PIRATES AND TRADERS:
Some Economics of Pirate-infested Seas

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Abstract

Even where all agents are risk-neutral, merchants can insure themselves against piracy. Such self-insurance is surprisingly invulnerable to moral hazard. Further, there exist a patrolling intensity and/or penalties for captured pirates which, along with mercantile self-insurance, could eliminate piracy.

Keywords : Piracy, violent crime, economies of scale, penalties, moral hazard, self-insurance.

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1. Introduction

Piracy on the high seas typically conjures up visions of swashbuckling adventurers from the pages of history (the economics and internal organization of such pirates were examined in Leeson (2007), (2009a),(2009b), (2009c) and several forthcoming papers, among others[3]). Recently, however, accounts of modern day pirate attacks and anti-piracy measures have dominated world news. Modern piracy results in an estimated worldwide loss of between 13 and 16 billion US dollars per year.[4] Reported pirate attacks trebled in the decade 1993-2003, according to the International Maritime Bureau.[5] Particularly vulnerable areas include the Straits of Malacca, West Africa, the waters off Somalia, Chittagong and the Indian Ocean.

Economists' analysis of organized crime began with Becker's (1968) pioneering study of crime and punishment. Subsequent studies of the impact and causes of organized crime or of optimal prevention methods include Anderson (1979), Reuter (1983,1987), Jennings (1984), Arlacki (1986), Jankowski (1991), Dick (1995), Konrad and Skaperdas (1998), Garoupa (2000), Skaperdas (2001), and Chang, Lu and Chen (2005). As Leeson (2007) points out, most literature on the economics of organized crime has regarded suppliers of organized crime as providing a service in the form of "protection" to others, and having a monopoly on coercion (following Schelling (1971)). Leeson himself looks at the internal organization of seventeenth and eighteenth-century pirates – criminals who provided no services to any outsider.

To the best of our knowledge, however, research by economists on modern high seas piracy is very limited. One such study is Anderson and Marcouiller (2005) which examines a two-country Ricardian trade model where individuals may choose between productive activity and piracy, and shows that autarky obtains over a large parameter space.

In this paper we examine the options and decisions open to pirates and merchants in a pirate-infested sea on which patrolling by international maritime police foils some attempts at piracy with the pirates being captured and punished. We show that in this scenario

(1) the merchant can insure himself against piracy,

[3] Although Leeson mentions contemporary pirates his papers do not model them as his main interest is in issues of their internal governance, unlike our focus here.

[4] ""Foreign Affairs - Terrorism Goes to Sea" – http://www.foreignaffairs.org/20041101faessay83606/gal-luft-anne-korin/terrorism-goes-to-sea.html

[5] http://news.nationalgeographic.com/news/2006/07/060706-modern-pirates.html

(2) contrary to expectations, such self-insurance is not vulnerable to moral hazard, and
(3) there exists a certain intensity of patrolling and/or certain penalties for captured pirates which, with the help of the merchant's incentive to self-insure, could eliminate piracy.

First, however, we look at some facts about modern piracy and their bearing on our model.

2. Some Facts about Contemporary Piracy

A major objective of pirates is valuable cargo (Kahn 1995, Rosenberg 2009, Kraska and Wilson 2008). Indeed the increasing volume of oil, arms and other valuable exports is a reason for high piracy levels (Rosenberg 2009, Kraska and Wilson 2008). 12% of the world's oil supply passes through the Gulf of Aden, and much through Nigerian waters and the Straits of Malacca: these are the world's major piracy hubs. Our main model, in which we assume that successful pirates seize the ship's cargo, captures this motive. However, our main conclusions remain unchanged if successful pirates merely seek a ransom[6] (see Appendix), provided this ransom is an increasing function of cargo value, as is the practice in such cases (Carbin 2009).[7]

Our stress on patrolling may be disputed on the ground that patrol interventions to prevent pirate attacks have been rare. However, our focus is on the *deterrent* effect of stringent policing and penalties: where these prevail and complement merchants' self-insurance, piracies would not be attempted at all. If patrolling is effective, actual interventions would be rare. Thus, coordinated patrolling of the Straits of Malacca by Singapore, Malaysia and Indonesia from 2004 reduced the probability of pirate attacks to .00019 in 2005. Of course, pirates deterred by patrols in one region may shift focus elsewhere so that the world-wide frequency of piracy may not fall without global increase in patrols. Intriguingly, more than 200 years ago, Jefferson proposed constant patrolling by navies of different countries to reduce piracy. However, his plan could not be implemented due to the financial impotence of the U.S. Congress (Kahn 1995).

Could crews effectively defend merchant vessels against pirates? Probably not: most governments actively discourage merchant seamen from carrying arms (Kahn 1995) and most ship-owners concur because of the cost of training civilians in using arms, the risk of lethal collateral damage to innocent outsiders and to themselves and their ship, the reluctance of other countries to allow merchant ships bearing arms to enter their waters and the possibility of

[6] Leeson (2009c) describes how many contemporary pirates do this.
[7] Carbin states that the ransom is for the safe delivery of the ship, its cargo and its crew, and accordingly ships carrying cargo of greater value were willing to negotiate higher ransom.

hijacking by the armed crewmen themselves (Carbin 2009). We have accordingly assumed that active defence against piracy requires external patrolling.

3. A Model without Self-Insurance

We define a pirate-infested sea as one in which there is an infinitely elastic supply of pirates prepared to attack any vessel whenever their expected income from doing so is positive. We assume that all agents have perfect knowledge of all the parameters and variables of the model. Pirates, for instance, know not only the intensity of patrolling but also the value of the cargo of each vessel. Some justification is lent to this assumption by recent evidence that pirates typically have inside information from secret agents in shipping companies or crews about freight values, route plans and the like. Merchants know the likelihood of rescue in the event of a pirate attack. We also assume that both pirates and traders are risk-neutral – so that conventional insurance by outside agencies is unprofitable. We show however that there exists a form of self-insurance against piracy that is open to the merchant – and it is on this option that our paper focuses.

A pirate who attacks a merchant ship hopes to capture a cargo of value C, but fears seizure and consequent punishment amounting to S. p, the probability of seizure, is an increasing function of the intensity of patrolling. The pirate's expected income from his venture will be

$$(1 - p)C - pS.$$

Piracy will be worthwhile iff

$$C > C^*(p) = pS/(1 - p)$$

where $C^*(p)$ is increasing in p

$$C^{*\prime}(p) = S[1 + p/(1 - p)]/(1 - p) > 0.$$

The merchant, while contemplating the voyage, considers the profit $\pi(C)$ he hopes for if successful, the expected likelihood of a successful pirate attack (which is 0 for $C \leq C^*$ and $1 - p$ for $C > C^*$) and the cost $f(C)$ he will incur in the event of such an attack (which will vary with the booty he carries : $f'(C) > 0$). We assume that there will be no more than one pirate attack per voyage: this is plausible because if the attack is successful, the vessel will no longer have a cargo to attract pirates while if it fails, that would be due to intervention by a patrol, which presumably escorts the ship to safety.[8] There are economies of scale in shipping – $\pi'(C) > \pi(C)/C$. A profit function of this kind – which we adopt only on account of its simplicity – is

$$\pi(C) = -a + bC$$

where profits are a fixed fraction $b < 1$ of the value of the cargo less the fixed cost a of the voyage. In the event of a successful pirate attack, the merchant loses his entire cargo C and the fixed cost of his voyage a. We assume that this is all he loses.

$$f(C) = a + C.$$

The merchant's expected income $\pi_1(C)$ if he risks the voyage amounts to

$$\begin{aligned} \pi_1(C) &= p(bC - a) - (1 - p)(C + a) \\ &= [p(1 + b) - 1]C - a \end{aligned}$$

if $C > C^*$ and

$$bC - a$$

if $C \leq C^*$. The voyage will be profitable if

$$p(1 + b) > 1 \text{ and}$$
$$C > \underline{C} = a/[p(1 + b) - 1]$$

(with $\underline{C}$ decreasing in p) when $C > C^*$, and if

$$C > a/b$$

when $C < C^*$.

4. A Model with Self-Insurance

This however is not our main focus. We have assumed so far that the merchant's cargo is exogenously determined. But the merchant has another option: he could divide up his cargo into lots, each no larger than C^* to eliminate the risk of piracy altogether. He could in effect insure himself, and since this would lead to diseconomies of small-scale shipment, such self-insurance could create moral hazard. Intensification of patrolling, by increasing the likelihood of seizure of pirates, may induce neglect of costly self-insurance, and increase the actual incidence of piracy.

Would it? We compare the merchant's expected profit $\pi_1(C)$ when he risks pirate attack with his profit $\pi_2(C, n)$ when he splits his cargo into lots that eliminate this risk (where $C = nC^*$

[8] We make this assumption for simplicity and also because it is in line with our general framework: (1) rational well-informed pirates who would not waste their time attacking an already plundered vessel, and (2) ships that depend primarily on maritime police for their defence (so that those that have foiled one attack are likely currently to be in the care of a naval convoy and so invulnerable to a second attack). Of course, occasionally one or both these assumptions may be violated.

+ R with integral n and R < C*). When C < C*, there is no piracy risk and the merchant trades whenever C > a/b (which implies pS/(1 – p) > C > a/b). But when C > C*, the options diverge:

$$\pi_1(C) = [p(1 + b) - 1]C - a$$

$$\text{and } \pi_2(C, n) = bC - (n + 1)a.$$

The merchant will run the risk of piracy whenever $\pi_1(C) > \pi_2(C, n)$ or

$$(1 - p)(1 + b)C < na.$$

He will split his cargo into (n + 1) lots when this inequality is reversed. This leads to

Theorem 1. If p > a/(1 + b)S, the merchant always insures against piracy. If p < a/(1 + b)S, he always risks piracy.

Proof: p > a/(1 + b)S implies

$$C^* = Sp/(1 - p) > a/(1 + b)(1 - p).$$

When C lies between nC* and (n + 1)C*,

$$C > nC^* > na/(1 + b)(1 - p)$$

$$\text{Or } (1 + b)(1 - p)C > na,$$

so that the merchant eliminates the chance of pirate attack by splitting his cargo into (n + 1) lots for any C in this interval. Since n can be any integer, this establishes the result for all C.

We prove the converse result, for p < a/(1 + b)S, by induction. Assume that $\pi_2((m - 1)C^*, m - 1) \leq \pi_1((m - 1)C^*)$. Then, for any C between (m – 1)C* and mC*,

$$\pi_2(C, m) = \pi_2((m - 1)C^*, m - 1) + bR - a$$

$$\pi_1(C) = \pi_1((m - 1)C^*) + [p(1 + b) - 1]R$$

Now, p < a/(1 + b)S implies

$$C^* = Sp/(1 - p) < a/(1 + b)(1 - p).$$

$$\text{So, } R < C^* < a/(1 + b)(1 - p)$$

$$\text{Or } [p(1 + b) - 1]R - (bR - a) > 0.$$

Further, by assumption

$$\pi_1((m - 1)C^*) \geq \pi_2((m - 1)C^*, m - 1)$$

So $\pi_1(C) > \pi_2(C, m)$ for all C between (m – 1)C* and mC*. In particular, $\pi_1(mC^*) > \pi_2(mC^*, m)$ – so that we can repeat the exercise for C between mC* and (m + 1)C*.

Finally, to complete the proof by induction, note that $\pi_1(C^*) > \pi_2(C^*, 1)$.

Theorem 1 implies that there is no moral hazard. Increased security for shipping never reduces and may actually increase the incentive for self-insurance. The intuitive explanation is that it raises the threshold value of cargo C^* below which pirates would not bother to risk an operation. This encourages merchants to restrict shipments to this limit – an effect which more than offsets the temptation to avoid the costs of self-insurance as patrolling is intensified.

An interesting corollary of our model is that p and S are exactly symmetrical in their effects. An increase in p could be substituted by an equiproportional increase in S: higher penalties for captured pirates would have the same effects as increased patrolling. This is crucial for self-insurance: it can be argued that economies of scale in shipping are so dominant ('a' so high) that, with a given S, $p > a/(1 + b)S$ may not be achievable (since p can never exceed unity) and traders may not therefore self-insure. However, an adequate increase in penalties could always do the trick. A major problem with anti-piracy operations is that most governments are reluctant to try captured pirates "on location" for fear of violating international law and so often allow them to go scot-free (Leeson, forthcoming).

Theorem 1 also means that no piracies will be attempted either when $C \leq C^*$ or when $p > a/(1 + b)S$. Given a cumulative distribution F(C) of cargoes (prior, that is, to any decision to split them up for insurance against piracy) and a total number of voyages M, the number of piracies attempted will be

$$N = M[1 - F\{C^*(p)\}] \text{ for } p < a/(1 + b)S$$
$$\text{and } 0 \text{ for } p > a/(1 + b)S.$$

We assume that $F(a/b) = 0$ – no voyages are proposed with cargoes that guarantee losses even in the absence of pirate attacks. N decreases in p up to the level $p = a/(1 + b)S$ – and then drops abruptly to zero. We can couple this piracy function with a function p(N) that depicts the international community's response in terms of intensity of patrolling to the piracies to figure out the equilibrium rate of piracy. However, the point of our exercise is that if the powers that be sustain a level of patrolling (and symmetrically a penalty for captured pirates) that ensures $p > a/(1 + b)S$ *even when there are no piracies*, the pirate menace will be taken care of by self-insurance on the part of merchants.

Appendix: Piracy for Ransom

Assume that successful pirates secure a ransom instead of stealing a ship and its cargo. Hence, the loss of the merchant in case of a successful pirate attack is now

$$f(C) = R(C) = X + yC \tag{A1}$$

Ransom, $R(C)$, is an increasing function of cargo ($y > 0$). X is independent of cargo (perhaps the ransom value of the ship and the crew). Without self-insurance, a pirate attacks if

$$(1 - p)(X + yC) - pS > 0$$

$$\text{or if } C > [pS/(1 - p) - X]/y = C^*(p) \tag{A2}$$

$C^{*\prime}(p) = S/y(1 - p)^2 > 0$ so this threshold is increasing in p. As in our main model, if $C < C^*(p)$, no piracies are attempted and the merchant's profit is $bC - a$, where a, the fixed cost, includes payment for the ship and the crew, so that he makes a voyage provided $C > a/b$. If $C > C^*(p)$, a merchant has to risk piracy and his profit is

$$\pi_1(C) = bC - a - (1 - p)(yC + X) = [b - (1 - p) y]C - a - (1 - p)X \tag{A3}$$

A profitable voyage requires $py > y-b$ and $C > [a + (1 - p)X]/[b-(1-p)y] = \underline{C}(p)$ (again, decreasing in p). Voyages without self-insurance are profitable only for cargoes above this threshold.

With self-insurance, if $C > C^*(p)$, a merchant will split his cargo into n+1 lots – n of size C^*, and the balance $B < C^*$ (his total cargo $C = nC^* + B$) rather than risk pirate attack iff $\pi_2(C, n) = bC - (n + 1)a > \pi_1(C)$, or iff

$$(1 - p)(yC + X) > na . \tag{A4}$$

Using this relationship, we establish two results:

1. *Appendix Result 1:* If $p < \underline{p} = (a + X)/(2S + X)$, a merchant *never* self-insures.

Proof: Consider an integer n and any C between nC^* and $(n+1)C^*$, $C = nC^* + B$ where $B < C^*$. Now, $p < \underline{p}$ implies $p < (a + X)/[S(1 + 1/n) + X]$ for all $n > 1$. Simplifying and substituting $C^* = [pS/(1 - p) - X]/y$, this reduces to $(1 - p)[y(n + 1)C^* + X] < na$. Since $C < (n + 1)C^*$, it follows that $(1 - p)[yC + X] < na$. (A4) then means no self-insurance for any C.

2. *Appendix Result 2:* If $p > p^* = (a + X)/(S + X)$, merchants *always* self-insure irrespective of the size of their cargo (restricting ourselves to $C > C^*$, as below there is no risk of piracy and hence no need for self-insurance).

Proof: $p > p^*$ implies $p > [a + X(1 - 1/n)]/[S + X(1 - 1/n)]$ (for all positive n), which, on simplification and substitution of $C^* = [pS/(1 - p) - X]/y$, yields $(1 - p)(ynC^* + X) > na$.. Since $C = nC^* + B > nC^*$, it follows that $(1 - p)(yC + X) > na$. (A4) means self-insurance for all C.

Low enough patrolling or penalties destroy the incentive for self-insurance, while intensive patrolling or high penalties, far from causing moral hazard, actually encourages self-insurance.

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