

Traders, Cops and Robbers*

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Abstract

We propose a simple model of trade outside the law preyed on by robbers and possibly protected by private cops. We establish the conditions for trade collapse, secure trade and insecure trade. Endogenous predation and enforcement can explain both puzzling failures of commonly observed state policies against illegal trade and puzzlingly large trade responses to liberalization in licit goods.

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A very significant part of trade and economic activity is outside state enforcement and notoriously subject to predation. The illegal drug trade alone accounts for about 8% of total world trade revenue, more than, for instance, motor vehicles or textiles.¹ The informal sector as a whole, including the production of licit goods and services hidden from tax authorities, accounts for at least 30% of GDP in most developing countries and for an average 15% of GDP in OECD economies.²

Several important puzzles are raised by trade outside the law. Why does liberalization and globalization often raise trade by more than the measured cost reduction can account for (Baier and Bergstrand, 2001)? Predation appears to significantly depress trade (Anderson and Marcouiller, 2002), suggesting that endogenous reductions in predation may account for the extra trade. But more trade seems to suggest more predation, so how might this work? State attacks on illegal trade provide another set of puzzles. They often produce little reduction or even perverse increases in trade volume. For instance, the breakup of the Colombian drug trade cartels, possibly the most tangible outcome of the U.S. government's "war on drugs", was followed by a rise in volume as new, much smaller scale traders successfully organized the trade.³ Why do state policies to disrupt or reduce illegal trade fail? What

¹Annual revenues were estimated at \$400bn. See United Nations Office for Drug Control and Crime Prevention (1998).

²See Schneider and Enste (2000).

³See US General Accounting Office (1999) and *The Economist*, 11 September, 1999. Notwithstanding the sizeable US resources devoted to curtail the drug trade, the last twenty years have seen prices falling steadily and availability remaining unchanged. For instance, the estimated retail price of cocaine in the US fell from \$420 per pure gram to \$180 per pure gram between 1981 and 1999 (Abt Associates, 2001). Current expenditure for anti-drugs policies is about \$40bn in the US alone (for data on anti-drug policy expenditure

works?

We provide a simple model of trade and predation outside the law as a framework to answer these and related questions. Traders purchase a good from a low price location and ship it for resale in the consumers' high price location. Trade services are produced neoclassically by capital and labor in fixed supply. Shipments are preyed on by predators (thieves or extorters) drawn from the same labor pool as the traders, hence both trading and predating come at increasing opportunity cost. In anarchy, enforcement is not available and traders attempt to elude predators in anonymous hide and seek. In the alternative variant of the model, a specialized monopoly enforcer (private cops for licit trade or the mafia for illicit trade) charges a fee in return for frustrating a portion of encounters between traders and robbers.

Potential predation obliterates trade in some parameter ranges while in other parameter ranges trade will be secure, namely no predation will occur in equilibrium. Despite casual intuition about the predator/prey relationship suggesting that at least a little bit of both trade and predation should emerge, this only obtains in some parameter ranges. Private provision of enforcement has ambiguous effects on the volume of trade —eliminating the enforcer can raise or lower trade, depending on ranges of parameter values that we identify.

A key general equilibrium property of the model is safety in numbers: the rational expectations equilibrium probability of successful insecure trade is increasing in the volume of trade. Failure to internalize this externality

see *The Economist*, September 2, 2000 and *The White House* 2002). For estimates of production and trade volume see United Nations Office for Drug Control and Crime Prevention, *Global Illicit Drug Trends*, various issues.

contributes to the collapse of anarchic trade, while internalization by the enforcer increases trade, all else equal. Safety in numbers is also a key ingredient in explaining why globalization raises trade by more than the direct cost reduction can account for, and in explaining the failure of state policies such as drug raids to reduce or even perversely to increase trade.

The remainder of the paper is organized as follows. Section 1 sets out the model and analyses the trade equilibrium when private specialized enforcement is not available. Section 2 analyzes specialized monopoly enforcement. Section 3 analyzes state policy toward trade outside the law. Section 4 concludes.

1 Traders and Robbers

The elements of the model are the traders and robbers and their technologies for these two alternative activities. Their general equilibrium interaction combines equality of returns in the two activities, the rational expectations equilibrium shipment success rate, the labor market clearing condition and the zero arbitrage condition in trading. For simplicity we shut down other channels of general equilibrium, arguing below that the simplification is harmless.⁴ Traders and robbers are not directly involved either in production or consumption; their sole interest is the highest expected return on

⁴A full general equilibrium treatment of trade and predation in a two good two country model is in Anderson and Marcouiller (2004), with similar qualitative results on autarky, secure and insecure trade. Simulation shows how narrow is the parameter range which permits trade. The terms of trade effects of predation can create a ‘paradox of trade-creating predation’, whereby predation brings terms of trade such that the fixed trade cost can be offset in both countries. The present paper simplifies the structure to obtain analytic results in a model with enforcement and state policy.

their time.

1.1 Elements

Traders

Traders hire labor and capital and ‘sell’ trade services by buying in low cost region 1 to sell in high price region 2. We fix buyers’ willingness to pay in region 2 at b and we assume that any quantity of the good can be purchased at price $0 < c < b$ in region 1.⁵

Minimum trade costs are given by the Cobb-Douglas function $w^\alpha r^{1-\alpha} q$ where q is the trade volume, w is the wage rate, r is the service price of trade capital and α is the parametric cost share for labor.⁶ It helps intuition to think of traders as using their own labor and hiring ‘ships’ and other labor, but capital could also represent infrastructure. The key ingredient is diminishing returns to labor in trade services. In equilibrium, traders and the workers in trade services earn the wage rate. The capital stock in trade services is fixed and its income plays no role in the model. The trade services unit cost, equal to the marginal cost of a price-taking competitive trading firm, is given by:⁷

$$t(q, w) = kwq^{\left(\frac{1}{\alpha}-1\right)}, \quad k > 0. \quad (1)$$

⁵The latter assumption is realistic for the trade in illegal drugs because coca and opium plants are generally cultivated by many small farmers with no market power. At the production stage the industry is therefore perfectly competitive.

⁶A number of our results hold for more general cost functions as we shall note below where applicable.

⁷The short run cost function with fixed capital K is given by $kwq^{1/\alpha}$, where $k = [(1-\alpha)/K]^{(1-\alpha)/\alpha} > 0$. This is formed by using $(1-\alpha)w^\alpha r^{-\alpha} q = K$ to solve for $r(w, K, q)$, then substituting to obtain $\bar{C}(w, K, q) = kwq^{1/\alpha}$.

The demand for labor in the trading industry is equal to⁸

$$q^{1/\alpha}k.$$

Robbers

Predation (robbery) is the alternative use of labor. Like traders, robbers are risk neutral.⁹ A simple model of interaction between traders and robbers yields clear implications which should hold up more generally. Robbers can only attempt to steal goods and only while these are in transit between the two regions. Once the trader and buyer meet exchange is secure.¹⁰ Robbers sell their loot in a thieves market at a price normalized to one.¹¹

Traders and robbers are specialized: traders never attack each other because such conflict is too expensive in the even match that results, and predators similarly do not attack each other even when one predator has goods to steal. Thus the only matches are between traders and predators, and predators always win. There is at most one match per period. Traders cannot coordinate on a common defense strategy, though each trader can individually take defensive actions to avoid meeting the robbers while in transit.

⁸Here we use Shephard's Lemma.

⁹Risk aversion in the absence of insurance markets would tend to diminish predation relative to trading under the plausible hypothesis that informal insurance and self insurance are easier for traders.

¹⁰If both goods and money are subject to predation or if goods can be stolen from buyers after purchase, the setups are more cumbersome, but nothing essential changes. Moreover, it is quite plausible that goods in transit are less secure than goods at rest; our model focuses on a convenient limit case. Our simplifying assumption can be rationalized by enforcement at points of sale, by reputation of buyer and seller, or by the ability of massed concentrations of buyers and sellers to coordinate to deter opportunism which is against their collective interest.

¹¹That traders and robbers sell the goods at different prices reflects the intuition that consumers' willingness to pay for stolen goods is different. All results are qualitatively unchanged if we assume that both traders and robbers sell at the same price b .

The common objective probability of successful shipment by traders, the probability that the prey avoids the predator, is a decreasing function F of the ratio of predators B to prey given by the volume of trade q . Agents form beliefs π about the success rate of traders, and in equilibrium the beliefs converge on F . For convenience, throughout this paper the objective probability is given by the logistic function $F(B/q) = 1/[1+\theta B/q]$ where θ is a parameter capturing the effectiveness of the robbers' technology for seeking and chasing relative to the traders' ability to hide and run. It is sometimes convenient to refer to this below as the predation technology. Many of our results hold for more general functions, as we shall note below where appropriate.¹²

There are diminishing returns to predation $[1 - F(B/q)] q/B$ under the logistic form of F . A rise in B/q has two opposite effects on each predator's payoff. On the one hand, the probability of catching a trader in transit improves ($-F'B/q$). On the other hand the larger loot has to be shared among more predators. Diminishing returns obtains because the congestion effect of higher B/q dominates the improved probability of a match.¹³

Toward Equilibrium

The full equilibrium is solved for the values of B and q , the wage rate w and the equilibrium success rate π . It is extremely useful to first characterize the rational expectations success rate conditional on trade volume. Potential predators allocate themselves between predation and trading to equalize

¹²The logistic functional form has been extensively used in the conflict literature. The rationale in that case is quite different: the variables (B, q) are replaced by the armaments or campaign expenditures of the two contestants, who interact non-anonymously.

¹³Diminishing returns holds more generally under plausible restrictions, for $-F'B/q < 1 - F$.

payoffs given the wage rate and their beliefs about success rates in predation. In equilibrium the beliefs converge to objective success rates (which depend on B). Labor market equilibrium links the wage to a given volume of trade, hence links the equilibrium success rate to a given volume of trade. The full equilibrium is solved from the zero profit condition in trading, embedding equilibrium wages and success rates.

1.2 The Equilibrium Success Rate

The agents' beliefs about π determine the expected payoffs to trading and predation and hence the choice between the two activities. In rational expectations equilibrium, the subjective probability must equal the objective probability, the returns to labor on both types of activity must be equal and the labor market must clear.

The expected return to predation per predator is $(1 - \pi)q/B$,¹⁴ while employment in trade services pays w . Agents are indifferent between predation and trade services when

$$w = \frac{(1 - \pi)q}{B} \Rightarrow \frac{B}{q} = \frac{1 - \pi}{w}. \quad (2)$$

Substituting the labor allocation condition (??) into the objective probability function yields the success rate conditional on the wage. For the logistic

¹⁴Predators sell their loot securely in a thieves market at constant price normalized to one, without loss of generality.

function this simplifies to:¹⁵

$$\pi(w) = w/\theta. \quad (3)$$

The labor market clears when the total supply of labor N is equal to the sum of labor demanded in trade services and predation. Using (??), (??) and the demand for labor in the trade industry $q^{1/\alpha}k$ yields:

$$N = kq^{1/\alpha} + q[1 - \pi(w)]/w \quad (4)$$

Solving (??) for the unique¹⁶ market clearing wage yields the equilibrium wage function:

$$w = W(q) \equiv \theta \frac{q}{\theta(N - kq^{1/\alpha}) + q}. \quad (5)$$

Note that $W_q > 0$, the equilibrium wage is an increasing function of trade volume.

Substituting (??) into (??), we derive the equilibrium success rate in anarchy as a function of the volume of trade q and of the exogenous parameters (N, k, θ, α) :

$$\Pi^a(q) = \pi[W(q)] = \frac{1}{\theta(N/q - kq^{1/\alpha-1}) + 1}. \quad (6)$$

¹⁵In general, the fixed point problem has a trivial solution at $\pi = 1$, since $F(0) = 1$. Graphing $F[(1 - \pi)/w]$ against π shows that if $\pi = 1$ is the only solution, it is stable under the plausible hypothesis that the subjective probability π adjusts toward the objective probability given the beliefs $F[(1 - \pi)/w]$. If an interior solution exists and is unique, it must be stable because $-F'/w < 1$ in the neighborhood of the solution. In this case the secure equilibrium is unstable. There could be multiple interior equilibria, depending on the shape of the cumulative density function F . With multiple equilibria, unstable interior solutions are flanked by stable interior solutions.

¹⁶The right hand side of (??) is decreasing in w and is unboundedly large at very low w , so a unique stable solution exists.

Safety in numbers is an equilibrium property of the model: *the equilibrium probability of successful shipment is increasing in the volume of trade.* Intuitively, an increase in the volume of trade has two opposite effects on the probability that traders manage to avoid the predators. On the one hand, for a fixed number of predators the probability that a given trader gets through without being attacked rises. On the other, a larger volume of trade attracts more predators, which decreases the probability of successful shipment. The former effect prevails. In equilibrium, predators allocate themselves so that $B/q = (1 - \pi)/w$. In rational expectations equilibrium, $\pi = w/\theta$ and w is in labor market equilibrium an increasing function of q . Thus in equilibrium, the ratio B/q falls with q , hence the success rate rises.

Safety in numbers arises because predators have increasing opportunity cost. The extreme case of constant opportunity cost is illuminating. When predators are available in infinitely elastic supply at a fixed opportunity cost \bar{w} , B rises in proportion to q to maintain $B/q = (1 - \pi)/\bar{w}$ at constant π . Increasing opportunity cost arises in the model because labor is subject to diminishing returns in trade services due to fixed capital, but the same property can be generated by heterogeneous labor or technological diminishing returns.

Safety in numbers does not follow from our assumptions on the functional form of $F(\cdot)$ and cost function $C(\cdot)$. Rather, safety in numbers is quite a general property of trade with predation when predatory resources face increasing opportunity cost. As discussed in detail below, safety in numbers has important consequences for the existence and security of trade in

equilibrium, and for the comparative statics of the model.

Predator/prey models with a form of safety in numbers have been used in a variety of settings, especially in the context of common resources management such as fisheries. Neher (1978) applies the predator/prey analogy to street robberies but, unlike ours, his model assumes safety in numbers rather than deriving it. Sah (1991) offers a related model in which criminals' probability of being caught by law enforcers falls as more criminals enter relative to a fixed stock of law enforcement resources, a partial equilibrium type of safety in numbers for predators. The payoff per crime is fixed in his model and the expected payoff rises with the number of criminals. In our model, the number of predators and the number of self-enforcing traders are both endogenous.

1.3 The Full Equilibrium

The equilibrium volume of anarchic trade is determined by the no arbitrage condition of profit-maximizing traders in a free entry equilibrium. Traders expect to break even when $\pi b - c - t = 0$. Their beliefs about π must be consistent with the equilibrium probability of success. The wage rate which helps determine the trade cost t and the success rate π must be consistent with labor market equilibrium for the volume of trade. The full equilibrium of the model is determined by goods and labor market clearance simultaneously, embedding the equilibrium probability of success as a function of the wage.

The equilibrium quantity for a given wage uniquely satisfies

$$Q(w) \equiv q : \frac{w}{\theta} b - c - wkq^{\left(\frac{1}{\alpha}-1\right)} = 0. \quad (7)$$

The equilibrium pair (w, q) is determined by equations (??) and (??).

There are three types of equilibria in the model: (i) zero trade, namely $q = 0$, (ii) secure trade, namely $q > 0$ and $\pi = 1$ and (iii) insecure trade, namely $q > 0$ and $\pi < 1$. The existence and stability of each type of equilibrium depends on the values of the exogenous parameters as illustrated in Proposition 1 below.

Proposition 1 *(a) Zero trade and secure trade equilibria always exist. Zero trade is always locally stable while secure trade is unstable for many parameter ranges. (b) When the predation technology is strong or gains from trade are small, there is no equilibrium with insecure trade and the equilibrium with secure trade is not stable. (c) When the predation technology is weak or gains from trade are large, there is at least one equilibrium with insecure trade and: (c1) for $(\frac{N}{k})^\alpha > [\frac{b-c}{\theta k}]^{\alpha/(1-\alpha)}$ there is at least one locally stable equilibrium with insecure trade, while the secure equilibrium is unstable and (c2) for $(\frac{N}{k})^\alpha < [\frac{b-c}{\theta k}]^{\alpha/(1-\alpha)}$ the secure equilibrium is locally stable.*

The proof of the proposition utilizes Figure 1. Here we depict the two equilibrium equations $Q(w)$ from (??) and $W(q)$ from (??). Q has horizontal intercept at $w_{\min}^a = \theta c/b$. Moreover, $Q_w > 0$ in the relevant range by the arbitrage condition and $Q_w(\theta c/b) = \infty$. $Q(w)$ is concave in w for $\alpha \leq 1/2$, as drawn in the figure.¹⁷ As for the equilibrium wage function, the intercepts are given by $W(0) = 0$, $W[(N/k)^\alpha] = \theta$. W has a positive slope and is

¹⁷Results are qualitatively unchanged for $\alpha > 1/2$ where the function is convex or has a convex region succeeded by a concave region.

generally convex for low q and concave for high q .¹⁸

The line $w = \theta$ represents the limiting case of secure trade. Figure 1 illustrates case (c1), with two insecure equilibria, the upper one of which is stable. Both zero trade and secure trade are also equilibria in the case of Figure 1, but the latter is unstable in the case drawn.

Proposition 1 (a) shows that equilibrium with positive trade may be prevented by potential predation, even though there are gains from trade net of trade costs and even though positive stable trade equilibria may exist.

Proposition 1 (b) follows from the fact that when the horizontal intercept of $Q(w)$, $\frac{\theta c}{b}$, is large enough, $Q(w)$ lies everywhere to the right of $W(q)$ so that insecure trade ($q > 0, \pi < 1$) cannot be an equilibrium. Secure trade is unstable because for these parameters' values it always pays to deviate into

¹⁸To be precise, $W_q = \theta \frac{\theta N + \theta k(1/\alpha - 1)q^{1/\alpha}}{D^2} > 0$, where $D = \theta(N - kq^{1/\alpha}) + q$. Then $W_{qq}/\theta = \frac{-qD_{qq}}{D^2} - 2\frac{(D - qD_q)D_q}{D^3}$. Next note that (i) $D_q = 1 - \frac{\theta k}{\alpha}q^{1/\alpha - 1} \leq 0$, (ii) $qD_{qq} = -\frac{\theta k}{\alpha}(1/\alpha - 1)q^{1/\alpha - 1} < 0$, (iii) $D - qD_q = \theta N + \theta k(1/\alpha - 1)q^{1/\alpha} > 0$. Finally, note that at $q = 0$, $W_{qq} = -2/\theta N^2 < 0$. As q grows sufficiently large (for example as N is sufficiently large), $D_q < 0$ and $W_{qq} > 0$. Thus W always has a concave region and may have a convex region. W_{qq} changes sign at most once.

predation.¹⁹ Intuitively, when $\frac{\theta c}{b}$ is large the predatory technology is quite effective and the gains from trade $(b - c)$ are low so that the only stable equilibrium is the one with no trade.

Proposition 1 (c) follows from the fact that when $\frac{\theta c}{b}$ is small, $Q(w)$ and $W(q)$ cross at least once. If they cross exactly once, $W(q)$ must cut $Q(w)$ from above and hence the interior equilibrium is unstable. This also implies that the vertical intercept of $W(q)$ is below that of $Q(w)$, namely $\left(\frac{N}{k}\right)^\alpha < \left[\frac{b-c}{\theta k}\right]^{\alpha/(1-\alpha)}$ so that the secure equilibrium is stable (part (c2)). The intuition is that when the gains from trade are large relative to the effectiveness of predation and all labor is employed in the trade industry, the wage is so high that any given agent would not benefit from deviating into predation.

In contrast, if the vertical intercept of $W(q)$ is above that of $Q(w)$, namely $\left(\frac{N}{k}\right)^\alpha > \left[\frac{b-c}{\theta k}\right]^{\alpha/(1-\alpha)}$ the secure equilibrium cannot be stable. However, when this is the case, $W(q)$ must cut $Q(w)$ from below at least once, which yields

¹⁹When all potential predators believe $\pi = 1$, then their gain from predation is equal to zero and they may opt to work as traders at the wage rate implied by the secure equilibrium zero arbitrage condition $(b - c)/kq^{1/\alpha - 1}$ where q is the quantity which exhausts the supply of labor, $(N/k)^\alpha$. If any single agent experiments with predation, however, his objective payoff for $B \rightarrow 0$ is equal to

$$\left[1 - \frac{1}{1 + \theta B/q}\right] q/B = \theta.$$

This is equal to the equilibrium wage when *all* workers are employed in trade services,

$$\theta \frac{q}{\theta(N - kq^{1/\alpha}) + q} = \theta.$$

But the zero arbitrage condition implies that the wage is equal to $(b - c)/k(N/k)^{1-\alpha} = (b - c)k^{-\alpha}N^{-(1-\alpha)}$. When this is less than θ , some labor is unemployed. For the unemployed labor, predation cannot be worse than no wage while for employed labor small deviations into predation from the secure equilibrium meet with surplus over opportunity cost. Thus the allocation of labor shifts to the insecure equilibrium.

a stable equilibrium with both trade and predation (part (c1)).²⁰

The proposition contradicts the simple but incorrect intuition that it would always pay to have a little bit of trade with a correspondingly small amount of predation at one limit, while at the other limit safe trade would always attract some predation. To see why trade can be secure, consider that expected payoffs to predation rise to a maximum θ as B/q falls to zero. There can then be a stable secure equilibrium when this maximum return θ is smaller than the wage at full employment in trade services under secure trade. Proposition 1 shows that as the gross margin $b - c$ fall or N grows, secure equilibrium becomes unstable and insecure equilibrium can arise as θ becomes larger than the secure equilibrium wage rate.

As for the collapse of trade, the diagram illustrates why, when gross margins $b - c$ are small or θ is large, there may be no trade in equilibrium. Indeed, any experimenting with trade will call forth predation too intense to sustain trade.

Two necessary ingredients cause the collapse of trade. One is the trade technology requirement that goods be acquired at cost $c > 0$ prior to shipping. This introduces a sunk cost of trade. Proof that $c > 0$ is necessary follows because when $c = 0$, Q does not depend on w and cuts $W(q)$ from

²⁰A closed form solution is available for the case of $\alpha = 1/2$ when the full model becomes quadratic. The solution is:

$$q = \frac{-(b - c) \pm \sqrt{(b - c)^2 + 4\theta^2 k N c (c - 1)}}{2\theta k (c - 1)}.$$

For the case of $c < 1$, and $(b - c)^2 + 4\theta^2 k N c (c - 1) \geq 0$, both roots are real and positive, yielding the unstable and stable equilibria respectively. For the case of $c \geq 1$, there is only one positive real root, yielding an unstable insecure equilibrium.

above at $q > 0$. The other necessary requirement is institutional: in anarchy, no institution exists to impose collective rationality. Predation is individually rational but collectively irrational: all workers acting collectively would always enjoy the higher wages of secure trade if they could commit themselves not to predate.

We emphasize that the standard reasons for coordination failure are *not* responsible for zero trade: there is always someone to trade with in this model if trade can be sustained and there is no need to achieve sufficient scale to pay for a shared infrastructure. Indeed, conventional fixed costs are absent from the model, so conventional scale effects of all kinds are absent.²¹ Interior (insecure) equilibrium depends on the interplay of diminishing returns to predation (due to the technology of predator/prey interaction) and diminishing returns to trading (due to the trade technology, the fixed stock of trade capital and the fixed supply of labor for trade and predation).

The safety in numbers property of the model helps to explain why many liberalizations cause puzzlingly large increases in trade, far larger than reductions in formal trade costs can account for.²² It is obvious from Figure

²¹The very plausible timing assumed in our trading technology, that the goods must be acquired and exposed to predation before being sold, does lead to sunk cost. In the absence of this sunk cost, no collapse of trade occurs. The volume of trade even with $c = 0$ will generally be inefficiently small, so the market failure remains.

²²Baier and Bergstrand (2001) show that world trade grew faster in the postwar era than formal trade cost reductions can explain. Taking a specific liberalization episode, Anderson and van Wincoop (2002) note that Mexico increased trade after NAFTA far more than any of the applied general equilibrium models predicted prior to NAFTA's inception. The excess response suggests endogenous reductions in trade costs, among them costs associated with opportunistic or predatory behavior. Insecurity associated with predation and imperfect contract enforcement substantially reduces trade, particularly of developing countries (Anderson and Marcouiller, 2002).

1 that a one unit fall in c will increase trade, while from the zero profit condition it is obvious that the quantity increase will be greater than $1/t_q$ which is implied by a constant success rate. Safety in numbers also provides a formal model of Adam Smith's (1976) observation that commerce tends to be civilizing.²³ It is also a new source of 'economies of agglomeration'.

At several points we explain that our qualitative analysis is more general than the special assumptions of the model. The Appendix relaxes the assumption of constant b and c and shows that the simplification is harmless. Endogenous b and c essentially act like more steeply rising trade costs, steepening the descent of marginal willingness-to-pay for trade.

2 Cops

"Cops" provide enforcement services which raise the success rate of traders. Example of private enforcement of trade abound. Associations of traders historically cooperated in both the suppression of predation and the enforcement of contracts. The trade in illicit drugs is protected and regulated by various organized crime groups such as the Mafia and the Colombian Cartels.²⁴

Private enforcers typically have monopoly over a given area and protect all trade in that area. It is plausible that protection of trade is something of a

²³*The Wealth of Nations* (Book III, Chapter IV), crediting Hume: "...commerce and manufactures gradually introduced order and good government, and with them the liberty and security of individuals, among the inhabitants of the country, who had before lived in almost a continual state of war with their neighbours, and of servile dependency on their superiors. This, though it has been the least observed, is by far the most important of all their effects."

²⁴See, for instance Anderson (1995), Falcone (1991), Firestone (1997) and Gambetta (1994). Mafia members can of course be directly involved in trade as well but the central organization deals mostly with enforcement.

natural monopoly: increasing returns to scale are due both to fixed costs and to the safety in numbers externality identified here. Moreover, protection is something of a public good, with imperfect exclusion inviting institutional developments to defeat free riding.²⁵ We simply assume that private cops are a monopoly and all traders purchase their protection services. We also refer to the enforcement monopoly as a mafia and use the two terms interchangeably except when emphasizing illicit trade and the mafia or licit trade and the cops. For sharper focus, we abstract from the discussion of enforcement market structure, e.g. the characteristics of the technology that allow the mafia to maintain its monopoly position and deter entry.

The cops' enforcement activity is assumed for simplicity to frustrate a fraction M of encounters between traders and predators which would otherwise result in property loss. Equivalently, the cops recover a fraction M of the loss. We do not model the determination of M here. We also abstract from the cost of enforcement. Fixed cost introduces familiar elements of the minimum scale needed to support the enforcement effort; profits must be large enough to cover the fixed cost of providing M . Marginal cost associated with the size of the volume of trade to be protected is an inessential

²⁵For traders to be willing to pay for private cops, the cops must offer a higher success rate than the traders experience with the avoidance behavior of anarchy. Maintaining this success rate presents a problem for the cops. If both anarchic and protected trade were simultaneously going on, predators would allocate themselves between the two types of trade so as to equalize the success rates. Traders choosing not to purchase protection would then free ride on the effectiveness of cop enforcement, which would eventually drive the private enforcers from the market. To prevent free riding and the collapse of their market, the private enforcers must force all traders to pay. Typically, the mafia threatens to seize the goods of traders who opt out, while trade associations or private security firms adopt less illegitimate methods. The discussion sheds light on the frequently observed compulsion associated with mafia protection.

complication, acting like the increasing trade cost already in the model.

Traders continue to avoid predators as in anarchy despite the presence of the cops, since avoidance is costless. We plausibly assume that the outcomes of evasion and enforcement activity are independently distributed. The success rate of enforced exchange is therefore a compound equal to the probability of avoidance plus one minus the probability of avoidance times the probability M that the cops frustrate a match (directly or by recovering stolen property) between predator and prey.²⁶ The shipment success rate for the protected trade is thus

$$\pi^m = F(B/q) + [1 - F(B/q)]M = M + (1 - M)F(B/q). \quad (8)$$

The cops or the mafia are assumed to be honest, which is rationalizable with a sufficiently low discount rate (high value of reputation). The cops maximize profits, incorporating in their pricing strategy to uncoordinated traders their (the cops') knowledge about the effect of marginal quantity increases on the willingness to pay for enforcement $\pi b - c - t$, reflecting (i) the marginal increase in trade cost t_q and (ii) the marginal increase in the success rate π , all using their understanding of the labor market equilibrium. To analyze the latter, we must first derive the success rate under enforcement.

As in Section 1.1, the rational expectations equilibrium probability conditional on the wage rate is obtained by substituting the predators' allocation condition $w = (1 - \pi)q/B$ into the logistic function for the probability of

²⁶If mafia cops on patrol intervene in trader-robber encounters to protect the former, M is likely to be a function of the force level of the mafia relative to the force level of the predators. We suppress this inessential complication.

successful avoidance (??):

$$\pi = \frac{1}{1 + \theta(1 - \pi)/w}(1 - M) + M \Rightarrow$$

$$\pi = \pi^m(w) = M + w/\theta. \quad (9)$$

Labor market clearance using (??) yields the equilibrium wage rate as

$$w = \theta(1 - M) \frac{q}{\theta(N - kq^{1/\alpha}) + q} = (1 - M)W(q). \quad (10)$$

Substituting the equilibrium wage into the equilibrium success rate yields the success rate as a function of trade volume q :

$$\begin{aligned} \Pi^m(q) &= \pi^m[(1 - M)W(q)] \\ &= M + (1 - M) \frac{q}{\theta(N - kq^{1/\alpha}) + q}. \end{aligned} \quad (11)$$

There is safety in numbers with enforcement: $\Pi_q^m \geq 0$. As in the case of anarchic trade, safety in numbers arises because W is increasing in q and B is decreasing in w . That is, as the volume of trade rises, the increase in the probability of successful trade due to traders being able to avoid predators dominates the decrease in probability due to the increase in the number of predators.

Enforcement reduces the importance of safety in numbers, since $\Pi^m(q) = M + (1 - M)\Pi^a(q)$ and Π_q^m is reduced by M , with $\lim_{M \rightarrow 1} \Pi_q^m = 0$. Intuitively, the marginal effect of more traders on increasing their joint success in avoiding predators loses relevance when the fraction of encounters that fail (or goods that can be recovered after a predator's attack) is high.

The sophisticated enforcer incorporates knowledge of the equilibrium response of wages to its quantity setting policy. Its objective function is

$$R(q; M, b, c, \theta, N) = [M + W(q; M, \theta, N)/\theta] bq - cq - W(q; M, \theta, N)kq^{1/\alpha}.$$

The first order condition is

$$\left[\frac{b}{\theta} - kq^{1/\alpha-1} \right] W_q q + \left[\frac{W}{\theta} + M \right] b - c - \frac{1}{\alpha} W k q^{1/\alpha-1} = 0$$

where

$$W(q; M, \theta, N) = \frac{q(1-M)}{N - kq^{1/\alpha} + q/\theta}.$$

The second order condition requires the monopoly to satisfy the first order condition in a region where $R_{qq} < 0$. Moreover, for an insecure enforcement equilibrium to exist, R must be positive at the optimal interior value of q .

The existence conditions for enforced trade equilibrium differ significantly from those for anarchic equilibrium.

Proposition 2. *There exists a threshold level of the enforcer's capability $\bar{M} = (1 - \alpha) + \alpha(c/b)$ such that:*

(a) *if the enforcer is strong ($M > \bar{M}$) or gains from trade are large, an equilibrium with positive trade always exists;*

(b) *if the enforcer is weak or gains from trade are small ($M < \bar{M}$), a sufficient condition for trade to take place is $M > c/b$;*

(c) *in either case, the equilibrium, if it exists, is insecure if $(N/k)^\alpha > (b/\theta k)^{\alpha/(1-\alpha)}$ and secure otherwise.*

Analysis of the existence of a monopoly enforcement equilibrium is aided by decomposing the unconstrained objective function $R(q; \cdot)$ into the objective function $\rho(q, w) = [M + w/\theta]bq - cq - wkq^{1/\alpha}$ to be maximized subject

to $w = W(q; \cdot)$. The first order condition implies

$$-\rho_q/\rho_w = W_q.$$

Since the right hand side is positive, there are two possibilities for equilibrium: values of (q, w) for which $\rho_q > 0, \rho_w < 0$ and values of (q, w) for which $\rho_q < 0, \rho_w > 0$. Given that $\rho_q = ((w/\theta + M)b - c - wkq^{1/\alpha-1}/\alpha)$ and $\rho_w = (qb/\theta - kq^{1/\alpha})$, the former case occurs when the enforcer is strong, that is when $M > (1 - \alpha) + \alpha(c/b)$. The latter applies when the enforcer is weak, that is if and only if $M < (1 - \alpha) + \alpha(c/b)$.

The intuition of the first order condition for the strong enforcement case is that the direct effect of a marginal increase in q in profits, ρ_q , should remain above zero because the indirect effect of an increase in q on raising the wage is negative, since the trade cost increase dominates safety in numbers. The intuition for the first order condition in the weak enforcement case is that at the maximum, the direct effect of a marginal increase in volume is negative ($\rho_q < 0$) but the indirect effect of raising wages is positive as it makes trade more secure and this effect dominates the effect of higher wages in raising trade costs.

To characterize the two possible cases, first consider limiting values of q for which $\rho_q[q, \theta(1 - M)] = 0$ and $\rho_w(q) = qb/\theta - kq^{1/\alpha} = 0$ respectively. These are given by

$$q^0 = \left(\alpha \frac{b - c}{\theta(1 - M)k} \right)^{\alpha/(1-\alpha)}$$

and

$$q^w = \left(\frac{b}{\theta k} \right)^{\alpha/(1-\alpha)}$$

respectively. Equilibrium requires $q \in [q^0, q^w]$. In the strong enforcement case $q^0 > q^w$, whereas in the weak enforcement case $q^0 < q^w$.

The analysis is aided by Figure 2 for the strong enforcement case and Figure 3 for the weak enforcement case. The iso-profit contours $\omega(q, \rho) = w^{27}$ have slope equal to

$$\omega_q = \frac{dw}{dq} \Big|_{\rho} = -\frac{\rho_q}{\rho_w} = -\frac{(w/\theta + M)b - c - wkq^{1/\alpha-1}/\alpha}{qb/\theta - kq^{1/\alpha}}.$$

The rate of change of the slope is given by

$$\omega_{qq} = \frac{d^2w}{dq^2} \Big|_{\rho} = \frac{1}{\rho_w} \frac{1-\alpha}{\alpha^2} wkq^{1/\alpha-2} \quad (12)$$

where the differentiation constrains $\omega_q = dw/dq$ to lie on the given profit contour ρ .²⁸ On the iso-profit contours w is convex (concave) in q as ρ_w is $> (<)0$, by (??). The switchover occurs at q^w .

Conditions for the existence of a unique interior equilibrium are based on the graph of ω_q and W_q . Figure 4 depicts the analysis. In the strong enforcement case, profits are non-negative in any equilibrium. This is guaranteed by $\rho_q > 0$, since $R/q = \pi b - c - t > \pi b - c - t/\alpha = \rho_q > 0$. An equilibrium with positive trade exists and is insecure if and only if $q^w < (N/k)^\alpha$. Necessity is visually obvious while sufficiency follows because by reducing ρ a sufficiently

²⁷For a given level of profit ρ , we can solve

$$w = \omega(q, \rho) = \frac{\rho + (c - Mb)q}{qb/\theta - kq^{1/\alpha}}.$$

²⁸This follows from simplifying the derivative:

$$\frac{d^2w}{dq^2} \Big|_{\rho} = -\frac{dw}{dq} \Big|_{\rho} \frac{b/\theta - kq^{1/\alpha-1}/\alpha}{qb/\theta - kq^{1/\alpha}} + \frac{\frac{1-\alpha}{\alpha^2} wkq^{1/\alpha-2}}{qb/\theta - kq^{1/\alpha}} + \frac{dw}{dq} \Big|_{\rho} \frac{b/\theta - kq^{1/\alpha-1}/\alpha}{qb/\theta - kq^{1/\alpha}}.$$

low level of $\omega_q(q, \rho)$ can always be found so that an intersection $\omega_q = W_q$ exists in the relevant range $q \in [0, (N/k)^\alpha]$. If $q^w > (N/k)^\alpha$ the equilibrium is secure.

In the weak enforcement case, a sufficient condition for non-negative profits is $M > c/b$, which follows because $\rho_w > 0$ and $\rho/q \rightarrow Mb - c$ as $w \rightarrow 0$. If $M > c/b$, an interior equilibrium obtains if $q^w < (N/k)^\alpha$. When $q^w > (N/k)^\alpha$ and the non-negative profit condition is met, the equilibrium is secure (and the first order condition is not met due to q being bounded by the full employment of labor).

When the nonnegative profit condition is not met, autarky is the only equilibrium in the weak enforcement case. The sufficient condition $M \geq c/b$ in part (b) guarantees that the incipient first unit of trade, undertaken at zero cost with $w = 0$, will earn a nonnegative expected value even though essentially all the labor force attempts to steal it. This condition is similar to the corresponding sufficient condition $c = 0$ for the existence of anarchic trade.

The second order condition must hold for an interior maximum in both the strong and weak enforcement cases. The second order condition is $\omega_{qq} > W_{qq}$ when $\rho_w > 0$ and $\omega_{qq} < W_{qq}$ when $\rho_w < 0$. By using (??) and graphing $\omega_q(q)$ and $W_q(q)$, it can be seen that so long as $q^w < (N/k)^\alpha$, the unique intersection of the two graphs must occur where the second order condition is met (Figure 4).

3 Comparative Statics

The comparative static derivatives of the model shed light on two puzzling observations, the sometimes large responses of trade volume to liberalization or globalization and the sometimes perverse response of illicit trade to state attacks on it.

The large response of trade to globalization is due to the endogenous change in the security of trade. Suppose that in contrast the success rate is fixed by an infinitely elastic supply of labor. Then anarchic trade rises with a rise in the expected gross arbitrage margin $\pi b - c$ by $1/t_q$. In our model of endogenous security the response is

$$\frac{dq}{d(\pi b - c)} = \frac{1}{t_q - (W_q/W)(\pi b - t)} > \frac{1}{t_q}.$$

For the monopoly enforcer the same comparison of the marginal response under infinitely elastic and fixed labor supply yields

$$\frac{dq}{d(\pi b - c)} = \frac{\alpha}{t_q - (W_q/W)(\pi b - t)} > \frac{\alpha}{t_q} = \left. \frac{dq}{d(\pi b - c)} \right|_w.$$

The difference in response can be quite large. Similarly, globalization defined as a fall in the trade cost parameter k will increase trade with a magnified response when security of trade is endogenous.

Turning to the response of trade to state policies, we assume that the state's interest is simply to reduce illicit trade.²⁹ To keep focus on the effect of different policies on the volume of trade, our analysis is only about the

²⁹We abstract from a host of normative issues here because the focus on volume is interesting in itself.

‘benefit’ side of state policies in reducing trade volume; a full analysis must incorporate the cost of the policies.

One thrust of state policy attacks illegal trade or its institutional foundations directly. Below we analyze three such policies: (i) eliminating the mafia, (ii) weakening the mafia and (iii) direct attacks, i.e. seizures of the illegal goods in raids. We show that these can be ineffective or even perversely increase the volume of trade.

The other thrust of state policy targets the consumers and producers of illegal substances (downstream or upstream attacks), including such policies as negative advertising and crop eradication. They do reduce trade, though their impact differs somewhat depending on the enforcement mechanism. We omit the analysis since the results are intuitive.

State policy toward trade outside the law differs between illicit and licit trade. For licit trade outside the law, state intervention presumably aims to promote efficiency. Consideration of efficient regulation in the NBER working paper version of this paper further clarifies the state’s role in treating the collectively irrational act of predation.

3.1 Eliminating the Mafia

Eliminating the mafia has an ambiguous effect on the volume of trade in our model, with an illuminating decomposition of factors. There are two cases to consider: when the elimination cause a shift between different types of equilibria and when it moves from one insecure equilibrium to another.

First consider shifts between different equilibrium types. The mafia can

enable trade in parameter ranges resulting in zero anarchic trade. Under mafia enforcement, trade always takes place when $M \geq (1 - \alpha) + \alpha(c/b)$ and may take place when $c/b < M < (1 - \alpha) + \alpha(c/b)$. Thus a sufficiently capable mafia can overcome the coordination failure (the inability of anarchic agents to commit not to predate) represented by zero trade.

Is it possible that in parameter ranges resulting in secure anarchic equilibrium, the mafia will trap the market in an insecure equilibrium? No, in our model. Anarchic trade is secure if $(\frac{N}{k})^\alpha < [\frac{b-c}{\theta k}]^{\alpha/(1-\alpha)}$ based on Proposition 1 while mafia enforced trade is insecure under the conditions of Proposition 2; i.e. if $(\frac{N}{k})^\alpha > (b/\theta k)^{\alpha/(1-\alpha)}$ and either $M > (1 - \alpha) + \alpha(c/b)$ or $c/b < M < (1 - \alpha) + \alpha(c/b)$. These conditions cannot both be met.

Now consider the effect on volume of mafia elimination when anarchic trade would also be insecure. The comparison is facilitated by evaluating the mafia's profit derivative at the anarchic volume of trade, $R_q(q^a)$. Eliminating the mafia will increase trade if $R_q(q^a) < 0$. The mafia's profit derivative is rearranged below as

$$R_q = [\pi b - c - t] - t \left(\frac{1}{\alpha} - 1 \right) + [(\pi - M)b - t] W_q q / W.$$

We utilize the zero profit condition $bw^a/\theta - c - t^a = 0$, hence

$$R_q(q^a) = [Mb(1 - \pi^a)] - t^a \left(\frac{1}{\alpha} - 1 \right) + cW_q q^a / W \quad (13)$$

At volume q^a using the zero profit condition of anarchic equilibrium, the first term on the right, the square bracketed term, $Mb(1 - \pi^a) > 0$, gives the expected marginal benefit of the goods recovered by having the mafia enforcement capability available at the anarchic trade volume. The second

term is the standard inverse elasticity term, always negative, indicating that the exercise of monopoly power implies reducing trade below its anarchic level. The third term, always positive, is the benefit due to the enforcer being able to internalize safety in numbers. The theft of the marginal unit is worth c , while the expected reduction in the loss from another unit traded is worth $cW_q q^a / W > 0$.

An interesting feature of the model is that trade volume under mafia enforcement can be higher than in anarchic trade even if the mafia does not have a superior enforcement technology, namely $M = 0$. It might be more natural to think of the model of the monopoly with $M = 0$ as a traders' association. By internalizing the benefit of safety in numbers the traders' association can provide a better success rate, with this activity dominating the advantage of coordinating on volume to reduce total trade costs.

Summarizing the implications, *eliminating the mafia might perversely increase the volume of trade. This is more likely to happen when the demand elasticity is low, the trade cost margin t/c is high, the gross margin b/c of the goods is low and the enforcement technology of the mafia is weak.* In deriving this implication, we divide (??) through by c .

3.2 Weakening the Mafia

Another method of state attack on the mafia is to reduce its enforcement capability M . For example, state patrols can force mafia enforcement patrols to be more clandestine, or imprisonment can lower the quality and quantity of enforcers working for the mafia. Since the second order condition R_{qq} is met,

dq/dz is signed by R_{qz} for changes in any parameter z , in this case $z = M$.

We evaluate the derivatives of R by decomposing $R(q, z) = \rho[q, W(q, z), z]$.

Note that $W_M = -W/(1 - M)$ and thus $W_{qM} = W_{Mq} = -W_q/(1 - M)$.

Then

$$\begin{aligned} R_{qM} &= \rho_{qM} + \rho_{qw}W_M + \rho_w W_{qM} \\ &= b - [(\pi - M)b - t/\alpha] \frac{1}{1 - M} - [(\pi - M)b - t] \frac{qW_q}{W} \frac{1}{1 - M} \\ &= b \end{aligned}$$

by the first order condition.. Thus *attacks on enforcement capability will always reduce trade.*

3.3 Raids

Raids on exchange are understood in our model as an increase in state sponsored predation. If the state hires predators from the common labor pool at the going wage, as is plausible, then in our model there is no net effect, regardless of whether or not there is a specialized enforcer. State predation displaces private predation one-for-one. To see this point, note that B can be interpreted as the sum of state and private predation.

In contrast, if the state brings in predators from outside, this has the effect of increasing the total labor supply N . At an interior stable anarchic equilibrium, the comparative static derivatives are illustrated by shifting the $Q^a(w)$ and $W(q)$ functions (Figure 1) with respect to N , then noting the change in q and π . An increase in N shifts $W(q)$ to the left while $Q^a(w)$ is unchanged, so the trade volume at the stable interior equilibrium falls.

The effect of raids on mafia protected trade are more interesting. Note that

$$W_N = -\frac{W^2}{q(1-M)} < 0$$

$$W_{Nq} = W_{qN} = \frac{W^2}{q^2(1-M)} \left[1 - \frac{W_q q}{W} \right].$$

Then substituting into $R_{qN} = \rho_w W_{qN} + \rho_{qw} W_N$ and simplifying using the first order condition we obtain

$$R_{qN} = \frac{W}{q(1-M)} [(\pi - M)b - t].$$

Thus R_{qN} has the sign of ρ_w . When safety in numbers dominates the cost effect, increased predation will increase trade. For M large, however, safety in numbers is reduced in importance and increased predation will decrease trade. Thus strong mafias reduce trade in response to increases in predation while weak ones increase trade.

In summary, *raids on illegal trade reduce anarchic trade and trade protected by a strong mafia, but will perversely increase trade volume protected by a sufficiently weak mafia.*

4 Conclusion

We have developed a model of trade subject to predation with and without enforcement. In anarchy, traders try to avoid predators; with private enforcement the traders try to avoid predators and, in addition, purchase protection. A key feature of the equilibrium interaction of predators and traders is safety in numbers: the success rate rises with the volume of trade.

Safety in numbers has important implications for the existence of trade and for the success of state policies against illegal trade. We show that two types of policy generally aimed at reducing the volume of trade, namely raids and eliminating the mafia, may perversely increase it.

We think the model offers a rich but fairly simple and flexible platform for extending the analysis of enforcement as protection of exchange from predation. First, 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. The terms of trade effects of predation and policies to suppress it may be fruitful to examine.

Second, the owners of specific capital in the trade services industry receive rents which vary with enforcement and tax policies. Allowing them an active political role in a political economy structure may enrich the explanations of trade and enforcement policies. Third, private enforcement is divorced from the ownership of specific capital in trade services. For some markets, the history of trading firms such as the British and Dutch East India Companies suggests combining these activities.

Finally, to the extent that traders and robbers allocate themselves between legal and illegal markets, the possibility that safety in numbers obtains across markets provides a positive spillover in demand for enforcement services. This leads to complementarity in demand as well as in enforcement strategies. Exploring the implications of this is likely to give insights into tolerance vs. hostility in state actions toward trade in illicit goods.

References

- [1] Abt Associates (2001) *The Price of Illicit Drugs: 1981 through the Second Quarter of 2000*, Washington, D.C.:Office of National Drug Control Policy
- [2] Anderson A. (1995) “Organised Crime, Mafia and governments” in Fiorentini, G. & Peltzman, S. *The Economics of Organised Crime*, Cambridge: Cambridge University Press.
- [3] Anderson J.E. and D. Marcouiller (2002), “Insecurity and the Pattern of Trade: An Empirical Investigation”, *Review of Economics and Statistics*, 84 (2), pages 342-352.
- [4] Anderson J.E. and D. Marcouiller (2004), “ Anarchy and Autarky: Endogenous Predation as a Barrier to Trade” with Douglas Marcouiller, *International Economic Review*, forthcoming.
- [5] Anderson, J.E. and E. van Wincoop (2002), “Borders, Trade and Welfare” in D. Rodrik and S. Collins eds. *Brookings Trade Policy Forum 2001*, Washington: The Brookings Institution.
- [6] Anderson, J.E. and E. van Wincoop (2004), “Trade Costs”, *Journal of Economic Literature*, forthcoming.
- [7] Baier, S. L. and J. H. Bergstrand (2001), “The Growth of World Trade: Tariffs, Transport Costs and Income Similarity,” *Journal of International Economics* 53, 2001, 1-27.

- [8] Buchanan J. (1988) “A Defense of Organized Crime?”, in Alper, N., Hellman, D. (eds.) *Economics of crime: A reader*. Needham Heights, Mass.: Simon and Schuster, Ginn Press, pages 258-75. (Previously published 1973)
- [9] Dixit, A. (2003) *Lawlessness and Economics*, Princeton University Press.
- [10] Falcone, G. and M. Padovani (1992) *Men of Honour: the Truth about the Mafia* London: Fourth Estate.
- [11] Firestone, T. (1997) “Mafia Memoirs: What They Tell Us About Organized Crime” in Ryan P. and G.Rush *Understanding Organized Crime in a Global Perspective*. Sage Publications.
- [12] Gambetta, D. (1993) *The Sicilian Mafia: The Business of Private Protection*, Cambridge, Massachusetts: Harvard University Press.
- [13] Niskanen, W. (1992) “Economists and Drug Policy” *Carnegie Rochester Conference Series on Public Policy*; 36(0), pages 223-48.
- [14] Neher, P. (1978) “The Pure Theory of the Muggery” *American Economic Review*, 68(3), pages 437-445.
- [15] Sah, R. K. (1991), “Social Osmosis and the Patterns of Crime”, *Journal of Political Economy*, 99(6), pages 1272-1295.

- [16] Schelling, T. (1984) "What is the Business of Organized Crime?" in *Choice and Consequence*. Cambridge: Harvard University Press.(Previously published: 1967).
- [17] Schneider, F. and D. Enste (2000) "Shadow Economies: Size, Causes, and Consequences" *Journal of Economic Literature*; 38(1), pages 77-114.
- [18] Smith, Adam (1976), *The Wealth of Nations*, Chicago: University of Chicago Press.
- [19] United Nations Office for Drug Control and Crime Prevention (1998) *Economics and Social Consequences of Drug Abuse and Illicit Trafficking*, New York, NY
- [20] United Nations Office for Drug Control and Crime Prevention, *Global Illicit Drug Trends*, New York, NY: 1999,2000,2001,2002.
- [21] US General Accounting Office (1999) *Drug Control: Narcotics Threat from Colombia Continues to Grow* Washington D.C.

5 Appendix: Endogenous b and c .

This appendix verifies our claim that endogenous b and c present no qualitatively new elements. We replace the constant b and c with $b(q)$, $b_q < 0$ and $c(q)$, $c_q > 0$. Maintaining all other elements of the model as in the text, the difference made by endogenous b and c shows up in the trade volume functions, changing their shapes but their slopes have the same sign ranges under essentially the same conditions.

For anarchic traders the insecure equilibrium volume satisfies:

$$Q(w) = q : \frac{w}{\theta}b(q) - c(q) - wkq^{1/\alpha-1} = 0$$

No closed form solution will generally be possible, but

$$Q_w = -\frac{b/\theta - kq^{1/\alpha-1}}{wb_q/\theta - c_q - wk(1/\alpha - 1)q^{1/\alpha-2}} > 0,$$

volume increases in w just as with constant b and c . The marginal response is less, however, as may be seen by examining the above expression as b_q and c_q become small. The limiting value of w where trade falls to zero is defined by $w_{\min} = \theta c(0)/b(0)$ while the limiting value of secure trade is implicitly defined by $b(q) - c(q) - \theta kq^{1/\alpha-1} = 0$. This does not have a closed form solution, but the implicit solution is qualitatively similar to $(\frac{b-c}{\theta k})^{\alpha/(1-\alpha)}$ in the constant b and c case.

For the monopoly enforcer case, the endogeneity of b and c increases its market power. The first order condition of the enforcer is given by

$$-\frac{\rho_q}{\rho_w} = W_q(q)$$

The new effect arises in $\rho_q = (\pi b - c - t/\alpha) + (\pi b_q - c_q q)$, where the second (negative) term complements the first term previously analyzed. In contrast, ρ_w is unchanged. The presence of the new terms makes it more likely that the insecure equilibrium is found in the region where $\rho_q < 0$. The new terms are independent of w plausibly, so they do not introduce any qualitatively new aspects to the comparative static analysis.

Figure 1. Anarchic Equilibrium

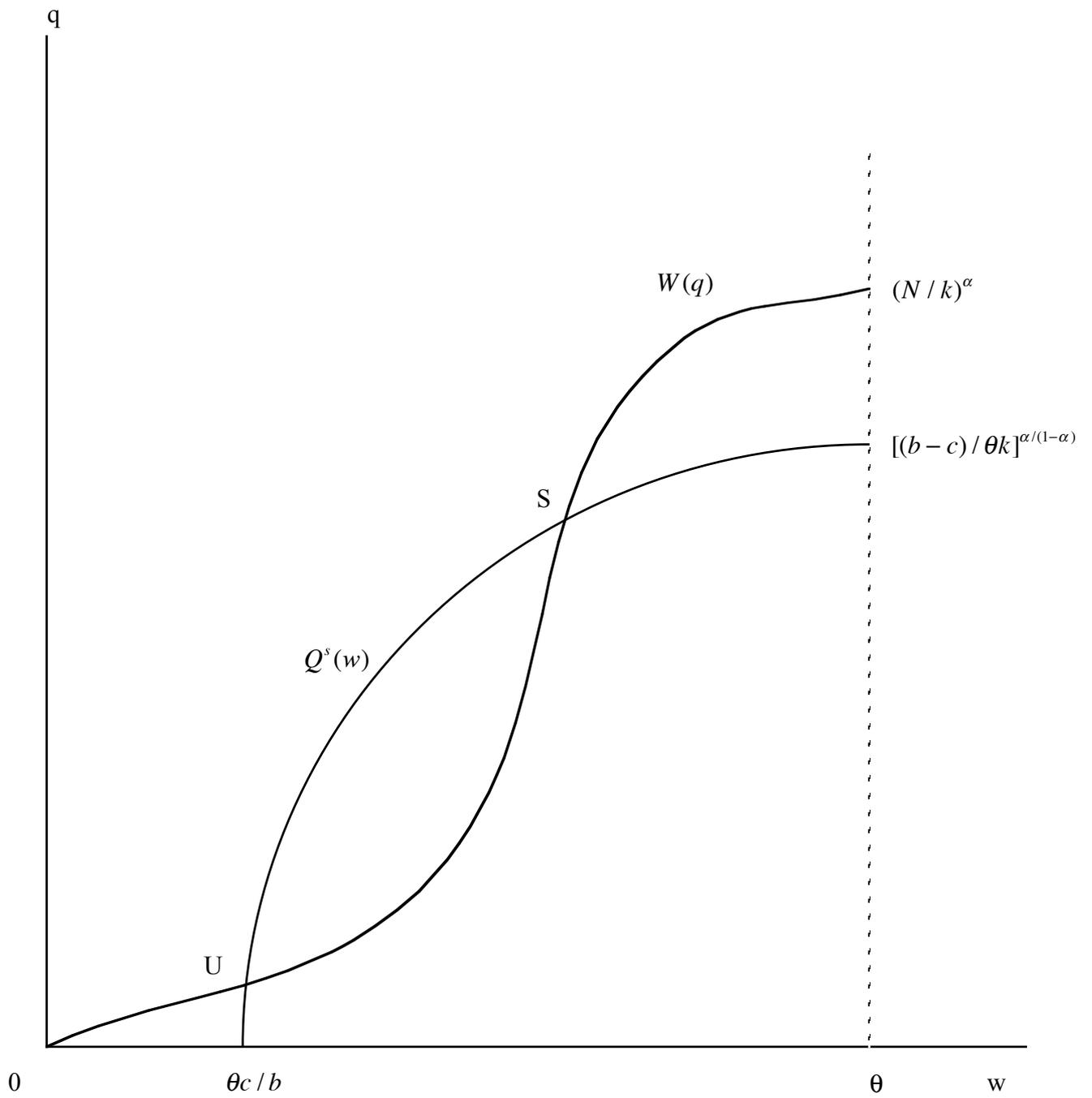


Figure 2. Strong Enforcement Equilibrium, $\rho_q > 0$

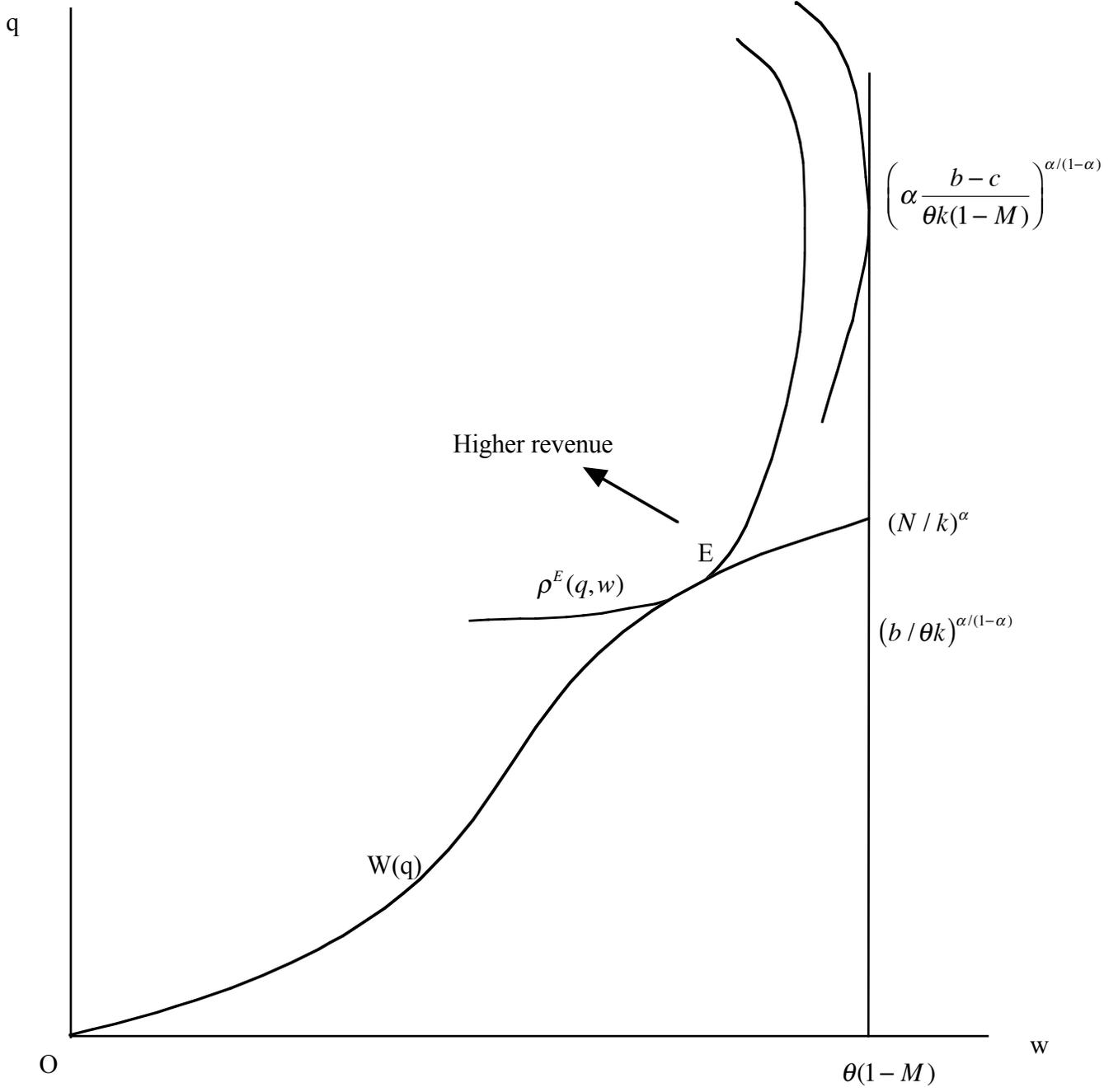


Figure 3. Weak Enforcement Equilibrium, $\rho_q < 0$

