Cops and Robbers: Informal Trade and the State

James E. Anderson
Boston College and NBER

Oriana Bandiera
London School of Economics and CEPR

Much trade occurs outside the perimeter of state law enforcement, especially in less developed and transitional economies but substantially even in highly developed economies. We explain the persistence of informal trade in countries with high institutional capacity and deeply legitimate governments by showing that extensive informal markets may be in the government's interest. We develops models of enforcement when trade is subject to predation. Private monopoly enforcement competes with self enforcement on the one hand and State enforcement on the other hand. Operating in parallel formal and informal markets, State and private enforcement are ordinarily stratetgic complements in our model. For this and other reasons, the benefits of State policy aimed at shrinking grey market or illegal exchange can often be perverse in our model.
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Predation on trade by corrupt officials and theives is costly, but good institutions can reduce the cost. For example, Anderson and Marcouiller (2001) show that officially measured trade is significantly reduced in economies with poor institutions, all else equal.[1] Property rights enforcement is normally done by States, but developing economies have large informal sectors and even highly developed ones tolerate grey markets in some goods. Illegal markets also are to be found in even the most developed economies. Examples of private enforcement agencies of both illegal and legal trade abound. Such were the "law merchants" in medieval France (Milgrom, North and Weingast (1990)) and the "merchant guilds" in late medieval Germany and Italy (Greif, Milgrom and Weingast (1994)). US airport security has notoriously been privately provided. Other markets use self enforcement to protect trade, as legendarily was so in the Wild West. As for illegal markets, the evidence suggests that, in addition to their traditional criminal activities, the Mafia and similar organized crime groups also "offer protection for the kinds of guys who can't go to the cops".[2]

Why do we observe such patterns? This paper explores institutions which enforce property rights to trade against predators. We explain the persistence of informal trade in countries with high institutional capacity and deeply legitimate governments by showing that shrinking informal markets may not be in the government's interest. We develops models of enforcement when trade is subject to predation. Private monopoly enforcement competes with self enforcement on the one hand and State enforcement on the other hand. Operating in parallel formal and informal markets, State and private enforcement are ordinarily strategic complements in our model. For this and other reasons, the benefits of State policy aimed at shrinking grey market or illegal exchange can often be perverse in our model. The model permits us to relate changes in the State's incentives to the level of economic development and other key parameters. We find no tendency for development to raise the enforcement share of the State.

The paper is part of a larger investigation of the economics of institutions. Institutional quality varies widely (see Table 1 below, based on data in the World Economic Forum, 1997). Lack of institutional capacity can-

[1] Think of piracy to stimulate the imagination, although predation in the form of actual theft is exceeded in impact for most of the modern world by demands for payment outside legal requirements by predators in officialdom or outside official channels.

[2] Quoted from Firestone (1997)'s analysis of mobsters' memoirs. Falcone (1992) and Gambetta (1994) present similar evidence for the Sicilian Mafia.

not be the whole explanation of the variation, since quality is not strictly ranked by level of economic development. This observation suggests that the benefits to better quality and the particular ways in which institutions have come to be organized play a role in the ultimate explanation; imperfect institutions may be a stable equilibrium (maybe optimal) under the constraints.

We begin with analysis of a single market in isolation. We develop a formal model of private enforcement in which the volume of exchange, the intensity of predation and the quality and pricing of enforcement are all endogenous. We first develop self enforcement equilibrium as the benchmark against which to set the Mafia form of the enforcement market. Specialized enforcement will arise at higher levels of development as the fixed cost of organization can be covered by the extractable surplus from the market. A key feature of the model is a positive externality among traders which we call 'safety in numbers': the probability of successful trade is rising in the number of traders (volume of trade). Safety in numbers mimics reality and is based on two assumptions which are realistic: the interaction of predators and prey in the market area is anonymous, and predators face increasing opportunity cost. We seek the answer to two questions. First, does the enforcement monopoly limit exchange relative to self enforced markets? The answer depends on the balance of the safety in numbers externality and the superior enforcement technology of the Mafia on the one hand and its monopoly power on the other hand. We find that Mafias are more likely to increase the volume of exchange when elasticities of demand and supply are high and when the intensity of predation is high (the latter depending on several parameters we analyze below). Second, which State policies are most effective at reducing illegal exchange? State activity in opposition to illegal trade may take different forms, such as direct action in the form of 'predation' on the illegal exchange (drug raids) and attacks on the underlying determinants of illegal exchange (spraying coca or opium poppy fields on the supply side, negative advertising on the demand side). We show that the effectiveness of these policies depends crucially on the strength of the Mafia's technology. Some seemingly obvious policies can backfire, as when breaking up the Mafia enforcement of the drugs trade increases the trade.

State enforcement is more realistically in competition with private enforcement. We explore this case with a two market analysis in which State enforcement prevails in one market while private enforcement prevails in the other. (Realistically, and in our setup, enforcement in a given market will be exclusively of one type.) In one variant (differentiated duopoly) the Mafia provides competition in enforcement with the State, and in the other variant (competitive fringe) trade in the informal sector is self enforced. The endogenous allocation of predators and traders between the two markets links them, and we show that State and Mafia enforcement are strategic complements through the multimarket version of safety in numbers. (The single market in isolation arises when all such links are broken.) Thus policies which enhance State revenues will also enhance Mafia revenues and conversely. This may help explain the persistence of Mafias even in the presence of States which appear able to eliminate competition in enforcement — the State can weaken the Mafia only by weakening itself. In the other variant, the State enforces formal sector trade alongside informal trade with self enforcement. Again the State loses revenue by attacking the informal sector. This insight adds a new element to the literature on dual economies (see for example Marcouiller and Young, 1995), which emphasizes substitutability between formal and informal sector activities.

Recent literature has devoted considerable attention to the analysis of private enforcement agencies. Dixit (2001) examines private governance in the context of asymmetric prisoners' dilemmas between two randomly matched agents. In his model, the need for enforcement arises because each of the parties involved in trade can cheat the other. In our case, in contrast, predators are specialized and their number is determined endogenously by the level of exchange and the enforcement technology. Olson (1993), Grossman (1995), and Moselle and Polak (1997) all analyze outcomes under a "predatory State", i.e. a centralized profit maximizing agency that provides public goods –loosely interpreted as enforcement services– in exchange for taxes. Compared to these, our model deals explicitly with the interaction between predators, traders and the enforcer. Grossman (1995) also consider the case of two agencies, selling enforcement in different markets which are linked because producers can operate in either. We similarly analyze the interaction of the Mafia and the State, but in a setting where both traders and predators can move between markets. More important, predators and prey interact anonymously, in contrast to Grossman's model. Also, our paper discusses State policies to reduce illegal exchange when this is ruled by a private enforcement agency. Finally, our model contributes to the new literature on nonformal trade costs, some of which focuses on predation (Anderson and Marcouiller, 2001).

The remainder of the paper is organized as follows. Section 1 sets out the model of self enforcement equilibrium and analyzes its existence and comparative statics. Section 2 analyzes the Mafia enforcement equilibrium and compares it with the self enforcement equilibrium. The comparative statics of the two forms show that self enforcement prevails at low levels of economic development, volume grows as the supply of predators shrinks (better jobs draw them away), and specialized enforcement emerges when the size of the market and its extractable surplus become large enough relative to the fixed cost of organization. Section 3 analyzes State policy to reduce Mafia-enforced illegal exchange in the isolated market. Section 4 analyzes the State and Mafia as rival providers of enforcement in linked white and grey markets. State policy is tolerant of the grey market competition due to the strategic complementarity of the State and Mafia enforcement decisions. Section 5 analyzes the State's enforcement in the formal sector alongside competition with a self enforcing competitive fringe informal sector. Again, 'strategic complementarity' gives the State an incentive to tolerate the informal sector. Section 6 presents simulations of the two market model in both its formal/informal (monopoly with competitive fringe) and State/Mafia (duopoly) versions. The simulations give no support to the hypothesis that development will imply that the informal or illegal sector will decline relative to the formal State protected sector. Section 7 concludes.

1 The Model of Self Enforcement Equilibrium

Predation on exchange will normally meet at least some protective or evasive action. Self enforcement is most simply modeled as uncoordinated evasive action. In any close encounter with a predator, the prey lose; but the prey often elude or escape the predators.[3] We model the probability of successful exchange as a decreasing function of the ratio of predators to prey, reflecting interaction between the two populations of given capacities to escape and pursue in the market zone. In equilibrium the atomistic interaction of predators and prey will equalize the probability everywhere in the zone.

[3]Think of biological interaction where the prey use camouflage, alertness and speed to protect themselves from predators who rationally pursue only the easy prey using their capacities of detection and speed.

Buyers and sellers meet in the market zone to exchange goods for money.[4] We assume that buyers can trade costlessly (for example because they reside in the market zone) while trade is costly for sellers (for example because they must travel to the trade zone) and these trade costs must be offset by their shares of the arbitrage gains.[5] For simplicity we fix buyers willingness to pay at b while the price on the domestic markets of the sellers is equal to c, with $b > c$. Sellers are endowed with differential ability (for example, they are located at different distances from the trade zone) and are ordered so that the most able enter trade first. Thus the unit trade cost function is $t(q)$, $t_q > 0$; where q denotes the volume of trade and the subscript denotes partial differentiation here and in the remainder of the paper.

To fix ideas, note that in the absence of predation the perfectly competitive market yields a market clearing trade volume q^0 defined by $b = c + t^s(q^0)$. At the market clearing volume, the market clearing price is $p^0 = b = c + t^s(q^0)$. The marginal seller of the market breaks even while inframarginal sellers earn rents on their superior ability, capturing the gains from trade.

Now consider predation on exchange in the form of a subjective probability $1 - \pi$ that the goods are stolen from sellers entering the market.[6] Literal theft is but one form of predation represented by the model — corrupt officials and their agents, who demand added payments to expedite passage of the goods, can also inflict the expected proportionate loss $1 - \pi$. Assume that traders are risk neutral for simplicity. Then if the price of successful exchange is p, a seller expects to receive πp. The marginal seller breaks even with $\pi p = c + t^s$. For a given probability of success, the volume of exchange q^c is determined by

$$\pi b = c + t(q^c). \tag{1}$$

[4] All the properties of our model survive into a general equilibrium version. Ricardian production can rationalize the fixed buyers' and sellers' home market prices we deploy. Downward sloping import demand and export supply functions are generated by standard general equilibrium excess demand structures.

[5] The results below are robust to the alternative assumption that also buyers face trade costs.

[6] We could alternatively assume that both goods and money are subject to predation or that goods can be stolen from buyers after purchase. These alternatives result in slightly different setups which are a bit more cumbersome to analyze. Nothing essential hangs on the simplification.

We solve implicitly for exchange volume as

$$Q(\pi),\ \pi \geq \pi_{\min} = [c + t(0)]\,/b.$$

For success rates π below the critical value, there is no exchange. As is intuitive, volume is increasing in the probability of success:

$$Q_\pi = \frac{b}{t_q} > 0.$$

Evidently $Q(1) = q^0$, while $Q\left(\pi_{\min}\right) = 0$.

The objective probability of success results from the anonymous interaction of predators and self protecting traders in the trade zone. Let B denote the number of predators. We assume that the objective probability of successful trade is given by

$$\frac{1}{1 + \theta B/q}.$$

This function is homogeneous of degree zero in B, q and decreasing in the ratio of predators to traders, as is eminently plausible. The odds of success are equal to $\theta B/q$.

The number of predators B is endogenous. We assume that a total potential mass $\overline{B}$ of predators has outside options in terms of the good being exchanged which are uniformly distributed on $[0, w]$. Successful predation earns $(1-\pi)q/B$ per predator. The uniform distribution of outside options implies that the number of predators is given by $B = (1-\pi)q\overline{B}/Bw$, which implies predator supply equal to:

$$B = (1-\pi)^{1/2} q^{1/2} (\overline{B}/w)^{1/2}. \tag{2}$$

In rational expectations equilibrium, the subjective probability of success must equal the objective probability. Substituting the predator supply equation (2) into the probability of success function, rational expectations equilibrium implies that:

$$\pi = \frac{1}{1 + \gamma(1-\pi)^{1/2} q^{-1/2}} \equiv f(\pi, q), \tag{3}$$

where $\gamma \equiv \theta(\overline{B}/w)^{1/2}$. This fixed point problem has a unique interior solution $\Pi(q) = \{\pi | \pi - f(\pi, q) = 0\}$.[7]

[7] Note that $f(1,q) = 1$ and $f(0,q) = \underline{\pi} < 1$. Also, $\lim_{\pi \to 1} f_\pi(\pi, q) \to \infty$, $f_\pi = \pi^2/(1+\pi) < 1$ at a solution and $f_\pi(0,q) = \underline{\pi}(1-\underline{\pi})\pi/(1-\pi) = 0$. The boundary and derivative conditions mean that the continuous function f must cross the 45^0 line once between $\underline{\pi}$ and 1.

An important externality characterizes the interaction of traders — safety in numbers. Formally:

$$q\Pi_q/\Pi = \frac{1-\pi}{2-\pi} \in [0, 1/2].$$

The exact form of the elasticity $q\Pi_q/\Pi$ is of course special to our model but the safety in numbers positive externality of trade is a fairly general characteristic of anonymous predation. It arises because of the increasing opportunity cost of predators interacting with the homogeneity property of anonymous predation. In the limiting case of constant opportunity cost, safety in numbers disappears, an expansion of q would lead to an equiproportionate expansion of B in order to preserve the equality of expected predator payoffs for a given success rate of predation $1 - \pi$.

Finally, we consider the existence and uniqueness of self enforcement equilibrium. The equilibrium with self defense results from the simultaneous solution of equations (1) and (3) for q^c and π. The analysis is displayed in Figure 1.

FIGURE 1 HERE

$Q(\pi_{\min}) = 0$ and $Q(1) = q^0$. $\Pi(0) = 0$ while the limit of Π as q increases without bound is 1. If the two functions do not intersect, the only equilibrium is secure (since $\pi = 1$ is always a solution to the fixed point problem $\pi = f(\pi, q)$). We are of course interested in insecure equilibrium, which arise when γ is large enough or $\pi_{\min}$ is small enough. The first condition requires that predators be efficient enough so that self defense is not completely effective. The second condition requires that the gains from trade are large enough to overcome inefficient self-defense.

If there is an interior equilibrium, it cannot be unique. To see this, note that for

$$\Pi(q) = \pi_{\min} = \sqrt{[c + t^s(0)]/b},$$

the critical value of π for which $Q = 0$, we know the corresponding value of q is positive: $\Pi(q)$ is above $Q = 0$ at this point. For there to be an interior solution, the Π function must cut the Q function from above and to the left. But because the Π function becomes very steep as it approaches $\pi = 1$ we know the Π function must cut the Q function from below for some value of π going toward 1 if Π ever lies inside Q. By a natural stability argument, we note that equilibria where Π cuts Q from the outside are unstable whereas the equilibrium with larger π, q is stable. We cannot generally guarantee only one pair of equilibria, hence cannot guarantee a unique stable equilibrium. For the constant elasticity case, simulation shows that if there is a stable equilibrium, it is the only stable equilibrium (the $\Pi(q)$ and $Q(\pi)$ functions cross twice only). Figure 1 illustrates. The simulation confirms that when $b-c$ is small or γ is large, there is no interior equilibrium.

1.1 The Comparative Statics of Self Enforcement Equilibrium

At an interior stable self enforcement equilibrium, the comparative static derivatives are illustrated by shifting the Q and Π functions with respect to parameters, then noting the change in q and π. All the comparative static derivatives are intuitive in sign.

Economic development should lower the supply of predators by raising their opportunity cost w or by reducing their mass $\overline{B}$. Either one lowers γ, which raises the equilibrium q and π. It does so by shifting to the right the Π function at the stable equilibrium. A fall in θ, the relative effectiveness of predators, will have the same effect.

Economic development may increase arbitrage margins. A fall in c or a rise in b will raise π and q. This arises as the Q function is shifted to the right, sliding the equilibrium up along the Π function. This result is expected but its structure is revealingly connected to stability. By increasing the total arbitrage margin $b-c$, we expect trade volume to rise. But lower volume reduces the number of predators and thus raises π, in turn tending to raise q. At a stable interior equilibrium the former effect dominates.

Finally, development reduces trade costs, which acts like decreases in c or increases in b. For the class of constant elasticity of trade cost functions, a fall in the elasticity of trade costs (associated with a rise in the price elasticity of demand or supply) increases π and q.
All these forces suggest that development spurs increases in trade. Foreshadowing the results of the next section, larger volume may make it worthwhile to incur the fixed costs of organizing specialized enforcement.

State policy in self enforced illegal markets has obvious effects, which we note mainly as a benchmark against which to set our detailed discussion of State policy against Mafia enforcement of illegal markets. The State can affect γ by acting on the predators. The State can predate directly itself thus changing the maximum potential mass $\overline{B}$ or it can affect the predators' outside opportunity w. Also, State policy can affect the marginal willingness to pay b, for instance with anti-drugs campaign, or the sellers' cost c. All these policies have the obvious effect in the sense that State predation on illegal exchange, reductions in b and increases in c all contribute to reducing the volume of exchange.

2 Specialized Enforcement Equilibrium

We model specialized enforcement as the ability of specialized enforcement to recover stolen property. It is natural to assume fixed cost and economies of scale in this activity due to coordination of information. In particular, we assume that the probability that the specialized enforcer recovers stolen goods is fixed and equal to M, a capability purchased by incurring a fixed cost F. For simplicity we assume that the size of the market is such that only a monopolist might be able to make non-negative profits given F.[8] We call the specialized monopoly enforcer the Mafia for emphasis.

Mafia and self enforcement cannot coexist in the same market when a homogeneous product is exchanged, as here. For traders to be willing to pay for Mafia enforcement, it must offer a higher success rate than self enforcement when both are available. But when both modes of enforcement are used, predators will allocate themselves between self- and Mafia-protected trade so as to equalize the success rates. Self enforcement free rides on the effectiveness of Mafia enforcement and ends in driving Mafia enforcement from the market. Free riding defeats what could be a socially beneficial equilibrium with a superior form of enforcement. To prevent free riding and the collapse of its market, the Mafia must force all traders to pay for its enforcement. In this, it resembles State enforcement, which compels traders who are active in its market zone to pay taxes or else prevents them from trading there. Typically, the Mafia threatens to seize the goods of self-enforcing traders, as it does not have the full range of powers of the State. The discussion casts a new light on the frequently observed compellence associated with Mafia protection. Markets where the Mafia cannot make a profit will use self enforcement.

[8]In contrast, guarding shipments will raise the success rate of traders and might more readily be decentralized. Since specialized enforcement combines guarding with recovery, the monopoly market structure due to the latter will prevail.

The success rate of Mafia protected exchange is a compound equal to the probability of avoidance plus one minus the probability of avoidance times the probability M that the Mafia recovers property from a successful predator. Here we assume that the outcomes of evasion and recovery are independently distributed, as is plausible.[9] We assume the same avoidance technology is used by the traders as with self enforcement. [10] The success rate for the Mafia protected trade is thus

$$\pi^m = \frac{1}{1+\theta B/q} + \left[1 - \frac{1}{1+\theta B/q}\right] M \tag{4}$$

Since B is a function of π and q via (2), an argument parallel to that for the self enforcement case shows that a unique fixed point $\Pi^m(q, M; \theta, \overline{B}/w)$ always exists. Note that there is safety in numbers with the Mafia:

$$q\Pi^m_q = \frac{(1-\Pi^m)(\Pi^m - M)}{2(1-M) - (\Pi^m - M)} \geq 1 - \Pi^m \geq 0. \tag{5}$$

The reason that the expression is always nonnegative is that from (4) we know that $\pi \geq M$ (π is a convex combination of 1 and M) and $1-M \geq \pi - M$ by $\pi \leq 1$. It is straightforward to show that $\Pi^m_M > 0$, $\Pi^m_w > 0$, $\Pi^m_{\overline{B}} < 0$.)

We assume as in Section 2 that both self enforcement and Mafia enforcement come at zero marginal cost. However, the Mafia faces a fixed cost F in setting up its enforcement system with capability M. When the Mafia charges τ per unit for enforcement, the equilibrium volume is determined by $b = [c + t^s(q) + \tau]/\pi$. Any level of q can be selected by Mafia pricing of enforcement $\tau = \pi b - [c + t^s(q)]$ provided the level of π is the equilibrium probability of success.

The Mafia's optimal quantity policy is defined by maximizing revenue R with respect to the volume:

$$\max_q q\Pi^m(q; \cdot)b - q[c + t(q)].$$

In this setup we assume that the Mafia is sophisticated in understanding that the number of predators it faces is affected by the volume of trade:

[9]We can interpret our story loosely as one of Mafia guards defeating predators in encounters too, but in that case we abstract from the complication that M is likely to be a function of the force level of the Mafia relative to the force level of the predators.

[10]Note that, since self enforcement is costless no moral hazard problem arises here.

$\Pi^m(q,\cdot) = \Pi^m(q, M; \theta, \overline{B}/w)$. The first derivative of revenue with respect to q, set equal to zero as the first order condition for the Mafia is,

$$R_q = [\Pi^m b - (c + t(q))] - t_q q + q\Pi^m_q b. \tag{6}$$

At an interior optimum, $R_{qq} < 0$, which holds globally with a mild restriction on the trade cost functions in our model. Revenue is positive at this interior equilibrium provided a self enforcement interior equilibrium exists. The Mafia will enter the market provided that $R(q^m) - F > 0$, where q^m is the revenue-maximizing value of trade.

The comparative static derivatives reported in the next section show that the factors associated with economic development and larger markets are also associated with larger Mafia revenues. Thus, as foreshadowed by our discussion in the preceding section, specialized enforcement can only emerge at higher levels of economic development. An exact description of the switchover requires a richer model which would, among other things, break open the black box of fixed costs F. *A fortiori,* a full story of replacing private enforcement with State enforcement requires a richer model.

Does the Mafia trade volume q^m exceed the self enforcement level of exchange, q^c?[11] As shown below, the Mafia equilibrium trade volume is greater or less than self enforcement equilibrium trade volume depending on the balance of three forces. The Mafia is able to internalize the safety in numbers externality based on (3). This internalization gives the Mafia an incentive to raise volume relative to self enforcement because the Mafia incorporates the effect of an increase in sales on raising the marginal willingness to pay of traders through an increased success rate. But second, the Mafia internalizes the decline in willingness-to-pay for enforcement as less able traders enter the market, acting to reduce volume. Finally, the Mafia has a enforcement technology which is superior to self-enforcement. This raises trade volume, all else equal. The balance of these three forces determines whether the Mafia increases trade volume as compared to self defense.

Assuming the global concavity of revenue and the same zero cost for Mafia and self enforcement, the ranking of trade volumes is determined by

[11] The Mafia is assumed here to be unconstrained in its pricing relative to traders switching to self enforcement. But traders will attempt to switch to self enforcement if the Mafia offers worse success than does self enforcement. Leaving aside extortionate power, the limit at which traders will switch is defined by $q^{m0} : \pi^m(q^{m0}) = \pi(q^c)$. So the constraint, if binding, limits the extent to which trade can be reduced by the Mafia.

the sign of marginal revenue of the Mafia at the self enforcement equilibrium volume of trade. Evaluating at q^c and using $\Pi(q^c)b - c - t(q^c) = 0$ we have:

$$R_q(q^c) = \Pi_q^m bq + [\Pi^m(q^c) - \Pi(q^c)]b - \varepsilon t(q^c)$$

where ε is the elasticity of trade costs with respect to volume. The first term on the right hand side represents the effect of the safety in numbers externality and is positive. The second term captures the effect of the different technology and is also positive: keeping the level of exchange constant the success rate is higher with Mafia enforcement due to its superior technology. The third term represents the monopoly pricing consideration of the Mafia and is negative. As the self enforcement equilibrium value of π rises to 1 the first (externality) term vanishes, by (5), while the second (technology) term also vanishes and, as is intuitive, only the negative consequence of monopoly remains.

The comparative statics of the preceding section associate high values of $\Pi(q^c)$ with low values of γ and high values of b relative to c. The same factors unfortunately tend to make the monopoly power term large in absolute value, so the net effect is ambiguous. Low values of the trade cost elasticities (high values of the conventional elasticities of supply and demand) tend to make the externality term predominant, so that the Mafia induces more trade volume than does self enforcement. Although the net effect is ambiguous analytically, simulation results in the constant elasticity case $t(q) = q^\varepsilon$ (reported in the Appendix) show that for low elasticity the externality term dominates while for high elasticity the monopoly term dominates.

3 The State, the Mafia and Illegal Exchange

The State may have good reason to reduce the Mafia's revenues. It may also wish to shrink the volume of trade protected by the Mafia. These goals can be in conflict.

Consider first the State's revenue reducing policies. In the limit, revenues can be driven below fixed cost and the Mafia will disappear. The analysis requires simple comparative statics. Using the envelope theorem, the effect of changes in the key variables is given by $R_b(q^m) = q^m\Pi > 0$, $R_c = -q^m$, $R_w(q^m) = q^m\Pi_w^m > 0$, $R_{\overline{B}} = q^m\Pi_{\overline{B}}^m < 0$. These results indicate that Mafias emerge only at higher levels of development, as noted above. The State can, however, act on the same variables to reduce Mafia profits through directly predating on the trade, through lowering willingness to pay or through raising cost c.

The State may at the same time want to reduce the volume of illegal exchange through its anti-Mafia policy, and this can be in conflict. Most obviously, driving the Mafia out of business can increase the volume of trade if the monopoly power of the Mafia predominates over its technology and internalization advantages. While policies which reduce Mafia profits will ordinarily reduce volume as well, we qualify these conclusions below. Finally, the comparative statics of our model suggest that the efficacy of the main methods of State attack on the Mafia depends on the effectiveness of the Mafia technology in recovering stolen goods, M in the model.

One method of State attack is to 'tax' Mafia members. We have in mind actual tax enforcement as well as raising the expected jail time over the member's life. Much of the effect of this policy will not affect the volume of protected activity, serving merely to raise fixed cost and reduce profits.

A second State policy against the Mafia is preying on the exchange which it protects. Think of the illegal drugs trade. One of the main State enforcement policies is to raid exchange between the small retailers and their customers. Our model implies that State raiding policy will generally lower the volume of illegal exchange, however the policy will be less effective when Mafia enforcement is powerful.

Finally, State policy can attack illegal exchange by attempting to narrow the arbitrage gains, lowering buyers' willingness to pay (say no to drugs campaigns, releasing the names of customers of prostitutes) or raising sellers' costs (spraying farmers' fields with pesticide or bribing them to grow other crops, limiting illegal immigration of prostitutes). These policies are effective in our model but, again, their impact depends on the effectiveness of the Mafia's technology. Moreover, a deeper consideration of demand reducing policies suggests a possible contrary effect. If we (plausibly) allow the buyers' willingness to pay to be sensitive to volume, negative advertising will generally act on both b and b_q. Negative advertising may make demand more elastic, raising the Mafia's marginal revenue and acting to increase the volume of exchange. We explore this case below.

3.1 State Predation on Exchange

State predation on exchange can be understood simplistically as an increase in $\overline{B}$ in terms of our model as the supply of predators shifts out. A rise in $\overline{B}$ raises γ and lowers illegal exchange. Taking the total differential of the first order condition in (6) we get:

$$\frac{dq^m}{d\gamma} = -\frac{b(\Pi_\gamma + q\Pi_{q\gamma})}{R_{qq}} < 0$$

The effect of State attacks on the volume of illegal exchange depends on the strength of the Mafia technology. In particular, State attacks are less effective when the Mafia is powerful. In the Appendix we show that:

$$\frac{\partial \left|\frac{dq^m}{d\gamma}\right|}{\partial M} = \frac{bR_{qq}(\Pi_{\gamma M} + q\Pi_{q\gamma M}) - b(\Pi_\gamma + q\Pi_{q\gamma})R_{qqM}}{(R_{qq})^2} < 0$$

Intuitively, an increase in the number of predators affects the volume of exchange through its effect on the probability of avoidance. Avoiding attacks, however, loses relevance when the Mafia has a powerful recovery technology (high M).

The proper general equilibrium approach to State predation on illegal exchange recognizes that State raids reduce the gains to private predation and thus there will ordinarily be an offsetting decline in private predation. We show that the net effect is positive: a rise in State predation always increases total predation.[12]

[12] Plausibly, State raiders are no better or worse than private predators at finding and stealing exchange. Then all raiders face the success rate $1 - \pi$ and have expected gain $(1 - \pi)q/B$, where $B = B_T + B_G$ and B_T is the private number of Thieves and B_G is the Government number of raiders. Private predator supply is determined by

$$\frac{B_T}{\overline{B}} v = (1 - \pi)q/(B_T + B_G).$$

Solving for the positive root, predator supply is given by:

$$B_T = -\frac{B_G}{2} + \frac{1}{2}[B_G^2 + 4(1 - \pi)q\overline{B}/v]^{1/2}.$$

It is straightforward to show that $\partial B_T/\partial B_G < 0$ and $\partial(B_T + B_G)/\partial B_G > 0$. Thus 'crowding out' is less than complete, State predation increases the total amount of predation, acting like a rise in $\overline{B}$.

3.2 State Attacks on Buyers' and Sellers' Prices

State policy can lower b or raise c. The Mafia responds to either of these policies with a fall in optimal trade volume.

Increases in b or reductions in c raise the arbitrage margin and the optimal Mafia pricing of enforcement accommodates this with a higher trade volume. Evaluating R_{qb} and R_{qc} we obtain:

$$\begin{aligned} \frac{dq^m}{db} &= -\frac{\Pi + q\Pi_q}{R_{qq}} > 0 \\ \frac{dq^m}{dc} &= -\frac{-1}{R_{qq}} < 0. \end{aligned}$$

Thus these policies are effective. We can also show (see Appendix) that an improvement in Mafia's technology reduces the effectiveness of supply-side policies while it has an ambiguous effect on the effectiveness of policies directed at reducing demand. The latter occurs because the marginal effect of the buyers willingness to pay on the volume of exchange depends positively on the probability of successful exchange, which, in turn, is higher when M is higher.

A deeper consideration of the nature of demand side policies suggests that marginal willingness to pay b is richly endogenous. In particular, b depends on quantity q, the substitution effect means $b_q < 0$ and substitution at the extensive margin suggests that $b_{qq} < 0$ (demand is less sensitive to price as quantity q falls). The Mafia in its choice of enforcement price τ would internalize b_q. Demand reducing policies of the State lower b but may raise or lower the slope b_q, so it appears possible that demand attack could raise sales. This possibility can be illustrated by considering the effect of anti-drugs advertising.

The effect of negative advertising A (e.g. antidrug television campaigns) on the Mafia enforcement level of exchange is given by:

$$\begin{aligned} \frac{dq^m}{dA} &= -\frac{1}{R_{qq}} R_{qA} \\ R_{qA} &= \pi b_A (1 + q\Pi_q^m/\Pi) + q\pi b_{qA}. \end{aligned}$$

The direct effect of advertising A on price b_A acts to reduce trade volume as expected. The effect on monopoly power acting through b_{qA} reduces (increases) trade volume as $b_{qA} < (>) 0$. More precise results obtain in the constant (inverse) elasticity case $qb_q/b = -\eta$, where η is a parameter. Constant elasticity implies a useful restriction on the effect of advertising on demand: $qb_{qA} = -b_A\eta > 0$, hence

$$\begin{aligned} R_{qA} &= \pi b_A \left[1 + q\Pi_q/\Pi - \eta\right] \\ &> 0 \; as \; \eta > 1 + \frac{(1-\Pi^m)(\Pi^m - M)}{2(1-M) - (\Pi^m - M)}. \end{aligned}$$

Thus in the constant elasticity case, advertising is counterproductive if η exceeds $2 - \Pi^m$; a condition met if the elasticity of demand is less than 1/2.

4 State Competition with the Mafia

The State and the Mafia compete for customers and revenue in property rights enforcement, whether the Mafia enforces in legitmate or illegal markets. Legitimate markets often separate into white and grey markets, as in the sale of cigarettes in the UK, or as in gambling in the US (which is provided by both State licensed lotteries and casinos and by illegal bookmakers and lotteries). As for illegal markets, the drug trade competes with the State's enforcement and taxation of alcohol. In either case, the State's desire for more revenue can conflict with its desire to shrink the Mafia's revenue or customer base.

We model the competition of the State and the Mafia as a duopoly with the two markets naturally differentiated by location in space, time of day and other features. The two markets are connected because both predators and traders can operate in either of the markets. Predators allocate themselves between markets to equalize their expected payoff. The perfect substitutes simplifying assumption is natural if predators are thieves, less so if the predators in formal markets are corrupt officials. Imperfect substitution of predators across markets weakens the multi-market aspect of the safety in numbers externality. The two markets need not be perfect substitutes for traders.

The rival enforcement 'firms' play Nash relative to each other. Moreover, we assume that both the State and the Mafia play Nash relative to the predators. This assumption is natural for a duopolist because the supply of predators he faces is affected by his rival's play. In contrast, we assume that the duopolists exploit the downward sloping demand for their services in their market strategies.

Predicting the result of State policy toward the Mafia depends on knowing the nature of their competition. We assume Cournot competition in the text because we think it is the relevant case as argued below. We show that the trade volumes are strategic complements if trade marginal costs are only weakly interdependent whereas the volumes are strategic substitutes if trade marginal costs are strongly interdependent. (If marginal costs are constant, independence holds. With increasing marginal costs, the issue is the extent to which trading resources in the two markets are close substitutes. For many cases of white and black markets, substitution is likely to be low.) With strategic complementarity, many State policies which reduce Mafia revenue also tend to reduce State revenue. Strategic complementarity thus may provide an explanation for the persistence of the Mafia or specialized private enforcement when State enforcement appears able to replace it. In contrast, with strategic substitutes the State can expand its revenue while shrinking the Mafia. Price (Bertrand) competition is modeled in the Appendix, where enforcement prices are shown to usually be strategic substitutes.

4.1 The Basic Setup

The probability of successful exchange is a compound of avoidance and the ability of the enforcer to recover goods or deter attack. We assume that the avoidance technology is the same in the two markets. We allow for possible asymmetry of enforcement between the Mafia and the State. Variables in the State protected market are denoted with a *. The probability of success in each market is given by

$$\begin{aligned}\pi^* &= \frac{1}{1+\theta B^*/q^*} + M^*\left(1 - \frac{1}{1+\theta B^*/q^*}\right) = \frac{q^* + M^*\theta B^*}{q^* + \theta B^*} \\ \pi &= \frac{q + M\theta B}{q + \theta B}.\end{aligned}$$

The predators allocate themselves between the two markets to equalize their expected payoffs. For simplicity we assume that the goods stolen in each market have a common exogenous price in the thieves market. (Endogenizing the prices in the thieves market would make the model more complex without adding much insight to the endogenous determination of the level and allocation of predation featured in our model. The common price assumption is a harmless simplification.) The supply of predators to both markets must earn its fixed opportunity cost. Thus:

$$\frac{B+B^*}{\overline{B}}w = (1-\pi)q/B = (1-\pi^*)q^*/B^*.$$

These four equations determine (π, π^*, B, B^*) as functions of q, q^* and the parameters. The Appendix shows that the system has a closed form solution which is quadratic, with only one positive, economically relevant root. This is the solution $\Pi(q, q^*)$ and $\Pi^*(q, q^*)$. Evaluating the key derivatives of Π with respect to q and q^* at the positive root we obtain $\Pi_q > 0$, $\Pi_{q^*} > 0$, and similarly for Π^*. The implication for the duopoly model is that sales in the two markets are complements due to the predators' allocation: more sales in one market will raise the willingness to pay in the other market.

4.2 Quantity (Cournot) Competition

We have previously supposed that the provision of enforcement capacity M requires fixed cost F. It is plausible that the required capacity and its cost differs with the size of the market. Guarding a trade zone and arranging information gathering about predators both appear to have resource requirements which vary with size. To preserve the simple expressions used previously, we assume that the marginal cost of capacity is constant (with a fixed cost component remaining which is invariant to size). Then marginal profit is equal to marginal revenue less a constant, which is formally equivalent to changing our expression R_q by augmenting the seller's cost c by a constant. All previous analysis remains valid.

The mode of competition between State and Mafia suggested by this setup is naturally capacity — effectively quantity — competition. The Nash equilibrium solution for the Mafia and the State in setting quantities (Cournot competition) is defined by simultaneous revenue maximization given the other player's quantity. Both players take the number of predators as given in calculating the marginal profitability of sales expansion. This is a natural consequence of Nash play in quantities, since the number of predators in each market depends on a success rate which is a function of the quantities in both markets. The anticipated probability of success must be rational, equal to the objective probability, but the players' derivative of the probability with respect to sales is 'naive'. Thus rather than Π_q the Mafia uses

$$\frac{q\pi_q}{\pi} = \frac{q\theta B(1-M)}{(q+M\theta B)(q+\theta B)}; \tag{7}$$

and rather than $\Pi^*_{q^*}$ the State uses

$$\frac{q^*\pi^*_{q^*}}{\pi^*} = \frac{q^*\theta B^*(1-M^*)}{(q^*+M^*\theta B^*)(q^*+\theta B^*)}. \tag{8}$$

The Mafia and State operating profits (marginal capacity cost is subsumed as part of c and c^*) are

$$\begin{aligned} R(\pi, q, q^*, \cdot) &= q[\pi b - c - t(q, q^*)] \\ R^*(\pi^*, q, q^*, \cdot) &= q^*[\pi^* b^* - c^* - t^*(q, q^*)]. \end{aligned}$$

Here we allow for cross effects in the trade cost functions as well as the cross effects which arise in the probability of success. If traders are equally capable in each market, then $t(q, q^*) = t^*(q, q^*) = t(q + q^*)$. The Cournot-Nash equilibrium is defined by

$$\begin{aligned} R_q &= \pi b - c - t + (q\pi_q/\pi)\pi b - (qt_q/t)t = 0 \\ R^*_{q^*} &= \pi^* b^* - c^* - t^{*s} + (q^*\pi^*_{q^*}/\pi^*)\pi^* b^* - (q^* t^*_{q^*}/t^*)t^* = 0, \end{aligned} \tag{9}$$

where the evaluation uses $\pi = \Pi(q, q^*)$ and $\pi^* = \Pi^*(q, q^*)$ and the levels of B, B^* used to evaluate π_q and $\pi^*_{q^*}$ are consistent with equilibrium:

$$\begin{aligned} B &: \Pi(q, q^*) = \frac{q + M\theta B}{q + \theta B} \\ B^* &: \Pi^*(q, q^*) = \frac{q^* + M^*\theta B^*}{q^* + \theta B^*}. \end{aligned}$$

We assume that the second order conditions $R_{qq} < 0$ and $R^*_{q^*q^*} < 0$ are met, which requires sufficiently large t_q and $t^*_{q^*}$, and is necessarily met somewhere with convex costs. We also assume the stability condition $D \equiv R_{qq}R^*_{q^*q^*} - R_{qq^*}R^*_{q^*q} > 0$. Finally, we assume the existence of equilibrium, which requires positive profits (surplus greater than the fixed costs) for each player.

A key property of the Cournot-Nash equilibrium is strategic complementarity: $R_{qq^*} > 0$ and $R^*_{q^*q} > 0$. This is based on safety in numbers:

$\Pi_{q^*} > 0$ and $\Pi^*_q > 0$. A contrary force comes from cross effects in marginal costs $t_{qq^*} > 0$, $t^*_{q^*q} > 0$ but complementarity holds provided these are not too strong.[13] A complicating factor arises because the elasticities $q\pi_q/\pi$ $(q^*\pi^*_q/\pi^*)$ depend on B (B^*) which in turn depend on q (q^*) through $\Pi(q, q^*)$ and $\Pi^*(q, q^*)$ respectively. The Appendix shows that, incorporating this extra complication, strategic complementarity still ordinarily holds when safety in numbers dominates cross effects in marginal costs.

4.2.1 State anti-Mafia Policies

The State can attack the Mafia's market in various ways, with implications given by the comparative statics of Cournot-Nash equilibrium. First, consider policy which shifts b or c in the Mafia-protected market:

$$\begin{aligned} dq/db &= \pi dq/dc = -\pi R^*_{q^*q^*}/D > 0 \\ dq^*/db &= \pi dq^*/dc = \pi R^*_{q^*q}/D > 0. \end{aligned}$$

Strategic complementarity implies that a State which seeks to enhance its sales by reducing the value of Mafia sales or by increasing the cost of business in the Mafia market will fail. This arises intuitively because the deflection of predators onto the State's market will end up reducing State sales. Moreover, this implies that State policy directed against the Mafia via reduction of b or increase in c will *reduce* profits: $dR^*/db = R^*_q dq/db$ and $R^*_q = qb\Pi_{q^*} - qt_{q^*} > 0$ ordinarily .

Now consider the comparative statics of action which reduces the Mafia's protective power M. From (13) we can show $\Pi_M > 0$ and $\Pi^*_M > 0$. The effect of a rise in M on State profits is given by $dR^*/dM = R^*_M + R^*_q dq/dM = b^*\Pi^*_M + \left[\Pi^*_q b^* - q^* t^{*s}_{q^*}\right] dq/dM$. From the best response system (9) we obtain with strategic complementarity:

$$dq/dM = \frac{1}{D}\left[-R^*_{q^*q^*}\Pi_M b + R_{qq^*}\Pi^*_M b^*\right] > 0.$$

[13]Even when trade in the two markets is perfectly substitutable for traders, strategic complementarity can obtain. Under perfect substitutes, the trade cost term in R_{qq} is equal to $-2t_q - qt_{qq}$ while the trade cost term in R_{qq^*} is equal to $-t_q - qt_{qq}$. The difference opens up space for $R_{qq} < 0$ and $R_{qq^*} > 0$. Simulation results for the loglinear trade cost case indicate that small cross elasticities of marginal trade cost $t_{qq^*}q^*/t_q$ suffice to reverse strategic complementarity.

Similarly, $dq^*/dM > 0$. Thus attacks on Mafia protective power reduce the volume of trade in both markets. Due to safety in numbers, $R_{q^*} > 0$, hence $dR^*/dM > 0$. An attack on the Mafia's power M ordinarily reduces the State's revenues.

Finally, note that a corollary of the preceding paragraph, using the essential symmetry of the model, is that an increase in State power to enforce, M^*, will ordinarily raise the revenue of the Mafia under strategic complementarity. Thus marginal improvements in State enforcement tend to strengthen the Mafia.

4.3 Policy Implications

We conclude that ordinarily State attempts to reduce the volume of exchange protected by the Mafia will reduce the volume of State protected exchange. State attacks on the Mafia market will reduce Mafia profits but will normally also reduce State revenues. Interpreting the Mafia protected exchange as undesirable (drugs), an extra expense of policies which reduce criminal exchange is the reduction in State revenue due to the rise in predation on State protected exchange. Alternatively interpreting the Mafia protected exchange as inherently productive, the policies which enhance State revenue must also enhance Mafia revenue. Strategic complementarity in enforcement may help explain the persistence of Mafias in States which appear capable of driving out Mafias.

5 The State and the Informal Sector

Suppose that the State offers formal enforcement to a market which operates alongside a self-enforcing informal market. The product exchanged in each market is differentiated by locational characteristics (physical location, time of day, etc.). It is possible to interpret the formal model alternatively as applying to the monopoly as the Mafia and the self enforcing market as the competitive fringe. For this setup, the policy issues arise as the State intervenes in hopes of changing the aggregate trade volume. We note an implication of this case below, but mainly stick to the formal/informal sector interpretation.

The monopoly/competitive fringe structure is explained by entry barriers. The State operates alongside an informal sector which is too costly to organize.. Organization cost may be due to the informal sector's location in a rebel region, ethnic distrust of the State by the traders in the informal sector or ethnic distaste by the State's enforcers for the informal sector traders.

The informal market has variables denoted with a *. The predator allocation conditions are just as in the Cournot duopoly case. The markets are connected because the predators move between them to equalize their payoffs in each. We assume that the predators sell the stolen products in a thieves market at a common fixed price for simplicity. Also, only sellers have costs and only sellers are attacked. The only difference from the duopoly case is that $M^* = 0$ for the self-protection market. This specialization implies that the reduced form success rate in the competitive fringe market is a function of the aggregate product, $\Pi^*(q + q^*)$, using (13) in the Appendix.

The equilibrium of this 2 market system is determined as follows. The quantity of product exchanged in the informal sector, or competitive fringe is the solution q^* to

$$\Pi^*(q + q^*)b^* - c^* - t^*(q^*) = 0 \tag{10}$$

The monopoly first order condition is

$$\Pi(q, q^*)b - c - t(q) + \frac{q\pi_q}{\pi}\pi b - \frac{qt_q}{t}t = 0. \tag{11}$$

The two conditions (10)-(11) may be treated as 'reaction functions' as in the Cournot case, and together they determine equilibrium. The 'competitive reaction' function may be positively or negatively sloped. Thus on the competitive fringe side the actions may be 'strategic substitutes'. (We place quote marks around strategic substitutes to indicate that the competitive market is not a strategic player, but may be treated as if it were.) Explicitly, for the competitive fringe we have

$$\frac{dq}{dq^*}|_{\pi^* b^* - c^* - t^* = 0} = \frac{t^*_{q^*}}{\Pi^*_{q^*} b^*} - 1 > -1.$$

Strategic complementarity implies $\Pi^*_{q^*} b^* - t^*_{q^*} < 0$, willingness to pay is decreasing in volume. While this is ordinarily quite reasonable, the case of strategic substitutes arises as $t^*_{q^*}$ is small (i.e., as the elasticity of supply is large) or as the safety in numbers externality is large. On the monopoly's side the actions continue to be strategic complements

5.1 Policy Implications

Interesting comparative statics of policy can occur in the monopoly with competitive fringe market structure. Policies which reduce competitive exchange reduce exchange in the monopoly market regardless of whether the competitive reaction is complementary or substitutable. In contrast, policies which reduce monopoly exchange can raise or lower competitive exchange.

Thus State efforts to enhance revenue by attacking the informal sector are doomed to failure (so long as formal and informal trade volumes are strategic complements for the state). In contrast, State efforts to enhance revenue directly (for example, by improving State enforcement capacity M) will succeed and as a by-product will raise (lower) informal sector trade and revenue as the informal sector reaction function is positively (negatively) sloped.

Interpreting the model as applying to trade in illegal substances in parallel Mafia and self enforced markets, State attacks on the Mafia monopoly market can lower or raise sales on the self enforced market. Thus paradoxically it is possible for total illegal sales to rise with a successful attack on the Mafia. (The slope of the competitive 'reaction function' dq^*/dq must be less than -1.) In contrast, a successful attack on the self enforced trade must always lower Mafia enforced trade and thus total trade. Thus a policy of attacking the retail trade and the small traders, contrary to conventional wisdom, may often be preferred to an attack on Mafia protected trade, all else equal.

6 Development and the Share of the State

Higher levels of economic development are roughly associated with better enforcement, according to the survey data in Table 1. Although measures of the size of informal sectors are notoriously inaccurate, subjective impressions suggest that the share of the formal sector is positively associated with level of economic development. These observations motivate an exploration of the effect of changes in parameters associated with the level of development on the relative shares of the formal and informal markets. Due to the complexity of the model, we simulated a constant cost elasticity version of the model to obtain results. We explored both the duopoly and competitive fringe versions of the model.

A natural benchmark is symmetry. We then introduce a fundamental asymmetry $M^* > M$ associated with the State having a stronger enforcement technology and then examine the effect of changes in $\overline{B}/w$, $b = b^*$ and $\theta = \theta^*$.on the shares of the State and Mafia. Asymmetry naturally increases the share of the favored player, while due to strategic complements, the other player also benefits. These effects are fairly substantial: R^*/R has an elasticity with respect to M^* around 1 while q^*/q has an elasticity around 0.15 in our simulations.

The key result is that the other parameters have very little effect on q^*/q and only quite small effects on R^*/R. Surprisingly, increases in $\overline{B}/w$, while they decrease revenues and trade volume, do so with quite small elasticities, around 0.1 to 0.15, and have quite small effects on the equilibrium probabilities of success. The same is true for changes in the other parameters. Our model provides no support for the hypothesis that higher levels of development defined by changes in predator supply drying up $\overline{B}/w$ or increases in the arbitrage margin $b = b^*$ relative to $c = c^*$ will increase the share of the State relative to the Mafia. Neither will development erode the prevalence of predation. We also experimented with shifts in the trade cost function, reasoning that development, especially commercial development, is associated with falls in transport costs. The effect of falls in transport costs is neutral between markets while of course raising volume in each and to a lesser degree raising revenue.

Another key implication of the simulations is that strategic complementarity obtains only when the cross effects on marginal trade costs are quite small. Thus while safety in numbers provides a presumption of complementarity, the exact way the model is parameterized will matter to whether this presumption holds up. None of the comparative static results of this section depends on whether actions are strategic substitutes or complements.

Turning to the competitive fringe case, we find in contrast a strong implication that the improvement in the level of development will *decrease* the share of the State, where development is represented by changes in predator supply drying up $\overline{B}/w$ or increases in the arbitrage margin $b = b^*$ relative to $c = c^*$. The arc elasticity of q^*/q with respect to $\overline{B}/w$ varies quite a bit in the unit interval but is usually substantial, and the average value in our simulations is 0.5. The difference between the duopoly and competitive fringe cases is because the competitive fringe responds much more strongly to improvements in trade opportunities than does a duopolist. Our model does not support a conclusion that the State will wither away as its enforcement role declines in importance because the State has other instruments with which to preserve its position. What seems fairly robust is that neither variant of the model provides support for development increasing the share of the State 'naturally' from the forces operating within the model.

7 Conclusion

We have developed a model of trade with predation and enforcement organized in a variety of institutional structures. A key feature of the interaction of predators and traders is safety in numbers: the success rate rises with the volume of trade. Monopoly enforcement will internalize this externality, leading to a rise in trade, all else equal. This trades off against the exercise of monopoly power and the better technology of specialized enforcement in determining whether volume rises with the establishment of specialized enforcement. Considering a market in undesirable products in isolation, State action against the trade can be perverse. For example, destroying the Mafia can increase trade if monopoly power is more important than internalization of safety in numbers and better technology. In a multimarket setting, safety in numbers leads to strategic complementarity between the enforcement capacities of duopoly enforcers. Thus a State may be reluctant to attack Mafia enforcement because of the loss of revenue it will suffer in its legitimate market enforcement business. With monopoly in one market and a 'competitive fringe' (self enforcement) in the other market, a State will lose revenue in the formal sector from attacking the informal sector (the self enforced market). This result may help explain the persistence of large informal markets in economies which appear capable of shrinking informal trade.

We think these models offer a rich but fairly simple and flexible platform for the future analysis of enforcement as protection of exchange from predation. One important issue is to endogenize the market structure. What prevents the monopoly from spreading to both (all, if there are many) markets? What would keep the monopoly safe from entry? How about collusion between State and Mafia? Another significant issue is closing the model with connections between the volume of trade and the supply of predators. Historically, at least, the expansion of trade through the commercialization of agriculture pushed out a landless peasantry, some into brigandage. The growth of State enforcement provides opportunities for a corrupt officialdom. Incorporating these forces into the model suggests the possibility of multiple equilibrium, with low trade poverty traps which are not trivially explained by coordination failures relative to fixed cost infrastructure. Finally, while the trade in the model can readily be international, we have suppressed conventional terms of trade effects (endogenous b and c) and allow for at most one active State. Relaxing one or both of these may provide more insights into trade-destroying policies of developing and transition economies.

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8 Appendix

8.1 Does Mafia enforcement promote illegal trade?

In Section 2 above we showed that the volume of exchange under Mafia protection might be larger or smaller compared to the volume under self enforcement depending on the balance of three forces: internalization of the "safety in numbers"externalit y, superior technology and monopoly pricing.

This Appendix presents the results of a simulation which shows that Mafia increases the volume of exchange, i.e. the first effects prevail, when trade elasticity is small while the opposite occurs when elasticity is large.

We assume that trade costs are of the constant elasticity type so that $t(q) = q^{\varepsilon}$.

Under self enforcement π, q^c solve:

$$\begin{cases} \pi = \frac{1}{1+\gamma \sqrt[2]{\frac{1-\pi}{q}}} \\ q = (\pi b - c)^{1/\varepsilon} \end{cases} \tag{A1}$$

A1 cannot be solved algebraically. We solve it numerically for the following combinations of parameters:

	$C1$	$C2$	$C3$	$C4$
b	10	10	10	50
c	1	1	5	1
γ	1	5	1	1
ε	$0.3, 0.5, 0.7, 1, 2, 5$	$0.3, 0.5, 0.7, 1, 2, 5$	$0.3, 0.5, 0.7, 1, 2, 5$	$0.3, 0.5, 0.7, 1, 2, 5$

We then evaluate

$$R_q(q) = \Pi_q^m bq + (\Pi^m(q) - \Pi(q)) - \varepsilon t(q)$$

at q^c, solution of A1.

The results suggest that:

1.for low elasticities (e.g. for $\varepsilon < 0.7$ in $C1$), the marginal revenue at q^c is positive $\rightarrow q^m > q^c$, whereas

2. for high elasticities (e.g. for $\varepsilon > 0.7$ in $C1$), the marginal revenue at q^c is negative $\rightarrow q^m < q^c$.

Figures 2 and 3 below depict marginal revenue evaluated at q^c as a function of M, with parameters as in $C1$ and $\varepsilon = 0.3$ and $\varepsilon = 2$ respectively.

8.2 State Policies to reduce illegal exchange.

We first show that

$$\frac{dq^m}{d\gamma} = -\frac{b(\Pi_\gamma + q\Pi_{q\gamma})}{R_{qq}} < 0$$

From the second order condition we know that $R_{qq} < 0$. Solving explicitly for π from $\pi = \frac{1}{1+\gamma \sqrt[2]{\frac{1-\pi}{q}}}$ we obtain $\Pi = \frac{(-q+X)+2\gamma M}{2\gamma^2}$ where $X = \sqrt{(q\,(q+4\gamma^2(1-M)))}$. Taking derivatives we have:

$$(\Pi_\gamma + q\Pi_{q\gamma}) = q\left(\frac{X-q-2\gamma^2(1-M)}{\gamma^3(-q-4\gamma^2(1-M))} + \frac{\left(-q-4\gamma^2(1-M)\right)X+q^2+6\gamma^2 q(1-M)+4\gamma^4(1-M)^2}{(-q-4\gamma^2(1-M))\gamma^3 X}\right)$$

where $X = \sqrt{(q\,(q+4\gamma^2(1-M)))}$

Simplifying we see that: $sign(\Pi_\gamma + q\Pi_{q\gamma}) =$
$sign\,[4q(q+4\gamma^2(1-M)^3 - (2q^2+12\gamma^2 q(1-M)+12\gamma^4(1-M)^2)^2] < 0$

Second, we show that: $\frac{\partial\left|\frac{dq^m}{d\gamma}\right|}{\partial M} = \frac{bR_{qq}(\Pi_{\gamma M}+q\Pi_{q\gamma M})-b(\Pi_\gamma+q\Pi_{q\gamma})R_{qqM}}{(R_{qq})^2} < 0$

It is easy to see that $R_{qqM} = 2\Pi_{qM} + q\Pi_{qqM} = -12\gamma^4 \frac{(1-M)^2}{(-q-4\gamma^2(1-M))^2 X} < 0$

Third, $\frac{dq^m}{db} = -\frac{\Pi+q\Pi_q}{R_{qq}} > 0$ follows from $\Pi + q\Pi_q > 0$. Indeed

$\Pi + q\Pi_q = \frac{1}{2}\frac{X(X-q)+2X\gamma^2 M+q^2+2\gamma^2 q(1-M)}{g^2 X} > 0$

Finally $\frac{\partial\left|\frac{dq^m}{db}\right|}{\partial M} = \frac{-(\Pi_M + q\Pi_{qM})(R_{qq}) + (\Pi + q\Pi_q)R_{qqM}}{(R_{qq})^2}$. From above we know that $(\Pi + q\Pi_q) > 0$ and $R_{qqM} < 0$. We can show that

$\text{sign}(\Pi_M + q\Pi_{qM}) = \text{sign}\ (12q^2\gamma^4(1-M)^2 + 64q\gamma^6(1-M)^3) > 0$; which implies that the sign of $\frac{\partial\left|\frac{dq^m}{db}\right|}{\partial M}$ is ambiguous.

8.3 Cournot Competition

The probability of success in each market is given by

$$\begin{aligned} \pi^* &= \frac{q^* + M^*\theta B^*}{q^* + \theta B^*} \\ \pi &= \frac{q + M\theta B}{q + \theta B}. \end{aligned}$$

The predators allocate themselves between the two markets to equalize the payoff. The supply of predators to each market must earn its fixed opportunity cost. Thus:

$$\frac{B + B^*}{\overline{B}} w = (1-\pi)q/B = (1-\pi^*)q^*/B^*.$$

These four equations determine (π, π^*, B, B^*) as functions of q, q^* and the parameters. The system has a closed form solution which is quadratic. First, manipulating the allocation equations yields

$$\begin{aligned} B &= (1-\pi)q\left[\frac{\overline{B}/w}{(1-\pi)q + (1-\pi^*)q^*}\right]^{1/2} \qquad (12) \\ B^* &= (1-\pi^*)q^*\left[\frac{\overline{B}/w}{(1-\pi)q + (1-\pi^*)q^*}\right]^{1/2}. \end{aligned}$$

Second, note that the probability of success equations imply:

$$\begin{aligned} (1-\pi)q &= (\pi - M)\theta B \\ (1-\pi^*)q^* &= (\pi^* - M^*)\theta B^*. \end{aligned}$$

Taken with the preceding expressions for B, B^* this implies that

$$\pi - M = \pi^* - M^*.$$

Substitute the expression for B into $(1-\pi)q = (\pi - M)\theta B$ to obtain:

$$[(1-\pi)q + (1-\pi^*)q^*]^{1/2} = (\pi - M)\theta \left(\overline{B}/w\right)^{1/2}.$$

Substituting $\pi^* = \pi + M - M^*$ into the preceding equation and solving, we obtain a quadratic in π :

$$\begin{aligned} a\pi^2 + b\pi + c &= 0 \\ a &= -\theta^2\overline{B}/w \\ b &= 2M\theta^2\overline{B}/w - (q+q^*) \\ c &= q + q^*(1 - M^* + M) - M^2\theta^2\overline{B}/w. \end{aligned} \tag{13}$$

If $ac < 0$, π has only one positive root. This is the solution $\Pi(q, q^*)$. We assume $c > 0$ to rule out complex roots on the one hand (which precludes the existence of equilibrium) and on the other hand the possibility of two equilibria of which one has perverse comparative statics and is unstable.

8.3.1 Strategic Complementarity

Start with the best response function of the Mafia defined in the text:

$$R_q = \pi b - c - t + \pi b\eta - qt_q = 0.$$

Here, η is the naive elasticity $\pi_q q/\pi$:

$$\eta \equiv \pi_q q/\pi = (1-M)\frac{q\theta B}{(q + M\theta B)(q + \theta B)}. \tag{14}$$

Strategic complementarity obtains iff $R_{qq^*} > 0$. Taking the derivative we obtain

$$R_{qq^*} = \Pi_{q^*} b(1+\eta) - qt_{qq^*} + \pi b\eta \left(\frac{\eta_B B}{\eta}\right)\left(\frac{B_{q^*}}{B}\right). \tag{15}$$

In the text, we note that B must be consistent with $\Pi(q, q^*) = \frac{q + M\theta B}{q + \theta B}$. This implies that B is a function of q, q^*. Thus

$$B = \frac{q}{\theta}\frac{1 - \Pi(q, q^*)}{\Pi(q, q^*) - M}. \tag{16}$$

The semi-elasticity of B with respect to q^* is given by differentiating (16):

$$B_{q^*}/B = -\Pi_{q^*}\left[\frac{1}{1-\pi} + \frac{1}{\pi - M}\right] < 0. \tag{17}$$

This is intuitive; via safety in numbers, the larger State market spreads the predators among the two by drawing some away from the Mafia market. The players use the naive elasticity in setting their quantities, based on ignoring the change in predation B. Notice that at $M = 0$, $\eta = \pi$. The elasticity of η with respect to B is given by

$$\frac{\eta_B B}{\eta} = 1 - \frac{M\theta B}{q + M\theta B} - \frac{\theta B}{q + \theta B} \quad (18)$$

$$= \frac{\eta}{1-M}\frac{1 - M(\theta B/q)^2}{\theta B/q}. \quad (19)$$

To obtain the last line, use the common denominator to evaluate the right hand side of (18) and then substitute from(14). This elasticity can turn negative as M becomes large, though negativity also requires that the probability of evasion $1/(1 + \theta B/q)$ must be large.

Substituting (18) and (17) into (15) we obtain

$$R_{qq^*} = \Pi_{q^*}b(1+\eta) - qt_{qq^*} - \Pi_{q^*}b\pi\eta\left(\frac{\eta}{1-M}\right)\left(\frac{1 - M(\theta B/q)^2}{\theta B/q}\right)\left(\frac{1}{1-\pi} + \frac{1}{\pi - M}\right)$$

$$= \Pi_{q^*}b\left(1 + \eta - \pi\eta\Omega\right) - qt_{qq^*}.$$

The size of the product of the three bracketed terms defining Ω is crucial. Using (14), (18) and (17) and defining $z \equiv \theta B/q$, the crucial product is simplified to:

$$\Omega \equiv \frac{1 - Mz^2}{1 + (1+M)z + Mz^2}\left(\frac{1}{1-\pi} + \frac{1}{\pi - M}\right).$$

At $M = 0$, $\eta = \pi$, $z = \theta B/q = (1-\pi)/\pi$ and Ω reduces to$1/(1-\pi)$. (15) reduces to

$$R_{qq^*} = \Pi_{q^*}b(1+\pi) - qt_{qq^*} - \Pi_{q^*}b\pi^2/(1-\pi)$$

$$= \Pi_{q^*}b[(1+\pi) - \pi^2/(1-\pi)] - qt_{qq^*}.$$

Thus we can claim that at $M = 0$, actions are strategic complements provided the probability of evasion is not too large and provided the safety in numbers externality outweighs the marginal cost cross effect. If π given $M = 0$ exceeds approximately 0.7, the actions are necessarily strategic substitutes when the marginal cost cross effect is minimal.

Now consider the effect of increases in M. First of all, η is decreasing in M directly. This acts to increase R_{qq^*}. Moreover, increases in M will ordinarily decease B for given q, by (16) and $\Pi_M > 0$. The result cannot be guaranteed, but is intuitive. The fall in B acts to increase R_{qq^*}. Second, if $\Omega_M < 0$, the effect of increasing M strengthens our conclusion. Evaluating,

$$\Omega_M/\Omega = -\frac{z^2}{1 - Mz^2} - \frac{z}{1 + (1+M)z + Mz^2} + \frac{1-\pi}{(\pi - M)(1-M)}.$$

At $M = 0$, Ω_M/Ω reduces to $\left(1 - \frac{1-\pi}{\pi}\right)\frac{1-\pi}{\pi} - (1-\pi)$. At $\pi = 1$, $[\Omega_M | M = 0] = 0$, while for $\pi < 1$, $\Omega_M < 0$. Thus at least locally, increases in M reinforce the conclusion that actions are strategic complements. As M rises, Ω_M changes both directly and due to changes in B, so tracing all the interactions is complex indeed. Presumptively, increases in M increase R_{qq^*}.

8.4 Bertrand Competition

The State and the Mafia may alternatively compete in prices (tax rates) given by τ, τ^*. In this case we define the demand functions as:

$$\begin{aligned} Q(\pi, \tau) &= \{q | \pi b - c - t^s(q) - \tau = 0\} \\ Q^*(\pi^*, \tau^*) &= \{q^* | \pi^* b^* - c^* - t^{*s}(q^*) - \tau^* = 0\}. \end{aligned}$$

Note that we have specialized the model to independent trade costs for simplicity.

The equilibrium probability of success in each market is solved as follows. Let p be the vector (π, π^*). Then the equilibrium vector of success rates is given by:

$$[P(\tau, \tau^*), P^*(\tau, \tau^*)] = \{(\pi, \pi^*) | \pi = \Pi[Q(\cdot), Q^*(\cdot)], \pi^* = \Pi^*[Q(\cdot), Q^*(\cdot)]\}.$$

We can readily show $P_\tau < 0$, $P_{\tau^*} < 0$ and similarly for P^*. Let $f(q/\beta) = M + (1-M)/(1 + \theta q/B)$. The naive success rates are given by:

$$\begin{aligned} \pi &= \tilde{\pi}[\tau, B] = \{\pi : \pi = f[Q(\pi, \tau), B]\}. \\ \pi^* &= \tilde{\pi}^*[\tau^*, B^*] = \{\pi^* : \pi^* = f^*[Q^*(\pi^*, \tau^*), B^*]\}. \end{aligned}$$

The State and the Mafia set prices to maximize revenue given the rival's price and given the supply of predators. Thus the Mafia solves

$$\max_\tau \tau Q[\tilde{\pi}(\tau, B), \tau],$$

while the State solves:

$$\max_{\tau^*} \tau^* Q^*[\tilde{\pi}^*(\tau^*, B^*), \tau^*].$$

Here, B and B^* satisfy $\tilde{\pi}(\tau, B) = P(\tau, \tau^*)$, $\tilde{\pi}^*(\tau^*, B^*)] = P^*(\tau, \tau^*)$. Thus implicitly the two predator allocations are functions of the prices τ, τ^*. Note that the two players's decisions interact only through the supply of predators, which each takes as fixed in Nash play against the predators. The best responses determine the Bertrand-Nash equilibrium:

$$\begin{aligned} R_\tau &= Q + \tau[Q_\pi \tilde{\pi}_\tau + Q_\tau] = 0 \\ R^*_{\tau^*} &= Q^* + \tau^*[Q^*_{\pi^*} \tilde{\pi}^*_{\tau^*} + Q^*_{\tau^*}] = 0. \end{aligned}$$

The levels of π, π^* and B, B^* used to evaluate these functions must be their equilibrium values.

The actions of the players are strategic substitutes in this model. For example, $R_{\tau\tau^*} = dQ/d\tau^* = Q_\pi \tilde{\pi}_B dB/d\tau^* = Q_\pi P_{\tau^*} < 0$. The comparative statics of the model are complex because all the parameters shift both of the best response functions. It is clear, however that ordinarily a rise in c, for example, will shift $R_\tau = 0$ by more than it shifts $R^*_{\tau^*} = 0$. Then the prices ordinarily move in opposite directions and so do the quantities. Therefore the comparative statics are qualitatively different from those of the strategic complements case.

Figure 1. Self Enforcement Equilibrium

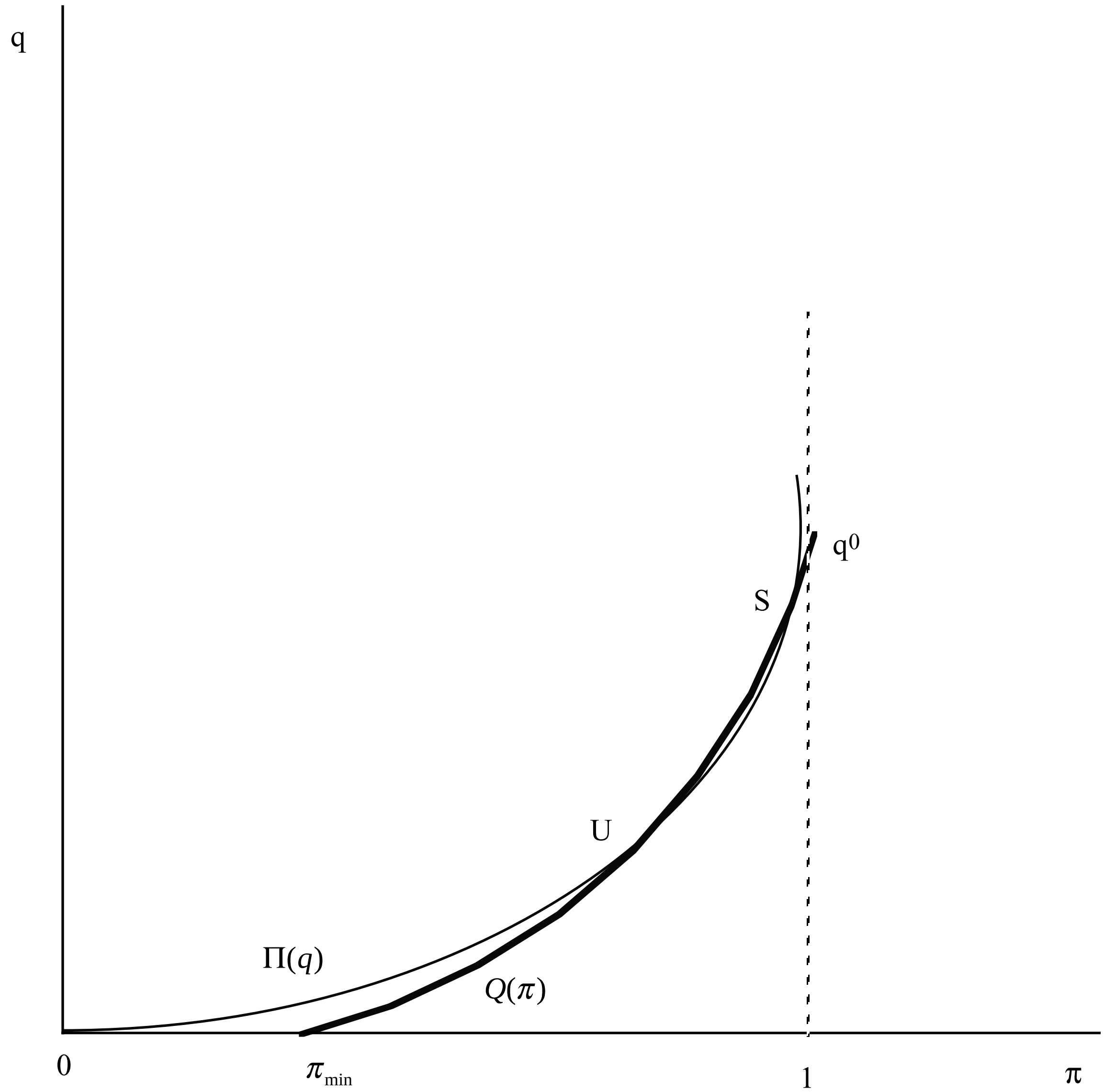

Table 1. Institutional Quality

Country	Transparency	Contract	Country	Transparency	Contract
ARGENTINA	3.41	4.18	JORDAN	2.75	3.88
AUSTRALIA	4.18	6.32	KOREA	3.26	5.35
AUSTRIA	3.32	6.51	MALAYSIA	3.68	5.85
BELGIUM-LUXEMBOURG	3.30	5.70	MEXICO	3.58	4.27
BRAZIL	3.56	5.11	NETHERLANDS	5.26	6.57
CANADA	4.44	6.77	NEW ZEALAND	5.36	6.54
CHILE	4.45	5.39	NORWAY	5.07	6.60
CHINA	4.03	3.76	PERU	4.46	4.19
CHINA: HONG KONG	5.44	6.48	POLAND	2.69	4.61
COLOMBIA	2.00	4.08	PORTUGAL	3.91	5.91
CZECH REPUBLIC	3.82	2.44	RUSSIA	2.11	2.94
DENMARK	4.12	5.82	SINGAPORE	5.70	6.64
EGYPT	4.14	4.00	SLOVAK REPUBLIC	2.36	4.64
FINLAND	5.31	6.60	SOUTH AFRICA	3.50	5.70
FRANCE	3.66	5.94	SPAIN	4.29	5.65
GERMANY	3.86	6.61	SWEDEN	3.86	6.62
GREECE	2.58	5.00	SWITZERLAND	4.49	6.64
HUNGARY	3.16	4.37	THAILAND	2.85	5.31
ICELAND	3.67	5.33	TURKEY	2.95	4.55
INDIA	3.15	5.24	UKRAINE	1.66	3.77
INDONESIA	3.47	4.41	UNITED KINGDOM	4.46	6.63
IRELAND	4.27	6.67	UNITED STATES	3.49	6.19
ITALY	3.23	4.95	VENEZUELA	2.85	2.41
JAPAN	3.58	5.99	ZIMBABWE	2.43	5.74

Transparency: Government economics policies are impartial and transparent
Contract: The legal system is effective in enforcing commercial contracts
Source: World Economic Form, survey of businessmen