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Barrgh-gaining with Somali Pirates

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Baargh-gaining with Somali Pirates

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November 2012

Abstract Ransoms paid to Somali pirates are drifting upward and negotiation times are increasing, yet there is huge variation in bargaining outcomes across ship-owners. We use a unique dataset of 179 Somali hijackings, and an underlying theoretical model of the bargaining process based on detailed interviews with ransom negotiators, to analyze the empirical determinants of ransom amounts and negotiation lengths. We find that ransom amount and negotiation length depend on the observable characteristics of both pirates and ships and on the "reference ransom" established by previous ransom payments for a specific ship type. International naval enforcement efforts have driven up ransom amounts. We also observe a "hump-shape" in ransoms, with relatively low ransoms being paid following both short and very long negotiations, and the highest ransoms paid following intermediate length negotiations.

Keywords: Piracy, ransom, duration, bargaining, law enforcement, Somalia.

JEL: K42, P48

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1. Introduction

Reported ransoms paid to Somali pirates have been rising steadily in the last few years, while new records are being set for the duration of the ransom negotiations. The value of ransoms paid to Somali pirates is estimated at around 200 million USD annually by Besley *et al.* (2012), and their estimate of the full economic cost of piracy is considerably larger at 1.5 billion USD annually.[1]

However, there is huge variation in ship-owners' experiences regarding both ransom payments and negotiation lengths (see Figure 1). Why can some ship-owners pay a couple of hundred thousand USD after a few weeks, while others must negotiate in excess of a year to ransom their ship for several million USD? In this paper we examine empirically the determination of ransom amounts and negotiation durations using a new dataset of hijackings and ransoms in Somalia.

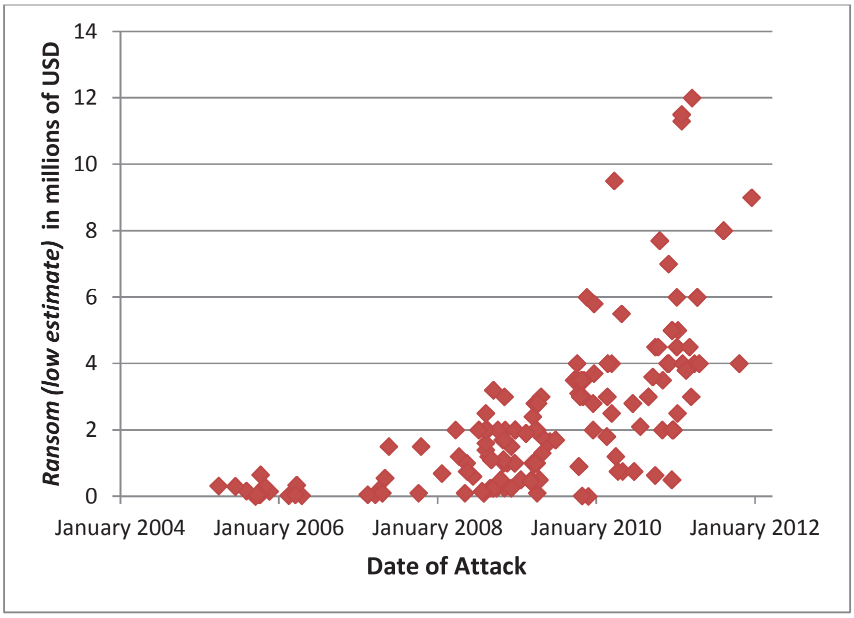

Figure 1a: Ransoms over Time

[1] For the growing literature investigating modern-day piracy see, e.g., Bendall (2001), de Groot *et al.* (2011), Hastings (2009), Iyigun and Ratisukpimol (2011) and Martínez-Zarzoso and Bensassi (2011). For more on the historical organisation of pirates see, e.g., Leeson (2007, 2009).

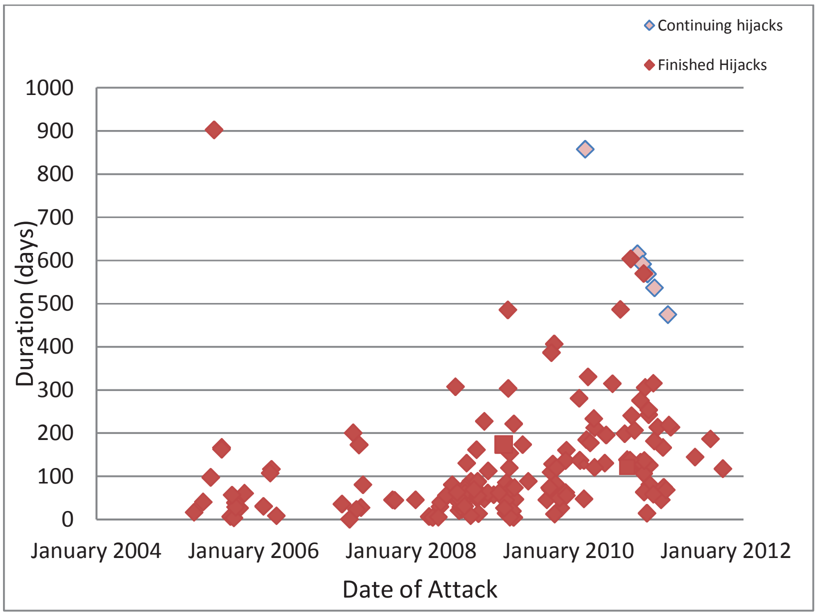

Figure 1b: Negotiation duration over time as of August 7, 2012

Drawing on a series of interviews with professional pirate negotiators, we develop a simple bargaining model (a finite game of alternating offers) that captures many aspects of modern-day pirate ransom negotiations, such as the transaction costs of negotiation, the pirate's seizure costs, the ship-owner's valuation of the ship, and the pirate's "reference" ransom – the minimum ransom the pirates consider "satisfactory" – which we model as a function of previous ransom amounts for comparable ships. We characterize the comparative-statics predictions of the model for the ransom amount under the simplifying assumption of perfect information. To understand the predictions of economic theory for negotiation length, we introduce considerations from the literature on bargaining under asymmetric information, where models with one-sided asymmetric information predict a negative relationship between negotiation duration and the ransom amount (e.g., Admati and Perry, 1987; Fudenberg *et al.* 1985; Grossman and Perry, 1986; Gul and Sonnenschein, 1988; Sobel and Takahashi, 1983). We argue, however, that pirate negotiations involve two-sided asymmetric information, which may alter the predicted relationship under one-sided asymmetric information. In particular, we argue that, for empirically reasonable parameter values, a plausible outcome is a hump-shaped relationship, whereby ransom amounts correlate positively with duration for short negotiations, but correlate negatively with duration for longer negotiations.

We estimate separate models for ransom amount and negotiation duration. Survival analysis is used to estimate negotiation length, and OLS to estimate ransom amounts. Our main findings for the ransom amount are, first, that "sophisticated" pirates (akin to organised criminal gangs) extract higher ransoms than "opportunists", who lack the infrastructure to sustain long negotiations. Second, we demonstrate that higher past ransoms are positively associated with subsequent ransom amounts. Hence higher ransom amounts impart a negative externality on future victims. This finding has policy implications for governments considering becoming involved in ransom negotiations. For instance, under political pressure to recover hostages, the Spanish government paid 1.2 million USD in 2008 for release of the Playa del Bakio, more than twice the previous record amount for a fishing vessel.

Our main findings for negotiation duration are that ransom durations have lengthened as pirates have developed the land-side infrastructure needed to protect and supply ships for long periods of time. In line with our theory, ships held by small-scale piracy operations and ships owned by well-resourced shipping companies (large ships crewed by sailors from developed countries) are released faster than average. We find that ransom amounts and negotiation length correlate positively for sufficiently low ransom amounts, and correlate negatively for sufficiently high ransom amounts, i.e. a hump-shaped relationship. This finding is consistent with our model in the presence of two-sided asymmetric information.

To our knowledge, ours is the first systematic empirical study of ransom amounts and negotiation lengths for modern-day piracy. Ambrus *et al*. (2011), however, examine historical data on captives ransomed from the Barbary Corsairs during rescue missions conducted by Spanish negotiating teams between 1575 and 1739. Their main contribution is a structural estimation of a one-sided asymmetric information bargaining model with transaction costs. We also use bargaining theory to inform our empirical models, and compare our findings to the predictions of bargaining theory. However, Ambrus *et al*. treat each negotiation in isolation, although, in reality, negotiations during each rescue mission were part of a repeated game, in which the same captive could be bargained for during multiple missions. Modern-day pirate ransom negotiations are also often just one stage of a repeated game. As discussed above, however, we allow, in both the theory and empirics, for the outcome of previous negotiations to influence later negotiation outcomes through the pirate's reference ransom.[2]

Our paper also relates to the literature on strategic bargaining with terrorist groups. This literature considers the bargaining game played between governments and terrorist groups, both theoretically (e.g., Sandler *et al*., 1983; Atkinson *et al*., 1987; Lapan and Sandler, 1988, 1993) and empirically (e.g., Sandler and Scott, 1987; Gaibulloev and Sandler, 2009). Different from this literature, however, pirate ransom negotiations typically take place between two private parties, with government involvement on the ship-owner's side generally limited to passive observation.[3]

Last, our paper contributes to the ongoing policy debate as to the best way(s) of reducing the welfare loss due to piracy. The current approach – sea-based intervention by navies and private security companies – appears to have reduced pirates' success rates and increased their costs. Our results suggest, however, that this approach may not have fundamentally undermined the pirate business model, as pirates have responded by raising the returns on successfully hijacked ships. The international community could intervene in the bargaining

[2] The papers also differ subtly in emphasis: Ambrus *et al*. use pirate negotiation data as a vehicle to test hypotheses concerning bargaining theory, whereas we use bargaining theory as a vehicle to test hypotheses concerning pirate negotiation data.

[3] Interviews with ransom negotiators. An exception is the Spanish government, which has played a highly active role in several recent negotiations.

process in two ways: first, as governments ultimately sanction ransom payments there could be concerted action to clamp down on record payments. Second, states could lower ransoms by making ship-owners more "patient" in their negotiations for example by providing emergency financial assistance to ship-owners and compensation to captive sailors.

2. Theoretical Considerations

The length of a ransom negotiation and the amount of the final ransom are the outcome of a bargaining process between a pirate gang and a ship-owner. In this section we develop a descriptive model of pirate bargaining in order to inform our empirical analysis. We augment this model with a discussion of the implications of allowing for incomplete information.

2.1 A Model

Real-world ransom negotiations are extremely complex – involving differential and time-variant discount rates and transaction costs, multiple parties, asymmetric and incomplete information, repeated interactions, negotiator skill, reference points, and learning. We therefore present a simple model that seeks to extract from this complexity the main descriptive factors predicted to shape the bargaining outcome, and that clarifies the expected direction of these relationships.

There are two classes of agent: pirates and ship-owners.[4] Each agent class is split into two types. A ship-owner is either "rich", or "poor"; a rich ship-owner can raise a maximum sum for ransom of f_r, and a poor ship-owner can raise f_p, where $f_r > f_p$.[5] Pirate gangs can be of two types, amateur or sophisticated, according to the degree of organization of their operations. Amateur piracy is essentially opportunistic, while sophisticated piracy behaves like organized crime.

At cost c_0, a pirate gang can seize a ship. Mounting a pirate expedition can be an expensive business: an attack group associated with a typical "sophisticated" gang involves 10-25 persons, 2-3 skiffs with high-powered motors, telecommunications equipment, at least one rocket-propelled grenade, several AK47s, and a sturdy, well-provisioned, "mother-ship" for excursions into the Indian Ocean (World Bank, forthcoming). Most expeditions are unsuccessful as ship-owners have increasingly invested in on-board defence systems

[4] In practice, ransom negotiations involve more than these two classes of agent. Insurers, who bear the ultimate liability, are not typically involved directly in the negotiation process. Insurers selling "kidnap and ransom" (K&R) insurance, however, usually ensure their interests are represented by recommending the ship-owner the services of a professional negotiator, whom they hold on a retainer contract. For ship-owners without K&R insurance, the emergence response team is organised by lawyers, generally drawn from a small pool of firms specialising in piracy cases. National law enforcement agencies may also seek involvement. On the pirate's side, an English-language speaker will negotiate on behalf of a pirate committee made up of the captain and financiers of the pirate venture and representatives of the local militias that provide protection while a ship is at anchor. Sometimes the pirate negotiator may become a distinct party, by attempting to secure a separate personal settlement, unbeknown to the pirate committee.

[5] The ship-owner's insurance will takes the form of an indemnity contract, in which the insurer will reimburse the ransom and other losses ex-post. An important constraint on finance is that ship-owners cannot use future insurance payouts as collateral for securing loans.

according to current Best Management Practice or private security guards (only around 20% of attacks succeed). Many pirate crews perish in storms or in failed attacks, or are arrested by naval forces.[6] The size of c_0 will, therefore, typically reflect the costs of more than one expedition.[7] The seized ship, along with its cargo and crew, has a value to the ship-owner at the opening of the negotiations of v. With each extra period of negotiations, the ship-owner's valuation depreciates by a factor $\tau \in (0,1)$ as cargo degrades or perishes, onboard supplies are consumed, and barnacles grow on the hull.[8]

Both parties incur costs associated with each additional period of negotiations. The pirates, for instance, must maintain a guard team on board the ship and employ an English-speaking negotiator. The ship-owner loses charter income during the negotiations and must delegate a member of senior management to monitor or conduct the negotiations and handle enquiries from the press and the crew's families. Let c_p and c_s be the per-period cost of prolonging negotiations for the pirates and ship-owner respectively. Future payoffs are discounted by a factor $\delta_p \in (0,1)$ by the pirates, and by a factor $\delta_s \in (0,1)$ by the ship-owner. The pirate's discount factor may reflect the degree of political and economic instability in the proximity of the anchorage, which may compromise their ability to retain control of the vessel. The ship-owner's discount factor may reflect time-to-insolvency considerations.

Drawing on the insights of behavioural economics, in particular the prospect theory of Kahneman and Tversky (1979), the pirates are assumed to have a reference level γ_p that is used to psychologically evaluate ransom amounts, such that ransoms $r \geq \gamma_p$ are considered "satisfactory", and ransoms $r < \gamma_p$ are considered "unsatisfactory". We write the reference ransom as $\gamma_p \equiv \gamma_p(\Psi)$, where Ψ contains all factors relevant to the reference ransom.

What might be the elements of Ψ? Ransom negotiators suggest that the reference ransom reflects a wide set of factors and is often only loosely related to objective estimates of the replacement cost of the ship and its cargo, and the value of the lives of the crew. For instance the reference ransom is claimed to be highly path-dependent, depending importantly on the size of the ransom agreed for the previous ship hijacked by the gang.[9] Simple measures, such as ship-size, are used by the pirates to scale the reference ransom. For instance, if the present ship is twice as big as that most recently captured by the gang, the reference ransom will be around double the amount of the preceding ransom. Social preferences may also matter:

[6] Even the much derided "catch and release" approach employed by many navies requires pirates to throw all weapons and incriminating equipment overboard (Shortland and Vothknecht, 2011).

[7] In practice, there is some variation according to type: for instance, sophisticated pirates are equipped with more advanced weaponry and therefore incur higher expedition costs.

[8] We include τ as a realistic feature of the bargaining process. From a theoretical point of view, however, it is not required for any of our results and can, if the reader prefers, be set to unity.

[9] In this way, the reference ransom captures the interdependence between ransom negotiations within a simple one-shot model. Modelling pirate negotiations explicitly as a repeated game might nevertheless alter our analysis, as it is known that for such games the subgame-perfect equilibrium does not implement the one-shot equilibrium in each repetition (Muthoo, 1999: 303). Consideration of the repeated nature of the interaction raises the stakes for both sides, as each must bargain over a stream of future ransoms, rather than only a single ransom. As it is unclear which (if either) party might benefit from this additional consideration, however, we do not formally develop it here.

pirate gangs apparently gain utility from outdoing each other, and therefore may take into account recent ransom amounts achieved by rival gangs in forming their reference ransom. These factors are consistent with evidence from behavioural economics that identifies self- and social-comparison (e.g., Rablen, 2008) and expectations (Kőszegi and Rabin, 2006) as important determinants of reference levels.

Objective features, such as type, age and flag-state of the ship, and the make-up of its crew, would also be expected to play a role. For instance, pirates recognise that a crew from richer countries increases the probability that the owner is also located in a rich country. In addition, as estimates of the value of a statistical life (VSL) vary between countries, crew from rich countries signals a higher value for v.[10] Accordingly, pirates will reckon British hostages to be more valuable than Filipino equivalents, for instance.

There are significant financial and logistical hurdles to holding a ship and its crew over a sustained period. First, pirates have to keep the ships safe from rival gangs as well as local law enforcement initiatives, whether these are local grass-roots or foreign-sponsored regional government campaigns. Access to a safe haven, where the local clan leadership guarantees security, requires a payment of a significant upfront anchorage fee and members of the local clan militia must be hired to guard captured ships and crew. Second, once on-board supplies have run out, crews and their guards have to be fed and diesel is needed to keep lights and desalination facilities operational. Last, many pirates are addicted to the stimulant leaf *khat* which deteriorates rapidly with time, meaning that reliable supply lines are needed. Sophisticated gangs therefore have well-established links to local merchants and financiers, as well as the clan elders, war-lords or militia leaders who can provide security (Shortland and Varese, 2012). Amateur pirates, however, lack these capabilities. Barring unrest on land (a problem for pirates of either type) a pirate gang can maintain hostage negotiations for φ periods: a sophisticated pirate gang can maintain hostage negotiations for φ_s periods, and an amateur gang for φ_a periods, where $\varphi_s > \varphi_a$.[11]

Bargaining is conducted with the ship-owner according to a sequence of alternating offers, with the pirates making the initial offer, and the ship-owner making the final offer. In each period $t = 1,\ldots,\varphi$, a ransom offer, r_t, is made, and is either accepted or rejected. This setting corresponds closely to the description of the bargaining process provided by professional ransom negotiators, although, in practice, the sequence of offers may deviate from strict alternation. The instantaneous payoff from accepting offer r_t at time t is therefore:

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[10] Bellavance *et al*. (2009) report mean VSL estimates from studies of eight different countries, ranging from 17 million USD for the UK and 12.8 million USD for Japan, down to 1.6 million USD for South Korea and 1.2 million USD for Taiwan.

[11] It is possible that some amateur pirates subcontract the ransom negotiation to a sophisticated pirate group to increase the final ransom. This would then be observationally indistinguishable from sophisticated piracy. However, not all amateur pirates will choose to do this as a) they might envisage difficulties in enforcing the agreement of a pay out after the ransom negotiation is concluded and b) while the final ransom would most likely increase, so too would the duration of negotiation and the number of people sharing the ransom (e.g. guards, negotiator, accountant, bribes to local and regional officials).

$$\pi_{pt} = r_t - \gamma_p - c_0 - tc_p; \qquad \pi_{st} = \tau^{t-1}v - r_t - tc_s.$$

The sequence of offers ends when offer is accepted. If the offer in the final period, $t = \varphi$, is rejected the game ends. If the negotiation ends in this way, the pirates can utilize the ship as a "mother-ship" in future expeditions, with a payoff of $\rho > 0$ in net present value. Ship-owners are able to recover an amount α through an insurance claim for constructive total loss. The terminal payoffs are therefore

$$\Pi_{p\varphi} = \rho - \gamma_p - c_0 - \varphi c_p; \qquad \Pi_{s\varphi} = \alpha - \varphi c_s.$$

The outcome of the negotiation process is given by a ransom r, and a duration d. The predictions of game theory for these two outcomes are given by the subgame perfect equilibrium of the game, which is found by backwards induction from the last period. The ship-owner moving last ($t = \varphi$) must offer the pirates at least what they can obtain from using the ship as a mother-ship, so $r_\varphi = \rho$.[12] For $t < \varphi$ the equilibrium path requires, in general, that the offer made must be such as to make the other party indifferent between accepting the other's offer immediately and accepting their own after a one-period delay. Hence the sequence of offers of the pirates satisfy

$$\tau^{t-1}v - r_t - tc_s = \delta_s\left(\tau^t v - r_{t+1} - (t+1)c_s\right) \qquad t = 1,3,\ldots,\varphi-1; \tag{1}$$

and those of the ship-owner satisfy

$$r_t - \gamma_p - c_0 - tc_p = \delta_p\left(r_{t+1} - \gamma_p - c_0 - (t+1)c_p\right) \qquad t = 2,4,\ldots,\varphi-2. \tag{2}$$

Because of the assumption of complete information, the negotiation is predicted to end after the first offer ($d = 1$). This version of the model does little, therefore, to help in understanding negotiation length. Nevertheless, it does yield comparative statics predictions for the ransom amount, which corresponds to $r = r_1$ if the ship-owner's finance constraint is not binding, and to $r = f$ otherwise.

Proposition 1 *The equilibrium ransom amount under complete information is:*

a) *increasing in the ship-owner's initial valuation of the ship v, and in the pirate's reference ransom γ_p;*

b) *increasing in the pirate's seizure cost c_0.*

Proof See Appendix.

Proposition 1 summarizes the main comparative statics predictions for the ransom amount. Each of these predictions has a straightforward intuition. The more the ship is worth to the

[12] If it is instead assumed that the pirates make the final offer, they must offer the ship-owner at least $r_\varphi = \alpha$. Our results are qualitatively unaffected by who makes the final offer, but quantitatively, there is a benefit from being the last-mover.

ship-owner, the more s/he is willing to pay. The higher is the pirate's valuation, the more the ship-owner will need to offer to give the pirates a given payoff. The sunk cost c_0 acts as a commitment device, allowing the pirates to credibly threaten to reject low offers. It is therefore associated with higher ransom amounts.

The model does not make a clear prediction for the effect of transactions costs on the ransom amount. For the pirates, for instance, higher costs imply that a higher ransom amount is required to achieve a given payoff. On the other, they weaken the pirate's bargaining strength in a prolonged negotiation. Which of these effects dominates is a function of the pirate's discount factor, and φ, the maximum possible length of the negotiation.

The model makes three further predictions, which our data do not allow us to test. These are that the ransom amount is predicted to be increasing in the amount ρ that a pirate gang can obtain from using the ship as a mother-ship; increasing in the pirate's discount factor; and decreasing in the ship-owner's discount factor. These quantities are observed only privately; hence data are not publicly available. Although discount rates should be affected by stability on land in the neighbourhood of the anchorage, obtaining objective measures for this is not possible in a country for which barely any data exists. Omitting these variables from the empirical analysis is therefore expected to result in a form of unobserved heterogeneity.

2.2 Incomplete Information

To further understand the bargaining process, particularly in respect to its length, the informational structure of the process must be taken into account. In practice, there is typically two-sided incomplete information, as agent type is private information. It is frequently difficult for the pirates to trace the ship-owner and establish his ability to raise a specific ransom.[13] Ownership structures are often (deliberately) opaque, with ships registered under flags of convenience and owned by various holding companies. Following these complicated ownership structures back to the ultimate decision maker tends to lead to an anonymous post-box address rather than a name.[14] Similarly, the ship-owner lacks presence on the ground in Somalia to verify the type of the pirates. However ship-owners can get information of the location of their ship either from the ship's AIS signal or on request from EUNavFor.[15]

Under incomplete information, the bargaining process is not normally predicted to conclude

[13] Negotiation is performed using the on-board telecommunication facilities. These specify an emergency number, which does not reveal the identity of the ship-owner.

[14] Interview with a ransom negotiator. For private individuals pirates may be using the internet to find information to condition their ransom demands. http://www.telegraph.co.uk/news/worldnews/africaandindianocean/somalia/8694887/Somali-pirate-used-mobile-to-surf-web-for-US-kidnap-victim-information.html

[15] There are further sources of incomplete and asymmetric information that we do not address here. For instance, each side better observes its own transaction costs, while the pirates better observe the state of the hostages, the condition of the vessel, and the stability of the anchorage.

immediately.[16] What, then, is the predicted relationship between ransom amounts and negotiation duration? Exploiting the informational vacuum, ship-owners of both types have an incentive to claim to be poor, while pirates of both types have an incentive to masquerade as sophisticated. Since Myerson (1979), economists have analysed such situations by looking for (incentive-compatible) mechanisms that induce parties to truthfully reveal their type.

Owing to the complexity of this bargaining environment a complete characterization of the incentive-compatible equilibrium is beyond the scope of the paper.[17] Instead we highlight one possible outcome when, as seems empirically plausible, φ_a is very small (amateur pirates cannot sustain negotiations for long), φ_s is very large (sophisticated pirates can sustain negotiations almost indefinitely), δ_s is sufficiently high that the ship-owner would never choose to conclude before revealing the pirate's type at time φ_a, and there is sufficient uncertainty on the part of the ship-owner's as to the type of the pirate gang (we rule out cases in which the ship-owners prior is that almost all pirates are of a single type).[18] In this situation, a ship-owner can cheaply screen out amateur pirates by making the offer $r_t = \delta_p^{\varphi_n - t}\rho + \gamma_p + c_0 + tc_p$ in every period up until $t = \varphi_a$, for this offer makes amateur pirates indifferent in every period between accepting the offer, or accepting the offer $r_t = \rho$ in period $t = \varphi_a$. Sophisticated pirates will reveal their type by rejecting such offers, thereby signalling their ability to continue negotiations beyond $t = \varphi_a$.[19]

For $t > \varphi_a$, the ship-owner knows the pirates are sophisticated, so the incomplete information becomes one-sided: the pirates do not know the ship-owner's type. For φ_s sufficiently high, it is in the interest of the ship-owner to seek an agreement, rather than play the game out. Let r_i, d_i (i = poor, rich), be the equilibrium ransom and duration for an i-type ship-owner, respectively. In order to induce rich ship-owners to reveal their type, it must hold that

$$\tau^{d_r - 1}v - r_r - d_r c_s \geq \tau^{d_p - 1}v - r_p - d_p c_s. \qquad (3)$$

As, from Proposition 1, the ransom is increasing in f through the reference ransom, the pirates will set $r_r > r_p$. Therefore, for (3) to hold, it must be that $d_p > d_r$. Intuitively, the pirates must commit to requiring poor owners to negotiate for longer. Rich owners are induced to reveal their type for an earlier settlement, but by so doing, they raise the pirate's reference ransom, and must settle at a higher ransom. Poor owners credibly signal their type by negotiating for

[16] Although general analytical results are not available, it appears from analysis of restricted classes of games and numerical simulations that the less complete is the information set, the longer the negotiation length (see, e.g., Cross, 1965; Perry, 1986; Kennan and Wilson, 1989).
[17] Studies that analyse bargaining games with two-sided asymmetric information include Cho (1990), Cramton (1992) and Watson (1998). However, owing to the complexity of these games, few general results exist.
[18] The conditions required for this equilibrium are not met in all cases. For instance, under political pressure to release hostages (low δ_s), the Spanish government has on several occasions concluded negotiations at speed without apparently learning the type of pirates.
[19] Alternatively, if φ_s is sufficiently low, it may be an equilibrium for the ship-owner to hold out until even sophisticated pirates are forced to conclude. Or, if φ_a is large, the ship-owner may find it too costly to determine pirate-type, and so negotiate under a probabilistic subjective belief about the pirate's type. We find no widespread empirical support for these alternative outcomes, however.

longer, and are ultimately able to secure a lower ransom amount. The implications for the ransom amount of these arguments are summarised as follows:

Proposition 2 *For φ_a sufficiently small and φ_s sufficiently large, the ransom amount is:*

a) Positively correlated with duration for $d \leq \varphi_a$;

b) Negatively correlated with duration for $d > \varphi_a$;

c) Higher, on average, for sophisticated pirates than for amateur pirates.

According to the first two parts of the Proposition, the combined effects of the two-sided asymmetric information yield a hump-shaped relationship between duration and the ransom: short negotiations are linked with low ransoms, as are very long negotiations, but the highest ransoms are associated with intermediate length negotiations. Part (*c*) notes the implications for the ransom amount – amateur pirates obtain small ransoms, irrespective of the ship-owner's type, whereas sophisticated pirates are able to extract larger ransoms from rich ship-owners. On average, therefore, sophisticated pirates should associate empirically with higher ransom amounts.

What other factors might influence negotiation length? The time-profile of transaction costs may play a role. For instance, parties may have an incentive to conclude negotiations around dates on which they will experience a discrete jump in their transaction costs. Such a discrete jump occurs for ship-owners when their loss-of-hire insurance expires, normally after 30, 60 or 90 days.[20] Similar considerations apply to the pirates: typically a ship will have supplies on board sufficient for 30-90 days, but they must supply their own thereafter.[21] Discount rates may also play a role. Hostility from the local population, or political/economic instability in the locality of the anchorage, may force even sophisticated pirates towards an early conclusion.[22]

3. Data

In order to be able to empirically test the predictions from the theoretical model outlined above, we construct a dataset on Somali piracy. The basis of this dataset is the annual piracy reports of the International Maritime Bureau (IMB), which contain detailed narratives for every reported act of piracy. Of the reported attacks since 2005, we take only those hijackings that were successful in the sense that the ship and (part of) its crew were indeed taken hostage. We do not include failed attacks. Furthermore, we exclude those hijackings where (*i*)

[20] There are large variations in the insurance cover bought by ship-owners and hence a clear empirical identification of the negotiation cost time profiles is unlikely.

[21] At some point a ship will also need to be replenished with fuel, as power is needed for a supply of desalinated water.

[22] For instance, according to Suna Times (2012), the MV LEILA, hijacked in February 2012, was chased out of its initial anchorage at Bargal after locals protested. The vessel was then moved to Hobyo, (via Eyl), where it came into contact with Galmudug security forces, who arrested six of the pirates. The vessel is now said to be at Labad village, 30 kilometres north of Hobyo.

the ship (and crew) was destroyed during the period of being held hostage, for example while being used as a mother ship, (*ii*) the vessel was freed by an outside force, without a ransom being paid and (*iii*) the vessel managed to escape from the pirates. We therefore limit our empirical analysis of ransoms to those cases with a negotiated outcome. We do, however, include in the analysis vessels that are currently still held and which are thus the continued subject of negotiations in the analysis of ransom durations.[23] In total, this leaves us with a population of 179 vessels under observation that are held for a cumulative total of 22,692 days. The variables that we have extracted from different sources include the following (summary statistics can be found in Table 1):

> *Duration*. This variable measures the difference between the date of attack and the date of release. The date of attack is found primarily in the IMB Yearbooks, which also reports the day of release if this date is within the same calendar year. For those cases in which the release took place beyond the calendar year, we use the date of release published in open sources.[24]
>
> *Ransom amount*. Ransom amounts are not always publicly disclosed, making reliable estimates difficult to obtain. However, using a combination of direct contacts with ransom negotiators, primary sources within Somalia and open sources, we are able to determine ransoms for a large majority of cases.[25] However, for a number of ships, we either do not find a consistent estimate across sources, or we only find that a ransom is paid, but not its size. In these cases, we use the ransom initially demanded by the pirates to provide lower and upper bounds of the estimated ransom.[26] We thus have three different variables. *Ransom_exact* exists only when we have consistent information across sources about the size of a ransom payment. *Ransom_min* and *Ransom_max* are the lower and upper bound estimates. In order to be able to use the

[23] It is not inconsistent with economic theory that we observe some negotiations of apparently indefinite duration, in which a ship has seemingly been abandoned by its owner. Under incomplete information even fully-rational actors may fail to reach an agreement despite the existence of an agreement zone (e.g., Myerson and Satterthwaite, 1983). In our model, the agreement zone shrinks with each additional round of negotiations; for both sides accumulate costs and the ship and its cargo depreciate. Entrenchment in the bargaining process may cause the agreement zone to disappear altogether.

[24] Primary sources include www.somaliareport.com, Lloyd's List and different media outlets. We cross checked the various sources to ensure that the release dates are correct to within 3 days in the final dataset. For 19 ships, we have no evidence of a release, nor evidence of them still being held. These vessels are not included in the analysis.

[25] Among the most-used open sources are Lloyd's List, www.somaliareport.com, www.eunavfor.eu, http://coordination-maree-noire.eu, security companies (PBI2, Oceanus Live) and other media outlets, such as AFP, BBC and Reuters.

[26] We use upper and lower bounds when there are significantly different estimates from media reports, and where no single report is identifiably more reliable than the others. We define lower and upper bound estimates when *i*) we know a ransom was paid and *ii*) we know the size of the initial ransom demanded. In that case, we use the initial demand as the upper bound, and one-tenth of the value as the lower bound. The exception to this rule is the MV Leopard, for which the initial demand was supposedly 36 million USD, which is an outlier. For this ship, we do not provide estimates. Finally, there are ships for which we know a ransom was paid but we do not have an initial demand or a final ransom. If these ships were caught during a time that other (similar) ships were also held, we use lower and upper bounds that are up to 15 times apart and centred around similar hijackings from the same period. For example, the MV Almarjan and MV Victoria both received a lower bound of 0.1 million USD and an upper bound of 1.5 million USD.

maximum available number of observations, but not overestimate the size of the ransoms, we use *Ransom_min* in our main regressions, and *Ransom_exact* as a robustness check. In the estimations, we log this variable in order to account for some of the extreme values.

In addition we use the World Bank's (2012) dataset on ransoms paid to Somali pirates as a robustness check. This dataset is based on data provided by governments (if directly involved in the negotiations), the European Union Naval Force and the United Nations Office on Drugs and Crime, as well as primary sources from Somalia. The World Bank dataset is less comprehensive than ours as it does not use the initially demanded ransom to create upper and lower bound estimates and it does not include the information obtained from ransom negotiators. It can be viewed as the best available data from open sources.

Gross_tonnage. As the value of the ship to its owner v is unobserved, gross tonnage of a ship is one of several variables we include as proxies. The data for gross tonnage come primarily from open sources, although for some ship types (yachts, in particular), gross tonnage is not commonly used as an indicator.[27] In order to capture these ship types in this measure of value, we estimate gross tonnage for such vessels.[28] According to Proposition 1, we should expect variables that proxy for v to be positively associated with ransom amounts.

Age_ship. The age of a ship is a second proxy for the value of the ship. We thus take the difference between the year of construction, available from open sources, and the year of capture to calculate the age in years.[29]

Flag State. The flag flown by a vessel may also correlate with v, and is usually provided by the IMB Yearbooks. Nearly fifty per cent of ships hijacked in Somalia fly well-known "flags of convenience", usually so as to save money, to avoid certain regulations and possibly to obscure ownership of a vessel. Beyond that, a significant portion of ships fly the flag of a developing country, but where ownership data exists, we observe that this does not necessarily imply that the owner too is located in those countries. Vessels with flags from developed countries, on the other hand, give a clear indication that their owners are also located in a developed country. As such, these ships are likely to have wealthy ship-owners. For that reason, we include a *Rich_flag* dummy in our estimations.

Crew_size. The number of crew on board is a further proxy for v. It is strongly

[27] Most information is available on www.shipspotting.com or www.marinetraffic.com, but the information for smaller ships is sometimes only reported in local media outlets.

[28] We calculate estimates of gross tonnage for yachts using the formula prescribed by the International Convention on Tonnage Measurement of Ships (Annex 1, Regulation 3): gross tonnage = [0.2 + 0.02 × log(volume)] × volume. For yachts whose volume is unknown, we estimate the relevant lengths from photographs to compute an estimate of volume.

[29] The primary open-sources we used are www.shipspotting.com and media reports.

dependent on ship type (typically, fishing vessels have above-average crews). The number of people on board the ship after it has been captured (so excluding those who fled during the hijacking, but including those who perish or flee while in anchorage) is usually available in the IMB Yearbooks or from media reports.

Crew_value. A final proxy for v is the composition of the crew, information on which is commonly reported in media reports about hijackings. A difficulty is how to translate the qualitative information on the nationalities of the crew into a quantitative variable that can be included in regression analysis. There are issues with using VSL estimates (e.g., Bellavance *et al*., 2009) as such estimates are not consistent between studies and published estimates are available only for a small set of nations. As a proxy, we instead take the GDP per capita in current prices expressed in USD (IMF, 2012) for the year of the hijacking and calculate the total value of the crew in this crude way. While the measure thus varies with the size of the crew, it is particularly sensitive to the nationalities of the crew members. At the extremes, the lowest value is found for the ten crew members on board the Kenyan-owned MV Miltzow captured in 2005 and the highest is found for the 30 crew members of the French-owned MV Le Ponant.

Location. Using different sources, we are able to determine the location where ships are held with reasonable precision. The most precise source is the Bloomberg Ship Tracking database, which uses GPS devices to determine the exact location paths of (some) ships. The UK Ministry of Defence provided us with the locations a number of additional ships from aerial and satellite reconnaissance.[30] Finally, we use the many open sources as indicators for the location where ships are held.[31] We then identify seven different regions in which the ships are anchored.[32] We use this information as an indicator of the level of sophistication of the pirates. If only one ship is held at a certain location-period (*One_ship*), this indicates that this is not likely to be a sophisticated gang of pirates and we should thus expect a shorter hijacking.[33] These data are time variant, which suggests that certain locations may go out of fashion after a while due to external influences, or that the pirates based there become more sophisticated with time. For these variables, Table 1 uses the ship-day combination as the unit of analysis.

Pirate hijack costs. We do not observe the pirate's hijack costs c_0. We are, however, able to test for a role for c_0 through known exogenous shifts in hijack costs over time. In particular, the introduction of naval intervention should have been associated with a discrete increase in c_0 as it drove piracy out of the Gulf of Aden into the open sea,

[30] Personal communication from the United Kingdom Maritime Component Commander in Bahrain.
[31] In particular, www.somaliareport.com and media outlets.
[32] Badnan, Eyl, Garacad, Haradhere, Hobyo, South Central Somalia and Northern Puntland.
[33] A total of seven vessels are held at several locations during their hijacking period. In these cases, we calculate the number of ships based in each of the anchorages for each day of a ship's hijacking period and take the highest number as the anchorage estimate.

Variable	N	Average	St.Dev.	Min	Max
Duration (days)	160	141.83	156.37	1	903
Ransom_min (mln USD)	143	2.300	2.398	0	12
Ransom_max (mln USD)	143	2.862	2.496	0	13.5
Ransom_exact (mln USD)	119	2.697	2.440	0	12
Ransom_WB (mln USD)	104	2.997	2.599	0	13.5
Gross_tonnage	157	15,331	26,661	20	162,252
Age_ship	140	17.64	12.26	0	60
Rich-flag	179	0.218	0.414	0	1
Crew_size	176	18.761	7.571	2	43
Crew_value (thou USD)	167	93.85	123.04	2.45	1092.3
One_ship	22,700	0.139	0.346	0	1
Reference_ransom (mln USD)	129	2.318	1.929	0.024	9.5
Tonnage_factor	129	1.950	4.584	0.033	33.529

Table 1. Summary statistics for the variables used in the empirical analysis. Definitions and sources are discussed in the text.

where mother-ships are needed (Shortland and Vothknecht, 2011). According to Proposition 1, therefore, we should expect to observe an increase in ransom amounts associated with the instatement of the Internationally Recommended Transit Corridor (IRTC) from February 2009.

Separate from the one-off effect of the IRTC, we might expect that, over time, pirates may have acquired know-how and criminal connections – what de Groot *et al*. (2011) collectively term "criminal capital". Therefore, although we formally assume pirate type to be fixed, in practice gangs may shift over time from opportunistic piracy to sophisticated piracy. As increases in sophistication are likely to be accompanied by increases in c_0, we control for this effect by including a linear time trend (*attackdate*).

Reference_ransom. Ransom negotiators agree that pirates use previous ransoms as reference ransoms for later ransoms. We therefore construct a reference ransom γ_p that corresponds to the average ransom paid on a set of "reference ships." To qualify as a reference ship for an arbitrary ship "A", a ship must be of the same type as A (bulk carrier, cargo, container, dhow, fishing vessel, passenger vessel, tanker, tug or yacht); have been held at the same anchorage as A; and have been released within a year of the date of capture of A. If the set of reference ships is empty, we drop the anchorage requirement, so as to achieve as many matches as possible. If the set of reference ships remains empty, the reference ransom is coded as missing.

Tonnage_factor. Pirates may also condition their reference ransom according to the size (tonnage) of the ship: negotiators report that ship sizes are compared during the negotiations with pirates expecting larger ransoms for larger ships. We therefore compute a tonnage adjustment to the reference ransom. We form reference sets for each ship in analogous fashion to the construction of the reference ransom, and compute the average tonnage of the ships in the reference set (the reference tonnage). The tonnage factor for “A” is then computed as the tonnage of A over the reference tonnage of A.

4. Results

As discussed above, we investigate two separate issues: the size of the ransom paid to pirates and the length of the hijacking. While these issues are obviously interrelated, we start by discussing them separately before combining the results to discuss their interaction.

4.1. Ransom Amount

We estimate the ransom size using a standard OLS estimation. If the dependent variable is not logged, the linear model predicts negative ransoms in a small number of cases. To avoid this, we employ a log-linear specification. The results are displayed in Table 2 using robust standard errors. The first column contains the estimates using only the variables that we identify as signals of the valuation of the ship-owner. The results for gross tonnage, ship age, crew value and the rich-flag dummy are as expected. In column 2, we add the variable for crew size, as we believe it may affect c_p. It turns out to be insignificant, although it does have the expected sign. As we add further explanatory variables some of the proxies for ship value become less significant, but this is not surprising as it is likely that the information content of these proxies overlaps to some extent.

Next, we focus on the time of hijacking (columns 3 and 4), experimenting with a straight time trend (*Attackdate*) in column 3 and the period since the instatement of the IRTC (*IRTC*) in column 4.[34] The final set of variables in the estimation of ransom amounts concerns the *Reference_ransom* and its accompanying *Tonnage_factor*, which capture the idea that pirates aim for a reference ransom that reflects (tonnage adjusted) recent ransom amounts (columns 5 and 6). As the inclusion of both *Gross_tonnage* and *Tonnage_factor* in the same specification is problematic we exclude *Gross_tonnage*.

In column 5 and 6 we also examine the question whether the observed time path of ransom amounts is best explained as a shift towards sophistication (captured by the time trend) or as inflation of reference ransoms over time. Both effects are observed to be significant, suggesting that each explanation plays some role.

[34] The models that include *Attackdate* have better explanatory power than the models that include *IRTC*. When IRTC and *Attackdate* are included in the same model, *IRTC* is not significant. We therefore use the attack date model in section 4.3 below to predict ransom amounts.

	1	2	3	4	5	6
Constant	-3.441***	-3.322***	-3.627***	-3.066***	-1.859**	-0.062
	(0.677)	(0.701)	(0.488)	(0.515)	(0.786)	(0.705)
Log(Gross_tonnage)	0.315***	0.330***	0.152**	0.235***		
	(0.052)	(0.058)	(0.059)	(0.057)		
Log(Age_ship)	-0.197**	-0.192**	-0.181***	-0.247***	-0.127*	-0.107
	(0.089)	(0.089)	(0.063)	(0.072)	(0.073)	(0.082)
Log(Crew_value)	0.315***	0.327**	0.277***	0.376***	0.205*	0.243**
	(0.119)	(0.128)	(0.099)	(0.111)	(0.110)	(0.122)
Rich-flag	0.433**	0.416**	0.293*	0.069	0.326**	0.223
	(0.203)	(0.205)	(0.149)	(0.175)	(0.156)	(0.178)
Log(Crew_size)		-0.105	-0.142	-0.157	-0.197	-0.348
		(0.227)	(0.187)	(0.201)	(0.253)	(0.271)
Attackdate			1.472***		1.361***	
x 1000			(0.155)		(0.253)	
IRTC				1.286***		0.612**
				(0.193)		(0.255)
*Log(Reference_*					0.289*	0.682***
ransom)					(0.147)	(0.108)
*Log(Tonnage_*					0.205***	0.249***
factor)					(0.069)	(0.073)
N	130	130	130	130	119	119
Adj. R^2	0.342	0.343	0.623	0.535	0.638	0.586

Table 2. Estimates for ransom amounts, using log(Ransom_min) *as the dependent variable. Robust standard errors in parentheses.*

We also show some robustness checks using *Ransom_exact* instead of *Ransom_min*. These estimates are displayed in Table 3. Rather than repeating all the previous specifications in tables 1 and 2, we show a selection thereof. Columns 1 and 2 focus on the variables that proxy for the ship's value and show results that are, by and large, the same as those found in Table 2. The main differences under this more restricted sample of hijackings are that some of variables, while they retain their expected sign, are no longer significant. Columns 3 and 4 include the reference ransom, which restricts the sample to only 98 observations. The reference values remain significant, but the *IRTC* variable in column 4 is no longer significant. Overall, our results seem largely robust the use of *Ransom_min* instead of *Ransom_exact*. The differences, where they exist, appear to be driven by the relatively few degrees of freedom and its effect on the standard errors. Finally, columns 5 and 6 use the variable *Ransom_WB*, which corresponds to the ransom amount reported by the World Bank. In these columns the sample is further restricted and the results weaken accordingly.

Variable	1	2	3	4	5	6
Constant	-3.366***	-2.790***	-1.048	0.700	-2.311**	0.394
	(.468)	(0.501)	(1.037)	(0.697)	(1.113)	(0.825)
Log(Gross_tonnage)	0.230***	0.317***				
	(0.046)	(0.048)				
Log(Age_ship)	-0.106*	-0.147**	-0.081	-0.035	-0.181**	-0.163*
	(0.061)	(0.070)	(0.082)	(0.080)	(0.082)	(0.085)
Log(Crew_value)	0.240**	0.266**	0.185	0.171	0.234	0.221
	(0.109)	(0.115)	(0.125)	(0.126)	(0.141)	(0.148)
Rich-flag	0.149	0.029	0.235**	0.250*	0.112	0.071
	(0.096)	(0.131)	(0.107)	(0.128)	(0.102)	(0.148)
Log(Crew_size)	-0.197	-0.244*	-0.205	-0.391*	0.062	-0.249
	(0.137)	(0.139)	(0.254)	(0.234)	(0.813)	(0.272)
Attackdate	1.124***		0.965***		1.466***	
x 1000	(0.118)		(0.312)		(0.360)	
IRTC		0.869***		0.077		0.413*
		(0.167)		(0.194)		(0.244)
*Log(Reference_*			0.368*	0.797***	0.024	0.582***
ransom)			(0.197)	(0.109)	(0.239)	(0.169)
*Log(Tonnage_*			0.195**	0.254***	0.111	0.216***
factor)			(0.079)	(0.071)	(0.083)	(0.077)
N	107	107	98	98	86	86
Adj. R^2	0.638	0.534	0.585	0.539	0.501	0.411

Table 3. OLS estimates using log(Ransom_exact) *as the dependent variable in columns 1-4 and* log(Ransom_WB) *as dependent variable in columns 5-6. Robust standard errors are in parentheses.*

4.2. Duration Analysis

In this section, we use duration models to estimate the determinants of the duration of a hijacking. The model we employ is the semi-parametric Cox proportional hazards model (Cox, 1972), which allows for greater flexibility than (possibly over-specified) fully parametric forms.[35]

In Table 4 we report the estimates of the hazard ratio concerning the probability of release. We start by looking at some of the determinants of pirate identity. Our dataset contains a number of variables that could indicate whether a pirate is opportunistic (amateur) or sophisticated. We know that, over time, pirate gangs have become more sophisticated so a time variable has to be included (*Attackdate* or *IRTC*). As predicted, *Attackdate* and *IRTC* have a significant negative effect on the probability of release (values below one indicate a negative effect on the probability of release and thus a longer duration).[36,37] Second, we can

[35] We used a parametric log-logistic model as an alternative model with very similar results.
[36] As the *Attackdate* is measured in days, the numerically small effects reported in the table are multiplied by a large number and become economically important.

identify, at each point in time, how many ships are held at a specific location. Anchorages holding only one ship are more likely to be home only to an amateur pirate gang, whereas busy anchorages might indicate the presence of a relatively large-scale (sophisticated) operation. Indeed, *One_ship* has a positive effect on the probability of release and is therefore associated with shorter hijackings. Next, we add a number of indicators that proxy for the value of the ship, hence the ship-owner's willingness to pay. Gross tonnage and a high-value crew significantly increase the probability of release.

Variable	1	2	3	4	5	6
Attackdate	0.999***		0.999***		0.999***	
	(0.000)		(0.000)		(0.000)	
IRTC		0.318***		0.230***		0.225***
		(0.059)		(0.054)		(0.048)
One_ship	1.561**	1.585**	1.615*	1.986***	1.794**	1.942***
	(0.348)	(0.354)	(0.411)	(0.500)	(0.410)	(0.448)
Log(Gross_tonnage)			1.226***	1.148**	1.193***	1.144***
			(0.075)	(0.065)	(0.062)	(0.054)
Log(Age_ship)			0.973	0.939		
			(0.095)	(0.089)		
Log(Crew_value)			1.261*	1.217	1.235**	1.263**
			(0.150)	(0.152)	(0.127)	(0.137)
Rich-flag			0.836	1.108		
			(0.194)	(0.262)		
N (obs/subj)	295/146	295/146	279/134	279/134	290/142	290/142

Table 4. Estimates for negotiation duration, using the Cox Proportional Hazards model.

According to theory, we may expect to observe bunching in the duration data around points where either party experiences a discrete jump in its transaction costs. Based on the insights of ransom negotiators, we test for bunching at the 30, 60 and 90 day cut-off points (± five days). Including a dummy for these periods is not possible when using the Cox duration model, for this variable displays no variance in that particular period. Instead, we perform the test with a complementary log-log regression. As, however, this shows no significant impact on duration around the 30, 60 and 90 day cut-offs, we do not report the results here. Not finding this effect does not constitute decisive evidence against such an effect, however, for our test was necessarily speculative. In practice, the point at which a captured ship will run out of supplies, or a ship-owner will lose loss-of-hire insurance, will vary from instance to instance, and will not normally correspond to exactly 30, 60 or 90 day periods.

4.3 Interaction between ransom and duration

As ransom amount and negotiation duration are determined simultaneously as joint outcomes

[37] For the duration models the IRTC dummy is more powerful than *Attackdate*: when both are entered into the regression attackdate becomes insignificant. In section 4.3 below we therefore use the IRTC dummy to predict duration.

of a single model, there can be no causal relationship between them. As, however, economic theory suggests the existence of common factors that cause both ransom amount and negotiation duration – for instance, whether the pirates are amateur or sophisticated – we should observe an empirical correlation between these variables. Bargaining theory with two-sided asymmetric information allows for many outcomes, but suggests a hump-shaped relationship between ransom amount and negotiation duration for plausible parameter values. We test for this prediction both graphically and statistically.

Beginning with a graphical interpretation, Figure 2a shows the raw data on *Duration* and *Ransom_low* used in our regression analysis, and Figure 2b shows the same relationship after removing the unexplained component of each series. Specifically, Figure 2b shows the predicted ransoms of the *Attack_date* model (model 5 from Table 3) against the predicted durations of the IRTC model (model 6 from Table 4), where we compute predicted duration $E(d|X)$ from the IRTC model by a sequence of relationships between the hazard rate, $\lambda(t|X)$, cumulative hazard rate, $\Lambda(t|X)$, and the survival function, $S(t|X)$:

$$\Lambda(t \mid X) \equiv \int_0^t \lambda(u \mid X)du; \quad S(t \mid X) \equiv e^{-\Lambda(t|X)}; \quad E(d \mid X) \equiv \int_0^\infty S(u \mid X)du.$$

Comparing the two panels of Figure 2 it is discernible that the predicted data displays less variability than does the raw data in the hijack duration dimension. This effect is due to outlying observations with respect to our duration model that occur at both extremes of the observed duration spectrum.

What is visually apparent in the raw data, and confirmed more clearly in the predicted data, is a hump-shaped relationship between ransom amount and negotiation length. In each panel, we show the fit to the data of a flexible degree-three polynomial. In each panel, these fitted polynomial trendlines adopt a concave, or hump-shaped, form.

Turning to a statistical treatment, to test Proposition 2 we estimate the correlation coefficient between the ransom amount and negotiation length. Figure 2b indicates that the turning point in the data, which should coincide with the maximum feasible negotiation length that amateur pirates can sustain φ_a, is at around 165 days. We therefore compare the correlation between the ransom amount and negotiation length above and below a 165-day cut-off. Table 5 shows that for the raw data, there is a positive correlation between duration and the ransom amount paid below the 165-day cut-off.

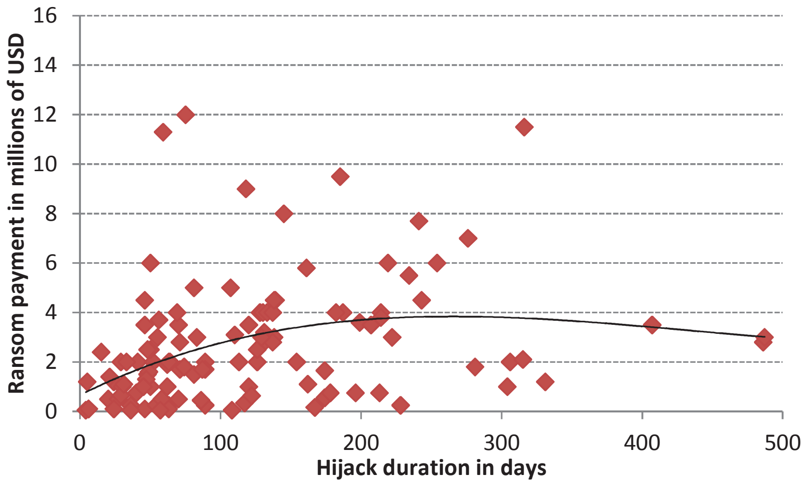

Figure 2a. The relationship between Duration *and* Ransom_low *with degree-three polynomial trendline.*

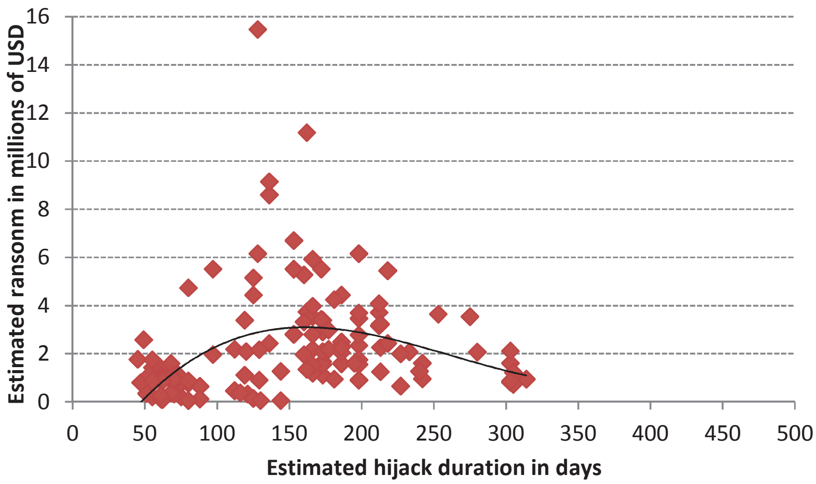

Figure 2b. The relationship between predicted Duration *and predicted* Ransom *with fitted degree-three polynomial trendline.*

Above the cut-off, however, the correlation appears to be negative, as is suggested visually in Figure 2, yet is insignificant. The lack of correlation above φ_a may, however, be a consequence of the degrees of noise in the data, and the relatively small number of observations. Consistent with this reasoning, when the same test is performed on the predicted data (which have had the noise removed) we find a different picture: both a positive correlation below the cut-off, and a negative correlation above it prove to be significant.

	Below 165 days			Above 165 days		
		95% conf. interval			95% conf. interval	
	Correlation	low	high	Correlation	low	high
Raw Data	**0.368**	0.151	0.552	-0.094	-0.144	0.322
Estimated Data	**0.569**	0.372	0.717	**-0.400**	-0.603	-0.148

Table 5. The correlation between ransom amount and negotiation length for φ_a = 165 days. Correlation coefficients that are significantly different from zero are in bold.

5. Conclusion

With the "professionalisation" of Somali piracy, bargaining over ransoms between ship-owners and Somali pirates has become increasingly formalised. The model developed in this paper captures key aspects of the actual bargaining process and the information structure of the participants: pirates' ability to sustain long negotiations and the ship-owner's ability to raise a high ransom can only be partially inferred from observables. This means that "only time can tell" what the appropriate ransom would be and the relationship between ransoms and negotiation length is hump-shaped. Record ransoms (conditioned on ship-type and size) are paid when rich ship-owners realise that they are dealing with highly organised criminal gangs. Opportunistic pirates are forced by dwindling supplies and local pressures to release early and cheaply and poor ship-owners have to wait for a long time to convince pirates of their limited means.

On average large, modern ships with high-value crew bring in higher ransoms in a shorter period than small, old ships staffed by low-value crew. Naval counter-piracy efforts, the adoption of best management practice and private security teams have successfully reduced the incidence of hijackings, but they have not reduced the total income from piracy: pirates have exploited the hijacked ships more intensively over time as success rates dropped and they have had to hunt ever further from the Somali coast.

The ransoms are not perfectly predictable, reflecting unobservable characteristics of the parties in the negotiation such as their respective discount factors, their pay-offs for failed negotiations (mother-ship / insurance pay-out) and their ability to sustain a negotiation over time. Expert negotiators exploit this information asymmetry. By sending consistent (cheap-talk) signals about their type ("sophisticated pirate" / "poor owner"), each side hopes to negotiate a better outcome. Indeed negotiators are highly paid and well regarded. However, whereas the pirates flaunt it when they call in an expert (as a sign of sophistication),[38] Western ship-owners prefer to hide their professional advisors to keep up the appearance of a

[38] See http://www.somaliareport.com/index.php/post/3308/.

poorly organised, shambolic enterprise on the brink of bankruptcy.[39]

In terms of policy conclusions, we confirmed that past ransoms shape expectations for future ransoms. Accordingly, there was considerable dismay in the ransom negotiation community about the ransoms facilitated by the Spanish government for the fast release of Spanish fishing trawlers. Such record payments educate pirates about the "value" of European sailors and ships – raising both ransoms and ransom durations for subsequent victims. As Western governments ultimately authorise ransom payments to the pirates, these negative externalities should be taken into account.

Our model also suggests that ransoms might be lowered by making rich ship-owners more patient by, for instance, by governments providing emergency loan guarantees to cover the running cost of the hijack, or compensating ship-owners for loss of hire, while offering significant financial compensation to the crew. Similarly, making the pirates less patient by giving them "heat" from the land-side (such as the Puntland Maritime Police Force) is predicted by our model to lead to lower ransoms and, subsequently, lower ransom expectations.

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Appendix: Proof of Proposition 1

The derivatives of r_1 with respect to an arbitrary parameter y are written as

$$\frac{dr_1}{dy} = \sum_{j=1}^{\varphi} \frac{\partial r_j}{\partial y} \prod_{i=1}^{j-1} \frac{\partial r_i}{\partial r_{i+1}}. \qquad \text{(A.1)}$$

Using $r_\varphi = \rho$ and equations (1) and (2) in the text we have that, for $t = 1,3,..., \varphi - 1$,

$$\frac{\partial r_t}{\partial r_{t+1}} = \delta_s > 0; \qquad \frac{\partial r_t}{\partial v} = \tau^{t-1}(1 - \delta_s \tau) > 0; \qquad \frac{\partial r_t}{\partial c_0} = \frac{\partial r_t}{\partial \delta_p} = 0;$$

and for $t = 2,4,..., \varphi - 2$,

$$\frac{\partial r_t}{\partial r_{t+1}} = \delta_p > 0; \qquad \frac{\partial r_t}{\partial v} = 0; \qquad \frac{\partial r_t}{\partial c_0} = 1 - \delta_p > 0; \qquad \frac{\partial r_t}{\partial \delta_p} = r_{t+1} - \gamma_p - c_0 - (t+1)c_p > 0.$$

Last, for $t = \varphi$, we have $\partial r_t \,/\, \partial \rho = 1 > 0$, with zero derivatives for all remaining variables. Using these results in (A.1) yields the proposition. ■