give the gang's optimal choice of violence and membership size respectively, holding the other input constant:

$$R_V\left(\widetilde{V},M\right)-\frac{M}{\hat{c}\left(1-p\right)} \equiv 0 \qquad (11)$$

$$R_{N^G}\left(V,\widetilde{M}\right)-g\left(V,\widetilde{M};\boldsymbol{\phi}\right)-\frac{V}{\hat{c}\left(1-p\right)\left(\ln N+\ln\left(1-p\right)-\ln\widetilde{M}\right)} \equiv 0 \qquad (12)$$

By varying size in equation 11, it is possible to trace the gang's optimal choice of violence in (M,V)-space. Similarly, by varying violence in equation 12, one acquires the gang's optimal size. Maintaining the assumption that $\eta>1$, Figure 4 displays the restricted demand functions for complements and substitutes. In both cases, the gang leaders' equilibrium choices are described by the intersection of the two curves, where their choice of violence is optimal given their size, and their choice of membership size is optimal given their level of violence. It is clear from Figure 4, however, that the comparative statics are different. When membership size and violence are complementary, both restricted demand functions slope upwards[6]. In this case, an exogenous increase in, say, the gang's restricted demand for violence ($\widetilde{V}\left(M,\boldsymbol{\phi}\right)$ shifts upwards) makes increasing size more profitable. Consequently, both increase concurrently. In contrast, when size and violence are substitutes, both curves slope downwards. An exogenous increase in the gang's restricted demand for violence makes size less profitable. In this case, the gang optimally reduces size as violence increases.

3 Policy with a Simple Gang

Policies designed to tackle crime, and organised crime in particular, are motivated by a simple stylised fact: crime is costly. The scale of the total loss to society caused by a criminal organisation will ultimately be related to the its two transient features - violence and membership size: $L\left(\hat{V},\widehat{M}\right)$. For a generic policy, ϕ, the change in social

[6]The slopes of the restricted demand curves are derived by a simple application of the Implicit Function Theorem. $\widetilde{V}\left(N^G,\boldsymbol{\phi}\right)$ is defined by $\Pi_V\left(\widetilde{V},N^G\right)\equiv 0$. This yields:

$$\widetilde{V}_{N^G}=-\frac{\Pi_{VN^G}}{\Pi_{VV}}$$

Since $\eta>\frac{1}{2}$, $\Pi_{VV}<0$. Under Assumption 1, $\Pi_{VN^G}>0$, so $\widetilde{V}_{N^G}>0$. Under Assumption 2, $\Pi_{VN^G}<0$, so $\widetilde{V}_{N^G}<0$. An equivalent argument holds for $\widetilde{N}^G_V$, noting that the slope of the curve in Figure 4 is $\frac{1}{\widetilde{N}^G_V}$.

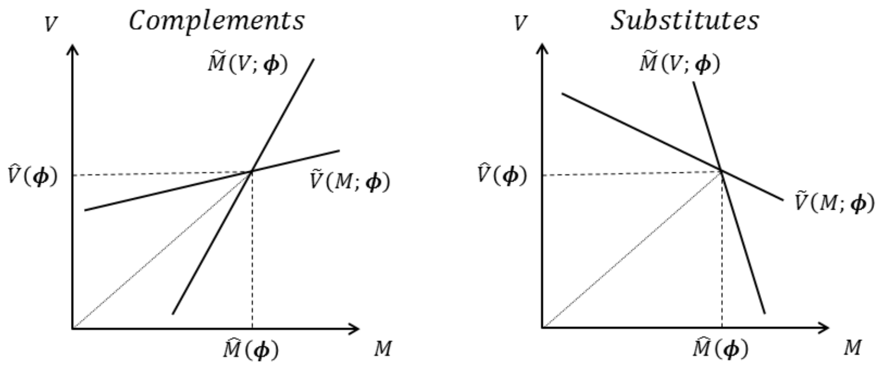

Figure 4: Restricted factor demands with complements and substitutes.

welfare will resulting for a small change will thus be given by:

$$L_\phi = L_V \hat{V}_\phi + L_M \widehat{M}_\phi \tag{13}$$

The loss to society from organised crime has three sources. As with all crime, by far the largest component (Cohen and Piquero 2009) is the fear of crime and victimisation costs that crime generates. With a larger gang, one would expect that more individuals are going to be victims of crime. Moreover, the loss each individual suffers will be increasing in the amount of violence inflicted.

Secondly, society must expend resources protecting itself from the gang. This includes the cost of preventative measures, from the policies discussed herein, to the measures taken by individuals to protect themselves. It also includes the resources expended investigating and prosecuting criminals, as well as the cost of enforcing punishment. One more, we would expect these costs to be increasing in both size and violence. With more members, crime is more prevelant. As such, the chance of becoming a victim of crime is higher. More crimes will need investigation, and will lead to more prosecutions. If violence is higher, a victim suffers a greater loss. As such, the return to investing in protection is higher and more investment will occur.

Finally, criminal organisations can be the cause of economic discrimination à la Lundberg and Startz 1983. It is possible that even youths who gain positive surplus by joining the gang would do better in the primary labour market if the gang were not present. Employers in the primary labour market may believe that youths from the gang's neighbourhood are less productive than those from elsewhere. As such, they will offer lower wages to anyone applying from that neighbourhood. This reduces the incentive to acquire primary labour market skills, and creates a self-fulfilling prophecy. Without the gang, no such signal would be generated and youths would be offered higher wages. In this sense, the gang is a source of economic discrimination[7]. Again, we would expect the size of the discrimination to be increasing in both size and violence. If the gang is larger, fewer youths will acquire primary labour market skills. As such, the average amount of skill acquired will be lower. This will lead to lower wage offers. Similarly, if the gang is more violent, employers are likely to have a more critical opinion of those from the neighbourhood. Again, lower wage offers will result.

Using the framework developed in the previous section, we will now discuss the effect on the social loss from organised crime of the four broad policy areas outlined in the introduction. Under certain conditions to be made clear below, we will find that policies can have unintended consequences. In particular, anti-crime policies could perversely, increase the amount of violence the gang employs (but never its membership size).

Each of the policies in the introduction is associated with a parameter in the model. Specifically:

1. Increasing the severity of punishment increases f.
2. Primary labour market policies increase w.
3. Increasing the arrest or conviction rate increases p.
4. Prevention of juvenile crime disrupts the ability of youths to learn criminal skills, increasing κ.

Note that the aim of this section is not to discuss *optimal* policy. That would require modelling of the technologies involved in manipulating these parameters, the associated cost functions, and a more detailed discussion of the properties of $L(\cdot,\cdot)$. Rather, the aim is more modest: to highlight conditions under which policies designed to combat organised crime may in fact worsen one of its features. I will first derive results for a generic policy, ϕ, before turning attention to the specific policies above.

3.1 Results for a Generic Policy

We can view the impact of a generic policy by considering its effects on the restricted demand functions. When a policy is implemented, it can change youth's incentives in two ways. Firstly, it may reduce the net benefit they gain from joining the gang. In order to retain members, this may necessitate the gang raising the wage they offer, or reducing the cost of violence they inflict upon their membership. Higher wages increase

[7] Indeed, the gang has an incentive to maximise the discrimination against youths from its neighbourhood. Discrimination will enable it to offer lower wages for the same amount of violence.

the marginal cost of size for the gang, as each new youth must be paid more, as shown in (12). Faced with the increased marginal cost, and no equivalent increase in marginal revenue, a profit-maximising gang will reduce its restricted demand for members, $\widetilde{M}$ as marginal profit derived from size, Π_M, becomes negative.

Secondly, a policy may affect how youths respond to changes in violence or gang wages. Some policies increase youths' sensitivity to violence. Once again, this will force the gang to increase its wage at every gang size, to retain the services of the marginal youth. Moreover, any increases in the level of violence the gang enforces will now require a larger amount of compensation. As such, the marginal cost of violence will also increase. As there is no equivalent increase in marginal revenue, the marginal profit derived from violence, Π_V, will also become negative. In this case, the gang will optimally reduce its restricted demand for violence, $\widetilde{V}$.

This intuition, combined with the first panel of Figure 4, leads us very quickly to our first result:

Proposition 2 (Policy with Complements) *Suppose that $\eta > 1$ and that Assumption 1 holds. Then any policy which reduces either Π_M or Π_V and does not increase the other, reduces both the amount of violence the gang employs, and the number of members that the gang chooses to recruit.*

This result is illustrated in Figure 5. If Π_M declines, then the restricted demand for size shifts inwards. Similarly, if Π_V declines, then the restricted demand for violence shifts inwards. Since both curves are upward sloping, any inward shift leads, unambiguously, to a fall in both size and violence. Now, any fall in say, size, reduces the marginal revenue product of violence. However, since fewer gang members need to be compensated for changes in violence, the marginal cost of violence also falls. If violence and size are complements, the fall in marginal revenue exceeds the fall in marginal cost, and the gang reduces its optimal level of violence. In turn, this causes a further reduction in size. This cycle reinforces the decline in both size and violence, leading to the result.

Unfortunately, the case with substitutes is not so clear cut, as shown in Figure 6. In contrast to complements, reductions in size cause the gang to substitute towards violence, and vice versa. As with complements, a fall in say, size, reduces both the marginal revenue product and the marginal cost of violence. Now, however, the decline in marginal cost exceeds the decline in marginal revenue, causing an endogenous increase in the restricted demand for violence. Similarly, a decline in violence makes size more profitable, causing an endogenous increase in the restricted demand for size. Consequently, if one of these effects were to offset the initial impact of the policy, we could have a situation

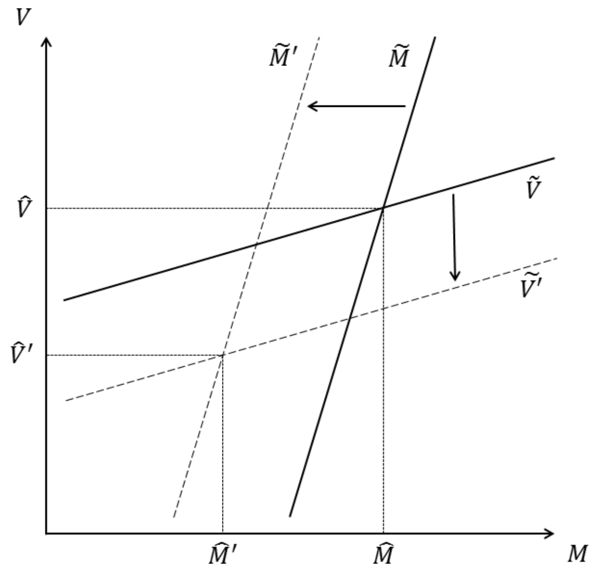

Figure 5: Policy Effects with Complements

in which either membership size or violence increases (but, fortunately, not both). As a result, it may even be possible that a policy designed to reduce the social loss from organised crime may actually increase it. The term which determines these effects is $\frac{\Pi_{M\phi}}{\Pi_{V\phi}}$, as the following proposition makes clear:

Proposition 3 (Policy with Substitutes) *Suppose that $\eta > 1$ and that Assumption 2 holds. Consider any policy which reduces either Π_M or Π_V and does not increase the other:*

1. *If $\frac{\Pi_{M\phi}}{\Pi_{V\phi}} < \left|\widetilde{V}_M\right|$ then the policy reduces violence, but increases size.*

2. *If $\frac{\Pi_{M\phi}}{\Pi_{V\phi}} \in \left[\left|\widetilde{V}_M\right|, \frac{1}{\left|\widetilde{M}_V\right|}\right]$ then the policy reduces both size and violence.*

3. *If $\frac{\Pi_{M\phi}}{\Pi_{V\phi}} > \frac{1}{\left|\widetilde{M}_V\right|}$ then the policy reduces size, but increases violence.*

Each case is outlined in Figure 6. The fact that $\eta > 1$ ensures that all three scenarios are feasible, i.e. that $\left|\widetilde{V}_M\right| < \frac{1}{\left|\widetilde{M}_V\right|}$. The immediate effect of the policy is to (weakly) reduce the restricted demand for each input. Which case occurs depends, crucially, upon the size of each shift. In case one, the restricted demand for violence shifts down by more than the restricted demand for size. $\widetilde{V}$ is defined by $\Pi_V = 0$. Fixing size, we have

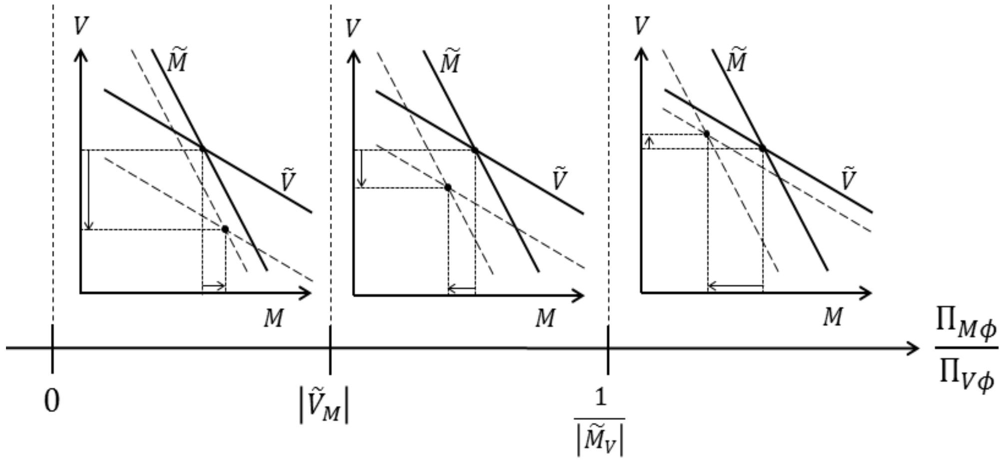

Figure 6: Policy Effects with Substitutes

that the vertical shift, $\widetilde{V}_\phi$, is given by:

$$\begin{aligned} \Pi_{VV}\widetilde{V}_\phi + \Pi_{V\phi} &= 0 \\ \iff \widetilde{V}_\phi &= -\frac{\Pi_{V\phi}}{\Pi_{VV}} \end{aligned} \tag{14}$$

Similarly, $\widetilde{M}$ is defined by $\Pi_M = 0$. Fixing size again, and considering the vertical shift, we have that:

$$\begin{aligned} \Pi_{VM}V_\phi + \Pi_{M\phi} &= 0 \\ \iff V_\phi &= -\frac{\Pi_{M\phi}}{\Pi_{VM}} \end{aligned} \tag{15}$$

So if the restricted demand for violence shifts downwards by more than the restricted demand for size:

$$\begin{aligned} \frac{\Pi_{V\phi}}{\Pi_{VV}} &> \frac{\Pi_{M\phi}}{\Pi_{VM}} \\ \iff \left|\widetilde{V}_{N^G}\right| &> \frac{\Pi_{M\phi}}{\Pi_{V\phi}} \end{aligned} \tag{16}$$

Intuitively, the marginal profit accruing to violence declines by much more than the marginal profit accruing to size. As such, the restricted demand for violence decreases dramatically. This fall in violence decreases both the marginal revenue and marginal cost of size. However, since the two inputs are substitutes, marginal cost reduces more, offsetting the initial fall in marginal profit. In case one, the fall in violence is so large that the marginal profit accruing to size actually becomes positive, creating an incentive for the gang to become larger.

Identical arguments can be made for the remaining two cases. In case two, the horizontal shift of the restricted demand for violence must exceed the horizontal shift in the restricted demand for size, and vice versa for the vertical shift. Neither input suffers a particularly large fall in marginal profit, and the substitution effects are not sufficient to counteract the initial declines in demand. In case three, the horizontal shift of the restricted demand for size must exceed the equivalent shift for violence. This time, the marginal profit accruing to size falls dramatically, creating a strong incentive for the gang to substitute away from size, towards violence.

The cross-elasticity, η, plays a large role in determining which case arises, as it is the key parameter in describing how strongly the gang chooses to substitute between violence and size. In particular, when η is large, $\left|\widetilde{M}_V\right|$ and $\left|\widetilde{V}_M\right|$ both decrease, as the two inputs are strong revenue complements, leading to large declines in their respective marginal revenue products. As such, case two becomes more prominent, as the size of the internal $\left[\left|\widetilde{V}_M\right|, \frac{1}{\left|\widetilde{M}_V\right|}\right]$ grows. Conversely, if η is small, there is a high degree of substitutability between size and violence, and it becomes increasingly likely that one of the two extreme cases occurs.

3.2 Results for Specific Policies

The direct effect of each of class of policy is to reduce the marginal profit of either violence, size or both inputs. As such, under Assumption 1, Proposition 2 holds, and both violence and size are unequivocally diminished. For each policy, we will therefore focus on what happens under Assumption 2.

3.2.1 Severity of Punishment (f)

When violence and size are substitutes, the effects of an increase in the severity of punishment are unambiguous. The situation is illustrated in Figure 7. When severity increases, the marginal cost of size increases (from (12)). Recruits require a greater degree of compensation for the possibility of being punished, increasing the wage the gang offers for any given gang size. As a result, the gang's restricted demand for members falls ($\Pi_{Mf} < 0$). However, if they still decide to join the gang, greater severity of punishment has no impact upon youths' willingness to acquire criminal skills (given by (4)). In particular, for each given gang size, the criminal skills acquired by the marginal youth remain unchanged. Consequently, there is no exogenous change in the gang's marginal cost of violence. By (11), the gang's restricted demand for violence remains

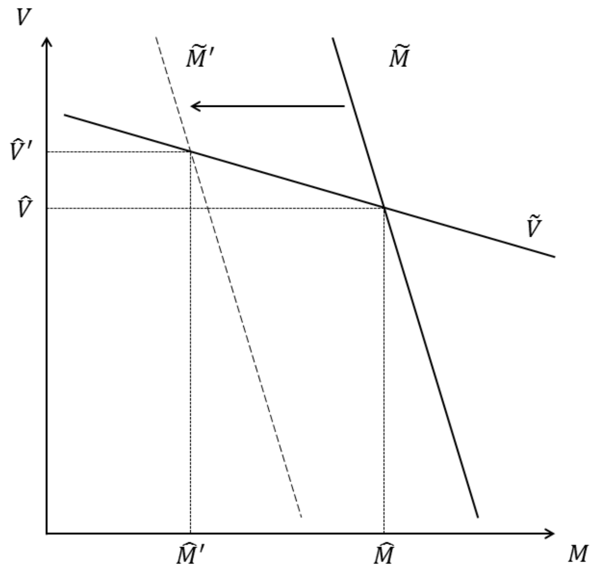

Figure 7: Effect of an increase in the severity of punishment (f) or the market wage (w)

unchanged ($\Pi_{Vf} = 0$). We are firmly in case one.

As the gang reduces its size, the marginal cost of violence also declines. Not only are there fewer members to compensate for changes in violence, but those that are left are less sensitive to those changes. The marginal revenue product of violence is also reduced, as membership size and violence are revenue complements. Under Assumption 2, the fall in marginal cost exceeds the fall in marginal revenue, and the gang chooses to increase the amount of violence it inflicts. Increasing the severity of punishment causes the gang to unambiguously substitute away from membership size, towards a greater degree of violence:

Lemma 1 *Suppose that $\eta > 1$ and that Assumption 2 holds. Then any increase in the severity of punishment will result in fewer gang members, but more violence.*

3.2.2 Primary Labour Market Policies (w)

The effect of an increase in the market wage is similar to that of an increase in the severity of punishment. The scenario is, once again, shown in Figure 7. The opportunity cost of joining the gang is increased. The gang must offer higher wages at every gang size, increasing the marginal cost of size. Consequently, by (12), the marginal cost of size exceeds the marginal revenue it generates, and the restricted demand for membership size declines ($\Pi_{Mw} < 0$). Upon deciding to join the gang, youths' incentives to acquire criminal skill are unaffected by the increase in w. As such, for each given size, the marginal cost to the gang of increasing violence is unchanged ($\Pi_{Vw} = 0$). As a result, by (11), the restricted demand for violence once again remains the same.

Gang size falls. Whilst the marginal revenue product of violence declines, smaller gangs require less compensation for violent behaviour. There are fewer members to pay, and those who remain are relatively insensitive to violence. The marginal cost of violence declines by more than its marginal revenue, and the gang increases the amount of violence it inflicts:

Lemma 2 *Suppose that $\eta > 1$ and that Assumption 2 holds. Then any improvement in the primary labour market will result in fewer gang members, but more violence.*

3.2.3 Arrest and Conviction Rate (p)

The arrest and conviction rate has the most complex effect of any of the policies areas I consider. The situation is shown in Figure 8. An increase in the probability of conviction reduces the restricted demand for membership size for three reasons. For a given level of violence, an increase in p increases the wage the gang must offer to maintain its membership. Not only does it become more likely that gang members will be punished (increasing pf), but the probability that they will be deprived of their wages also rises. Youths discount for this in (7), and consequently require even more pay in order to join. Moreover, maintaining the same size of gang involves recruiting lower ability members, as more members are locked away (and are thus unproductive). Since lower ability individuals are more sensitive to violence, a third increase in the wage the gang offers is required. Combined, these three wage increases raise the marginal cost of size in (12). As marginal revenue is thus far unaffected, the restricted demand for size declines ($\Pi_{Mp} < 0$).

In contrast to the previous two policies, increasing the probability of conviction also reduces the restricted demand for violence. For given gang size, the ability of the marginal youth is lower. Lower ability youths find it more costly to invest in criminal skills. The marginal youth is thus relatively sensitive to changes in violence ($\hat{c}$ falls in (8)). As a result, any increase in violence requires a greater increase in the wage the gang offers, in order to retain their membership. In addition, youths incur the cost of violence irrespective of whether they are arrested or not. Since there is a greater chance that they will not receive their wages, they require proportionally more compensation should the amount of violence they inflict increase. Both these effects increase the marginal cost of violence in (11), reducing the restricted demand for violence ($\Pi_{Vp} < 0$).

In sum, both the restricted demand curves shift inward. Consequently, depending

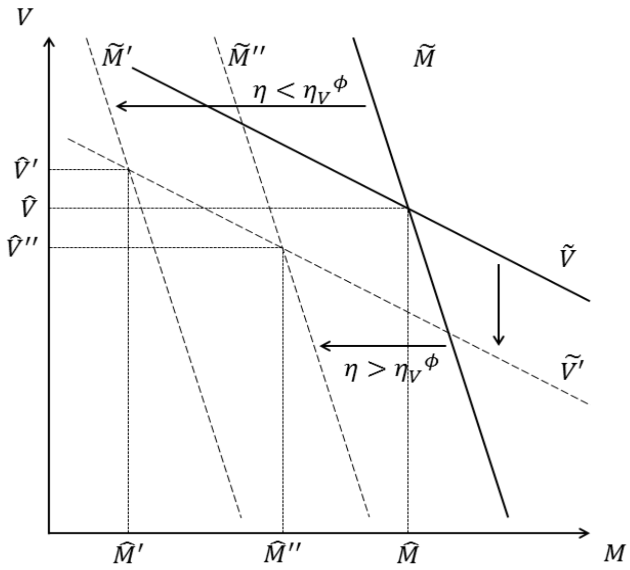

Figure 8: Effect of an increase in the arrest and conviction rate ($\phi = p$) or in the prevention of juvenile crime ($\phi = \kappa$).

upon the size of the shifts, any of the cases outlined in Proposition 3 appear feasible. This turns out not to be the case, as we have the following result:

Lemma 3 *Suppose that $\eta > 1$ and that Assumption 2 holds. Then any improvement in the arrest and conviction rate may result in:*

1. *Fewer gang members, but more violence; or*

2. *fewer gang members and less violence.*

It can never be the case that more gang members, but less violence results.

The result hinges upon η. If η is large, then membership size and violence are relatively weak profit substitutes. As such, when the restricted demand for violence and size decline, the incentive to substitute is insufficient to cause the gang to increase their demand for either input. Conversely, if η is low, there is a strong incentive to substitute and the gang could potentially increase demand for either input. In particular, there is a threshold value of η, call it $\eta_V^p > 0$, such that if $\eta < \eta_V^p$ then the gang has a strong enough incentive to increase demand for violence. Similarly, there exists $\eta_M^p > 0$ such that if $\eta < \eta_M^p$ then the gang increases membership size. It is possible to show that $\eta_M^p < 1$. As we require that $\eta > 1$, we can rule out the gang's increasing its membership as a result of increased arrests and convictions. The increase in the marginal cost of membership size always dominates the increase in marginal revenue, even taking into account changes in violence.

The same cannot be said for η_V^p. It is therefore possible that the level of violence the gang inflicts actually increases. However, if the gang size is either very large or very small, violence will certainly decline. If it is small, then the ability of the marginal youth is high. When the arrest and conviction rate is increased, the marginal cost of size remains relatively unchanged. Wages are very close to $\frac{w+pf}{1-p}$, as the marginal youth does not require a lot of compensation for the violence they inflict. As a result, since the marginal revenue product of size is large for a small gang, gang size also remains relatively stable. This provides a relatively weak incentive to substitute. The increase in the marginal revenue product of violence is insufficient to counteract the exogenous fall in the restricted demand for violence.

When gang size is very large, the ability of the marginal youth is low. They therefore require a large amount of compensation for the violence the gang requires them to inflict. Any fall in the restricted demand for size will thus decrease the marginal cost of size substantially. Once again, the result is that the gang's size does not decline very much. The incentive to substitute is dominated by the decline in the restricted demand for violence.

3.2.4 Prevention of Juvenile Crime (κ)

The effects of an increase in κ are shown in Figure 8. As with the conviction rate, increasing the effort to prevent juvenile crime impacts upon both the restricted demand for size, and the restricted demand for violence. For each degree of violence, youths find it more difficult to acquire criminal skills (from (4)). They suffer more from the violence the gang requires them to inflict. Youths therefore require a larger wage to retain their membership. Moreover, the marginal youth is disproportionately affected by the policy. As the youth with the lowest ability, they are more sensitive to changes to the cost of acquiring criminal skills (see (8)). Any attempt by the gang to increase its membership therefore require a larger increase in the wage than before the introduction of the policy. Both the higher wage and the larger wage increase required to recruit more members increase the marginal cost of size for the gang (in (12)), reducing its restricted demand ($\Pi_{M\kappa} < 0$).

Since all youths acquire fewer criminal skills, the marginal cost of violence increases as well. In particular, for each gang size, increasing violence whilst retaining the marginal youth is more expensive. With fewer criminal skills, they are more sensitive to violence, and consequently require a greater increase in their wage to compensate them for the additional violence the gang wishes them to inflict. As the marginal revenue product of violence is unaffected by the policy, the increased marginal cost induces the gang to reduce its restricted demand for violence as well ($\Pi_{V\kappa} < 0$).

Once more, it appears that all three cases in Proposition 3 are feasible. Both restricted demand curves have shifted inwards. Again, this turns out to be incorrect:

Lemma 4 *Suppose that $\eta > 1$ and that Assumption 2 holds. Then any improvement in the prevention of juvenile crime may result in:*

1. *Fewer gang members, but more violence; or*

2. *fewer gang members and less violence.*

It can never be the case that more gang members, but less violence results.

The value of η is again critical in determining which outcome occurs. As with changes in the arrest and conviction rate, if η is large, then membership size and violence are weak profit substitutes. The endogenous increase in profitability of each input resulting from the decline in the other is never sufficient to offset the exogenous decline resulting from the policy change. However, there exists $\eta_V^\kappa > 0$ such that, if $\eta < \eta_V^\kappa$ then the endogenous increase in the profitability of violence resulting from the decline in size dominates the initial decline. In this case, the gang will increase its demand for violence. Similarly, there is $\eta_M^\kappa > 0$ such that, if $\eta < \eta_M^\kappa$ then demand for membership size increases.

As before, it is possible to rule out increases in membership size, since $\eta_M^\kappa < 1$. The increase in the marginal revenue product of size resulting from an exogenous decline in violence is never large enough to offset the increase in the marginal cost caused by the increase in juvenile crime prevention. We can also rule out increases in violence for very large or very small gangs. In both cases, the improvement in the prevention of juvenile crime will result in relatively small changes in gang size, creating a very weak incentive to substitute towards violence.

4 A Model with a Discriminating Gang

The analysis performed in the previous few sections was done under the assumption that the gang was unable to discriminate between individuals. It offered one wage rate, and one level of violence. I now relax that assumption, and instead ask how the various policies perform when the gang is free to implement any wage scheme and associated violence schedule. In order to do this, some adjustments are required to the model from Section 2.

When considering a discriminating gang, youths' decisions become more complicated. In order to be able to distinguish between its recruits, the gang must first induce youths to reveal something about their respective abilities. In addition to criminal skill and career decisions, each youth also decides upon a signal, $s_i \geq 0$, to send to the gang when they join. Based upon the signals received, the gang offers each youth a *contract*, $(g(s_i;\boldsymbol{\phi}), V(s_i;\boldsymbol{\phi}))$. Given the same policy environment as before, and the same cost of acquiring criminal skills, the resulting payoff for a youth with ability σ_i who sent signal s_i is thus:

$$G(\sigma_i, s_i;\boldsymbol{\phi}) = (1-p)\, g(s_i;\boldsymbol{\phi}) - pf - \frac{V(s_i;\boldsymbol{\phi})}{c_i} - \kappa C\left(\frac{c_i}{\sigma_i}\right) \tag{17}$$

There are two possible interpretations for this signal. Firstly, assuming a one-to-one relationship between signals and contracts, a youth's choice of contract in itself could be the signal, as in the price discrimination literature. In this case, the gang simply offers a range of contracts, and new recruits select the best contract for them. Alternatively, one could view the signal as the result of an initiation. Initiation rituals are a salient feature of many criminal organisations, and range from the violent (see Decker 1996) to the symbolic (Iwai 1986, Paoli 2003 or Gambetta 2009). However, all involve some test of the initiate's ability either before or during the ritual.

The gang's profit function must also be adapted to allow for the variety of contracts. In the previous section, every youth inflicted identical amounts of violence. As such, they generated identical amounts of revenue. This is no longer the case. Instead, each youth who sends a signal s_i inflicts violence $V(s_i;\boldsymbol{\phi})$, and consequently generates revenue $r(V(s_i;\boldsymbol{\phi}), M)$. They also receive a different wage, $g(s_i;\boldsymbol{\phi})$. So each youth generates profit:

$$\pi(s_i, M;\boldsymbol{\phi}) \equiv r(V(s_i;\boldsymbol{\phi}), M) - g(s_i;\boldsymbol{\phi}) \tag{18}$$

The gang's aggregate profit function is therefore given by:

$$\Pi\left(\{(g(s;\boldsymbol{\phi}), V(s;\boldsymbol{\phi}))\}_{s\geq 0}, M\right) = ME\left[\pi(s_i, M;\boldsymbol{\phi})\,|j_i = 1\right] \tag{19}$$

Suppose that every youth were to send the same signal. Then each youth would receive identical wages, g, and inflict identical amounts of violence, V. This scenario is equivalent to that in which the simple gang finds itself. The gang's costs are clearly identical to those of the previous model: gM. Moreover, the revenue generated by each youth is simply equal to the average, $r(V, M)$. Consequently, total revenue is $Mr(V, M)$. If we are to be consistent with section 2, it must be the case that $R(V, M) = Mr(V, M)$. As such, $Mr(V, M)$ must also exhibit constant returns to scale and diminishing marginal returns in all inputs.

The primary labour market remains unchanged. The timing is as follows. Given the policy environment, the gang announces its contract schedule. This contract becomes common knowledge. Youths learn their ability (which is private information), and simultaneously make criminal skill acquisition and career decisions. If they choose to work in the primary labour market, they receive wage w. If instead they opt to join the gang, they send a signal regarding their ability. Having done so, the gang allocates the youth a contract consisting of a wage and a level of violence.

4.1 Equilibrium with a Discriminating Gang

As in Section 2.1, I consider symmetric subgame perfect equilibrium. In this setting, such an equilibrium consists of a profit-maximising contract schedule, $\{(g(s; \boldsymbol{\phi}), V(s; \boldsymbol{\phi}))\}_{s \geq 0}$, implemented by the gang, followed by career, criminal skill and signal decisions for each youth. As before, I proceed by backwards induction.

4.1.1 Youth Decisions

In the model with a discriminating gang, a youth with criminal ability σ_i faces the following utility maximisation problem:

$$\max_{j \in \{0,1\}, c \geq 0, s \geq 0} \left\{ (1-j)\, w + j \left[(1-p)\, g(s; \boldsymbol{\phi}) - pf - \frac{V(s; \boldsymbol{\phi})}{c} \right] - \kappa C\left(\frac{c}{\sigma_i}\right) \right\} \tag{20}$$

The youth's choice of criminal skill and career are identical to before. If they join the gang, they will acquire criminal skills $c^*(\sigma_i, s_i^*; \boldsymbol{\phi})$ satisfying:

$$\frac{V(s_i^*; \boldsymbol{\phi})}{c^*(\sigma_i, s_i^*; \boldsymbol{\phi})^2} \equiv \frac{\kappa}{\sigma_i} C'\left(\frac{c^*(\sigma_i, s_i^*; \boldsymbol{\phi})}{\sigma_i}\right) \tag{21}$$

otherwise, they will not invest anything. Moreover, they will join the gang if:

$$(1-p)\, g(s_i^*; \boldsymbol{\phi}) - pf - \frac{V(s_i^*; \boldsymbol{\phi})}{c^*(\sigma_i, s_i^*; \boldsymbol{\phi})} - \kappa C\left(\frac{c^*(\sigma_i, s_i^*; \boldsymbol{\phi})}{\sigma_i}\right) \geq w \tag{22}$$

If a youth of ability σ_i joins the gang, it is straightforward to show that all youths with ability $\sigma > \sigma_i$ also join the gang. Suppose that the youth with ability σ_i sends signal s_i^*.

If they join, it must be the case that $G^*(\sigma_i, s_i^*; \boldsymbol{\phi}) \geqslant w$. Now, any youth sending signal s_i^* to the gang is offered the same contract $(g(s_i^*; \boldsymbol{\phi}), V(s_i^*; \boldsymbol{\phi}))$. Moreover, as discussed in Section 2.1.1, for given g and V, a youth's payoff is increasing in σ. So any youth with ability greater than σ_i can guarantee themselves a payoff greater than w by joining the gang and sending signal s_i^*. The payoff from joining the gang must once again be strictly increasing in ability. Consequently, there exists a marginal youth, who has the lowest ability of any gang member, $\hat{\sigma} \geq 0$.

Finally, each youth who decides to join the gang chooses a signal to maximise the payoff they receive from their membership:

$$(1-p)\frac{\partial g}{\partial s}(s^*(\sigma_i; \boldsymbol{\phi}); \boldsymbol{\phi}) \equiv \frac{1}{c^*(\sigma_i, s_i^*; \boldsymbol{\phi})}\frac{\partial V}{\partial s}(s^*(\sigma_i; \boldsymbol{\phi}); \boldsymbol{\phi}) \tag{23}$$

A youth will therefore truthfully reveal their ability if and only if σ_i satisfies the above equation, i.e. $s^*(\sigma_i; \boldsymbol{\phi}) = \sigma_i$.

4.1.2 Gang Leader Decisions

The gang leaders' decisions are significantly more complicated. They must now choose a profit-maximising contract schedule, subject to its being implementable. The form of an implementable contract schedule is given by the following:

Proposition 4 (Implementable Contracts) *A contract schedule,* $\{(g(s; \boldsymbol{\phi}), V(s; \boldsymbol{\phi}))\}_{s\geq 0}$, *is implementable if and only if it is of the form:*

$$g(s; \boldsymbol{\phi}) = \frac{w+pf}{1-p} + \frac{V(s; \boldsymbol{\phi})}{c^*(1-p)} + \frac{\kappa}{1-p}C\left(\frac{c^*}{s}\right) + \frac{1}{1-p}\int_{t=\hat{\sigma}}^{s}\frac{V(t; \boldsymbol{\phi})}{tc^*}dt \tag{24}$$

Proof. See appendix B. ■

This relationship between wages and violence bears a tremendous similarity to that of the marginal youth in a simple gang, given by (7). The first three terms simply state that each youth must be compensated for the expected costs incurred by joining the gang. The difference arises in the final term of (24), and is most succinctly explained by considering a youth's net payoff from joining the gang:

$$w + \int_{t=\hat{\sigma}}^{\sigma}\frac{V(t; \boldsymbol{\phi})}{tc^*}dt \tag{25}$$

In a perfect information setting, the gang would choose the level of violence they wished each youth to engage in, and then simply pay them enough to make them indifferent

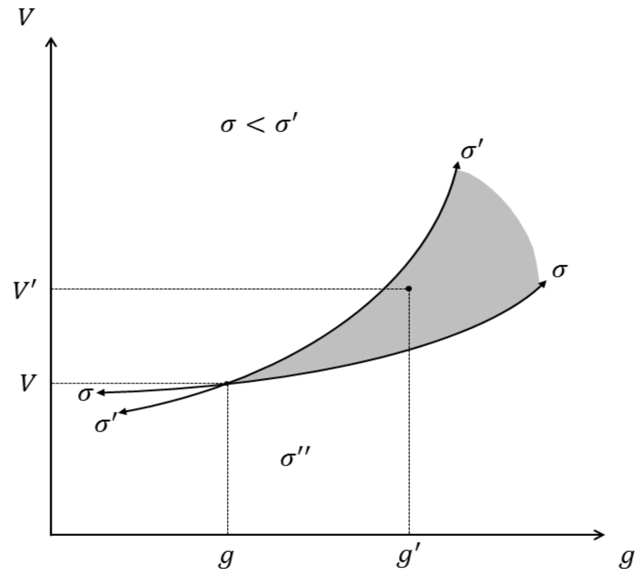

Figure 9: An Example of an Implementable Contract

between joining the gang or joining the primary labour market. Youths would earn w irrespective of their career choice. However, the gang must elicit each youth's ability. Since a higher ability youth can gain positive surplus by pretending to be of a lower ability, the gang must pay an informational rent to ensure that they are made at least as well off by revealing their true ability.

An example of an implementable contract schedule is shown in Figure 9, displaying indifference curves for two youths. Higher ability youths are less sensitive to violence. As such, less compensation is required when violence is increased in order to maintain indifference: their indifference curves are steeper. The contract schedule is designed so that each youth weakly prefers the contract designed for their ability to all others. For example, the youth with ability $\sigma' > \sigma$ prefers (g', V') to (g, V).

An important feature of an implementable contract is made clear by Figure 9: wages and violence must both be increasing in ability. To see this, note that for a youth with ability σ' to prefer a bundle (g', V') to (g, V) it must lie to the south-east of the σ'-indifference curve passing through (g, V). Similarly, for a youth with ability σ to prefer (g, V) over (g', V'), (g', V') must lie to the north-west of the σ-indifference curve passing through (g, V). Only contracts in the shaded region satisfy both properties, so g and V must both be increasing in ability.

Restricting attention to implementable contracts, we now turn our attention to the gang's profit maximisation decision. Since the gang's choice of violence uniquely determines the wage it must pay to its members, it is sufficient once again to think of the gang as maximising profits with respect to $\{V(s;\boldsymbol{\phi})\}_{s\geq 0}$ and M. Its optimal choice of $g(s;\boldsymbol{\phi})$ will then be given by (24). In other words, the gang solves:

$$\begin{aligned}\left(\left\{\hat{V}(s;\boldsymbol{\phi})\right\}_{s\geq 0},\widehat{M}\right) &= \underset{\{V\}_{s\geq 0},M\geq 0}{\arg\max}\left\{N(1-p)\int_{s=\hat{\sigma}}^{\infty}\pi(s,M;\boldsymbol{\phi})\lambda e^{-\lambda s}ds\right\} \quad (26)\\ \text{subject to} &: \quad (24)\end{aligned}$$

The solution is described in two stages. Firstly, for each ability and each gang size, I describe the optimal choice of violence. This provides a restricted violence schedule, dependent upon the gang's membership size $\left\{\widetilde{V}(s,M;\boldsymbol{\phi})\right\}_{s\geq 0}$. Then, incorporating this restricted violence schedule into (26), the gang chooses membership size to maximise its profits. Without further ado:

Proposition 5 (Restrcited Violence Schedule) *Suppose that, for each σ, $\eta(\sigma) > \frac{1}{2}$ and $1+\frac{\frac{c^*}{\sigma}C'''\left(\frac{c^*}{\sigma}\right)}{C''\left(\frac{c^*}{\sigma}\right)} > \varepsilon\left(\frac{c^*}{\sigma}\right)$. Then, for each gang size, M, there exists a unique violence schedule, $\left\{\widetilde{V}(s,M;\boldsymbol{\phi})\right\}_{s\geq 0}$ that maximises profits.*

Proof. See appendix C. ■

For each gang size and each $\sigma \geq \hat{\sigma}$, the gang selects $\widetilde{V}(\sigma;\boldsymbol{\phi})$ to satisfy:

$$r_V\left(\widetilde{V}(\sigma;\boldsymbol{\phi}),M\right)-\frac{1}{c^*(1-p)}-\frac{1}{c^*(1-p)}\frac{1+\varepsilon}{\lambda\sigma(2+\varepsilon)}\equiv 0 \quad (27)$$

where $c^* = c^*(\sigma,\sigma;\boldsymbol{\phi})$ and $\varepsilon = \frac{\frac{c^*}{\sigma}C''\left(\frac{c^*}{\sigma}\right)}{C'\left(\frac{c^*}{\sigma}\right)}$, as before. This expression is very similar to (11). The marginal benefit to the gang of increasing a member's violence comes in the form of additional revenue they will be able to generate. The marginal cost comprises two elements. Firstly, it is necessary to compensate the individual for the disutility they suffer from inflicting more violence. In equation (11), the gang had to compensate every member equally, increasing their wage bill by M times $\frac{1}{\hat{c}(1-p)}$. In this setting, that is not necessary, as only the individual with ability σ inflicts more violence. The second element of the marginal cost represents the need to increase the informational rent paid to members. Increasing violence for a youth with ability σ increases the informational rent to all members with ability greater than σ. The rent paid to those with lower ability is unaffected (see (24)). As increasing size involves attracting lower ability members to the gang, the increase in informational rent is unaffected by the size of the gang.

Substituting the restricted violence schedule into (26), we are now in a position to calculate the gang's optimal size.

Proposition 6 (Profit Maximisation with Discrimination) *Suppose that Proposition 5 is satisfied, and that $r_{MM} > 0$, $r_{MMV} < 0$, $r_{MV}r_{MVV} < 0$ and $\frac{\partial^3 \pi}{\partial V^2 \partial \sigma} < 0$. Then there exists a unique gang size, $0 < \hat{M} < N$, that maximises profits.*

Proof. See appendix D. ■

Given a violence schedule, the gang choose a membership size to satisfy:

$$r\left(V\left(\hat{\sigma};\boldsymbol{\phi}\right),\widetilde{M}\right)-g\left(\hat{\sigma};\boldsymbol{\phi}\right)+N\left(1-p\right)\int_{s=\hat{\sigma}}^{\infty}r_{M}\left(V\left(s;\boldsymbol{\phi}\right),\widetilde{M}\right)\lambda e^{-\lambda s}ds-\frac{V\left(\hat{\sigma};\boldsymbol{\phi}\right)}{\hat{c}\left(1-p\right)}\frac{1}{\lambda\hat{\sigma}}\equiv 0 \tag{28}$$

where $\hat{c} = c^*\left(\hat{\sigma},\hat{\sigma};\boldsymbol{\phi}\right)$.When the gang increases its size, its new members generate revenue equal to $r\left(V\left(\hat{\sigma};\boldsymbol{\phi}\right),\widetilde{M}\right)$. The marginal cost has several components. First, each new member must be paid. Their wage is given by (24), but does not need to incorporate any informational rent since a youth would never choose to overperform during initiation. Secondly, since the aggregate revenue function has diminishing marginal returns, it must be the case that an increase in size reduces the revenue each inframarginal member is able to generate. Finally, the gang must increase the wages paid to all youths who were already planning to join the gang. Otherwise, there would exist a higher ability youth who would choose to send signal $\hat{\sigma}$ to acquire the low wage-low violence contract.

5 Policy with a Discriminating Gang

When the gang is able to discriminate between its recruits, the loss to society generated by each youth will be different. Our loss function, given by (13), needs to be adjusted. When violence varies across youths, the loss to society is:

$$L^D\left(\left\{\hat{V}\left(s;\boldsymbol{\phi}\right)\right\}_{s\geq 0},\widehat{M}\right)=N\left(1-p\right)\int_{s=\hat{\sigma}}^{\infty}l\left(\hat{V}\left(s;\boldsymbol{\phi}\right),\hat{M}\right)\lambda e^{-\lambda s}ds \tag{29}$$

The loss will once again consist primarily of victimisation costs, investment in protection and economic discrimination. As before, we would expect the loss to be increasing in all arguments.

In section 3, the extent to which violence and membership size were revenue complements was critical in determining the effects of policy. When a policy reduced demand for, say, size, the marginal revenue product and marginal cost of violence fell. With fewer members, the gang was less able to convert violence into higher revenue. However, the gang needed to compensate fewer members for the violence they were required to inflict. When size and violence were strong revenue complements, the fall in the marginal revenue product of violence exceeded the fall in marginal cost. The demand for violence fell. Conversely, if they were weak revenue complements, the opposite was true.

This intuition proves to hold when the gang is capable of discriminating between recruits. When gang size increases, there are two opposing effects on the marginal revenue product of violence. Firstly, as there are more members inflicting violence, aggregate revenue from violence increases. The increased membership will also impact upon the personal marginal revenue products of violence of those already in the gang. Gang members may be able to take advantage of network externalities and returns to scale, increasing their marginal revenue products of violence. Conversely, congestion effects may reduce the marginal revenue product, as more individuals are attempting to extract rents from the neighbourhood. So long as the first effect dominates the second, we are consistent with the model of the previous section, as the marginal revenue product of violence will rise on aggregate. However, the degree of revenue complementarity will be strongly affected by whether the second effect is positive or negative. This leads us to make one of two assumptions:

Assumption 3 (Discriminating Complements) *An individual gang member's marginal revenue product of violence is strictly increasing in the gang's size:* $r_{VM}(V, M) > 0$.

Assumption 4 (Discriminating Substitutes) *An individual gang member's marginal revenue product of violence is strictly decreasing in the gang's size:* $r_{VM}(V, M) < 0$.

Clearly, if Assumption 3 holds, then size and violence are very strong revenue complements. When the gang's membership increases, additional members increase the amount of violence the gang is able to bring to bear, and enable existing members to take advantage of network externalities. This makes violence more profitable for each member. If Assumption 4 holds, on the other hand, size and violence are weak revenue complements. Whilst the additional members enable the gang to inflict more violence, the neighbourhood becomes satiated and existing gang members see their personal returns to violence fall.

5.1 Results for a Generic Policy

The impact of a generic policy is similar to that discussed in section 3. Each policy still acts to increase the gang's marginal cost of membership size and (in certain cases) violence. For a given violence schedule, policies reduce the surplus youths receive from joining the gang. As such, any increase in membership necessitates paying a higher wage than before. This is compounded by the need to maintain truthful revelation.

If the gang offers higher wages to new (low ability) members, and do not ask them to inflict more violence, then there will exist a higher ability youth who will strictly prefer to underperform during initiation and accept the contract offered to the new members. The gang must therefore increase the wages of all its members (informational rent payments may increase). Given this increase in marginal cost, the gang will optimally choose to reduce its size.

Policy may also affect youths' response to changes in violence. In contrast to the previous model, however, each youth inflicts different levels of violence, so the gang adjusts its violence schedule on a youth-by-youth basis. Assuming that a policy affects every youth in a similar way, each youth will require an increase in their wages to compensate them for increases in the level of violence they are required to inflict. For given gang size, the marginal revenue product of violence is unaffected. So, once again, the gang will optimally reduce the amounts of violence it requires its members to inflict.

The overall effect also depends upon the strength of revenue complementarity between membership size and violence. If they are strong complements, we have the following result, equivalent to Proposition 2 in section 3:

Proposition 7 (Policy with Discrimination and Complements) *Suppose the conditions given in Proposition 6 and Assumption 3 hold. Then any policy which reduces either π_v or Π_M and does not increase the other reduces both the amount of violence each member of the gang inflicts and the number of members the gang chooses to recruit.*

Consider a policy that reduces the gang's size. Under Assumption 3, gang members are no longer able to take advantage of economies that were previously available to them. As a result, the marginal revenue product of violence declines for each gang member. The marginal cost of violence is unaffected by changes in size. Consequently, $\pi_V < 0$ for every gang member, and the gang chooses to reduce the amount of violence it requires its members to inflict.

Now consider a policy that reduces the amount of violence the gang's members inflict for each M. By the Envelope Theorem, the only effect on the marginal profitability of size manifests itself in a decline of the personal marginal revenue products of size of the inframarginal recruits. Consequently, $\Pi_M < 0$ and the gang chooses to reduce its size.

These two effects reinforce declines in both gang size and the amount of violence each member inflicts, giving rise to the result in Proposition 7.

If increases in membership cause congestion, size and membership are relatively weak revenue complements. As with the simple gang environment, this makes the policy effects much more difficult to predict. A policy that reduces the gang's size increases the marginal revenue product of violence for each gang member. With fewer members, each individual is able to extract greater rents from the neighbourhood by employing violence. It could be the case that this increase in marginal revenue exceeds any increase in marginal cost resulting from the direct impact of the policy. If so, the gang will increase the amount of violence each member inflicts.

Similarly, any policy which reduces violence increases the marginal revenue product of size. With the neighbourhood less satiated with violence, there are greater opportunities for new members to generate revenue. Once again, if this increase in marginal revenue exceeds the increase in marginal cost resulting from the policy, the gang will opt to increase its membership.

This intuition is formalised in the following proposition, equivalent to Proposition 3 in section 3:

Proposition 8 (Policy with Discrimination and Substitutes) *Suppose the conditions given in Proposition 6 and Assumption 4 hold. Consider any policy which reduces either π_v or Π_M and does not increase the other:*

1. *If $\Pi_{M\phi} < M \int_{s=\hat{\sigma}}^{\infty} \pi_{V\phi} |V_M| \lambda e^{-\lambda(s-\hat{\sigma})} ds$ then the policy reduces the amount of violence each member of the gang inflicts, but increases size.*

2. *If $\Pi_{M\phi} > M \int_{s=\hat{\sigma}}^{\infty} \pi_{V\phi} |V_M| \lambda e^{-\lambda(s-\hat{\sigma})} ds$ then the policy reduces the size of the gang, and:*

   (a) *Individual gang members for which $\frac{\pi_{V\phi}}{r_{VM}} > |M_\phi|$ inflict less violence.*

   (b) *Individual gang members for which $\frac{\pi_{V\phi}}{r_{VM}} < |M_\phi|$ inflict more violence.*

The conditions given in Proposition 8 are equivalent to those seen before. Size is defined by $\Pi_M = 0$. If, after a policy was enforced, size were to remain unchanged, we would have:

$$\Pi_{M\phi} + M \int_{s=\hat{\sigma}}^{\infty} \pi_{V\phi} V_M \lambda e^{-\lambda(s-\hat{\sigma})} ds = 0 \tag{30}$$

The direct decline in the marginal profitability of size resulting from the policy would be exactly offset by the increase in marginal profitability resulting from a fall in violence. The condition in case one states that there is an overal increase in the marginal profitability of size, resulting in a net increase in members. In case two, the opposite is true. Note that, if every gang member inflicts the same amount of violence, (30) becomes $\Pi_{M\phi} - M\pi_{V\phi} |V_M| = 0 \iff |V_M| = \frac{\Pi_{M\phi}}{M\pi_{V\phi}} = \frac{\Pi_{M\phi}}{\Pi_{V\phi}}$, exactly as before.

As different youths engage in different levels of violence, the effect of policy on violence is significantly more complex than in Proposition 3. In particular, there is no such thing as $\widetilde{M}_V$. Instead, consider the effect on the marginal profitability of violence of policy for a given level of violence:

$$\pi_{V\phi} + r_{VM} M_\phi \tag{31}$$

When a policy is implemented, its direct effect may incorporate an immediate decline in the profitability of violence. However, if size also declines, the neighbourhood becomes less congested. This enables each youth to generate more revenue through violence. The marginal cost of each youth increasing violence is unaffected by size, as changes in violence only affect the informational rents of those youths with higher ability. If the decline in gang size is sufficiently large, the increase in the marginal revenue product of violence may dominate the fall in profitability caused by the policy. In this case, $\pi_{V\phi} + r_{VM} M_\phi > 0$ and the gang optimally increases the amount of violence the youth is required to inflict. The conditions given in Proposition 8 are thus precisely those that dictate whether the marginal profitability of violence increases or decline.

5.2 Results for Specific Policies

When the gang can discriminate between its members, and Assumption 3 holds, the effects of any of the policies I consider are unambiguous. Since all policies' direct effects include reducing the marginal profit generated by membership size, size declines. This causes a reduction in the marginal revenue product of violence for all members, in turn reducing violence. Proposition 7 holds. Under Assumption 4, the results are less clear, and are outlined below.

5.2.1 Severity of Punishment (f)

Increasing the severity of punishment only affects the restricted demand for size. It increases the expected cost of joining the gang. However, once a youth has decided to join, it leaves their incentive to acquire criminal skills (and hence their sensitivity to violence) unaltered. In order to maintain the size of the its membership, the gang must increase the wages it pays to all of its members for a given violence schedule (see (24)). If it were to attempt to attract new members, it would need to offer them a higher wage as well. The marginal cost of size has increased, as shown in (28). Since the violence schedule is as yet unaffected, the marginal revenue product of size remains constant, leading to a fall in the marginal profitability of size, $\Pi_M < 0$. The gang chooses to reduce its membership.

The decline in size increases the marginal revenue product of violence. There is less congestion in the neighbourhood than there otherwise would be, enabling each recruit to generate greater revenues through violence. As the marginal cost of violence is accrued by each individual, it is unaffected by the falling gang size. The marginal profitability of violence therefore increases, $\pi_V > 0$, and the gang increases the amount of violence each youth engages in:

Lemma 5 *Suppose the conditions given in Proposition 6 and Assumption 4 hold. Then any increase in the severity of punishment will result in fewer gang members, but each member will increase the amount of violence they inflict.*

5.2.2 Primary Labour Market Policies (w)

The effect of improvement in the primary labour market is, once again, identical to an increase in the severity of punishment. As the opportunity cost of joining the gang increases, the gang must offer the marginal youth a higher wage, given the violence schedule. This increases the marginal cost of size in (28), whilst having no effect upon its marginal revenue product. The marginal profitability of size declines, and the gang optimally reduces its size.

Under Assumption 4 this reduces congestion in the neighbourhood, increasing the marginal revenue product of violence for each member above its marginal cost. The gang therefore increases the amount of violence it requires each member to inflict:

Lemma 6 *Suppose the conditions given in Proposition 6 and Assumption 4 hold. Then any improvement in the primary labour market will result in fewer gang members, but each member will increase the amount of violence they inflict.*

5.2.3 Arrest and Conviction Rate (p)

When there is an increase in the arrest and conviction rate, the marginal cost of size increases. In a similar manner to the previous two policies, the expected cost of joining the gang has increased, as it is more likely that an individual will be punished (pf is higher in (24)). Furthermore, if youths are caught, their wages are witheld. When deciding upon whether to join the gang, they discount their wages for this possibility, and consequently require higher wages to encourage them into a criminal career. With no equivalent increase in the marginal revenue product, the marginal profitability of size declines in (28), and the gang chooses to reduce its size.

The marginal cost of violence also increases for every youth. Gang members are only arrested after committing crime. However, it is during the commission of crime that they inflict violence. Irrespective of whether they are caught, they therefore incur the cost of violence. The compensation they receive for doing so, on the other hand, are conditional on their evading arrest. Consequently, when the arrest rate increases, and gang members discount their wage further, any increase in violence requires a more substantial increases in pay. With no change in the marginal revenue product of violence, this causes the gang to reduce the levels of violence it requires its members to inflict.

Combined, these two effects give rise to the following result, equivalent to Lemma 3:

Lemma 7 *Suppose the conditions given in Proposition 6 and Assumption 4 hold. Then any improvement in the arrest and conviction rate may result in:*

1. *More gang members and less violence;*
2. *Fewer gang members and less violence; or*
3. *Fewer gang members and more violence.*

Under Assumption 4, an exogenous decrease in violence for every member increases the marginal revenue product of size. Similarly, a reduction in size increases the marginal revenue product of violence for each member of the gang. It is therefore possible that the reduction in violence may cause a sufficient increase in the marginal revenue product of size to offset the increase in marginal cost. This would create an incentive for the gang to recruit more members. In this case, the marginal revenue product of violence would decline further, leading to an additional reduction in violence, reinforcing the growth in gang size.

Conversely, the fall in gang size may cause a sufficiently large increase in the marginal revenue product of violence as to offset the increase in marginal cost. As such, the gang would increase the amount of violence it required its member to inflict (compensating them accordingly). In turn, this would further reduce the marginal profitability of size, leading to a further decline in membership.

5.2.4 Prevention of Juvenile Crime (κ)

Increases in the prevention of juvenile crime reduces the restricted demand for size. The cost of acquiring criminal skills increases. For a given violence schedule, every prospective member of the gang invest less, and consequently suffers a greater disutility from the violence they are forced to inflict. The marginal youth is particularly affected. As the youth with the lowest intrinsic ability, they are more sensitive to changes in the cost of acquiring criminal skills, and consequently reduce their skills dramatically. The cost of retaining their membership increases. They require higher wages. This leads to increases in the informational rent paid to all inframarginal members. The marginal cost of size increases. As, given the violence schedule, there is no equivalent increase in the marginal revenue product of size, the marginal profit associated with size declines ($\Pi_M < 0$). The gang optimally reduces the number of members it recruits.

Concurrently, the policy also reduces the restricted demand for violence. As each youth incurs a higher cost of acquiring criminal skills, they reduce their investment. In turn, this causes them suffer a greater disutility from the violence they are required to inflict. Moreover, as they have lower levels of criminal skill, they also become more sensitive to changes in violence. Each youth therefore requires a greater level of compensation for any changes in the level of violence they are required to inflict. The marginal cost of violence increases for every gang member. For a given gang size, there is no change in the marginal revenue product of violence. The marginal profitability of violence declines for all members ($\pi_V < 0$). The gang reduces every element of its violence schedule.

We have the following result:

Lemma 8 *Suppose the conditions given in Proposition 6 and Assumption 4 hold. Then any improvement in the prevention of juvenile crime may result in:*

1. *More gang members and less violence;*

2. *Fewer gang members and less violence; or*

3. *Fewer gang members and more violence.*

As both the restricted demand for size and the restricted violence schedule decline, the overall effect is uncertain. The direct fall in demand for size increases the marginal revenue product of violence. This may be sufficient to offset the increase in the marginal cost of violence caused by greater difficulties in acquiring criminal skills. As a result, the gang may choose to raise the amount of violence it requires of its members. This would lead to a further decline in the marginal revenue product of size, reducing size and reinforcing the increase in violence.

The opposite may also be true. The reduction in the restricted violence schedule increases the marginal revenue product of size. If this exceeds the increase in marginal cost caused by having to compensate youths more for acquiring criminal skills, the gang will increase its size. In turn, this would reduce the marginal revenue product of violence for each individual member, again reinforcing the increase in size.

Finally, it could be the case that neither endogenous increase in marginal revenue product outweighs the direct increase in marginal costs caused by improvements in the prevention of juvenile crime. Both size and violence would therefore decline.

6 Conclusions

Over recent years, numerous policies have been put forward to combat the social loss associated with crime. These policies aim to decrease individuals' incentive to engage in crime and, in doing so, reduce the amount of crime that occurs. However, when applied to neighbourhoods where organised crime is prevalent, this argument breaks down. When a policy is implemented, criminal organisations may adjust its inputs, substituting towards increasing the intensity of violence. This may increase the loss society suffers at the hands of organised crime.

This paper has shown the effects of several popular policies in such an environment. As criminal organisations tend to operate within a well-defined geographical territory, they act as a monopsonist employer for all criminals within that territory. Irrespective of whether the organisation operated a single wage or more complicated recruitment strategy, results were shown to be robust.

The effects of policy depend upon the degree of complementarity between inputs in the criminal organisation's revenue function. If they are strong complements, policies that one input reduce the marginal profitability of the other. Both size and violence decline. Conversely, if they are weak revenue complements, the organisation may choose to substitute between size and violence, possibly undoing the some of the effects of the policy. In this case the loss society suffers may increase.

When there is an incentive to substitute, policies which simply increase the opportunity cost of joining a criminal organisation, such as improved labour market wages or more severe punishment, fair badly. As they do not affect youths' incentive to acquire criminal skill, they actually reduce the marginal cost of violence. Those who chose to remain in the organisation after the policy is implemented are highly skilled. They do not require as much compensation when violence is intensified. As such, criminal organisations will always choose to increase violence, at the expense of membership.

Other policies prove slightly more effective. Prevention of juvenile crime and improved arrest or conviction rates may cause an intensification of violence, but only in relatively extreme circumstances. Otherwise, these policies diminish both the organisation's size and violence. Preventing juvenile crime not only increases the opportunity cost of joining a criminal organisation, but also reduces the incentive to acquire criminal skill. By doing so, it increases not only the marginal cost of acquiring members, but also the marginal cost of violence. Improving arrest rates have a similar effect. As youths may be prevented from receiving their wages, they require more compensation *ex ante* for the violence they inflict. As such, the marginal cost of violence once again increases. If the degree of substitutability between size and violence is particularly large, then the criminal organisation may still choose to substitute away from size towards violence. Otherwise, it will reduce both its size and the violence it inflicts.

In summary, anti-crime policies are most effective against organised crime when they not only reduce the incentive of youths to join the organisation, but also hamper its ability to increase violence.

A Proof of Proposition 1

Firstly, note that $M = N$ is never profit maximising, as it involves the gang paying infinitely large wages. Also, if $\hat{V} = 0$ or $\widehat{M} = 0$, equilibrium profit for the gang, $\hat{\Pi}$, is non-positive. So, to prove that the gang will operate with positive V and M, it will be necessary to show that positive profits will result.

Now, the first order conditions for profit maximisation are:

$$\begin{aligned}\Pi_V &= R_V\left(\hat{V},\widehat{M}\right) - \frac{\widehat{M}}{\hat{c}\,(1-p)} \equiv 0 \\ \Pi_M &= R_M\left(\hat{V},\widehat{M}\right) - g\left(V,\widehat{M};\boldsymbol{\phi}\right) - \frac{\hat{V}}{\lambda\hat{\sigma}\hat{c}\,(1-p)} \equiv 0\end{aligned}$$

Given that the revenue function has constant returns to scale, $R_{VM} = -\frac{V}{M}R_{VV} = -\frac{M}{V}R_{MM}$. Substituting appropriately, this yields second-order conditions:

$$\begin{aligned}\Pi_{MM} &= -\frac{\hat{V}}{\widehat{M}}\frac{1}{\widehat{M}\hat{c}\,(1-p)}\left[\eta + \frac{1}{\lambda\hat{\sigma}}\left(1 + \frac{1}{\lambda\hat{\sigma}} + \frac{1}{\lambda\hat{\sigma}}\frac{1+\varepsilon}{2+\varepsilon}\right)\right] \\ \Pi_{VM} &= \frac{1}{\widehat{M}\hat{c}\,(1-p)}\left[\eta - \left(1 + \frac{1}{\lambda\hat{\sigma}}\frac{1+\varepsilon}{2+\varepsilon}\right)\right] \\ \Pi_{VV} &= -\frac{\widehat{M}}{\hat{V}}\frac{1}{\widehat{M}\hat{c}\,(1-p)}\left[\eta - \frac{1}{2+\varepsilon}\right]\end{aligned}$$

Necessary and sufficient conditions for a maximum are that $\Pi_{MM} < 0$, $\Pi_{VV} < 0$, and $\Pi_{VV}\Pi_{MM} - \Pi_{VM}^2 > 0$. The first of these conditions is satisfied unambiguously upon inspection, since $R_{VM} > 0$. The second condition is satisfied if and only if $\eta > \frac{1}{2+\varepsilon}$. A sufficient condition is that $\eta > \frac{1}{2}$. Thirdly, we require that $\Pi_{VV}\Pi_{MM} > \Pi_{VM}^2$. With relatively little work, it can be shown that this is satisfied if and only if:

$$\eta > \frac{1 + \frac{1}{\lambda\hat{\sigma}}\left(1 + \frac{\varepsilon}{2+\varepsilon}\right) + \frac{1}{\lambda^2\hat{\sigma}^2}}{2 - \frac{1}{2+\varepsilon} + \frac{1}{\lambda\hat{\sigma}}\left(2 + \frac{\varepsilon}{2+\varepsilon}\right) + \frac{1}{\lambda^2\hat{\sigma}^2}\left(1 + \frac{\varepsilon}{2+\varepsilon}\right)}$$

A sufficient condition is that $\eta > 1$. So any point where both first order conditions are satisfied constitutes a local maximum. Rearranging these conditions yields:

$$\left|\frac{\Pi_{VM}}{\Pi_{VV}}\right| < \left|\frac{\Pi_{MM}}{\Pi_{VM}}\right|$$

Note that these inequalities do not simply hold at a point of profit maximisation - they hold everywhere. Therefore, assuming that the sign of Π_{VM} never changes, any profit maximising point will be unique.

Finally, it remains to show that the profit derived by the gang in any such equilibrium is positive. From the first-order conditions, we have that $\hat{V}R_V\left(\hat{V},\widehat{M}\right) = \frac{\widehat{M}\hat{V}}{\hat{c}(1-p)}$ and $\widehat{M}\left(R_M\left(\hat{V},\widehat{M}\right) - g\left(V,\widehat{M};\boldsymbol{\phi}\right)\right) = \frac{\widehat{M}\hat{V}}{\hat{c}(1-p)\left(\ln N + \ln(1-p) - \ln\widehat{M}\right)}$. Noting that the revenue function is homogeneous of degree one, it is clear that:

$$\hat{\Pi}\left(\boldsymbol{\phi}\right) = \frac{\widehat{M}\hat{V}\left(1 + \ln N + \ln\left(1-p\right) - \ln\widehat{M}\right)}{\hat{c}\left(1-p\right)\left(\ln N + \ln\left(1-p\right) - \ln\widehat{M}\right)} > 0$$

This completes the proof.

B Proof of Proposition 4

A contract is implementable if it is incentive compatible and individually rational. Considering first the issue of incentive compatibility, a youth has a strict incentive to truthfully reveal their type if:

$$\sigma = \arg\max_{s\geq 0}\left\{\left(1-p\right)g\left(s;\boldsymbol{\phi}\right) - pf - \frac{V\left(s;\boldsymbol{\phi}\right)}{c^*} - \kappa C\left(\frac{c^*}{\sigma}\right)\right\}$$

where c^* is a function of both σ and V. Taking first-order conditions, this is equivalent to:

$$\left(1-p\right)\frac{\partial g}{\partial s}\left(\sigma;\boldsymbol{\phi}\right) \equiv \frac{1}{c^*}\frac{\partial V}{\partial s}\left(\sigma;\boldsymbol{\phi}\right)$$

Integrating both sides over the range $[\hat{\sigma}, \sigma]$ yields:

$$g(\sigma; \boldsymbol{\phi}) = g(\hat{\sigma}; \boldsymbol{\phi}) + \frac{V(\sigma; \boldsymbol{\phi})}{c^*(1-p)} - \frac{V(\hat{\sigma}; \boldsymbol{\phi})}{\hat{c}(1-p)} + \frac{1}{1-p}\int_{t=\hat{\sigma}}^{\sigma} \frac{V(t; \boldsymbol{\phi})}{c^{*2}} \frac{\partial c^*}{\partial t} dt$$

Now, for $\hat{\sigma}$ to be the marginal youth, it must be the case that $G(\hat{\sigma}, \hat{\sigma}; \boldsymbol{\phi}) = w$. Otherwise, if $G(\hat{\sigma}, \hat{\sigma}; \boldsymbol{\phi}) > w$, a lower ability youth will be able to gain a larger payoff by joining the gang and sending signal $s_i = \hat{\sigma}$, contradicting the fact that $\hat{\sigma}$ is the marginal youth. On the other hand, if $G(\hat{\sigma}, \hat{\sigma}; \boldsymbol{\phi}) < w$, then the marginal youth would strictly prefer to join the primary labour market, again providing a contradiction. So:

$$g(\hat{\sigma}; \boldsymbol{\phi}) = \frac{w + pf}{1-p} + \frac{V(\hat{\sigma}; \boldsymbol{\phi})}{\hat{c}(1-p)} + \frac{\kappa}{1-p} C\left(\frac{\hat{c}}{\hat{\sigma}}\right)$$

Also, we have that:

$$\begin{aligned} \frac{\partial}{\partial \sigma}\left(\kappa C\left(\frac{c^*}{\sigma}\right)\right) &= \frac{\kappa}{\sigma} C'\left(\frac{c^*}{\sigma}\right)\frac{\partial c^*}{\partial \sigma} - \frac{\kappa c^*}{\sigma^2} C'\left(\frac{c^*}{\sigma}\right) \\ &= \frac{V(\sigma; \boldsymbol{\phi})}{c^{*2}} \frac{\partial c^*}{\partial \sigma} - \frac{\kappa c^*}{\sigma^2} C'\left(\frac{c^*}{\sigma}\right) \end{aligned}$$

So, by (21):

$$\begin{aligned} \int_{t=\hat{\sigma}}^{\sigma} \frac{V(t; \boldsymbol{\phi})}{c^{*2}} \frac{\partial c^*}{\partial t} dt &= \kappa \int_{t=\hat{\sigma}}^{\sigma} \frac{\partial}{\partial t}\left(C\left(\frac{c^*}{t}\right)\right) dt + \int_{t=\hat{\sigma}}^{\sigma} \frac{\kappa c^*}{t^2} C'\left(\frac{c^*}{t}\right) dt \\ &= \kappa C\left(\frac{c^*}{\sigma}\right) - \kappa C\left(\frac{\hat{c}}{\hat{\sigma}}\right) + \int_{t=\hat{\sigma}}^{\sigma} \frac{V(t; \boldsymbol{\phi})}{t c^*} dt \end{aligned}$$

Substituting, we have that:

$$g(\sigma; \boldsymbol{\phi}) = \frac{w + pf}{1-p} + \frac{V(\sigma; \boldsymbol{\phi})}{c^*(1-p)} + \frac{\kappa}{1-p} C\left(\frac{c^*}{\sigma}\right) + \frac{1}{1-p}\int_{t=\hat{\sigma}}^{\sigma} \frac{V(t; \boldsymbol{\phi})}{t c^*} dt$$

Finally, we must show that this is individually rational. The implementable payoff from joining the gang is:

$$w + \int_{t=\hat{\sigma}}^{\sigma} \frac{V(t; \boldsymbol{\phi})}{t c^*} dt$$

For any youth with $\sigma > \hat{\sigma}$, the payoff from joining the gang strictly exceeds the wage they would earn in the primary labour market. For the marginal youth, the two are equal. For any youth with ability less than the marginal youth, they strictly prefer the primary labour market. This completes the proof.

C Proof of Proposition 5

Before evaluating the profit maximisation problem, consider the expected cost of informational rent for the gang:

$$I = \frac{1}{1-p}\int_{s=\hat{\sigma}}^{\infty}\int_{t=\hat{\sigma}}^{s}\frac{V(t;\boldsymbol{\phi})}{tc^*}dt\lambda e^{-\lambda(s-\hat{\sigma})}ds$$

Performing a standard integration by parts yields:

$$I = \frac{1}{1-p}\int_{s=\hat{\sigma}}^{\infty}\frac{V(s;\boldsymbol{\phi})}{\lambda sc^*}\lambda e^{-\lambda(s-\hat{\sigma})}ds$$

so the gang leadership's objective function becomes:

$$N(1-p)\int_{s=\hat{\sigma}}^{\infty}\left[r(V(s;\boldsymbol{\phi}),M) - \frac{w+pf}{1-p} - \frac{V(s;\boldsymbol{\phi})}{c^*(1-p)}\left(1+\frac{1}{\lambda s}\right) - \frac{\kappa}{1-p}C\left(\frac{c^*}{s}\right)\right]\lambda e^{-\lambda s}ds$$

Now, given gang size, for each $\sigma \geq \hat{\sigma}$, the restricted demand for V must maximise $\pi(V,M)$. It must therefore satisfy:

$$\pi_V = r_V\left(\widetilde{V},M\right) - \frac{1}{c^*(1-p)}\left[1+\frac{1}{\lambda\sigma}\frac{1+\varepsilon}{2+\varepsilon}\right] \equiv 0$$

The associated second-order condition is:

$$\begin{aligned}
\pi_{VV} &= r_{VV}\left(\widetilde{V},M\right) + \frac{1}{\widetilde{V}c^*(1-p)(2+\varepsilon)}\left[1+\frac{1}{\lambda\sigma}\frac{1+\varepsilon}{2+\varepsilon}\right] \\
&\quad - \frac{\varepsilon}{\widetilde{V}c^*(1-p)(2+\varepsilon)^3}\frac{1}{\lambda\sigma}\left(1+\frac{\frac{c^*}{\sigma}C'''\left(\frac{c^*}{\sigma}\right)}{C''\left(\frac{c^*}{\sigma}\right)} - \varepsilon\right) \\
&= r_{VV}\left(\widetilde{V},M\right) + \frac{r_V\left(\widetilde{V},M\right)}{\widetilde{V}(2+\varepsilon)} - \frac{\varepsilon}{\widetilde{V}c^*(1-p)(2+\varepsilon)^3}\frac{1}{\lambda\sigma}\left(1+\frac{\frac{c^*}{\sigma}C'''\left(\frac{c^*}{\sigma}\right)}{C''\left(\frac{c^*}{\sigma}\right)} - \varepsilon\right)
\end{aligned}$$

By assumption, the final term is positive. So the second-order condition is unambiguously negative if:

$$\begin{aligned}
r_{VV}\left(\widetilde{V},M\right) + \frac{r_V\left(\widetilde{V},M\right)}{\widetilde{V}(2+\varepsilon)} &< 0 \\
\iff \quad -\frac{\widetilde{V}r_{VV}\left(\widetilde{V},M\right)}{r_V\left(\widetilde{V},M\right)} &> \frac{1}{2+\varepsilon}
\end{aligned}$$

Defining $\eta(\sigma) \equiv -\frac{V r_{VV}}{r_V} = -\frac{V R_{VV}}{R_V} = \frac{N^G R_{VNG}}{R_V}$, as before, a sufficient condition is $\eta(\sigma) > \frac{1}{2}$. This completes the proof.

D Proof of Proposition 6

Making liberal use of the envelope theorem, the gang's optimal size, $\hat{M}$, satisfies the following first-order condition:

$$\Pi_M = r\left(\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right),\hat{M}\right) - \frac{w+pf}{1-p} - \frac{\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right)}{\hat{c}\,(1-p)}\left(1+\frac{1}{\lambda\hat{\sigma}}\right) - \frac{\kappa}{1-p}C\left(\frac{\hat{c}}{\hat{\sigma}}\right)$$
$$+N(1-p)\int_{s=\hat{\sigma}}^{\infty} r_M\left(\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right),\hat{M}\right)\lambda e^{-\lambda s}ds \equiv 0$$

The associated second-order condition is:

$$\begin{aligned}
\Pi_{MM} &= 2r_M\left(\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right),\hat{M}\right) - \frac{\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right)}{\lambda\hat{\sigma}\hat{M}\hat{c}\,(1-p)}\left[1+\frac{1}{\lambda\hat{\sigma}}\frac{3+2\hat{\varepsilon}}{2+\hat{\varepsilon}}\right] \\
&\quad +N(1-p)\int_{s=\hat{\sigma}}^{\infty}\left[r_{MV}\left(\widetilde{V}\left(\sigma,\hat{M};\boldsymbol{\phi}\right),\hat{M}\right)\frac{\partial\widetilde{V}}{\partial M} + r_{MM}\left(\widetilde{V}\left(\sigma,\hat{M};\boldsymbol{\phi}\right),\hat{M}\right)\right]\lambda e^{-\lambda s}ds \\
&= 2r_M\left(\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right),\hat{M}\right) - \frac{\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right)}{\lambda\hat{\sigma}\hat{M}\hat{c}\,(1-p)}\left[1+\frac{1}{\lambda\hat{\sigma}}\frac{3+2\hat{\varepsilon}}{2+\hat{\varepsilon}}\right] \\
&\quad +N(1-p)\int_{s=\hat{\sigma}}^{\infty}\left[r_{MM}-\frac{r_{MV}^2}{\pi_{VV}}\right]\lambda e^{-\lambda s}ds
\end{aligned}$$

Consider the final term:

$$\begin{aligned}
I &= N(1-p)\int_{s=\hat{\sigma}}^{\infty}\left[r_{MM}-\frac{r_{MV}^2}{\pi_{VV}}\right]\lambda e^{-\lambda s}ds \\
&= M\hat{r}_{MM} - M\frac{\hat{r}_{MV}^2}{\hat{\pi}_{VV}} + N(1-p)\int_{s=\hat{\sigma}}^{\infty} r_{MMV}\frac{\partial V}{\partial s}e^{-\lambda s}ds \\
&\quad -2N(1-p)\int_{s=\hat{\sigma}}^{\infty}\frac{r_{MV}r_{MVV}}{\pi_{VV}}\frac{\partial V}{\partial s}e^{-\lambda s}ds + N(1-p)\int_{s=\hat{\sigma}}^{\infty}\frac{r_{MV}^2}{\pi_{VV}^2}\frac{\partial^3\pi}{\partial V^2\partial s}e^{-\lambda s}ds
\end{aligned}$$

where $\hat{r}_{MM} = r_{MM}\left(\widetilde{V}\left(\hat{\sigma},\hat{M};\boldsymbol{\phi}\right),\hat{M}\right)$ and $\frac{\hat{r}_{MV}^2}{\hat{\pi}_{VV}} = \frac{\partial\widetilde{V}}{\partial M}(\hat{\sigma})$.By assumption:

$$N(1-p)\int_{s=\hat{\sigma}}^{\infty} r_{MMV}\frac{\partial V}{\partial s}e^{-\lambda s}ds - 2N(1-p)\int_{s=\hat{\sigma}}^{\infty}\frac{r_{MV}r_{MVV}}{\pi_{VV}}\frac{\partial V}{\partial s}e^{-\lambda s}ds$$
$$+N(1-p)\int_{s=\hat{\sigma}}^{\infty}\frac{r_{MV}^2}{\pi_{VV}^2}\frac{\partial^3\pi}{\partial V^2\partial s}e^{-\lambda s}ds < 0.$$

So:

$$\Pi_{MM} < 2\hat{r}_M - \frac{\hat{V}}{\lambda\hat{\sigma}\hat{M}\hat{c}\,(1-p)}\left[1+\frac{1}{\lambda\hat{\sigma}}\frac{3+2\hat{\varepsilon}}{2+\hat{\varepsilon}}\right] + M\hat{r}_{MM} - M\frac{\hat{r}_{MV}^2}{\hat{\pi}_{VV}}$$

The right hand side is negative if and only if:

$$\begin{aligned} 2\hat{r}_M\hat{\pi}_{VV} - \frac{\hat{V}}{\lambda\hat{\sigma}\hat{M}}\hat{r}_V\hat{\pi}_{VV} - \frac{\hat{V}}{\lambda^2\hat{\sigma}^2\hat{M}\hat{c}\,(1-p)}\hat{\pi}_{VV} + M\hat{r}_{MM}\hat{\pi}_{VV} - M\hat{r}_{MV}^2 > {} & 0 \\ \iff \hat{r}_M\hat{r}_{VV} + \hat{r}_M\gamma + \frac{1}{\lambda\hat{\sigma}}\hat{r}_M\left(\hat{r}_{VV}+\gamma\right) - \frac{\hat{V}}{\lambda^2\hat{\sigma}^2\hat{M}\hat{c}\,(1-p)}\left(\hat{r}_{VV}+\gamma\right) & \\ + M\hat{r}_{MM}\left(\gamma - \frac{\hat{r}_V}{\hat{V}}\right) - \frac{\hat{r}_M\hat{r}_V}{\hat{V}} > {} & 0 \end{aligned}$$

where $\gamma \equiv \frac{\hat{r}_V}{\hat{V}}\frac{1}{2+\varepsilon} - \frac{\varepsilon}{\widetilde{V}c^*(1-p)(2+\varepsilon)^3}\frac{1}{\lambda\sigma}\left(1+\frac{\frac{c^*}{\sigma}C'''\left(\frac{c^*}{\sigma}\right)}{C''\left(\frac{c^*}{\sigma}\right)} - \varepsilon\right)$. Substituting for γ, and given the properties of $r(\cdot,\cdot)$, it is possible to show that this is unambiguously positive. Thus the second-order condition is invariably negative. This completes the proof.

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