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Maritime Piracy and Armed Robbery Confrontations Across the Globe: Can Crew Action Shape the Outcomes?

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MARITIME PIRACY AND ARMED ROBBERY CONFRONTATIONS ACROSS THE
GLOBE: CAN CREW ACTION SHAPE THE OUTCOMES?

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Bachelor of Arts in Economics
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2012

A thesis submitted in partial fulfillment
of the requirements for the

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Can Crew Action Shape the Outcomes?**

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Abstract

The recent tightening of military budget constraints has called into question the feasibility of costly multilateral naval intervention used to combat maritime piracy off the eastern coast of Africa. Though past studies agree that the transformation of the Somali economy and government is crucial for a long-term solution to piracy in this part of the world, short to medium-run solutions are needed to bridge the gap. Such solutions should be fiscally sensible and serve as effective deterrents, as well as be applicable in addressing the problem of piracy and maritime armed robbery in other parts of the globe.

In this paper, I build upon the foundations laid in Mejia, Cariou, & Wolff (2009) and Mileski, Mejia, & Carchidi (2013) by examining the following question: given that a ship is engaged by pirates, what factors help shape the outcome of the confrontation? I find that observable action taken on the part of a ship's crew is extremely effective in decreasing the risk of a ship being successfully robbed or hijacked. There has yet to be a reported incident where pirates successfully hijacked a vessel that had a security team on board, and so though the effectiveness of security in this matter can be inferred, it cannot be empirically tested.¹

This may provide some guidance for policymakers; if naval intervention is to be scaled back, the encouragement and oversight of shipping companies' crew response procedures (and perhaps of onboard security measures) by international governments could pose a valid alternative.

¹ The same is true (in this dataset) of the effect of onboard security on deterring robberies.

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Chapter 1: Introduction

Maritime piracy² is a consequential global issue, but within the context of more dire and fundamental challenges facing the international community such as poverty, terrorism, healthcare and education, it is a relatively small one.³ In the face of tightening budget constraints on the part of governments that combat piracy, finding the most cost-effective solutions becomes an important concern (LaGrone, 2013).

Existing research has provided insight into the economic theory and political economy of maritime piracy as well as what helps shape pirates' decisions, but questions remain as to how effective different measures are in expelling pirate attacks across the globe. Using the International Maritime Organization's *Reported Incidents of Piracy and Armed Robbery* dataset, which provides background information on vessels that were attacked as well as the type of actions taken by pirates and crews, I employ a multinomial logistic model to examine how crew action and the naval intervention impacts the probability that pirates disengage a vessel instead of conducting a successful robbery or hijacking.

I find that both crew action and naval intervention play a large and statistically significant role in preventing pirates from being successful once they have engaged a vessel, after accounting for other important factors such as

² For the sake of brevity, the word "piracy" throughout this refers to both the formal definition of piracy and armed robbery against ships unless specified.

See:

<http://www.imo.org/OurWork/Security/PiracyArmedRobbery/Pages/Default.aspx>

³ The economic consequences of Somali piracy amounted to an estimated \$5.7-6.1 billion (USD) in 2012 (Bellish, J. & Baltic & International Maritime Council, 2013).

geographic area of the incident, vessel type, and waters type (international, territorial, or in port). This may speak towards crew response procedures being practical alternatives or complements to costly naval deployments.

This paper proceeds as follows. Section 2 examines relevant maritime piracy research, while Section 3 proceeds to discuss my empirical framework and underlying intuition. Section 4 describes and illustrates key characteristics of my dataset. Section 5 presents and provides a general discussion of my results, and Section 6 concludes with a summary and recommendations for future research.

Chapter 2: Literature Review

There is a strong body of existing research related to maritime piracy, that the following sections acknowledge in an effort to frame the context of my own analysis.

a.) Naval Intervention

In order to estimate the basic economic impact of naval intervention in trade lanes on the Far East-Europe route, Fu, Ng, & Lau (2010) use a sophisticated spatial demand and supply framework, with “shipping demands and liner competition ... piracy risk, traffic allocation and route choice all endogenously determined within one model.”⁴ The two basic questions the authors use this tool to answer are:

- 1.) What are the overall losses in this route’s trade volumes due to Somali piracy, and how would these be impacted if naval support was withdrawn?
- 2.) What are the corresponding efficiency losses faced by firms as they redirect vessels through sub-optimal routes in an attempt to avoid dangerous areas?

Once the analysis is complete, the issues of whether or not piracy poses a threat to the “sustainability of the marine shipping industry’s status quo”, and if military intervention to combat piracy is justified are discussed within the context of the paper’s results (namely, that without the current naval intervention to curb Somali piracy trade along this route would decrease by ~30%, with only ~18.4% of it being rerouted, leading to an annual economic welfare loss of approximately \$30

⁴ An original optimization model based on profit-maximizing objectives of vessel operators in a competitive market, where parameters are derived from global data and substituted in to obtain the static equilibria of interest.

billion USD). The significance of these results provides the general impetus for further studies designed to gain a deeper understanding of this type of criminal activity, its causes, and the type of sustainable solutions that may be possible.

b.) Economics of Crime and Piracy

Hallwood & Miceli (2013) extend economics-of-crime intuition to the issue of piracy, and develop a strategic interaction⁵ framework (based on factors that shape expected outcomes) that leads to equilibrium and provides insight into what may comprise an “optimal enforcement policy”. While theoretical (and not empirical) in nature, the paper still generates some tangible conclusions. Namely, such an optimal policy would likely vary greatly from the policy currently in place, where naval enforcement is handled by multiple entities. Enforcement action taken by any individual entity leads to uncompensated external benefits, the authors argue, and, relative to a single entity system, the status quo is likely to lead to free-riding and underinvestment in enforcement. Though the installation of a unilateral enforcement authority does not appear to be a likely course of action,⁶ the overall cost-benefit lens used here is something I seek to augment with my own empirical findings.

⁵ “Of the efforts of pirates to locate potential targets, and of shippers to avoid pirates”

⁶ *UN Chief Urges Collective Action to Fight Piracy, Armed Robbery at Sea in Central Africa*. (2013, 08 23). Retrieved from <http://www.un.org/apps/news/story.asp?NewsID=45690>

c.) Exogenous Factors and Political Economy

Aside from events occurring during an attack that impact piracy outcomes, factors determined before an attack takes place -such as pirates' country of origin- also play an important role and are worth acknowledging since they are not explicitly included in my dataset.⁷ Hastings (2009) analyzes the problems of maritime piracy -and the motivations of participants- at an institutional level. Specifically, the author concerns himself with how pirates' behavior varies depending on whether their respective operations are located within either "failed" states or "weak" states. To examine this, he employs a case study based approach in conjunction with a logistic regression model of the factors that impact the probability of a pirate attack being "sophisticated" or "unsophisticated". In the two estimated logistic models with the highest explanatory power, only the binary independent variable representing pirates' operations being based out of a failed state is significantly (negatively) associated with the sophistication of an attack, and only the binary independent variable representing the level of state governance is significantly (positively) associated with the sophistication of an attack.

Thus, Hastings (2009) concludes that pirates whose operations are based in failed states are more likely to engage in "unsophisticated" attacks involving kidnappings or ransom, since there exists little to no chance of intervention (enforcement) from their respective state. However, pirates based out of weak states are shown to carry out more "sophisticated" attacks where entire ships and cargoes are commandeered and sold, since there still exists the necessary "markets

⁷ I believe that my variable 'geographic area' captures much of the country of origin's role, if imperfectly.

and transportation infrastructure” to make such undertakings possible and worthwhile. It is my endeavor to complement this paper’s findings of seemingly *exogenous* characteristics that impact confrontational outcomes by analyzing the roles played by *endogenous* characteristics (those observed or occurring during an attack).

Also important to acknowledge is the work presented in Kraska (2010), which provides a variety of perspectives critical to understanding the issue of piracy. After a solid introduction to maritime economics, the paper transitions into a brief history of Somali piracy in the 21st century that is complementary to the contents of my International Maritime Organization dataset. Most importantly, however, the author gives a primarily qualitative but highly insightful treatment of the political economy of Somali piracy that covers great ground in not only describing the socioeconomic climate of coastal Somalia but also in explaining the incentives that have caused piracy to be an issue in the first place. These are: the extreme instability of the Somali government over the past two decades, a history of poverty, and a crippled fishing industry which once played a key role in the Somali economy.

Like Hallwood & Miceli (2013), Kraska (2009) emphasizes the disparate imbalance in the large amount of resources (money) spent on protection from pirates and the comparatively small amount being spent to aid Somalis. This paper’s conclusion calls for a “strengthening of local and regional authorities (to)...stabilize the economy, create productive jobs for the legions of Somalia’s unemployed young men, and rehabilitate the social structure in society.” I believe this perspective is

likely to be of great importance when considering what might comprise a long-term solution to piracy.

Beloff (2010) turns the lens in another useful direction; we have an intuitive understanding of how piracy could affect the shipping industry, but what piracy activity means for the country in which it is practiced is perhaps more ambiguous. Beloff (2010) argues that piracy has a negative impact upon the Somali economy in the way that merchant ships are deterred from calling at ports. (In essence, the aggregate supply of goods decreases as ships refuse to call while aggregate demand remains the same, resulting in stagflation.) Pirates' corrupt influence upon enforcement entities is said to keep this issue from being addressed. The author argues for the implementation of more farsighted, non-military solutions. Interestingly, he calls for the development of a free market capitalist system under the leadership of the widespread and wealthy Somali Diaspora.

d.) Risk Determinants

The primary foundation for my own investigation is Mejia, Cariou, & Wolff (2009). This paper is thus far the principal investigation into whether or not ship or scenario specific characteristics impact whether or not a merchant marine vessel is attacked by pirates. Using a probit model and an extensive dataset that includes observations of all reported acts⁸ of piracy from 1996-2005 (from the International Maritime Bureau of the International Chamber of Commerce) as well as on the total world merchant fleet within that time period (from the Institute of Shipping and

⁸ Or attempted acts

Logistics of Bremen), the authors examine whether acts of piracy are randomly determined -or rather that targets are randomly selected- or if factors such as year, type of vessel, or flag of origin play an important role.

Their results indicate that both a vessel's type and its flag of origin have statistically significant impacts upon its likelihood of it being engaged by pirates. Specifically, containerships are "significantly more exposed" (which may be logical: cargo goods transported in containers may be far more conducive to resale after capture than what is typically transported on bulk carriers, tankers, or chemical product carriers), and so are vessels registered under the Indian, Malaysian, or Singaporean flags. Though the authors acknowledge that their results are "very basic", their approach nonetheless provides compelling evidence as to the potentially nonrandom nature of maritime piracy. This general conclusion agrees with the findings of Marchione & Johnson (2013), who go a step further and find that "incidents of piracy cluster in time and space, and do so more than would be expected if their timing and location could be explained by the fact that some locations are more attractive to pirates than others... following an incident at one location, the risk of others is likely to be temporarily elevated around that location...". Their conclusion includes an emphasis on the need for further work on patterns relating different types of piracy attacks in different parts of the world. Though not the principal focus of my study, I touch upon this at a basic level when controlling for geographic and waters-type characteristics in examining what determines a successful robbery or hijacking, or an unsuccessful piracy engagement.

The aspect of piracy that poses the greatest risk to human life is hostage taking. Though it is not something that I address due to the nature of my dataset,⁹ it is of great importance to the maritime sector at large and deserves to be acknowledged. De Groot, Rablen, & Shortland (2012) conduct a valuable empirical study of pirate ransom negotiations, and come to a series of interesting conclusions. The length of negotiations appears to play an important role; smaller ransom payments are observed when negotiations are both very short and very long in duration. Additionally, ransom amounts paid out in the present time period also depend on what pirates have been able to get in the past in the past for different varieties of ships. Ship flag is also found to be a significant variable, though I believe that this is likely because, in the hostage negotiation process, pirates have the opportunity to see through the often “opaque” flagging process that the authors address.

Mileski, Mejia, & Carchidi (2013) stems from Mejia, Cariou, & Wolff (2009) and is most closely related to my study. Here, the authors examine how different situational factors (including actions taken by the ship) impact the probability that different outcomes occur given that a ship is attacked, which is in essence the same objective that I have. However, there are key differences in the approach I use, which facilitate my paper being complementary to Mileski, Mejia, & Carchidi (2013).

Mileski, Mejia, & Carchidi (2013) run five separate logistic regressions: one for each dependent variable (hostages taken, property stolen, ransom was paid,

⁹ Some incidents of hostage taking are reported in my dataset, but the terminology consistency and quality reporting is insufficient for a true analysis.

pirates escaped, or any combination of these).¹⁰ Unlike in my specification, hijacking is not treated as a dependent outcome, but as an explanatory variable. The independent variable, crew action, is divided up into several categories.¹¹ In addition, Mileski, Mejia, & Carchidi (2013) use ship's flag as an explanatory variable, which is logical given the conclusions of Mejia, Cariou, & Wolff (2009).¹² I choose not to include ship's flag in my model primarily because de Groot, Rablen, & Shortland (2012) state that although vessel flag is likely to play an important role in hostage situations where the interaction between crew and pirates can be lengthy and transparent, registry is quite often "opaque" (selected for convenience and not representative of much real information on its own). I do not believe that vessel flag is likely to have a causal link with anything other than the outcome of hostage negotiations, even though a statistically significant correlation has been shown to exist with other outcomes. If this is the case, the vessel flag's relationship with these other piracy outcomes may just as well be contained in the error term.

Mileski, Mejia, & Carchidi (2013) find that "defense" strategies significantly lower the probability of hostages being taken, but that no other types of crew action

¹⁰ I question whether the payment of ransom (as a dependent variable) has a nested, endogenous relationship with whether hostages are taken, which is not included as an independent variable in that model.

¹¹ 'Defense': firing warning shots or fire hoses, retreating to citadel, *authority intervention*, etc.

'Deterrence': sounding alarm, mustering crew, conducting evasive maneuvers, etc.

'Cooperation': alerting authorities, sending distress signals, firing flares, "investigating by authorities, capturing pirates by authorities, rescuing crew and/or taking other action, (implying that the authorities were informed)" *, etc.

'Intelligence': whether ship Best Practices were employed

* I question the appropriateness of the measures in quotations as explanatory variables, since it occurs after the attack. Even though this could be a logical instrument for the concept of Cooperation, it may suffer a causality loop issue.

¹² i.e., that vessel flag has a statistically significant relationship with piracy behavior

can be said to impact any of the other piracy outcomes. In addition, their results indicate that hijacking has a significant and positive relationship with hostages being taken, which while intuitive, can add context to the results of my study that do not examine hostage-taking. Indeed, my study and Mileski, Mejia, & Carchidi (2013) can be seen as complements, with my effort utilizing newer data and examining separately the effectiveness of confrontationally observable crew action and naval intervention in a way that directly facilitates discussion of the naval budgetary issues at hand.

Chapter 3: Empirical Framework

The core goal of this study is to examine factors-other than naval, police, or general military intervention- that effectively deter incidents of maritime piracy and armed robbery at sea.¹³ As such, the underlying economic intuition stems from the foundation laid in Becker (1974), where a criminal's decision making process is said to be a function of both the expected benefit and expected penalty of a criminal action.¹⁴ A great deal of work has since been done relating to the economics of crime, but Hallwood & Miceli (2013)'s application to maritime piracy is particularly relevant:

Once a ship is encountered and b (pirates' monetary gain) is observed, the pirate will commit the act of piracy (attack) if and only if $b \geq ps$, where p is the probability of subsequent capture (failed attack), and s is the dollar cost of the sanction in that event, including forfeiture of the booty as well as possible imprisonment or death (p. 347).

An effective piracy deterrent-all else constant- would thus presumably increase pirates' perceived cost of a failed attack, perceived probability of a failed attack, or both. [For instance, the effectiveness of the increased naval patrols beginning in 2009 could be seen as having increased both the gravity of potential consequences

¹³ The involvement of onboard security in a piracy confrontation is an obvious candidate for an effective deterrent. Unfortunately, even though data on security involvement is present in my dataset, including it in my model results in perfect prediction (of pirates disengaging). I believe this speaks quite strongly towards promoting onboard security being a viable policy option.

¹⁴ Where expected penalty is very generally defined as the product of the cost of failure and the probability of failure.

to pirates (i.e., potential loss of life or international detainment) and the probability of their being caught.]

With this in mind, I set up an empirical model to test which ship and scenario specific characteristics play a large and statistically significant role in explaining pirates' decisions to give up an on an attack (disengage a vessel). In proceeding, I consider these possible confrontational outcomes:

- Disengaged: Pirates abandoned attempt without achieving anything
- Robbery: Pirates successfully stole some of ship's cargo and/or stores
- Hijacking: Pirates successfully commandeered the vessel

And these explanatory variables:

- Crew Action: whether or not a vessel's crew took any action, *observable to pirates*, for the purpose of deterring or otherwise inhibiting pirates (ex: electrifying rails, mustering crew in citadel, increasing vessel speed)
- Naval Intervention: if pirates' attack was intercepted by outside naval, police, or other military authorities *before* the outcome of the attack was determined
- Onboard Security: whether or not an onboard security team took any action, *observable to pirates*, for the purpose of deterring or otherwise inhibiting pirates (ex: firing warning flares, mustering/advertising their presence, discharging firearms). There are 205 instances in my dataset where onboard security was involved, and each of these instances ended

with pirates disengaging the vessel. Because of the resulting perfect prediction -which the multinomial logistic model does not allow- I regrettably cannot apply include this variable in my model and apply traditional techniques in evaluating this variable's statistical significance. It should be noted that I interpret this variable as being highly significant in deterring piracy and maritime armed robbery, and that the necessity to run my model without it may very well result in omitted variable bias.

- Geographic Area: Indicator Variables representing the ship's location- as classified by the IMO- during the time of the pirate attack (South China Sea, East Africa, West Africa, Malacca Strait, Indian Ocean, Arabian Sea)¹⁵
- Vessel Type: Indicator Variables representing the following consolidated categories:
 - *Vessels with Tow*=Tug & Barge, Tug & General Cargo Ship, Barge & Supply Ship
 - *Tanker*= Chemical, LPG, Oil product, Oil, Product, Tanker, Gas Carrier-LNG, Gas Carrier-non specified
 - *Special Carrier*= Heavy Load, Livestock, Cement, Refrigerated Cargo, Vehicle Carrier, Reefer, Ro-Ro, Multi-Purpose, Passenger
 - *Specialized Vessel*= Navy ship, Warship,¹⁶ Special Purpose Ship, Research Ship, Fishing Vessel

¹⁵ The IMO dataset also includes reported incidents occurring in: Far East, China Sea, North Pacific Ocean, Yellow Sea, Persian Gulf, Mediterranean Sea, North Atlantic Ocean, South America-Caribbean, South America-Atlantic, South America-Pacific and North Sea. Each of these areas contain <50 observations for my time period of interest, and are thus omitted from my analysis.

- *Personal Sized Craft*= Yacht, Dhow, Landing Craft, Tug Only
- *Containership*= Containership, Unitized Vessel
- *Bulk Carrier, Supply Ship Only, Barge Only, General Cargo Only*

are additional categories

- Waters Type: Indicates whether vessel was in international, territorial, or port waters at the time of attack
- Year: Year of attack (2010-2014)
- Crew Action*Waters Type-(Interaction Variable)¹⁷:

The multinomial logistic regression framework is chosen for its facility in allowing me to analyze how these different factors impact the *relative risk* of a vessel being hijacked or robbed versus disengaged, given that they are attacked, with the added convenience that it “does not assume normality, linearity, or homoscedasticity” (Starkweather & Moske, 2011). Its specification is as follows:

$$Y = \begin{matrix} | \\ \text{Disengaged} \\ | \\ \text{Robbery} \\ | \\ \text{Hijacking} \end{matrix} = \alpha_i + \lambda^j \text{Crew Action} + \phi^j \text{Naval Intervention} + \Sigma \theta^j_i \text{Geographic Area} \\ + \Sigma \psi^j_i \text{Vessel Type} + \Sigma \kappa^j_i \text{Waters Type} + \Sigma \varphi^j_i \text{Year} + \Sigma \delta^j_i (\text{Crew Action} * \text{Waters Type}) \\ + \text{error}$$

¹⁶ Yes. Pirates have attacked ships of this type.

¹⁷ Other interaction variables are of potential interest, but the one listed on this page is the only one that did not result in perfect prediction or model non-convergence. See Appendix II.

As with binary logistic regression models, STATA® initially reports multinomial logistic coefficient estimates as being the impact changes in explanatory variables have upon the log-odds of observing the dependent variable(s). In order to facilitate a more intuitive interpretation of my model's output, coefficient estimates are instead reported both as marginal effects and as relative risk ratios. Marginal effects represent the change in the average probability of a given outcome (category) being observed given a change in the value of an explanatory variable from 0 to 1¹⁸ all else constant and relative to the base category. For example, consider the variable 'East Africa' in the model output table. Its marginal effect for the 'Hijacking' category is .132, indicating that if a vessel is travelling in East African waters and is engaged by pirates, it has on average a 13% higher chance of being hijacked than it would if engaged by pirates and travelling in the South China Sea (the base category). Relative risk ratios, on the other hand, represent "the ratio of the probability of choosing one outcome category over the probability of choosing the baseline category" given a unit change in an explanatory variable (UCLA, 2014).¹⁹ Essentially, they express changes in the relative magnitude of risk given a change in an explanatory variable. As an example, consider again the variable 'East Africa' in the model output table. Its relative risk ratio for the 'Hijacking' category is 2.34, indicating that if a vessel is travelling in East African

¹⁸ All of this model's explanatory variables are binary in nature. In STATA®, these variables are coded as "factor variables" in order to facilitate calculating the marginal effects via discrete differences rather than differentiation (which would be appropriate for continuous variables). The procedure is simple: compare the (predicted) average probability of observing the outcome of interest when the binary explanatory variable of interest =0 and =1. The discrete difference between these two average probabilities represents the marginal effect (Rodriguez, 2013).

¹⁹ These are calculated simply by exponentiating the original, log-odds coefficients.

waters and is engaged by pirates, the magnitude of its risk of being hijacked *rather than* disengaged is roughly 2.3 times higher than it would be if it were engaged by pirates and travelling in the South China Sea.

Chapter 4: Dataset

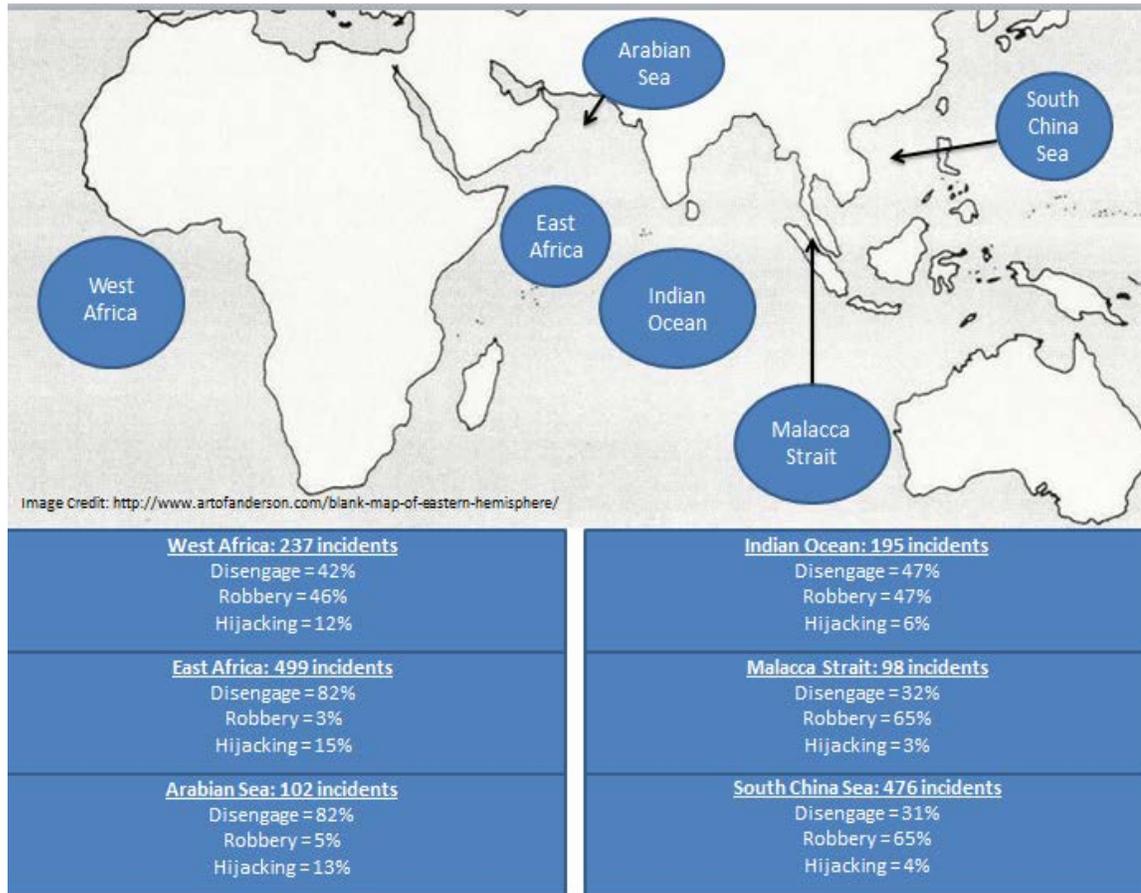
I utilize data from the International Maritime Organization (IMO)'s *Reported Incidents of Piracy and Armed Robbery*, which houses roughly 1,600 observations²⁰ for the period January 2010-May 2014²¹ and consists entirely of binary variables (there are no continuous variables). This collection of data represents every reported incident of piracy and maritime armed robbery for the timeframe in question and contains valuable information on ship and geographic characteristics as well as a written chronicle of how each incident unfolded. The written chronicle component varies from one report to another in terms of descriptiveness, length and clarity, and it should be noted that while I have attempted to interpret and classify their contents in a logical and consistent manner, there remains the potential for human error, observations that are not independent, and reasonable alternative interpretations of the reports.

To preface and frame the results of my analysis the following map is provided, which illustrates the general locations of geographic areas in my dataset and includes summary statistics for each area.

²⁰ For the aforementioned groups with a sample size >50. A small number of observations within these groups are omitted from my analysis due to either missing information or excessive lack of clarity in the written chronicle.

²¹ Though the dataset reaches back into the early 2000's, I begin in 2010. My intention is to examine piracy post- the introduction of large scale multilateral naval cooperation in 2009.

Figure 1: Map and Summary Statistics



At first glance, some interesting characteristics can be observed:

- The proportion of incidents resulting in Robbery is much higher in the South China Sea and Malacca Strait than anywhere else
- The proportion of incidents resulting in Hijacking is comparatively high in East Africa, West Africa, and the Arabian Sea
- Pirates disengage vessels the largest proportion of the time in East Africa and the Arabian Sea; perhaps this is due to perceived (potential) threats from the large naval presence in both of these areas

Chapter 5: Results and Discussion

The following section presents the STATA® output for the multinomial logistic model and segues into a general discussion of my findings.

Table 1: Multinomial Logistic Regression Output

Multinomial Logit Model Results				
	Relative Risk Ratios		Marginal Effects	
	Robbery	Hijacking	Robbery	Hijacking
East Africa	0.061*** <i>0.000</i>	2.34** <i>0.048</i>	(0.361)*** <i>0.000</i>	0.132*** <i>0.000</i>
West Africa	- <i>-</i>	5.44*** <i>0.000</i>	(0.074)*** <i>0.003</i>	0.104*** <i>0.001</i>
Indian Ocean	- <i>-</i>	3.06** <i>0.033</i>	- <i>-</i>	- <i>-</i>
Arabian Sea	0.104*** <i>0.000</i>	- <i>-</i>	(0.273)*** <i>0.000</i>	0.108*** <i>0.006</i>
Vessels with Tow	3.37*** <i>0.007</i>	- <i>-</i>	0.118*** <i>0.006</i>	- <i>-</i>
Special Carrier	- <i>-</i>	- <i>-</i>	- <i>-</i>	(.04)** <i>0.049</i>
Personal Sized Craft	3.87*** <i>0.002</i>	- <i>-</i>	0.135*** <i>0.002</i>	- <i>-</i>
Container Ship	1.95*** <i>0.007</i>	0.276** <i>0.034</i>	0.104*** <i>0.000</i>	(0.06)*** <i>0.000</i>
Supply Ship Only	6.39** <i>0.011</i>	- <i>-</i>	0.203*** <i>0.002</i>	- <i>-</i>
General Cargo Only	2.11** <i>0.013</i>	- <i>-</i>	0.094*** <i>0.005</i>	- <i>-</i>
Bulk Carrier	1.8*** <i>0.004</i>	- <i>-</i>	0.081*** <i>0.001</i>	(.031)** <i>0.036</i>
International Waters	0.295*** <i>0.003</i>	4.54*** <i>0.006</i>	(0.212)*** <i>0.000</i>	0.111*** <i>0.000</i>
Crew Action	0.116*** <i>0.000</i>	0.016*** <i>0.000</i>	(0.18)*** <i>0.000</i>	(0.272)** <i>0.014</i>
Naval Engagement	0.198** <i>0.016</i>	0.1*** <i>0.007</i>	(0.156)** <i>0.025</i>	(.062)*** <i>0.005</i>
Action*International Waters	0.384** <i>0.039</i>	- <i>-</i>	- <i>-</i>	- <i>-</i>
Constant	12.27*** <i>0.000</i>	- <i>-</i>	- <i>-</i>	- <i>-</i>
Prob > Chi ² (Overall)	0.000			
Pseudo R ²	0.467			
Hausman Tests for IIA: Fail to reject that odds are independent of other alternatives				
Numbers in italics are p-values. Numbers in parentheses are negative values.				
*** and ** indicate statistical significance at the 1% and 5% levels, respectively.				
Significant Explanatory Variables shown only.				
> Disengaged is base outcome				
> South China Sea is base Geographic Area				
> Tanker is base Vessel Type				
> Port Area is base Waters Type				

In terms of model performance, the overall significance can be verified by the estimated p-value being equivalent to zero. The independence of irrelevant alternatives assumption, (IIA) which states “that adding or deleting alternative outcome categories does not affect the odds among the remaining outcomes” is satisfied²² according to Hausman tests for IIA (UCLA, 2014).²³

In terms of the model’s results, some interesting findings emerge. Robbery is significantly less likely to be the confrontational outcome in East Africa and the Arabian Sea. Viewed another way: in no other geographic area are ships more at risk of being robbed versus disengaged than in the South China Sea. Vessels traveling in waters off of East Africa and West Africa face relative risks of being hijacked rather than disengaged (over 2 and 5 times, respectively) greater than those in the South China Sea. In no other geographic areas are ships so comparatively vulnerable to hijacking if they are engaged by pirates. These findings agree with the descriptive statistics shown in Figure 1.

Being in international versus port waters also increases this relative risk of hijacking by over 4.5 times. This could logically be ascribed to pirates’ perceptions of expected penalty. Compared to tankers, vessels with tow, personal sized crafts, container ships, supply ships, general cargo ships, and bulk carriers are much more

²² Both Hausman tests computed in STATA® with the command ‘mlogtest’ support the null hypothesis of independence of irrelevant alternatives. One test resulted in negative Chi² values, which according to Freese & Scott Long (2000) provides evidence that the IIA assumption has not been violated. See Appendix III.

²³ The idea behind these tests is to evaluate whether or not a restricted model (with an outcome category omitted) produces consistent parameter estimates. Two separate multinomial models (restricted & unrestricted) are estimated and “an evaluation of the difference in the parameter estimates” is conducted (Vijverberg, 2011).

likely to be robbed than disengaged given they are attacked. Containerships, however, are at significantly less relative risk of being hijacked. I hypothesize that this may be due to their comparatively higher maximum speed.

Both naval engagement and observable crew action appear to play large and statistically significant roles in decreasing a ship's relative risk for both robbery and hijacking. If a crew takes action to deter/engage their attackers (e.g. raise alarm, employ fire hoses, lock pirates out of control room), this decreases the ship's relative risk of being robbed versus disengaged by ~88% and of being hijacked versus disengaged by almost 98%. The estimated impacts of naval intervention alone are smaller for deterring robbery-which could reasonably be due to the ability of pirates to escape overboard with at least some stolen wares- as well as for deterring hijacking. It should be noted however, that in my dataset there are only two instances of successful hijackings when naval/police/military intervention occurred during the confrontation, and only one of those instances was void of crew action (so having to hold crew action constant is perhaps what resulted in the somewhat less potent coefficient estimate for naval intervention than is realistic, even though it is still quite strong). Therefore, I do not conclude that crew action is necessarily more effective in shaping outcomes than naval intervention, especially considering the role that increased naval intervention plays in pirates' decisions to attack in the first place, -per Fu, Ng, & Lau (2010)- and knowing that the likely substantial role played by onboard security throughout this dataset cannot be controlled for. Rather, I believe crew action is likely to play a strong, complementary role in deterrence.

Chapter 6: Conclusion

The chief goal of this analysis is to add to the understanding of what shapes the outcome of maritime piracy confrontations in different parts of the globe, and to see if, once controlling for naval interventions, observable crew response procedures appear to play a significant role in preventing robberies or hijackings from occurring. My results indicate that:

- i.) Crew response procedures can reduce the relative risk of a ship being robbed by approximately 88%
- ii.) Crew response procedures can reduce the relative risk of a ship being hijacked by approximately 98%
- iii.) Differences in ship type and geographic location can play statistically significant roles in shaping the outcome of confrontations

There are other important matters that I am unable to address in this study which would likely be of great importance in framing my results in such a way as to be able to inform direct policy prescriptions. Firstly, based on my dataset, onboard security appears to play a crucial, but empirically unverifiable by my model, role in preventing pirates from achieving any kind of success once they engage a vessel. Indeed, all 205 instances in my sample where pirates engaged a vessel that had onboard security involved in the confrontation resulted in pirates disengaging the vessel without successfully robbing or hijacking it. More work should be done to verify the efficacy of this deterrent measure, especially since it could potentially also serve as an alternative to naval deployments. It would also be of use to better understand any potential negative spillover effects of both crew action and onboard

security; the presence of deterrents on one vessel may encourage pirates to attack other vessels in the surrounding area. In addition, it could also be of interest to incorporate data from before 2010 into an analysis such as this and examine whether the deterrent effects of naval intervention and crew action vary significantly in the periods pre-and post- the 2009 increase in multilateral naval outlays.

My results could perhaps be best applied within the context of a larger, future cost-benefit analysis that weighs the impacts of potential incremental changes in the amount of resources allocated to supporting different piracy-combatting strategies. Though likely only one piece of the puzzle of mitigating (and eventually solving) the problem of maritime piracy, the importance of crew action in deterring both robbery and hijacking speaks towards its potential relevance to policymakers seeking effective deterrent strategies in the face of cutbacks.

Appendix I: Insignificant Variables

Table 2: Model Variables Insignificant at 5% level

Multinomial Logit Model Results-Insignificant Variables		
	Relative Risk Ratios	
	<i>Robbery</i>	<i>Hijacking</i>
2011	0.7	0.571
	<i>0.107</i>	<i>0.067</i>
2012	0.989	0.747
	<i>0.965</i>	<i>0.428</i>
2013	0.845	0.489
	<i>0.477</i>	<i>0.134</i>
2014	0.682	0.294
	<i>0.241</i>	<i>0.151</i>
Malacca Strait	0.989	0.586
	<i>0.972</i>	<i>0.468</i>
Special Carrier	1.111	0.38
	<i>0.815</i>	<i>0.125</i>
Specialized Vessel	0.351	0.802
	<i>0.117</i>	<i>0.654</i>
Barge Only	1.868	0.461
	<i>0.346</i>	<i>0.441</i>
Territorial Waters	0.806	1.96
	<i>0.655</i>	<i>0.325</i>
Crew Action*Territorial Waters	0.694	0.518
	<i>0.485</i>	<i>0.676</i>

Appendix II: Unusable Interaction Variables

The following result in Perfect Prediction, Excessive Multicollinearity, or

Model Non-Convergence:

- Geographic Area*Waters Type
- Naval Intervention*Geographic Area
- Security*Naval Intervention
- Ship Type*Waters Type
- Year*Geographic Area
- Naval Intervention*Waters Type
- Security*Year
- Security*Crew Action
- Security*Geographic Area
- Security*Waters Type
- Crew Action*Naval Intervention
- Crew Action*Geographic Area
- Crew Action*Year

Appendix III: Hausman Tests for IIA

Table 3: Hausman Tests of IIA Assumption

. mlogtest, iia					
**** Hausman tests of IIA assumption (N=1607)					
Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives.					
Omitted		chi2	df	P>chi2	evidence
-----+-----					
2		-18.697	25	---	---
3		-15.139	25	---	---

Note: If chi2<0, the estimated model does not meet asymptotic assumptions of the test.					
**** suest-based Hausman tests of IIA assumption (N=1607)					
Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives.					
Omitted		chi2	df	P>chi2	evidence
-----+-----					
2		35.463	25	0.080	for Ho
3		27.516	25	0.331	for Ho

According to Freese & Scott Long (2000), negative Chi² values provide evidence that the IIA assumption has *not* been violated.

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- Provided decision support analyses for the Maintenance, Materials and Labor departments
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