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A THEORY AND SOME EMPIRICS ON MODERN MARITIME PIRACY

by

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This thesis entitled:

A Theory and Some Empirics on Modern Maritime Piracy

By **Watcharapong Ratisukpimol**

has been approved for the Department of Economics

_____

Professor **Murat Iyigun**, Chair

_____

Professor **Charles de Bartolomé**

Date: _____

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

Ratisukpimol, Watcharapong (Ph.D., Economics)

A Theory and Some Empirics on Modern Maritime Piracy

Thesis directed by Professor Murat Iyigun

This dissertation is composed of three studies on the root causes and determinants of modern maritime piracy.

The first chapter discusses the root and proximate causes of modern maritime piracy. It then presents a theoretical model of extralegal appropriation and production applied to maritime piracy. The model shows that (1) the lack of economic opportunities stimulates piracy by lowering its opportunity cost, (2) weak states raise the return to piracy due to a lack of protection of property rights in those states, and (3) the existence of piracy and its effectiveness impact the maritime trade.

The second chapter empirically examines the trends and determinants of modern-era piracy. It utilizes a new dataset of 3,362 maritime piracy incidents that occurred worldwide between 1998 and 2007. To test model predictions, the data cover detailed information on the location, timing, the number of pirates involved, the ship's characteristics and success of each attack, as well as the material damage and violence inflicted upon the crew and the cargo. I combine this data with macroeconomic variables and the institutional quality of countries where piracy incidents occurred. I find the results strongly support the model in that economic and political factors do matter with the number of pirates involved in incidents, the success of attack and the property damage imposed. I also find that piracy incidents affect the regional maritime trade volume.

The third chapter (coauthored with Murat Iyigun, my primary dissertation advisor) empirically focuses on the evolution of piracy attacks over time due to learning-by-doing and skill accumulation. We find that economic factors and the law do matter: higher per-capita incomes as well as more effective legal and political institutions dampen both the physical violence and material damage of modern-day piracy. But we also document significant learning-by-doing and skill accumulation among the pirates: a history of successful piracy attacks locally improves the odds of success, making it more likely that pirates inflict more violence on the crew and take control of vessels in their entirety. The learning-by-doing effects are detectable even after controlling for our proxies for capital use and labor input.

Dedication

This dissertation is dedicated first and foremost to my beloved parents, Boonsong and Ounruen Ratisukpimol, and my brothers, Mongkoltat, Ratanapol and Sontichai Ratisukpimol, for all the love, care and support they always give me, and for their patience and understanding for many years while I was in the Ph.D. program in Economics at University of Colorado at Boulder. And with great reverence, I dedicate this research to the guarding angels of my families. May you continue looking after my family members for our health, prosperity and peace eternally.

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INTRODUCTION

After being virtually extinct in the post Second World War era, maritime piracy began to stage a gradual comeback starting in the mid-1990s, turning into an epidemic that today, seriously affects sea traffic, trade and commerce. There is a long and fairly standard narrative as to why ancient piracy disappeared. Accordingly, it was the combination of faster and more technologically advanced merchant ships that could more easily evade piracy attacks, increased naval presence by the rising colonial powers, better government supervision of maritime coasts as well as stricter international regulations that accounted for the fall of conventional piracy. It is not too surprising that the rise of modern maritime piracy is often explained as a corollary of the decline of some of these factors, such as an increase in the number of failed or weak states in East Africa, lax international maritime legislation, as well as technological advances in communications and seafaring technologies which drastically reduced the costs of piracy in the modern period. In this, the economic opportunity costs of piracy, by way of economically retarded and weakening states, are also often highlighted as potential culprits. However, systematic academic work on these hypotheses remains scant to non-existent.

Because of this scarcity in such work, this dissertation, "A Theory and Some Empirics on Modern Maritime Piracy", examines the reappearance of the modern maritime piracy. Specifically, I investigate the root causes of modern maritime piracy. These include a discussion of the factors leading to piracy in two global hot spots: Somalia and

the Southeast Asia region, augmenting a theoretical model of extralegal appropriation and production to explain why economic conditions play an important role for modern-day piracy, and then testing the validity of that model empirically by employing the novel dataset of modern piracy incidents.

(1) Modeling the Root Causes of Modern Maritime Piracy

The main purposes of this chapter are (1) to present the factors which are important in shaping piracy and (2) to present a theoretical model applied to maritime piracy by developing the extralegal appropriation and production model. In the model, an individual can choose between productive employment providing labor income and subversive activity which in this case takes the form of piracy. In the production sector, the fraction of the exported goods is expropriated during the transportation. I show that, in equilibrium, the time that average family allocates to extralegal activity is increasing in its effectiveness, in the resource endowment, and in the proportion of exports, but decreasing in the number of families, in the wage of productive activity, and in the number of cargo ships. I also characterize the probability of the successful attack and the piracy profit. These findings help explain why economic conditions play an important role for modern-day piracy. Furthermore, I analyze the production sector and show that the subsistence of piracy and its effectiveness reduce the incentive to trade.

(2) Understanding the Root Causes of Modern Maritime Piracy

The purpose of the second chapter is to test the validity of the model presented in Chapter 1 by presenting an empirical analysis of the determinants of modern piracy. It employs a new dataset of 3,362 maritime piracy incidents that occurred worldwide

between 1998 and 2007. The data cover detailed information on the location, timing, the number of pirates involved, the vessel's characteristics and success of each attack, as well as the material damage and violence inflicted upon the crew and the cargo. I combine these data with macroeconomic and aggregate measures on per-capita incomes, rates of economic growth, unemployment rate and institutional quality of countries where piracy incidents occurred. In it, I find the results strongly support the model in that economic and political factors do play a role in the number of pirates involved in attacks and the probability of the successful attack. But economic factors also seem to alter the outcome of modern piracy attacks; accordingly, higher per-capita incomes are associated with fewer successful attacks that culminated with cash robberies and vessel hijackings, while they are related more frequently to cases with cargo goods robbery and ransom demand. I also find that political institutions and legal enforcement are important factors, although not as much nor consistently as economic factors.

(3) Learning Piracy on the High Seas

This last chapter is coauthored with my dissertation advisor. We focus on the evolution of piracy attacks over time due to learning-by-doing and skills accumulation. The central result is that, even after controlling for geographic, economic and sociopolitical factors as well as a variety of fixed effects, learning-by-doing and skills accumulation among the pirates seemed to have played an important role in maritime piracy turning into a more potent threat over time. In particular, we find that a history of successful piracy attacks locally improves the odds of future success in piracy, making it more likely that pirates launch successful raids aimed at larger vessels closer to land. The learning-by-doing effects are detectable even after controlling for our proxies for capital use and

labor input (the number of pirates).

CHAPTER 1

Modeling the Root Causes of Modern Maritime Piracy

1.1 Introduction

Oceans and seas provide relatively cheap transportation of goods and services. From the earliest times, movement of cargo across open water has attracted predation by pirates. Since the early 1990s, modern maritime piracy has become one of the major threats to sea commerce. Numerous pirate attacks have caused serious physical and economic harm, affecting international trade, economics, and politics. Several international organizations including the International Maritime Bureau (IMB) and the International Maritime Organization (IMO) as well as the governments of trading countries are attempting to coordinate multinational efforts to stem piracy. However, the problem of piracy continues to spread because all of these entities have not implemented effective policing efforts.

Maritime Piracy, according to the United Nations Convention on the Law of the Sea (UNCLOS) of 1982, consists of any criminal acts of violence, detention, or depredation committed for private ends by the crew or the passengers of a private ship (or aircraft) that is directed on the high seas against another ship, aircraft, or against persons or property on board a ship (or aircraft). Piracy can also be committed against a ship, aircraft, persons, or property in a place outside the jurisdiction of any State (IMB, 2008).

Acts of piracy can be dated back to the fourteenth century BCE off the coast of what is now Turkey. The Golden Age of Piracy occurred from the end of seventeenth century to the beginning of eighteenth century. It was a peak period since many ships carried slaves from Africa to America and carried sugar, rum and other goods from the Americas to Europe.[1] Currently, modern pirates can be successful because a large amount of international commerce occurs via shipping. For commercial reasons, many cargo ships move through narrow bodies of water such as the Suez Canal, the Panama Canal, and the Strait of Malacca. As usage increases, many of these ships have to lower cruising speeds to allow for navigation and traffic control, making them prime targets for piracy.[2]

In this paper, I analyze the root causes of modern maritime piracy which mainly takes place in two global hot spots: Somalia and the Southeast Asia region. I then augment a conceptual model of extralegal appropriation and production applied to maritime piracy. The model indicates that opportunity cost of engaging extralegal activities, which is wage employment in the legal production sector, and a lack of enforcement of the law both lower the threshold wage employment below which piracy becomes attractive. This application helps to formalize the conjectures on the determinant of modern maritime piracy.

In the model, the indigenous population can divide their time between wage employment in the productive employment sector, or subversive activity (being a pirate). Part of production, which is exported through maritime transportation, is subject to extralegal appropriation. I show that, in equilibrium, the allocation of time to extralegal

[1] "Tracing the Golden Age of Piracy" by Casey Sheehan (2010) at http://www.cindyvallar.com/tracinggoldenage.html.

[2] "Modern Day Pirates" by PirateReport.org (2010) at http://www.piratereport.org/modern-day-pirates.

appropriation is increasing in its effectiveness, in the resource endowment, and in the proportion of exports, but it is decreasing in the indigenous population, in the wage rate in production, and in the number of cargo ships. The model shows that the lack of economic opportunities stimulates piracy by lowering its opportunity cost. It also shows that weak states raise the return to piracy due to a lack of protection of property rights in those states. This model is laying the foundation of the empirical analysis of the root causes of modern maritime piracy which will be presented in the next chapter.

The basic theoretical model explaining why economic conditions play an important role for modern-day piracy is based on the political economy literature on production and extralegal appropriation. The main objectives are to identify the factors that determine resource allocation between productive and appropriative activities and the equilibrium distortion of resources and income. The model developed in this chapter adds to a growing literature that analyzes conflict over the control of property and income within the framework of general equilibrium. The model was originated by Haavelmo (1954) and further developed by follow-up papers such as Hirshleifer (1991), Grossman (1994), Grossman and Kim (1995), Grossman and Iyigun (1995, 1997), Skaperdas (1992, 2005), Bates et al. (2002), Hafer (2006) and Caruso (2007).

The next section briefly discusses the root causes of modern maritime piracy in Somalia and Southeast Asia region, and then presents the theory on modern maritime piracy.

1.2 Root Causes of Modern Maritime Piracy

Until the 1980s, piracy was commonly considered mostly extinct, but the 1990s has seen a resurrection of maritime piracy. Since a majority of modern piracy acts occur in

the vicinity of Somalia and Southeast Asia, and an important potential culprit of modern piracy relates to weak institutional infrastructure, in what follows I review the literature explaining root causes of modern-day piracy. There is speculation that the presence of weak or failed states is the main cause of maritime piracy incidents on East Africa and Southeast Asia (See Sherman 2009, Folsum 2009, Uher 2009, Webber 2009 and Tran 2009).

Piracy off the African shore was a rare occurrence until the 1990s, when many African countries including Somalia fell into political and economic chaos. Many of the problems that plague the African continent either stem from the consequence of European colonization or the Cold War between the West and Soviet Union (Tran, 2009). In 1991, the Somali Civil War took place. Since then and now, Somalia still lacks a central government and the interim government is virtually powerless to stop piracy. Somalia's devolution advanced over two decades because of several factors; Somalia is one of the poorest countries in the world, with a totally ineffective central government.

Since the early 1990s, there have been at least 14 failed Somali central governments in two decades (Sherman, 2009). Somalia is controlled by a clan system of fiefdoms, with warlords and their cronies running the show as opposed to one central government, each with a leadership and quasi-military structure of its own. Major destruction and mayhem followed the civil war, and the country has not recuperated yet, with a great majority of the population facing famine. In a land so brutally lawless, it was only a matter of time before the growing and more powerful gangs turned to ocean piracy. Some of the more organized clans have total control over various areas. Except for the warlords, gang leaders, weapons smugglers and ocean-going pirates, most of the population of Somalia exists in dire poverty. The average per-capita income in Somalia is $400 a

year (Sherman, 2009). The warlords needed to expand their hunt for money and other resources to strengthen their forces and to expand control of territories. Enter the modern day pirates, and migration towards the coastal waters rises, desperate young men are suddenly given a chance to feed their families. Now, more and more clans established themselves as pirates, riding out in the high seas in old, antiquated fishing boats and attacking the most modern vessels that dare to navigate Indian Ocean.

Moreover, geographically speaking, Somalia is located on the mouth of Gulf of Aden, which is by all means one of the most crucial shipping route in the world. After the successful attack and bringing in a few million US dollars in ransoms, the clan system continues to grow stronger as they accumulate more wealth, buy arms and improve technology in targeting vessels. With more wealth, they will be able to bring even more men into their folds, possibly strengthening the piracy industry in Somalia (Babineau, 2009).

The consequences of being a failed state led other nations to take advantage of Somalia. According to Sherman (2009), maritime piracy did not only evolve from clan activity, but also from the country's fishing activity. The large, highly-sophisticated fishing fleets from Japan, Russia and other developed countries constantly violated the legal waters around Somalia and began to wipe out entire fish population in Indian Ocean. Their actions were destroying the traditional fishery. Moreover, many foreign ships used the area to dump their highly toxic refuse, thereby accelerating the devastating process of destroying all marine creatures. Attempting to protect their territorial water, some Somali fishermen organized into bands of raiders, and boarded nearby ships, forcing those ships'crews to compensate for the income loss from mass fishing operations. Given their success in collecting tributes, the powerful clan in Somalia decided to expand on

the local fishermen' idea of demanding money from intruders. Until the large nations began to send armed vessels recently, pirates had a virtually free ride for more than a decade (Sherman, 2009).

The International Maritime Bureau (2010) proposed a solution to stop the surge of piracy on Somalia. There was a desperate need for a stable infrastructure in this area. It continues to be vital that governments and the United Nations devote resources to developing workable administrative infrastructures to prevent criminals from exploiting the vacuum left from years of failed local government. All measures taken at sea to limit pirates' attacks are undermined due to a lack of responsible authority in Somalia, where the pirates begin their voyage and then return with hijacked vessels (IMB, 2010).

The second hot spot, Southeast Asia, particularly the South China Sea and Malacca Strait, is vulnerable to pirate attacks. The region's geography and importance as a strategic trade route create narrow waterways densely packed with a number of cargo ships carrying goods and energy resources to all of Asia. Ninety percent of the world's trade moves by ship and one-third of the world's shipping moves through Southeast Asia's waters (Bulkeley, 2003).

A main root cause of Southeast Asian maritime piracy is a weak political control in the region. Pirates in Southeast Asia region can be divided into two groups: (1) opportunistic sea-robbers, involved in small scale attacks, and (2) sophisticated organized pirate gangs, responsible for hijacking and kidnapping. Both types can conduct attacks because they exploit security shortcomings in the maritime environment and benefit from political, social, and economic development, which encourage attacks (Liss, 2010).

Literature surrounding maritime piracy in Southeast Asia has tended to fall into two categories: policy-oriented that largely ignores or glosses over a rich, informative,

historical socio-political-cultural context, and historical accounts of piracy that are not related to contemporary phenomena, generally remaining isolated in the past (Young, 2004). The consequences of being a weak state have driven the existence of maritime piracy into several outcomes such as over-fishing, lax maritime regulations, the existence of organized crime syndicates, the presence of radical politically motivated groups, and widespread poverty (Liss, 2010). Although Southeast Asian countries recovered after the 1997 economic crisis, poverty is still widespread. For those among the more desperate left behind in the region, who live close to the sea shore, piracy can be an alternative source of income. Frecon (2006) argues that poverty and the lack of other employment opportunities are the most important motivations for people to become pirates. Actually, those involved in piracy are often unemployed sailors, fishers, or taxi-boat drivers who do not find a sufficient number of passengers during the day to make a living (Frecon, 2005).

In addition, lack of regional cooperation can explain this subsistence on maritime piracy. Smaller developing nations cannot defend against pirate attacks occurring within their jurisdiction. Local authorities in areas such as Malaysia and Indonesia are not equipped with the technology and resources to combat pirates. While Singapore and Malaysia have increased their army forces, Indonesia, in particular, needs help in reducing pirate activities. This corresponds to Mo's (2002) suggestion that the most effective way to combat maritime piracy in Southeast Asia is regional cooperation, but the lack of cooperation is still a problem.

1.3 Theoretical Framework

1.3.1 Individual Choice

Consider the following model of a representative economy. Assume that the resource endowment of this economy is given, $\overline{\omega}$. The economy uses resources to produce the good for domestic consumption and exports to another economy by water transportation. Let t be the proportion of the resource produced for domestic consumption , $0 < t < 1$. Thus, exports are $(1-t)\overline{\omega}$. The population of the economy consists of N identical indigenous families. Each family can divide its time between productive and subversive activities. Specifically, each indigenous family is endowed with one unit of time of which it allocates the fraction f, $0 \leq f \leq 1$, to wage employment and the fraction p, $0 \leq p \leq 1$, to subversive activity. The productive activity (being a farmer) is a wage employment offered by producers. Workers in this sector produce the good for domestic consumption and export.

The income of a family from productive activity is $w_f f$ where w_f is the wage rate of each unit time of labor and f is the fraction of its time that this family allocates to productive activity. Define p as the fraction of the time that family allocates to subversive activity (being a pirate). That is,

$$f + p = 1 \tag{1}$$

In subversive activity, pirates attack cargo ships containing exported goods produced in the economy from productive activity. Assume that the exported good is split into R identical cargo ships exporting from this country. The total piracy income is

$\lambda\beta(1-t)\overline{\omega}$ where λ is the price of good produced and β is the fraction of cargo lost due to the attack; $0 \leq \beta < 1$.

The total income from attacking cargo ships is divided among all families proportionately to the time allocated by each family to subversive activity. Therefore, the income of a family from attacking cargo ships is $\lambda\beta\left(\frac{(1-t)\overline{\omega}}{N}\frac{p}{P}\right)$ where P is the fraction of its time that the average family allocates to being a pirate. Thus, the total income of a family, i, is given by

$$i = w_f f + \beta\lambda\left(\frac{(1-t)\overline{\omega}}{N}\frac{p}{P}\right) \tag{2}$$

Each family takes w_f and $\beta\lambda\left(\frac{(1-t)\overline{\omega}}{NP}\right)$ as given and chooses f and p, subject to the constraint $f + p = 1$, to maximize i. The Kuhn-Tucker condition for maximizing i implies

$$p^* = \begin{cases} 0 & \text{if } w_f > \beta\lambda\left(\frac{(1-t)\overline{\omega}}{NP}\right) \\ [0,1] & \text{if } w_f = \beta\lambda\left(\frac{(1-t)\overline{\omega}}{NP}\right) \\ 1 & \text{if } w_f < \beta\lambda\left(\frac{(1-t)\overline{\omega}}{NP}\right) \end{cases} \tag{3}$$

and

$$f^* = 1 - p^* \tag{4}$$

Equation (3) indicates that, other things being equal, each family would allocate all of the time to only one activity if the returns to that activity are greater than the return to the other activity. Each family would allocate time to both activities only if the returns to both activities are equal.

1.3.2 Subversive Technology

Recall that β is simply the probability that the cargo ship will get attacked. In the absence of protection, let us assume that it is an increasing and concave in $\frac{NP}{R}$ which is the total time that all families allocate to extralegal activity per ship. A simple technology of attacking vessels that incorporates this assumption is

$$\beta = \frac{x}{1+x} \text{ where } x = \phi\frac{NP}{R}, \qquad \phi \geq 0 \tag{5}$$

In equation (5), the parameter ϕ determines the effectiveness of time allocated to subversive activity in appropriating the cargo goods.

In equilibrium, since all families are identical, p is equal to P ,which is the fraction of its time that the average family allocates to being a pirate, and f is equal to F, which is the fraction of its time that the average family allocates to productive activity. Therefore, the average family would allocate the time according to

$$P^* = \begin{cases} 0 & \text{if} \quad w_f > \frac{\phi\lambda(1-t)\overline{\omega}}{R} \\ \frac{\frac{\phi\lambda(1-t)\overline{\omega}}{Rw_f}-1}{\phi\frac{N}{R}} & \text{if} \quad \frac{\frac{\phi\lambda(1-t)\overline{\omega}}{R}}{1+\frac{\phi N}{R}} < w_f < \frac{\phi\lambda(1-t)\overline{\omega}}{R} \\ 1 & \text{if} \quad w_f < \frac{\frac{\phi\lambda(1-t)\overline{\omega}}{R}}{1+\frac{\phi N}{R}} \end{cases} \tag{6}$$

and

$$F^* = 1 - P^* \tag{7}$$

Proposition 1 *The time that the average family allocates to extralegal appropriation, P, is increasing in its effectiveness, ϕ, in the resource endowment, $\overline{\omega}$, in the price of good, λ, and in the proportion of exports, $(1-t)$, but it is decreasing in the indigenous population, N, in the return of a legal job, w_f, and in the number of cargo ships, R.*

Proof.

By comparative static analysis,

Since $P = \frac{\frac{\phi\lambda(1-t)\overline{\omega}}{Rw_f}-1}{\phi\frac{N}{R}} = \frac{\phi\lambda(1-t)\overline{\omega}-Rw_f}{\phi N w_f}$, I have

$\frac{\partial P}{\partial \phi} = \frac{R}{N\phi^2} > 0$

$\frac{\partial P}{\partial \overline{\omega}} = \frac{\lambda(1-t)}{Nw_f} > 0$

$\frac{\partial P}{\partial \lambda} = \frac{(1-t)\overline{\omega}}{Nw_f} > 0$

$\frac{\partial P}{\partial (1-t)} = \frac{\lambda\overline{\omega}}{Nw_f} > 0$

$\frac{\partial P}{\partial N} = -\left[\frac{\phi\lambda(1-t)\overline{\omega}-Rw_f}{\phi N^2 w_f}\right] < 0$

$\frac{\partial P}{\partial w_f} = -\left[\frac{\lambda(1-t)\overline{\omega}}{N\left(w_f\right)^2}\right] < 0$

$\frac{\partial P}{\partial R} = -\frac{1}{N\phi} < 0$

■

The results from the proposition are straightforward and make economic sense. One may wonder why the time allocation for subversive activities is decreasing in the number of cargo ships. More ships sent with exports on board should be more attractive to the pirates. The reason seems to be differ from the common assumption. For a given

level of subversive technology, more ships mean fewer resources devoted to piracy attacks per ship. This, however, lowers success probability (or share of resources captured by pirates). In turn, this makes piracy even less attractive.

In equation (5), substituting x into the success contest function, I obtain

$$\beta = \frac{\phi NP}{R + \phi NP} \tag{8}$$

Plugging P^* from the individual optimization in equation (6) into the contest success function in equation (8), I obtain

$$\beta = 1 - \frac{Rw_f}{\phi\lambda(1-t)\overline{\omega}} \tag{9}$$

Proposition 2 *The success of attack, β, is increasing in the time that average family allocates to subversive activity, P, in the resource endowment, $\overline{\omega}$, in the price of good, λ, in the proportion of exports, $(1-t)$, and in the effectiveness of time allocated to be a pirate, ϕ, but decreasing in the return of a legal job, w_f, and in the number of ships, R.*

Proof.

By comparative static analysis,

From equation (8), since $\beta = \frac{\phi NP}{R+\phi NP}$, I have

$\frac{\partial \beta}{\partial P} = \frac{\phi RN}{(R+\phi NP)^2} > 0$

From equation (9), since $\beta = 1 - \frac{Rw_f}{\phi\lambda(1-t)\overline{\omega}}$, I have

$$\frac{\partial \beta}{\partial \overline{\omega}} = \frac{Rw_f}{(1-t)\phi\lambda(\overline{\omega})^2} > 0$$

$$\frac{\partial \beta}{\partial \lambda} = \frac{Rw_f}{(1-t)\phi\overline{\omega}(\lambda)^2} > 0$$

$$\frac{\partial \beta}{\partial (1-t)} = \frac{Rw_f}{\phi\lambda(1-t)^2\overline{\omega}} > 0$$

$$\frac{\partial \beta}{\partial \phi} = \frac{Rw_f}{\phi^2\lambda(1-t)\overline{\omega}} > 0$$

$$\frac{\partial \beta}{\partial w_f} = -\frac{R}{\phi\lambda(1-t)\overline{\omega}} < 0$$

$$\frac{\partial \beta}{\partial R} = -\frac{w_f}{\phi\lambda(1-t)\overline{\omega}} < 0$$

■

Success of attack does not imply that pirates can appropriate properties on board. Pirates can successfully board ships but leave empty handed because of the crew alert. Now I consider the success of appropriation on economic outcomes. In order to model the success of theft, I introduce piracy profits as a proxy since profits come not only from hiring the optimal number of pirates, but also from liquidating appropriated goods in the market. In the following section, I analyze the labor market for pirates and derive the determinants of profits from piracy.

1.3.3 Competitive Labor Market of Pirate Firms

Assume that, with the large number of indigenous families, the labor market for pirates is competitive.[3] Output (cargo appropriated) is obtained from using pirates with the technology $\lambda p^{\alpha}, 0 < \alpha < 1$, where p is the unit of labor time of pirating and λ is a parameter reflecting productivity as well as the relative price of the goods produced by

[3]I assume the labor market of pirates is in perfect competition since it corresponds to the literatures on maritime piracy that claim that several clans have established themselves as pirates.

the economy. Given this technology, the gross profit obtained from attacking one ship is $\pi = \lambda p^{\alpha} - w_p p$. Recall from individual optimization that $w_p = \beta\lambda\left(\frac{(1-t)\overline{\omega}}{NP}\right)$. Substitute $w_p = \beta\lambda\left(\frac{1-t)\overline{\omega}}{NP}\right)$ into the profit function, which becomes

$$\pi = \lambda p^{\alpha} - \beta\lambda\left(\frac{1-t)\overline{\omega}}{NP}\right)p \tag{10}$$

The pirate firms take $\beta\lambda\left(\frac{1-t)\overline{\omega}}{NP}\right)$and λ as given and choose p to maximize π. This maximization implies that p satisfies

$$p = \left(\frac{\alpha NP}{\beta(1-t)\overline{\omega}}\right)^{\frac{1}{1-\alpha}} \tag{11}$$

The market-clearing condition for the labor market is that labor demand (the unit of labor time of pirates times the number of cargo ships) is equal to the labor supply (the fraction of time that the average family allocates to piracy times the number of families).[4] That is,

$$pR = NP \tag{12}$$

Taken together, equations (11) and (12) imply that the market-clearing wage rate equals the marginal product of labor:

$$\left[\frac{NP}{R}\right]^{1-\alpha} = \frac{\alpha}{\left[\frac{\beta(1-t)\overline{\omega}}{NP}\right]} \tag{13}$$

[4]Recall that R is a number of total ships in the vicinity. This information is well known for both production and appropriation sectors. In this simple model, I assume that pirates will attack all R ships.

$$w_p = \left[\frac{\beta\lambda(1-t)\overline{\omega}}{NP}\right] = \frac{\alpha\lambda}{\left[\frac{NP}{R}\right]^{1-\alpha}} \tag{14}$$

Substitute the first-order and market-clearing conditions into the profit function.

$$\pi = \lambda\left(\frac{NP}{R}\right)^{\alpha} - \left[\frac{\alpha\lambda}{\left(\frac{NP}{R}\right)^{1-\alpha}}\right]\left(\frac{NP}{R}\right) \tag{15}$$

Therefore, profits from attacking each cargo ship are

$$\pi = \lambda(1-\alpha)\left(\frac{NP}{R}\right)^{\alpha} \tag{16}$$

Plugging P^* from the individual optimization in equation (6) into the profit function above, I obtain

$$\pi^* = \lambda(1-\alpha)\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha} \tag{17}$$

Proposition 3 *The piracy profits, π, are increasing in the number of pirates, P, in the price of cargo goods, λ, in the resource endowment, $\overline{\omega}$, in the proportion of exports, $(1-t)$, and in the effectiveness of time allocated to be a pirate, ϕ, but decreasing in the return of a legal job, w_f, and in the number of ships, R.*

Proof.

By comparative static analysis,

From equation (16), since $\pi = \lambda(1-\alpha)\left(\frac{NP}{R}\right)^{\alpha}$,

$\frac{\partial \pi}{\partial P} = \lambda(1-\alpha)\alpha\left(\frac{NP}{R}\right)^{\alpha-1}\left(\frac{N}{R}\right) > 0$

From equation (17), since $\pi^* = \lambda(1-\alpha)\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha}$,

$\frac{\partial \pi}{\partial \lambda} = (1-\alpha)\left[\lambda\alpha\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha-1}\frac{(1-t)\overline{\omega}}{Rw_f} + \left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha}\right] > 0$

$\frac{\partial \pi}{\partial \overline{\omega}} = \lambda(1-\alpha)\alpha\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha-1}\left[\frac{\lambda(1-t)}{Rw_f}\right] > 0$

$\frac{\partial \pi}{\partial (1-t)} = \lambda(1-\alpha)\alpha\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha-1}\left[\frac{\lambda\overline{\omega}}{Rw_f}\right] > 0$

$\frac{\partial \pi}{\partial \phi} = \lambda(1-\alpha)\alpha\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha-1}\left[\frac{1}{\phi^2}\right] > 0$

$\frac{\partial \pi}{\partial w_f} = \lambda(1-\alpha)\alpha\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha-1}\left[-\frac{\lambda(1-t)\overline{\omega}}{R(w_f)^2}\right] < 0$

$\frac{\partial \pi}{\partial R} = \lambda(1-\alpha)\alpha\left[\frac{\lambda(1-t)\overline{\omega}}{Rw_f} - \frac{1}{\phi}\right]^{\alpha-1}\left[-\frac{\lambda(1-t)\overline{\omega}}{w_f(R)^2}\right] < 0$

■

I also extend this analysis by assuming a monopsonized labor market of pirates and compare the results with the case of perfectly competitive labor market. The analysis shows that the comparative static analysis does not alter the results.

1.3.4 Exporter's Problem

Now, consider the productive sector in which the fraction of output produced is exported. Let M denote the profits of exports net of extralegal appropriation and the net of the cost of ship protection. Thus,

$$M = \lambda(1-\beta)(1-t)\overline{\omega} - gR \tag{18}$$

where $\lambda(1-\beta)(1-t)\overline{\omega}$ is revenue from successfully selling exported good and g is the marginal cost of ship protection from pirates. The country chooses the number of ships sent to other trading countries, R, and takes ϕ, N, P, $(1-t)\overline{\omega}$ and g as given in order to maximize M. The constraint on this maximization problem is the subversive technology of extralegal appropriation, given by equation (5). Substitute equation (5) into the profit function, which becomes

$$M = \left(\frac{R}{R+\phi NP}\right)\lambda(1-t)\overline{\omega} - gR \tag{19}$$

The first-order condition is

$$\frac{\partial M}{\partial R} = \frac{\lambda(1-t)\overline{\omega}\phi NP}{(R+\phi NP)^2} - g = 0 \tag{20}$$

Solving for R^*, I obtain

$$R^* = \sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}} - \phi NP \tag{21}$$

with the restriction $\frac{\lambda(1-t)\overline{\omega}}{g} \geq \phi NP$ to ensure a nonnegative value of R. This implies that a country will send ships out for export if the ratio of the value of export per cost of ship protection is greater than or equal to the effectiveness of total time all the population allocate to extralegal activity.

The second-order condition is also satisfied as

$$\frac{\partial^2 M}{\partial R^2} = -\frac{2\lambda(1-t)\overline{\omega}\phi NP}{(R+\phi NP)^3} < 0 \tag{22}$$

Proposition 4 *The optimal number of ships sent for export, R^*, is increasing in the resource endowment, $\overline{\omega}$, in the proportion of exports, $(1-t)$, and in the price of good, λ, but it is decreasing in the cost of ship protection, g. However, it is decreasing in the effectiveness of time allocated to be a pirate, ϕ, and in the labor supply of pirates, NP, when $\phi NP < \frac{\lambda(1-t)\overline{\omega}}{g} < 4\phi NP$.*

Proof.

By comparative static analysis,

Since $R^* = \sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}} - \phi NP$, I have

$\frac{\partial R^*}{\partial \overline{\omega}} = \frac{1}{2\sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}}} \frac{\lambda(1-t)\phi NP}{g} > 0$

$\frac{\partial R^*}{\partial (1-t)} = \frac{1}{2\sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}}} \frac{\lambda\overline{\omega}\phi NP}{g} > 0$

$\frac{\partial R^*}{\partial \lambda} = \frac{1}{2\sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}}} \frac{(1-t)\overline{\omega}\phi NP}{g} > 0$

$\frac{\partial R^*}{\partial g} = \frac{1}{2\sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}}} \frac{-\lambda(1-t)\overline{\omega}\phi NP}{g^2} < 0$

$\frac{\partial R^*}{\partial \phi} = \frac{1}{2\sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}}} \frac{\lambda(1-t)\overline{\omega}NP}{g} - NP$

$\frac{\partial R^*}{\partial \phi} < 0$ if and only if $\phi NP < \frac{\lambda(1-t)\overline{\omega}}{g} < 4\phi NP$

and $\frac{\partial R^*}{\partial \phi} > 0$ if and only if $\frac{\lambda(1-t)\overline{\omega}}{g} > 4\phi NP$

$\frac{\partial R^*}{\partial NP} = \frac{1}{2\sqrt{\frac{\lambda(1-t)\overline{\omega}\phi NP}{g}}} \frac{\lambda(1-t)\overline{\omega}\phi}{g} - \phi$

$\frac{\partial R^*}{\partial NP} < 0$ if and only if $\phi NP < \frac{\lambda(1-t)\overline{\omega}}{g} < 4\phi NP$

and $\frac{\partial R^*}{\partial NP} > 0$ if and only if $\frac{\lambda(1-t)\overline{\omega}}{g} > 4\phi NP$

■

Substitute R^* from equation (21) into the profit function in equation (19).

The exporter's profits are

$$M^* = \lambda(1-t)\overline{\omega} - 2\sqrt{\lambda(1-t)\overline{\omega}\phi NPg} + \phi NPg \tag{23}$$

Proposition 5 *The exporter's profits, M^*, are increasing in the resource endowment, $\overline{\omega}$, in the proportion of exports, $(1-t)$, and in the price of good, λ, but it is decreasing in the time that average family allocates to subversive activity, P, in the cost of ship protection, g, in the effectiveness of time allocated to be a pirate, ϕ, and in the population, N.*

Proof.

Recall that we have a restriction $\frac{\lambda(1-t)\overline{\omega}}{g} \geq \phi NP$ to ensure a nonnegative value of R.

By comparative static analysis,

Since $M^* = \lambda(1-t)\overline{\omega} - 2\sqrt{\lambda(1-t)\overline{\omega}\phi NPg} + \phi NPg$, I have

$\frac{\partial M^*}{\partial \overline{\omega}} = \lambda(1-t) - \frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\phi NPg$

$\frac{\partial M^*}{\partial \overline{\omega}} < 0$ if and only if $\lambda(1-t) - \frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\phi NPg < 0$

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} < \phi NP$

This is a contradiction. Therefore, $\frac{\partial M^*}{\partial \overline{\omega}} > 0$

$\frac{\partial M^*}{\partial (1-t)} = \lambda\overline{\omega} - \frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda\overline{\omega}\phi NPg$

$\frac{\partial M^*}{\partial (1-t)} < 0$ if and only if $\lambda\overline{\omega} - \frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda\overline{\omega}\phi NPg < 0$

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} < \phi NP$

This is a contradiction. Therefore, $\frac{\partial M^*}{\partial (1-t)} > 0$

$\frac{\partial M^*}{\partial \lambda} = (1-t)\overline{\omega} - \frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot (1-t)\overline{\omega}\phi NPg$

$\frac{\partial M^*}{\partial \lambda} < 0$ if and only if $(1-t)\overline{\omega} - \frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot (1-t)\overline{\omega}\phi NPg < 0$

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} < \phi NP$

This is a contradiction. Therefore, $\frac{\partial M^*}{\partial \lambda} > 0$

$\frac{\partial M^*}{\partial P} = -\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}\phi Ng + \phi Ng$

$\frac{\partial M^*}{\partial P} < 0$ if and only if $-\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}\phi Ng + \phi Ng < 0$

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} > \phi NP$

Therefore, $\frac{\partial M^*}{\partial P} < 0$

$\frac{\partial M^*}{\partial g} = -\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}\phi NP + \phi NP$

$\frac{\partial M^*}{\partial g} < 0$ if and only if $-\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}\phi NP + \phi NP < 0$

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} > \phi NP$

Therefore, $\frac{\partial M^*}{\partial g} < 0$

$\frac{\partial M^*}{\partial \phi} = -\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}NPg + NPg$

$\frac{\partial M^*}{\partial \phi} < 0$ if and only if $-\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}NPg + NPg < 0$

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} > \phi NP$

Therefore, $\frac{\partial M^*}{\partial \phi} < 0$

$\frac{\partial M^*}{\partial N} = -\frac{1}{\sqrt{\lambda(1-t)\overline{\omega}\phi NPg}} \cdot \lambda(1-t)\overline{\omega}\phi Pg + \phi Pg$

$\frac{\partial M^*}{\partial N} < 0$ if and only if

which implies $\frac{\lambda(1-t)\overline{\omega}}{g} > \phi NP$

Therefore, $\frac{\partial M^*}{\partial N} < 0$

■

This analysis suggests that the existence of piracy and its higher effectiveness will reduce the incentive to trade by sending fewer ships out.

1.4 Conclusion

The theory sketched above provides suggestive implications about the economics of extralegal appropriation, which in this case takes the form of piracy. This paper presents

the root causes of modern maritime piracy which mostly occur in two regions: Somalia and the Southeast Asia. Either being failed or weak states is the real root cause explaining the rise of modern maritime piracy. To support these hypotheses, I develop the theoretical framework of extralegal appropriation and the production model. The model signifies that the opportunity cost of engaging extralegal activities can be viewed as wage employment in the legal production sector, and that a lack of enforcement of the law both lower the threshold wage employment below which piracy becomes attractive. In the model, the indigenous population can divide their time between wage employment in the productive employment sector, or subversive activity (being a pirate). Parts of production, which are exported through maritime transportation, are subject to extralegal appropriation. I show that, in equilibrium, the allocation of time to extralegal appropriation is increasing in its effectiveness, in the resource endowment, and in the proportion of exports, but it is decreasing in the indigenous population, in the wage rate in production, and in the number of cargo ships. These factors also play a significant role in determining the probability of successful attacks and piracy profits. Considering the supply side, I explore the production sector when facing pirates during exportation to determine the optimal trade value. I also show that existence of piracy and its higher effectiveness affect maritime trade volume. Based on this theoretical framework, the extralegal activities are affected by economic incentives. Therefore, the rise of modern-era maritime piracy is inversely related to the economic conditions of regions from which modern pirates emerge. This application helps to formalize the conjectures on the determinant of modern maritime piracy. This model is laying the foundation of the empirical analysis of the root causes of modern maritime piracy in the next chapter.

CHAPTER 2

Understanding the Root Causes of Modern Maritime Piracy

2.1 Introduction

When hearing the word "pirates", most people imagine cruel men with the eye patches and green parrots on their shoulders. But maritime piracy is one of the oldest criminal professions, which made a deadly comeback in the early 1990s and became a serious global threat to sea commerce.

According to the International Maritime Organization (IMO), the total number of incidents of piracy and armed robbery against ships, reported to have occurred or to have been attempted from 1984 to the end of December 2010, is 6,078. Up to that date, the number of acts of piracy and armed robbery against ships in 2010 reported was 445, an increase of 35 (8.54%) over the number reported in 2009. The following seven locations recorded nearly 75% of all attacks from a total of 445 incidents reported in 2010, Somalia, Gulf of Aden, Indonesia, South China Sea, Red Sea, Bangladesh and Nigeria. Not surprisingly, eighty percent of international maritime freight travel is largely unguarded and only one percent of maritime pirates get arrested (Maggio, 2007).[5]

International Maritime Bureau (2010) claims that A total of 219 incidents in 2010 was attributed to Somali pirates. These incidents continue to threaten an extended

[5] "Maritime Piracy: Poverty in lawless lands breeds a new era of piracy on the seas" by TakePart, LLC (2010) at http://www.takepart.com/issues/maritime-piracy/16433

geographical region. Attacks by Somali pirates cover a vast area, which includes the Gulf of Aden, southern Red Sea, off Yemen, off Oman, Arabian Sea, off Kenya, off Tanzania, off Seychelles, off Madagascar, off Mozambique, the Indian Ocean, off the Indian west coast and off the Maldives west coast. Most of the attacks involve the use of lethal weapons, which is a cause of great concern to the merchant navy fleet since it poses a serious threat not only to injury and death of seafarers but also to the ship, cargo and environment. Another concern regarding Somali pirates' attacking behavior is that they are using more hijacked ocean going fishing vessels and hijacked merchant vessels to conduct piracy operations. This has greatly enhanced the ability of pirates to attack many unsuspecting passing vessels. Skiffs are launched from the hijacked vessels, which quickly intercept and attack innocent vessels resulting in some vessels being hijacked. Being in control of these hijacked vessels, the pirates are no longer limited by capability and there is no boundary that can constrain the pirates given enough fuel onboard. Attacks in the Gulf of Aden have dropped by more than fifty percent due to the international naval patrols and positive actions of the seafarers. Nevertheless, in other parts off Somalia, including the Red Sea and the wider Indian Ocean where naval patrols are not covered, attacks have gone up substantially (IMO, 2010).

Corresponding with this rise are the violence inflicted on the crews and the material damage from attacks between 1991 and 2010, during this period 390 crew members were killed, 945 crew members were reportedly injured/assaulted, 7,111 crew members were reportedly taken hostage or kidnapped; and 203 crew members went missing. Assaults on crews were typically involved by groups of five to ten pirates, some of whom were heavily armed. More people were taken hostage at sea in 2010 than in any year since records

began. Pirates captured 1,181 seafarers and killed eight. Fifty-three ships were hijacked. The figures for the number of hostages and vessels taken are the highest ever seen. As a percentage of global incidents, piracy on the high seas has increased dramatically over armed robbery in territorial waters (IMO, 2010).

Despite these figures, maritime piracy incidents are underreported by as much as fifty percent (Chalk, 2008). Statistical data provides an overall view of the problem but it is by no means an accurate indicator of the actual criminal activity that takes place (Kellerman, 1998). Why are not all piracy cases reported to international organizations? First, port authorities are likely to dock the ship and its crew while they investigate the attack. Thus, if the cost to do so exceeds the sustained loss, the ship owners are unlikely to report. In 1997, investigation costs amounted to $10,000 per day whereas Abhyankar (1999) estimates that the average loss per attack to be approximately $5,000. Also, higher insurance costs and salaries for future crews can be a factor in maritime companies not to report. If local law enforcement is suspected of being in league with the pirates or is turning a blind eye to their activities, then the likelihood of the attack being reported is again very low. Gottschalk et al. (2000) calculate that those losses amounted to $0.32 for every $10,000 of goods shipped in 1997. Overall, the financial incentive for shipping companies to address the issue are not too high.

In this chapter, I examine the economic and political determinants of modern-day piracy empirically. In order to do so, I test the empirical implications of the model presented in Chapter 1. In the model, the maritime piracy incidents represent the subversive activity and the resources devoted for extralegal appropriation are the labor inputs used for piracy. Data include 3,362 worldwide modern-day piracy incidents that occurred between 1998 and 2007. I have detailed information on the location, region, timing and

success of each attack, as well as the material damage and violence inflicted upon the crew and the cargo. I combine these incident-based data with macroeconomic and aggregate measures on per-capita incomes, rates of economic growth, the unemployment rate and institutional quality of countries where the incident took place. I also incorporate the number of pirates involved and the vessel characteristics (the gross registered tonnage (GRT), flags, type of vessels) for each incident.

Empirical study reveals the following findings. First, the results fit the theoretical model well in that economic factors play a significant role in the number of pirates, the success of the attack and the property damage inflicted. For instance, higher real per-capita incomes and lower unemployment rates tend to reduce the number of pirates. Political institutions are also important in explaining this phenomenon. For example, the incidents that occur in a country with greater political freedom tend to have a lower number of pirates and incidents that do occur in the territories of more democratic countries have a reduced chance of successful attacks. Incidents that take place in more democratic locations also tend to involve fewer cases in which pirates board the ship and ask for ransom.

However, there are not many studies in quantitative economics that focus on modern maritime piracy. Given the limited amount of work, there are few papers that analyze this phenomenon in the following aspects. Maggio (2007) estimates the damage caused by maritime piracy and armed robbery and reveals that piracy and hijackings cost world shipping and industry around \$16-\$25 billion a year. Bowden (2010) conducts a large-scale study to quantify the cost of piracy, which are the sum of direct financial costs and secondary (macroeconomic) costs. Direct financial costs of piracy consist of ransoms, insurance premiums, the costs of re-routing to avoid piracy regions, deterrent security

equipment, naval forces, piracy prosecutions, and organization budgets dedicated to reducing piracy. The secondary (macroeconomic) costs include costs to regional trade, fishing and oil industries, cost food price inflation, and reduced foreign revenue. Based on her calculations, Bowden asserts that maritime piracy is costing the international economy between $7 to $12 billion per year. Nevertheless, Murphy (2007) warns against exaggerating the threat posed by maritime pirates. He notes that even $16 billion in losses is a minimal amount compared to annual global maritime trade value, which is in the trillions of dollars. This also explains why shipping companies do not give a serious attention to this threat. Despite this fact, this terrorism cannot be negligible since maritime piracy incidents sometimes occur in international waters beyond the reach of the law in key locations that can affect the global security of nations around the world as well as the world economy.

Moreover, Mejia et al. (2009) focus on the randomness of maritime piracy. They estimate the probability that the cargo ship will be attacked by using a Probit model and the results show that both flags of registry and types of vessel are significant factors explaining maritime piracy. They also inquire whether there is a difference in the probability of being attacked between ships that fly Asian flags and those that fly non-Asian flags. Thus, piracy is clearly non-randomly selected.

Another quantitative analysis on the modern maritime piracy focuses on political institutions and state status. Hastings (2009) explores whether the difference between the geographies of state failure and state weakness matters for piracy. He argues that state failure is associated with less sophisticated attacks, whereas state weakness supports more sophisticated attacks since weaker states provide the facilities necessary for pirating. Moreover, pirates from failed states are likely to appropriate more liquid assets, whereas

the ones from weak states tend to appropriate assets with less liquidity. Moreover, failed states also face a trade-off. If they improve their political and economic systems to escape from state failure, they might encounter an increased number in high-skilled pirates.

2.2 The Empirical Analysis

2.2.1 Data and Descriptive Statistics

I created the data using several specific underlying datasets. For the full description of each piracy incident between 1998 and 2007, the main information sources are the annual reports by the International Maritime Bureau (*IMB*) and the annual and monthly reports from International Maritime Organization (*IMO*). For statistical purposes, the IMB defines Piracy and Armed Robbery as "An act of boarding or attempting to board any ship with the apparent intent to commit theft or any other crime and with the apparent intent or capability to use force in the furtherance of that act." This definition covers actual or attempted attacks whether the ship is berthed, at anchor or at sea. Trivial thefts are excluded unless the thieves are armed. This definition has been adopted by the IMB as the majority attacks against ships take place within the jurisdictions of States, and piracy, which is defined under United Nations Convention on Law of the Sea (1982) does not address this aspect.

Each incident of piracy and robbery against a seafaring vessel allowed me to create data on the exact time of the incident (i.e., year and month), its location by type of waters (port area, territorial water or international waters), the identity of the ship including its flag of registry, its type of goods carried; its gross registered tonnage (*GRT*), the type of violence perpetrated against the crew, ranging from no harm done to deaths, the type of goods stolen or appropriated, and the number of pirates involved in each incident. I

also identify whether the attack is actual or attempted.[6]

Then, based on the location of the attack, I combined the above data with country-level economic and political measures. Data such as real GDP per capita and its 10-year growth rate are sourced from the *Penn World Tables*, Mark 6.3. Annual data on unemployment rates are obtained from the *World Databank.* The data on political and institutional measures primarily come from two different sources: *Freedom House* world political and civil freedom measures, and the *Polity IV* project, "Political Regime Characteristics and Transitions". The Freedom House data provide three measures of political rights, civil liberties and political freedom status. Political rights and civil liberties are measured on a one-to-seven scale, with one representing the highest degree of freedom and seven the lowest.[7] The freedom status is classified into three categories: free, partly free and not free.[8] And the *Polity IV* project provides the institutionalized democracy score, institutionalized autocracy score and the modified polity score.[9]

[6]IMB defines "actual" attack as the incidents where the pirates successfully boarded the target ship regardless of the consequences to the crews and goods. They also define "attempted" attack as the incidents where the pirates failed to board the ship underway and finally gave up the chase. Although the attack is attempted and pirates cannot rob any goods, it can cause injury to the crews by firing upon the target from their ships.

[7]The ratings process is based on a checklist of 10 political rights questions and 15 civil liberties questions. The political rights questions are grouped into three subcategories: Electoral Process, Political Pluralism and Participation, and Functioning of Government. The civil liberties questions are grouped into four subcategories: Freedom of Expression and Belief, Associational and Organizational Rights, Rule of Law, and Personal Autonomy and Individual Rights.

[8]Until 2003, countries whose combined average ratings for Political Rights and for Civil Liberties fell between 1.0 and 2.5 were designated "Free"; between 3.0 and 5.5 "Partly Free," and between 5.5 and 7.0 "Not Free". Beginning with the ratings for 2003, countries whose combined average ratings fall between 3.0 and 5.0 are "Partly Free" and those between 5.5 and 7.0 are "Not Free".

[9]The institutionalized democracy score is conceived as three essential, interdependent elements. One is the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders. Second is the existence of institutionalized constraints on the exercise of power by the executive. Third is the guarantee of civil liberties to all citizens in their daily lives and in acts of political participation. The operational indicators of democracy and autocracy are derived from the competitiveness of political participation, the openness and competitiveness of executive recruitment, and constraints on the chief executive. They are an additive eleven-point scale (0-10). The Polity score is computed by subtracting the institutionalized autocracy score from the institutionalized democracy score; the resulting unified polity scale ranges from -10 (strongly autocratic) to +10 (strongly

Finally, the data on maritime trade per capita is obtained through *Shipping Statistics Yearbooks* from the Institute of shipping and Logistics of Bremen (*ISL*). The maritime trade per capita is obtained from the loading and unloading cargo traffic volume by selected ports divided by the total population in the region.

There are five geographic regions covered: Asia, Africa, America, Europe and Oceania. I calculate the cargo traffic volume within each region based only on selected ports, although those data represent 71 percent of the actual world seaborne trade over the ten years for which I have data.

Table 2.1 presents the overall trends in piracy attacks over the period between 1998 and 2010. As shown, 2000, 2003, 2009 and 2010 were particular busy years in which the number of incidents exceeded 400. After the peak in 2003, the number of incidents dropped and rose again in 2008. The trend shows that from now on the number of incidents tends to increase. 2009 is the only year in which the number of attempted attacks is higher than the number of actual attacks.

In Table 2.2, I present the number of piracy incidents by five main locations in which piracy incidents commonly occur, Southeast Asia, Far East, Indian Subcontinent, South America and Africa. In 2005, the number of incidents in Southeast Asia declined since Indonesia, Malaysia and Singapore jointly cracked down on piracy, subsequent to the designation of the Malacca Strait as a war zone by Lloyd's of London. On the other hand, the number of incidents in Africa has risen continuously since 2007, especially in the East Africa on Somalia and Gulf of Aden.

democratic). It is a modified version in order to facilitate the use in time-series analysis by converting the standardized authority scores to conventional polity scores.

Table 2.1: Total Piracy Incidents by Year

Year	Actual Attacks	Attempted Attacks	Total
1998	157	35	192
1999	242	58	300
2000	318	151	469
2001	238	97	335
2002	286	84	370
2003	332	113	445
2004	239	90	329
2005	205	71	276
2006	176	63	239
2007	187	76	263
2008	200	93	293
2009	202	204	406
2010	249	196	445

Source: International Maritime Bureau (IMB), 2010

Table 2.2: Actual and Attempted Attacks by Location and Year

Location	2004	2005	2006	2007	2008	2009	2010
Southeast Asia	158	102	83	70	54	46	70
Far East	15	20	5	10	11	23	44
Indian Subcontinent	32	36	53	30	23	30	28
South America	44	25	29	20	14	37	40
Africa	73	80	61	120	189	266	259
Rest of the World	7	13	8	13	2	4	4
Total	329	276	239	263	293	406	445

Source: International Maritime Bureau (IMB), 2010

The summary and descriptive statistics of some of the key variables are listed in Table 2.3. Close to 75 percent of all attacks succeeded over the ten years in the sample. The $YEARS$ variable ranges from one to ten in chronological order. It equals one if the incidents happened in 1998 and ten if they happened in 2007. The frequency of incidents over time is slightly backloaded although spread fairly evenly, with the average incident occurring between the fifth and sixth years in the decade-long sample (i.e., between 2002 and 2003). For the 2,300 observations for which I have data on the number of pirates involved in the incident, the average number of pirates employed in each incident is about six. Most attacks involved one pirate. Of course, these incidents only happened at ports. But close to ten percent of these attacks involved more than ten pirates, and 43 were reported to take more than twenty. There are five incidents in which more than 80 pirates involved with a maximum of 200 pirates. Variable $GOODS$ ranges anywhere from zero to seven on the basis of the economic damage inflicted by the pirates: this variable equals zero if no economic harm was done; $GOODS$ equals one if the pirates left with some cash; it equals two if they stole spare parts; three, four or five if they took storage material, spare parts or equipment, respectively; six if they sought ransom and seven if they commandeered the vessel. For every one hundred incidents recorded in the dataset, there were ten incidents in which cash items were stolen; four in which cargo goods are robbed; three in which the pirates sought ransom; and five cases where the vessels were captured.[10]

For countries where the incidents happened, the real per capita incomes are roughly $7,600 based on 2005 constant U.S. dollars. The 10-year growth rate of real GDP per capita is around 22 percent and the unemployment rate is about 8 percent. The

[10]The definition of variable $CASH$ includes Captains and crews' cash and their personal valuables and belongings.

$STATUS$ dummy variable ranges from zero to two. It equals to zero if countries where the incidents happened have "Not Free" status, one if "Partly Free" status and two if "Free" status. The mean value of the freedom status is about 1, implying that by average the countries where the incident happens have partly free status. The $WATER$ variable ranges from one to three. It equals to one if the incidents happen in the port area, two if happen in territorial water, and three if they happen in the international water. It also can be interpreted as the distance from the sea shore. The mean of the variable $WATER$ is around 1.8. The interpretation is that, on average, the incidents happened at ports or local waters. For vessels attacked by pirates, on average, the total internal volume is around 16,800 tons.[11] The mean value of maritime trade per capita is 1.15 metric tons.

[11]Some carriers attacked by pirates are fishing boats and other small ships which have very low tonnages and their values were not recorded by IMO and IMB. Thus, I assume the minimum value of variable $TONNAGE$ is zero.

Table 2.3: Descriptive Statistics

Variables	*Observations*	*Mean*	*St. Dev.*	*Min*	*Max*
$YEARS$	$3,371$	5.45	2.62	1	10
$PIRATES$	$2,300$	5.95	7.57	1	200
$SUCCESS$	$3,371$	0.744	0.436	0	1
$GOODS$	$3,371$	1.559	1.981	0	7
$CASH$	$3,371$	0.096	0.295	0	1
$CARGOGOODS$	$3,371$	0.036	0.187	0	1
$VESSEL$	$3,371$	0.045	0.208	0	1
$RANSOM$	$3,371$	0.028	0.165	0	1
$RGDPCAP$	$3,362$	$7,595$	$39,804$	345.517	$653,046$
$GROWTH$	$3,371$	22.04	21.73	-65.5087	130.991
$UNEMP$	$3,371$	8.01	4.35	0.691563	50
$PRIGHTS$	$3,371$	4.26	1.50	1	7
$STATUS$	$3,371$	1.08	0.603	0	2
$POLITY$	$3,371$	4.26	4.35	-10	10
$WATER$	$3,371$	1.80	0.780	1	3
$TONNAGE$	$3,371$	$16,768.04$	$21,602.44$	0	$218,593$
$MTRADECAP$	$3,371$	1.152	1.121	0.367487	21.1

Examining the correlation matrix shown in Table 2.4 a, the success rate of attacks has increased over time but the number of pirates has declined over time. Note that the success rate of attacks and the number of pirates decline slightly with increases in per-capita income and the unemployment rate, but they are positively correlated with the growth rate of real GDP per capita. Also, the number of pirates declines when citizens have more freedom and political rights and when countries are more democratic. With the smaller number of pirates, the probability of all types of property appropriation declines.

Turning to Table 2.4 b, we see that it is harder to successfully attack when the ships are sailing farther from the land and when the ships are larger. But the success rate of attacks is positively correlated with the maritime trade per capita and the number of vessels. It is interesting to observe that the farther the distance from port, the higher chance of robbing for cash, vessel hijacking and ransom demanding but not for robbing cargo goods. The reason is that it is easier to successfully operate when the ships are at the port for loading and unloading the cargo. The number of robberies decreases as the size of vessel increases. This could be because larger ships imply a higher protection level.

In Table 2.4 c, incidents with cash and cargo goods robberies have declined slightly over time, whereas incidents involving vessel hijacking and ransom demanding rose. The number of pirates is increasing with all four types of robberies.

Table 2.4: Correlation Matrices

Table 2.4 a:

The Correlation Matrix									
	$SCCS$	$YEAR$	$PRTS$	$GOOD$	$RGDP$	GRW	$UNEM$	$PRGT$	$STAT$
$SCCS$	1	...	...	...	...	...	...	...	...
$YEAR$	.0305	1	...	...	...	...	...	...	...
$PRTS$	.0302	-.019	1	...	...	...	...	...	...
$GOOD$	.4851	.0345	.1723	1	...	...	...	...	...
$RGDP$	-.061	-.059	-.02	-.024	1	...	...	...	...
GRW	.0792	.1286	.0107	-.032	.188	1	...	...	...
$UNEM$	-.063	.0979	-.045	-.012	-.055	-.327	1	...	...
$PRGT$	.1496	.0298	-.023	.0225	-.111	.0004	.1297	1	...
$STAT$	.1488	.0892	-.037	.0038	-.078	.0974	.0892	.8894	1
$POLT$	.1229	.0176	-.024	.0276	-.148	-.027	.0248	.888	.768

Table 2.4 b:

The Correlation Matrix									
	$SCCS$	$PRTS$	$CASH$	$CRGO$	$RNSM$	$VESL$	$TONN$	$MTRD$	WTR
$SCCS$	1	...	...	...	...	...	...	...	...
$PRTS$	.0318	1	...	...	...	...	...	...	...
$CASH$	.2227	.0473	1	...	...	...	...	...	...
$CRGO$	.1223	.1287	-.057	1	...	...	...	...	...
$RNSM$	.0964	.0979	-.045	-.0247	1	...	...	...	...
$VESL$	.1120	.0975	-.052	-.0287	-.0227	1	...	...	...
$TONN$	-.141	-.084	-.098	-.0524	-.1010	-.1204	1	...	...
$MTRD$	.0495	-.02	.0679	-.0149	-.0248	.0048	-.0074	1	...
WTR	-.405	.0622	.1338	-.0576	.1341	.0605	.0055	-.0125	1

Table 2.4 c:

The Correlation Matrix					
	$YEAR$	$PRTS$	$CASH$	$CRGO$	$VESL$
$YEAR$	1	...	...	...	...
$PRTS$	-0.0178	1	...	...	...
$CASH$	-0.0146	0.0473	1	...	...
$CRGO$	-0.0283	0.1287	-0.0572	1	...
$VESL$	0.0200	0.0975	-0.0524	-0.0287	1
$RNSM$	0.0630	0.0979	-0.0451	-0.0247	-0.0227

2.2.2 Main Results

Now, to validate the extralegal appropriation model as an application to modern maritime piracy, I utilize the dataset described above to estimate the number of pirates, the success rate of attacks, and piracy profits on economic and political explanatory variables. I also estimate the regional maritime trade volume per capita on piracy-specific incident variables. The time that the average family allocates to subversive activity is represented by the data on the number of maritime pirates involved in each incident. The success rate of attacks is a proxy for subversive technology of attacking vessels and piracy profits are represented by the success rate of the economic outcomes.

2.2.2.1 Reduced-Form Estimates

I derive the baseline empirical results by estimating the following reduced-form equation:

$$\begin{aligned} OUTCOME_{it} &= \alpha + \Gamma_{it}\boldsymbol{\beta} + \Omega_{it}\boldsymbol{\gamma} + \sum_{j=1998}^{2007} \psi_j \times I_j \\ &\quad + \sum_{k=1}^{29} \lambda_k \times I_k + \sum_{m=1}^{8} \lambda_m \times I_m + \varepsilon_{it} \ , \end{aligned} \tag{24}$$

where $OUTCOME_{it}$ is an outcome of the piracy act that took place in location i at time t; it is based on the number of pirates, the success rate of attacks or the nature of the appropriation involved. In (24), α is a constant and Γ_{it} represents incident-specific explanatory variables related to the vessel or geographic location where the incident occurred. And Ω_{it} represents economic or political variables associated with location i

at time t. Finally, the I_j , I_k and I_m represent controls for time fixed effects, location fixed effects and carrier fixed effects, with the second being based on the 29 locations and the latter being based on the eight types of carrier in my database where piracy incidents were reported.[12] The 29 locations covered in our dataset account for 3,039 observations out of the total of 3,362, corresponding roughly to 90 percent of our data points.

In alternative specifications, my dependent variable $OUTCOME_{it}$ is the number of pirates involved in each incident, $PIRATES$. Another specification uses $SUCCESS_{it}$ as a dependent variable. It is a dummy variable that takes on the value of one if pirates succeed in boarding the vessel and zero is the attack is attempted which means the pirates could not successfully board the vessel. Alternatively, my dependent variable $OUTCOME_{it}$ is also one of four measures of economic outcomes: whether or not the pirates stole cash from the crew or the vessel, $CASH_{it}$; they used the crew for ransom demands, $RANSOM_{it}$; they succeeded in capturing the vessel, $VESSEL_{it}$; or they stole cargo goods for sale; $CARGOGOODS_{it}$. All of dependent variables are dummies except $PIRATES$.

In terms of the incident-specific economic or political explanatory variables in the matrix Ω_{it}, there are per capita real GDP, its growth rate and unemployment levels at time t in location i, $RGDPCAP_{it}$, $GROWTH_{it}$ and $UNEMP_{it}$, respectively. This matrix also includes measures on political rights, political freedom status and the polity score, labeled as $PRIGHTS_{it}$, $STATUS_{it}$ and $POLITY_{it}$, respectively.[13] The matrix

[12]On this basis, I end up with ten year fixed effects for 1998 through 2007; eight carrier fixed effects for liquid gas tankers, chemical tankers, oil tankers, container ships, bulk carriers, general cargo ships, fishing vessels and others; and 30 location fixed effects that cover Bangladesh, Brazil, Cameroon, Colombia, Dominican Republic, Ecuador, Ghana, Guinea, Guyana, India, Indonesia, Ivory Coast, Jamaica, Kenya, Malaysia, Nigeria, Peru, Philippines, Somalia, Sri Lanka, Tanzania, Thailand, Venezuela, Vietnam, the Malacca Strait, the South China Sea, the Gulf of Aden, the Singapore Strait, the Red Sea, and finally, "others" for locations that are not covered by these 29 locations.

[13]To facilitate interpreting the results in the empirical analysis, I generated a new variable representing

of incident-specific vessel and geographic explanatory variables, Γ_{it}, includes the month and year of the incident, its geographic location, the type of water where the incident happens ($WATER$) as well as the gross registered tonnage ($TONNAGE$), flag, type of vessel and the maritime trade volume per capita in the region where the incident occurs ($MTRADECAP$).[14]

In Tables 2.5 through 2.10, I report the baseline, reduced-form estimates. Table 2.5 includes the economic and political factors and outcome related to the number of pirates and the next table turn to the success rate of attacks. Table 2.7 through 2.10 then turn to an assessment of more economic-based outcomes. From Table 2.5 to Table 2.10, the regressions in column (1) are the simplest specification, with only key economic and politico-institutional measures employed with the fixed effects on attack locations and years. The second regression then adds fixed effects based on the attacked carriers. The third column adds $WATER$ as a basic right-hand side control. The next regression then adds $TONNAGE$ of the vessels and $MTRADECAP$ as additional controls. And the final column in table 2.6 through 2.10 includes the number of pirates, $PIRATES$, as an additional control variable.

In terms of the incident-related or geographic variables that are controlled for in all regressions in Table 2.5, I include the $TONNAGE$ of the vessels because the number of pirates required for an attack might be associated with the size of the vessel. Since the

the inverse of the index value such that the higher score implies the higher degree of political rights freedom.

[14]I have dummies for the flags of 20 countries under which the vessels attacked sailed. The incidents invloving ships under these country flags account for more than 75 percent of the data. The countries for which I have flag dummies include: Antigua and Barbuda, Bahamas, Cyprus, Denmark, Greece, Hong Kong, Indonesia, India, Liberia, Malaysia, Malta, Marshall Islands, Netherlands, Norway, Panama, Saint Vincent, Singapore, Thailand, the United Kingdom, and the United States. I also have eight carrier-type dummies: Liquid gas tankers, Chemical tankers, Oil tankers, Container ships, Bulk carriers, General cargo ships, Fishing boats and Others (Passenger ferries, Tugs, Barges, Yachts and Supply ships).

variable $WATER$ could be interpreted as the distance from the sea shore, the position of the attack could affect the amount of pirates employed when attacking the vessel. Hence, I include $WATER$ as a basic right-hand side control. I include a measure of the volume of maritime trade per capita of the region where the attack occurred, $MTRADECAP$, on the idea that maritime trade volumes could, independently, affect the number of pirates necessary for attacking in a particular region. $MTRADECAP$ can also be interpreted as the sum of the demand and supply for goods and services transported by sea in the region.

The set of our basic economic variables as well as those for political stability and institutional controls are self-explanatory. In any case, the main economic variables are real income per capita, $RGDPCAP$, economic growth, $GROWTH$, and the unemployment rate, $UNEMP$. And the main controls for political stability and institutional quality are the political rights index, $PRIGHTS$, the freedom status, $STATUS$, and the polity score, $POLITY$.

In the first column of Table 2.5, I regress the number of pirates, $PIRATES$, on the simplest set of only economic and political variables and fixed effects for location and year. As shown, the number of pirates depends negatively on per-capita income and the freedom status of the country where the incident took place. Adding fixed effects for the vessels attacked reveals that GDP per capita and freedom status are still statistically significant determinants on the number of pirates. In column (3), I add $WATER$ as an additional control which is statistically significant. This implies that more pirates were needed when they attacked ships farther from shore. Moreover, the unemployment rate becomes statistically significant with the positive sign. The number of pirates is higher when the unemployment rate is rising. In the final column, I present the estimate with

the full set of controls and fixed effects plus the gross registered tonnage, $TONNAGE$ and maritime trade per capita, $MTRADECAP$, as additional controls. The earlier set of results remain the same while $TONNAGE$ is statistically significant, implying that less pirates were needed when they attacked larger ships. As stated in Proposition 1 in Chapter 1, for a given level of piracy effort, larger ships mean fewer resources devoted to piracy attacks.

Table 2.5: Reduced-Form Estimates with The Number of Pirates as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)
RGDPCAP	-3.97e-06**	-3.89e-06**	-3.98e-06**	-4.06e-06*
	(1.71e-06)	(1.79e-06)	(1.93e-06)	(2.02e-06)
GROWTH	-0.00120	0.00236	0.000193	0.000172
	(0.00660)	(0.00737)	(0.00689)	(0.00700)
UNEMP	0.0881	0.0983	0.107*	0.107*
	(0.0587)	(0.0617)	(0.0614)	(0.0619)
PRIGHTS	0.635	0.555	0.470	0.547
	(0.447)	(0.413)	(0.406)	(0.408)
STATUS	-1.998***	-1.868***	-1.694***	-1.721***
	(0.646)	(0.613)	(0.590)	(0.568)
POLITY	-0.0916	-0.101	-0.0972	-0.109
	(0.0611)	(0.0614)	(0.0630)	(0.0672)
WATER			0.763*	0.779*
			(0.445)	(0.439)
TONNAGE				-1.43e-05**
				(5.58e-06)
MTRADECAP				-0.0948
				(0.0669)
LOCATION FE	Y	Y	Y	Y
YEAR FE	Y	Y	Y	Y
CARRIER FE	N	Y	Y	Y
Observations	2,294	2,294	2,294	2,294
R-squared	0.038	0.052	0.055	0.056

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Table 2.6, the dependent variable is the success rate of attacks by pirates, $SUCCESS$. Note that the success rate of attacks produces binary outcomes. Thereby, it would be more appropriate to estimate by using the Probit technique. With the most parsimonious regression in column (1), only real income per capita matters. Real income per capita produces the expected negative sign. Higher per capita incomes are associated with the lower probability of the successful attack. The results remain the same in column (2) when I add the fixed effect for carriers. When the $WATER$ is added to column (3), it becomes statistically significant with the negative sign. The probability that pirates successfully attack is higher when they target the ships closer to land. As the dataset suggests, the probability of successful attacks at the port is about 88% while the probability of success in international waters is around 46%. In column (4), when $TONNAGE$ and $MTRADECAP$ are added, only $TONNAGE$ is statistically significant with the expected sign. $TONNAGE$ produces a negative sign; the larger the ship, the lower probability of a successful attack. In the last column when the number of pirates is added into the specification, the result is the same as in column (4) whereas $PIRATES$ is not statistically significant.

Table 2.6: Reduced-Form Estimates with Probit Regressions with The Success Rate of Attacks as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)	(5)
RGDPCAP	-1.22e-06***	-9.86e-07***	-6.72e-07**	-7.45e-07**	-4.52e-07*
	(1.86e-07)	(2.25e-07)	(3.00e-07)	(3.16e-07)	(2.68e-07)
GROWTH	-0.00104	-0.000651	6.92e-05	0.000140	-0.00198
	(0.00118)	(0.00121)	(0.00143)	(0.00142)	(0.00137)
UNEMP	-0.000262	0.00359	-0.00299	-0.00211	-0.000952
	(0.00546)	(0.00609)	(0.00517)	(0.00538)	(0.00641)
PRIGHTS	-0.00521	-0.0129	0.0394	0.0498	0.124
	(0.0579)	(0.0680)	(0.0724)	(0.0786)	(0.0930)
STATUS	0.0657	0.0709	0.00344	0.00730	-0.0808
	(0.109)	(0.110)	(0.121)	(0.122)	(0.145)
POLITY	-0.00776	-0.00991	-0.0172	-0.0203	-0.0261
	(0.0146)	(0.0173)	(0.0191)	(0.0209)	(0.0194)
WATER			-0.595***	-0.593***	-0.645***
			(0.0727)	(0.0724)	(0.0717)
TONNAGE				-6.50e-06***	-8.61e-06***
				(2.25e-06)	(2.46e-06)
MTRADECAP				-0.00574	0.0112
				(0.00877)	(0.00952)
PIRATES					0.0123
					(0.00946)
LOCATION FE	Y	Y	Y	Y	Y
YEAR FE	Y	Y	Y	Y	Y
CARRIER FE	N	Y	Y	Y	Y
Observations	3,363	3,363	3,363	3,363	2,294

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Since the success rate of attacks solely does not imply success in appropriation, I, then, consider economic outcomes as dependent variables. Because the level of piratical profits comes from the number of appropriation incidents, I test the model by using economic outcomes as a proxy of profits. Table 2.7 through 2.10 present four measures of common economic outcomes pirates appropriated: whether or not the pirates stole cash, cargo goods, hijack vessel and demand ransom. Again, since the types of properties taken by pirates produce binary outcomes, I run the baseline, reduced-form regressions with the Probit approach.

In Table 2.7, I turn to cash robberies as outcomes and find that $RGDPCAP$, $UNEMP$ and $STATUS$ are statistically significant in all columns. When levels of income per capita and the vessels' total volume were higher, cash robberies did decline significantly. When the political freedom status of the countries where the incidents happen are higher, incidents involving cash robbery significantly dropped. $PRIGHTS$ is significant only in column (1), (2) and (3). $WATER$ is significant only in column (3) and (4). $PIRATES$ is also positively significant. Cash robberies are higher when the incidents happen farther from the land and when more pirates are involved. Paradoxically, however, I also find that a higher unemployment rate was also associated with fewer piracy incidents with cash robberies. This might be because pirates shift toward other targets. $TONNAGE$ and $MTRADECAP$ are statistically significant.

In Table 2.8, I use the cargo goods robbery as a dependent variable. For column (1), (2) and (3), the results are the same in which the economic growth rate and political and civil freedom status are significant. Illogically, cargo goods robbery is increasing in countries with more political and civil freedom. When $TONNAGE$ and $MTRADECAP$ are included in column (4), those variables become significant with the negative sign.

Larger vessels and higher maritime trade volume result in fewer cargo goods robberies. In the last column, when adding the number of pirates into the equation, $PIRATES$ is significant with a positive sign. Income per capita and unemployment rate now become significant with the positive signs. Irrationally, cargo goods robbery is increasing with real income per capita. $TONNAGE$ is no longer significant.

I explore the determinants of vessels captured by pirates in Table 2.9. None of the variables is significant in the first column. When the carrier fixed effect is included in the second column, the growth rate of real income is significant. $UNEMP$, $STATUS$, $TONNAGE$ and $PIRATES$ become significant in the last column. But the economic growth rate is no longer significant. The number of vessel hijackings is decreasing in the countries with higher political and civil freedom status and in the regions with higher trade volumes by water.

Finally, Table 2.10 presents the impact of my explanatory variables on the extent to which pirates seek ransom. As seen, the income level is significant in the last column only. But it produces a positive sign which implies that higher real income is associated with the higher number of incidents involved with the ransom demand. Strangely, $STATUS$ is also significant with the positive sign in all columns. The strength of democracy, the distance from the land, the size of the vessel, the volume of maritime trade per capita and the number of pirates involved also matter for the demand for ransom.

It is interesting to note that the sign of $MTRADECAP$ is positive only when the economic outcome is cash. In the region with the higher regional trade volume by water per capita, pirates tend to appropriate cash rather than other types of booty. $PIRATES$ is positively significant and $TONNAGE$ is negatively significant in all types of good appropriated.

Table 2.7: Reduced-Form Estimates with Probit Regressions with Cash Robbery as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)	(5)
RGDPCAP	-2.22e-06*	-2.22e-06**	-2.36e-06**	-2.44e-06**	-2.88e-06**
	(1.17e-06)	(1.11e-06)	(1.02e-06)	(1.07e-06)	(1.14e-06)
GROWTH	-0.000998	-0.000584	-0.000811	-0.000505	-0.00253
	(0.00493)	(0.00484)	(0.00492)	(0.00506)	(0.00433)
UNEMP	-0.0262***	-0.0257***	-0.0220***	-0.0313***	-0.0266***
	(0.00701)	(0.00704)	(0.00640)	(0.00829)	(0.00808)
PRIGHTS	0.228**	0.244**	0.218*	0.185	0.0561
	(0.108)	(0.110)	(0.114)	(0.116)	(0.142)
STATUS	-0.412**	-0.415**	-0.350*	-0.369*	-0.370*
	(0.190)	(0.196)	(0.185)	(0.194)	(0.225)
POLITY	-0.0148	-0.0208	-0.0195	-0.0143	0.0134
	(0.0194)	(0.0198)	(0.0198)	(0.0188)	(0.0225)
WATER			0.335*	0.332*	0.370
			(0.197)	(0.198)	(0.234)
TONNAGE				-7.11e-06***	-1.23e-05**
				(1.77e-06)	(4.85e-06)
MTRADECAP				0.0765***	0.0716***
				(0.00876)	(0.0129)
PIRATES					0.0181**
					(0.00756)
LOCATION FE	Y	Y	Y	Y	Y
YEAR FE	Y	Y	Y	Y	Y
CARRIER FE	N	Y	Y	Y	Y
Observations	2,959	2,959	2,959	2,959	1,991

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.8: Reduced-Form Estimates with Probit Regressions with Cargo Goods Robbery as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)	(5)
RGDPCAP	-1.21e-06	-1.18e-06	-1.10e-06	-7.19e-07	3.02e-06***
	(7.89e-07)	(9.04e-07)	(9.54e-07)	(9.55e-07)	(1.12e-06)
GROWTH	-0.00697*	-0.00910**	-0.00883**	-0.00879**	-0.0161**
	(0.00401)	(0.00410)	(0.00386)	(0.00366)	(0.00712)
UNEMP	0.000809	-0.00284	-0.00301	0.00324	0.0386***
	(0.0120)	(0.0100)	(0.0108)	(0.0118)	(0.0125)
PRIGHTS	-0.136	-0.123	-0.123	-0.0902	-0.169
	(0.136)	(0.120)	(0.122)	(0.144)	(0.179)
STATUS	0.477***	0.415***	0.414***	0.441***	0.473
	(0.120)	(0.112)	(0.113)	(0.114)	(0.296)
POLITY	-0.00850	-0.0119	-0.0112	-0.0151	0.0238
	(0.0393)	(0.0378)	(0.0379)	(0.0422)	(0.0584)
WATER			-0.101	-0.0786	-0.127
			(0.168)	(0.159)	(0.148)
TONNAGE				-1.29e-05*	-1.45e-05
				(7.84e-06)	(1.24e-05)
MTRADECAP				-0.287**	-0.415***
				(0.114)	(0.144)
PIRATES					0.0181***
					(0.00407)
LOCATION FE	Y	Y	Y	Y	Y
YEAR FE	Y	Y	Y	Y	Y
CARRIER FE	N	Y	Y	Y	Y
Observations	2,885	2,885	2,885	2,885	1,374

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.9: Reduced-Form Estimates with Probit Regressions with Vessel Hijacking as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)	(5)
RGDPCAP	-3.75e-07	3.30e-07	2.91e-07	2.59e-07	-2.05e-06
	(1.25e-06)	(1.41e-06)	(1.41e-06)	(1.41e-06)	(1.72e-06)
GROWTH	0.00225	0.00531**	0.00522**	0.00582**	0.00628
	(0.00188)	(0.00212)	(0.00208)	(0.00228)	(0.00697)
UNEMP	-0.00486	0.00557	0.00579	0.0138	0.0320**
	(0.0124)	(0.0121)	(0.0124)	(0.0149)	(0.0148)
PRIGHTS	0.116	0.0755	0.0749	0.141	0.180
	(0.132)	(0.147)	(0.147)	(0.170)	(0.175)
STATUS	-0.180	-0.166	-0.163	-0.201	-0.654**
	(0.149)	(0.160)	(0.162)	(0.170)	(0.310)
POLITY	-0.0157	-0.0163	-0.0171	-0.0266	0.0206
	(0.0242)	(0.0325)	(0.0317)	(0.0357)	(0.0402)
WATER			0.0414	0.0305	-0.103
			(0.0785)	(0.0643)	(0.0948)
TONNAGE				-1.82e-05	-8.03e-05*
				(1.73e-05)	(4.32e-05)
MTRADECAP				-0.0885***	-0.0587**
				(0.0188)	(0.0276)
PIRATES					0.0147***
					(0.00358)
LOCATION FE	Y	Y	Y	Y	Y
YEAR FE	Y	Y	Y	Y	Y
CARRIER FE	N	Y	Y	Y	Y
Observations	2,813	2,813	2,813	2,813	1,146

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.10: Reduced-Form Estimates with Probit Regressions with Ransom Demand as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)	(5)
RGDPCAP	-3.72e-08	1.17e-07	-3.63e-07	-2.60e-07	3.35e-06**
	(5.69e-07)	(6.56e-07)	(6.50e-07)	(5.38e-07)	(1.46e-06)
GROWTH	0.00103	0.000706	-0.000806	-0.00167	-0.00144
	(0.00498)	(0.00445)	(0.00480)	(0.00499)	(0.0111)
UNEMP	0.0134	0.0253*	0.0251*	0.0304*	-0.0253
	(0.0170)	(0.0152)	(0.0147)	(0.0172)	(0.0411)
PRIGHTS	-0.186**	-0.178	-0.225*	-0.0990	-0.111
	(0.0949)	(0.110)	(0.122)	(0.132)	(0.326)
STATUS	0.850***	0.925***	1.109***	1.173***	2.657***
	(0.268)	(0.298)	(0.355)	(0.366)	(0.478)
POLITY	-0.0411	-0.0713*	-0.0821*	-0.108**	-0.179***
	(0.0280)	(0.0369)	(0.0429)	(0.0525)	(0.0691)
WATER			0.406***	0.455***	0.492***
			(0.0900)	(0.0905)	(0.127)
TONNAGE				-6.01e-05***	-6.63e-05***
				(1.27e-05)	(1.05e-05)
MTRADECAP				-0.436*	-0.241
				(0.252)	(0.371)
PIRATES					0.0172*
					(0.00959)
LOCATION FE	Y	Y	Y	Y	Y
YEAR FE	Y	Y	Y	Y	Y
CARRIER FE	N	Y	Y	Y	Y
Observations	2,475	2,286	2,286	2,286	1,285

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Now, I inspect the effects of maritime piracy incidents on regional maritime trade volume. I assume that the piracy incidents and the incentive to trade are not contemporaneous. The decision to trade by water decreases in the face of previous piracy incidents. To see how past piracy incidents impact maritime traffic volume in the current period, I create seven lagged variables on piracy-related factors; $LAG\_SUCCESS_{it-1}$, the probability of successful attack in period t-1, $LAG\_INCIDENTS_{it-1}$, the total number of piracy incidents in period t-1, $LAG\_AVGPIRATES_{it-1}$, the average number of pirates involved in each incident in period t-1, LAG_GOODS_{it-1}, the level of economic damage inflicted by pirates in period t-1, $LAG\_SHIP\_TRADE_{it-1}$, the number of piracy incidents which happen to the vessels carrying traded goods in period t-1[15], LAG_PORT_{it-1}, the number of piracy incidents occurred at the port area in period t-1, $LAG\_CREWHARM_{it-1}$, the number of piracy incidents in which the crews were subject to physical harm in period t-1.[16]

Observing the correlation matrix shown in Table 2.11, the maritime trade volume per capita in the current period is positively correlated with the probability of successful attack in the last period, the average number of pirates involved in each incident in the last period, the level of economic damage inflicted by pirates in the past period, and the number of piracy incidents in which the crews were subject to physical harm in the last period. Given the higher total number of piracy incidents in the last period, the higher number of piracy incidents that happen to the vessels carry traded goods in the last period and the higher number of piracy incidents that occur at the port area in the last period, the volume of maritime trade per capita of the region in the current

[15]Vessels carrying traded goods consist of six types of carriers: liquid gas tankers, chemical tankers, oil tankers, container ships, bulk carriers and general cargo ships.

[16]This is a dummy variable that attains the value of one if the pirates either threatened, physically assualted, kidnapped or killed at least one vessel crew, and is zero otherwise.

period declines. The probability of the successful attack is positively correlated with the number of incidents, the average number of pirates involved in each incident, the level of economic damage inflicted, the number of incidents that happen to the vessels containing traded goods, the number of piracy incidents that occur at the port area and the number of piracy incidents where the crews were subject to physical harm.

Table 2.11: Correlation Matrix on lagged piracy-related variables and Regional Maritime Trade per Capita

	$MTPC$	L_SCS	L_INC	L_AVPRT	L_GDS	L_SHIP	L_PRT
$MTRADECAP$	1	...	...	...	...	...	...
$L\_SUCCESS$	0.1188	1	...	...	...	...	...
$L\_INCIDENTS$	-0.2743	0.151	1	...	...	...	...
$L\_AVGPIRATE$	0.0152	0.3265	-0.1745	1	...	...	...
L_GOODS	0.0111	0.5613	-0.0509	0.1971	1	...	...
$L\_SHIPTRADE$	-0.4137	0.0313	0.2523	-0.0196	-0.4865	1	...
L_PORT	-0.2548	0.5004	0.2637	0.0932	0.1213	0.2307	1
$L\_CREWHARM$	0.2751	0.7448	-0.1339	0.3401	0.5364	-0.1598	0.1991

Next, I report the baseline, reduced-form estimates with the region maritime trade per capita, $MTRADECAP_{it}$, as a dependent variable. In the first column of Table 2.12, I regress $MTRADECAP$ on (1) $LAG\_SUCCESS$, (2) $LAG\_INCIDENTS$, (3) $LAG\_AVGPIRATES$, (4) the simplest set of six economic and political variables, which are $RGDPCAP$, $GROWTH$, $UNEMP$, $PRIGHTS$, $STATUS$ and $POLITY$, and (5) the gross registered tonnage, $TONNAGE$. As shown, the regional maritime trade volume depends negatively on the regional economic growth and the tonnage but positively on the political rights level. But none of the lagged variables on piracy-specific explanatory variables is significant. In column (2), I add LAG_GOODS as an additional control but it is not significant.

In column (3), I added LAG_SHIP_TRADE into the specification. Now variables $LAG\_AVGPIRATES$, LAG_GOODS, LAG_SHIP_TRADE and $STATUS$ are negatively significant but economic growth is no longer significant. Once LAG_PORT is introduced in column (4), we see that in the past period the average number of pirates involved in each incident, the economic damage level caused by pirates, the incidents that happen to the vessels carrying traded goods and the incidents that happen at the port area negatively and significantly influence the region maritime trade volume in the current period. In the last column, I add $LAG\_CREWHARM$ as an additional control but it is not significant. The result is the same as in column (4).

In sum, I find evidence that the existence of modern-day piracy affects the maritime trade. Piracy incident-related factors that affect the regional maritime trade per capita are the number of pirates involved, the level of economic damage, the type of vessels and the position of the attack.

Table 2.12: Reduced-Form Estimates with the Region Maritime Trade per Capita as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)	(5)
L_SUCCESS	-4.044	-3.304	2.822	4.522	6.126
	(2.761)	(3.121)	(3.426)	(3.372)	(4.255)
L_INCIDENTS	0.000307	-0.00163	-0.00955	-0.00920	-0.00969
	(0.00725)	(0.00819)	(0.00773)	(0.00737)	(0.00748)
L_AVGPIRATES	-3.054	-3.785	-7.378**	-7.243**	-7.173**
	(2.599)	(2.966)	(2.888)	(2.752)	(2.783)
L_GOODS		-0.375	-2.682**	-2.968***	-2.861***
		(0.705)	(0.983)	(0.947)	(0.973)
L_SHIP_TRADE			-11.17***	-11.18***	-11.22***
			(3.671)	(3.498)	(3.535)
L_PORT				-4.428*	-4.280*
				(2.201)	(2.236)
L_CREWHARM					-2.428
					(3.856)
RGDPCAP	-0.000131	-0.000102	0.000113	4.29e-05	6.56e-05
	(0.000131)	(0.000144)	(0.000146)	(0.000143)	(0.000149)
GROWTH	-0.116**	-0.110**	-0.0546	-0.0441	-0.0394
	(0.0450)	(0.0468)	(0.0454)	(0.0435)	(0.0446)
UNEMP	-0.0248	-0.0299	-0.0340	-0.0567	-0.0181
	(0.148)	(0.150)	(0.133)	(0.127)	(0.143)
PRIGHTS	5.453**	5.798**	6.056***	5.465***	5.469***
	(2.114)	(2.234)	(1.987)	(1.916)	(1.936)
STATUS	-4.495	-5.004	-7.451*	-7.124*	-7.121*
	(4.024)	(4.180)	(3.801)	(3.625)	(3.663)
POLITY	-0.658	-0.703	-0.599	-0.219	-0.296
	(0.505)	(0.518)	(0.461)	(0.478)	(0.499)
TONNAGE	-0.000261***	-0.000254**	-0.000224**	-0.000194**	-0.000218**
	(9.52e-05)	(9.71e-05)	(8.68e-05)	(8.40e-05)	(9.33e-05)
Observations	43	43	43	43	43
R-squared	0.684	0.687	0.761	0.790	0.793

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.2.2.2 Alternative Specifications & Robustness

Although I show the reduced-form estimates with the Probit regression when the dependent variables are dummies, I performed the reduced-form linear regressions to test the robustness of qualitative results. I perform the analogs of the regressions shown in the final columns of Tables 2.6 through 2.10. The results show that qualitative results are very similar to the ones reported in Table 2.6 through 2.10.[17]

Next, one problem with estimating the incidents of appropriation by using the reduced-form approach comes from the fact that some explanatory variables are endogenous; $TONNAGE$, $WATER$, $PIRATES$. They are choice variables that the pirates have full control over because they can decide on how many pirates are hired, which ships to attack and where to attack them. Thus, I did two-stage least square estimates (*2SLS*) in which I construct an instrument for these endogenous variables. My instrument choice is a set of (twelve) dummies for month of attack. The idea is that because weather conditions are not only highly seasonal but also significantly influence whether or not attacks in the open seas or harbors would succeed with higher likelihood. The baseline *2SLS* empirical results were estimated and they did not alter in any qualitative manner.

Although I report a subset of the analyses conducted, I experimented with a variety of alternative specifications to test the robustness of my qualitative results. For example, besides the three institutional and polity measures I have included in the tables above, I also have three other related measures such as the civil liberty index, the democracy and autocracy indices of countries in which attacks occurred. Utilizing these variables in conjunction with or in lieu of $PRIGHTS$, $STATUS$ and $POLITY$ in a variety of

[17] All results discussed but not shown are available upon request.

alternative regressions, the key results did not alter in any meaningful way, although the measures I reported on the above generally produced the most significant effects on outcomes and the signs of their coefficients were not always consistent with predictions.

2.3 Conclusion

This chapter attempts to test the validity of the extralegal appropriation and production model as an application to modern maritime piracy. Based on the theoretical framework presented in Chapter 1, the extralegal activities are affected by economic incentives. Accordingly, the rise of modern-era maritime piracy is inversely related to the economic conditions of regions from which modern pirates emerge.

In order to test the empirical relevance of economic factors for piracy, I rely on a dataset that includes worldwide 3,362 modern-day piracy incidents that occurred from 1998 to 2007. The data provide detailed information on the location, timing and the type of each attack, whether it is actual or attempted, the characteristics of the target vessel as well as the material damage and violence inflicted upon the crew and the properties. Based on the country where the incident take place, data on macroeconomic and aggregate measures of per-capita incomes, rates of economic growth, unemployment and political quality are included.

I have emphasized three main findings: First, the empirical results strongly support the proposed theoretical model as economic factors play a significant role in explaining the modern maritime piracy behavior. For instance, higher real per-capita incomes and lower unemployment rates are likely to reduce the number of pirates involved in each incident. Seaborne trade volume is increasing in the number of pirates and the success rate of attacks. Second, political institutions are also important explaining this phenom-

enon although they are not as much nor consistent as economic factors. For example, the incidents that occur in the countries with greater levels of political and civil freedom tend to have fewer pirates involved in each incident, and more democratic countries tend to better protect the sea which reduces the success rate of attacks. More democratic countries have fewer cases in which pirates board the ship and demand ransom. Finally, I found that there are also other factors that explain maritime piracy incidents such as the ships' size, the distance between the incident position and the shore, the total merchant fleet in each year and the cargo traffic volume by marine transportation. For example, attacking larger ships requires that more pirates are involved in order to succeed. Pirates tend to successfully kidnap the crews and ask for ransoms in the regions with higher maritime trade volume per capita.

CHAPTER 3

Learning Piracy on the High Seas

3.1 Introduction

It was not long ago that high-seas piracy was mostly the stuff of legends, maritime history, and adventure novels. Starting in the mid-1990s, however, piracy began making a comeback, steadily turning into an epidemic that, today, seriously afflicts sea traffic, trade and commerce.

Consider: The data on international maritime piracy is maintained by the Piracy Reporting Center of the International Maritime Organization (IMO) but, as a sign of the increasing prevalence and relevance of modern maritime piracy in the 1990s, systematic incidents data is available starting only in 1995. This data shows that the frequency of reported incidents rose 270 percent within less than a decade, rising from 126 cases of maritime piracy in 1995 to 465 in 2003. In fact, most of that increase was recorded within a shorter span of two years between 1998 and 2000, when the number of piracy incidents went from 191 cases to 483, reflecting an increase of 183 percent. Commensurate with this rise, of course, are the human and material tolls of piracy. In 1998, there were 30 cases in which the crew were physically assaulted; 24 incidents in which hostages were taken; ten cases with crew deaths and nine ship seizures. Within five years, 40 incidents

involved physical assault; 71 cases involved hostage-taking; nine incidents of crew death; and 33 cases in which the vessels were surrendered to pirates.

Gathmann and Hillmann (2009) claim that the conventional narrative attributes the fall of ancient piracy to a combination of more sophisticated and evasive merchant ships, the naval presence of colonial powers and to international regulations.[18] The reemergence of maritime piracy in the modern era is, then, often explained as a corollary, such as the contemporary prevalence of failed or weak states in East Africa, lax international maritime legislation as well as pirate-friendly technological advances in communications and seafaring technologies. In this, the economic opportunity costs of piracy, by way of economically retarded and weakening states, are also often highlighted as potentially important culprits.

In this paper, we study the determinants of modern-era piracy, in particular, its *success* and *evolution* over time. Our work is based on a new dataset that includes 3,362 modern-day piracy incidents that occurred around the world between 1998 and 2007. The data encompasses detailed information on the location, timing and success of each attack, as well as the material damage and violence inflicted upon the crew and the cargo. We combine these incident-based data with macroeconomic and aggregate measures of per-capita incomes, rates of economic growth and the institutional quality of countries whose territorial waters either witnessed these piracy incidents or were in closest proximity.

In the end, we come away with three important empirical findings. First, economic factors do indeed play an important role in the sustenance of modern maritime piracy:

[18]Gathmann and Hillmann (2009) study the decline of another form of ancient piracy. They argue that the decline of British privateering in the eighteenth century was based on the expansion of overseas trade and the ensuing decline in the profitability of commerce raiding.

higher per-capita incomes dampen both the physical violence and material damage of attacks. For example, higher par-capita incomes and rates of employment are associated with fewer successful attacks that culminated with vessel seizures and ransom demands, while they are related more frequently with cases in which the crews go unharmed. Second, we detect that political institutions and legal enforcement are also important, although not as much nor consistently as economic factors. In particular, we find that incidents that occur in the territorial waters of countries with more effective polities and authoritarian governments tend to involve fewer cases in which pirates launch successful raids, rob the crew or the ship of their cash, or seize the vessel. And conversely, such polities and governments are associated with more incidents in which the crews escape safely.

Above all, however, we document significant learning-by-doing and skill accumulation among the pirates that have helped modern piracy evolve into a more potent threat. A history of successful piracy attacks locally improves the odds of success in piracy, making it more likely that pirates target larger vessels in closer proximity to land. To a weaker extent, it even influences the extent to which pirates are able to inflict violence on the crew and seize the ship. Moreover, these learning-by-doing effects are robust to the inclusion of a host of other controls, location, region and year fixed effects as well as some proxies for capital use, such as vessels, equipment and spare parts stolen in previous raids, and labor input, given by the number of pirates involved in attacks.

There are not many papers in the economics literature that focus on maritime piracy, and empirical work on the topic is scant. But existing studies typically show that institutions and state capacity matter, although there is some debate on whether those determinants exert a non-monotonic influence. According to Piazza (2008), for instance,

state failure is more conducive to piracy than higher state capacity. But there are also those, such as Menkhaus (2004), who instead argue that the economic and geographic infrastructure that weak states can sustain — but failed states cannot — complement acts of piracy. Hastings (2009) reconciles these findings by differentiating acts of maritime piracy by the sophistication level required for different kinds of booty: Pirates from failed states commit more time-intensive crimes, such as kidnapping for ransom, because of a lack of legal enforcement and markets in which economically valuable booty can be liquidated. In contrast, pirates who hail from weak states tend to target goods, cargo and vessels that can be seized and sold in markets that are sufficiently deep, liquid and anonymous.[19]

Regarding the role of economic factors in the reemergence of piracy, there is much media coverage but not enough quantitative empirical analyses. Nonetheless, a consensus seems to have converged on the hypothesis that adverse economic conditions help to sustain 21st-century piracy.[20] Any such claims that the economic conditions matter for modern-day piracy are, at least implicitly, based on the political economy literature on production and extralegal appropriation. The hypothesis that extralegal appropriation and violent conflict over the ownership of resources should be modeled as an alternative to economic production was originally articulated by Haavelmo (1954) and further developed by follow-up papers such as Hirshleifer (1991), Grossman (1994), Grossman and Kim (1995), Grossman and Iyigun (1995, 1997), Skaperdas (1992, 2005), Bates et al.

[19] Two other papers by Leeson (2007) and Ambrus and Chaney (2010) focus on ancient maritime piracy. Leeson's main emphasis is on the informal social and institutional arrangements pirates of the yore mustered in order to operate with some degree of organization and efficiency. Ambrus and Chaney explore the extent to which dynamic bargaining principles applied in Spanish dealings with Barbary Corsairs' ransom demands between the sixteenth and eighteenth centuries.

[20] "Modern High Seas Piracy" by Countrman and McDaniels Law Offices (2000, 2005), at http://www.cargolaw.com/presentations_pirates.html#Introduction.

(2002), and Hafer (2006). Accordingly, the opportunity cost of modern maritime piracy involves legal and gainful labor employment. On that basis, poor economic opportunities are the prime driver of modern-day piracy, especially as they pertain to the incidents off the eastern coasts of Africa. As our empirical findings indicate, there is some consistent evidence that the level of per-capita incomes and employment are inversely related to the success of piracy attacks and they have explanatory power in the motives for seeking economically-valuable booty.

Beyond that, however, our results have special pertinence, because modern-era piracy is a capital- and skill-intensive endeavour that is subject to potential refinements in technique, a learning curve and job-specific skills acquisition. As Hastings (2009) articulates, modern incidents of piracy require logistical planning and support not only on the *front end*, which defines the point up to the attack and the boarding of vessels, but also the *back end* too, which covers the period from the attack to culmination with a potential liquidation of the booty.

On the front end, skills and capital are required in order to identify, track and close in on targets. On the back end, infrastructure, networks and connections are needed to sell or repurpose the ships and their cargo. Or, in the case of hostages, to set up 'accommodations' during the often lengthy and risky phase of ransom negotiations,[21] our findings show that modern-era piracy has evolved over time on the basis of accumulated piracy experience locally to yield not only higher success rates, but also more economically-valuable booty and higher risk to the crew. In fact, we find that the

[21]Some pirate outfits are organized enough that they have military command-and-control structures and the pirates wear uniforms. Attacks have been recorded as much as 450 km. from the coastlines, made possible in part by the pirates use of mother and satellite ships as well as GPS trackers. There are also cases in which the pirates are known to have inserted moles on board targeted vessels. For more details, see Hastings (2009).

learning-by-doing effects in modern maritime piracy are important enough to, at least partially, offset the dampening role of better economic and political conditions.

There is a sizeable literature on the role of learning-by-doing on worker and firm productivity, industrial organization as well as economic growth. Arrow (1962), Lucas (1988), Stokey (1988), Parente (1994), Jovanovic and Nyarko (1996), Iyigun (2006) and Iyigun and Owen (2006) are among those who hypothesize that on-the-job learning and knowledge spillovers are important for endogenous economic growth. More recently, Thompson has taken some empirical exception to the productivity impact of worker learning and experience. Spence (1981), Cabral and Riordan (1994), and Benkard (2004) show the influence of learning by doing on industrial organization by illustrating how firm experience can lead to increases in industry concentration through the emergence of a low-cost dominant firm. There is also a strand which documents the existence of relationship-specific learning. For instance, Kellogg (2009) argues that relation-specificity matters by identifying that the joint productivity of an oil production company and its drilling contractor is enhanced significantly as they accumulate experience working together.

3.2 The Empirical Analysis

3.2.1 Data and Descriptive Statistics

We created our dataset using several specific underlying sources of information. For the full description of each piracy incident between 1998 and 2007, we relied on the annual reports by the International Maritime Bureau (*IMB*) and the annual and monthly reports of the International Maritime Organization (*IMO*). For each attempted incident of piracy and robbery against a seafaring vessel, these publications provided us data on the exact time of the incident (year, month, day and hour); its location by territorial

waters (whether or not the attack was attempted in international waters); the identity of the ship including its flag of registry; its gross registered tonnage ($TONNAGE$); the type of violence perpetrated against the crew (ranging from no harm done to deaths); the types of goods stolen or appropriated; and the number of pirates involved.

Based on the location of the attack, we then augmented the above data with country-specific economic and political measures. Data such as real GDP per capita and its growth rate are cited from the *Penn World Tables*, Mark 6.3. Annual data on unemployment rates are obtained from the *World Databank*. The data on political and institutional measures primarily come from two different sources: *Freedom House* world political and civil freedom measures, and the *Polity IV* project, "Political Regime Characteristics and Transitions." The Freedom House data provide us three measures of political rights and freedoms.[22] Polity IV, on the other hand, supplies the institutionalized democracy score, institutionalized autocracy score and the modified polity score.[23]

Our data on maritime trade per capita are from the *Shipping Statistics Yearbooks* by the Institute of Shipping and Logistics of Bremen (*ISL*). They are based on the loading and unloading cargo traffic volume by selected ports divided by the total population in

[22]Political rights are measured on a one-to-seven scale, with one representing the highest degree of freedom and seven the lowest.

[23]The institutionalized democracy score is conceived as three essential, interdependent elements: The first one is the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders. The second element is the existence of institutionalized constraints on the exercise of power by the executive. The third component then is the guarantee of civil liberties to all citizens in their daily lives and in acts of political participation.

The operational indicators of democracy and autocracy are derived from the competitiveness of political participation, the openness and competitiveness of executive recruitment, and constraints on the chief executive. All of these indices are based on an additive eleven-point scale (0-10). The Polity score is computed by subtracting the institutionalized autocracy score from the institutionalized democracy score; the resulting unified polity scale ranges from -10 (strongly autocratic) to +10 (strongly democratic).

the region. There are five geographic regions covered: Asia, Africa, America, Europe and Oceania. We calculate the cargo traffic volume within each region based only on selected ports, although that data represents 71 percent of the actual world seaborne trade over the ten years for which we have data.

The summary and descriptive statistics of our key variables are listed in the Table 3.1 a. As shown, close to 75 percent of all attacks succeeded over the ten years in our sample. And close to 85 percent of all incidents occurred in or off the coasts of Asia and Africa, while the rest took place in or off the coasts of the Americas, Oceania, and Europe. Contrary to widespread public perception, only 20 percent of attacks in our dataset occurred in Africa, whereas close to 65 percent of them took place somewhere in Asia. These incidents occurred in the ports or waters of countries with real per capita incomes of roughly $7,600 based on 2005 constant U.S. dollars, although there is a very high variance in the per-capita income levels of countries associated with piracy attacks. The frequency of incidents over time is slightly backloaded although spread fairly evenly, with the average incident occurring between the fifth and sixth years in our decade-long sample (i.e., between 2002 and 2003). Examining the correlation matrix shown in the bottom panel, we see that the probability of a successful attack, $SUCCESS$, is higher in Africa than in Asia; that it is harder to successfully attack larger ships, $TONNAGE$; that the success rate of attacks declines slightly with increases in per-capita income, $GDPCAP$; and that cumulative histories of successful piracy raids locally and regionally, $CUMSUCCESS$ and $CUMSUCCESS\_REGION$ respectively, are slightly positively related to the likelihood of successful future attacks.

Considering the top panel of Table 3.1 b, we see that attacks mostly occurred at

harbors when the vessels were anchored or in a country's own territorial waters.[24] For every one hundred incidents recorded in our dataset, there were close to two crew deaths, $DEATH$; three in which the pirates sought ransom, $RANSOM$; and five cases where the vessels were captured in their entirety, $VESSEL$. As shown in the bottom panel, all outcomes are more likely in open and international waters, although the probability of a successful attack is correlated negatively with $WATER$. Incidents where vessels were stolen or the crew were killed are more likely in areas with higher per-capita incomes, but those in which cash robberies, hostage taking or ransom seeking occurred are less likely in higher-income areas. The cumulative number of successful piracy attacks at location i up to and including time $t-1$, $CUMSUCCESS$, is highly negatively correlated with whether piracy attacks occurred in international waters. A longer and successful local history of piracy attacks also correlates positively, although weakly, with ship seizures and negatively with crew deaths and ransom seeking. The correlation of the regional histories of piracy success, $CUMSUCCESS\_REGION$, is positive with almost all other variables except the crew deaths. And, not surprisingly, $CUMSUCCESS$ and $CUMSUCCESS\_REGION$ are very highly and positively correlated.

[24]Our variable $WATER$ attains three values: one, if the attack occurred when the vessel was docked or anchored in an harbor; two, if it took place in the territorial waters of a given country; and three, in international waters. Thus, it increases with distance to the shores and state authorities.

Table 3.1 a: Descriptive Statistics and the Correlation Matrix

1998 – 2007		
$n = 3362$	*Mean*	*St. Dev.*
$SUCCESS$	.744	.436
$AFRICA$	.204	.403
$ASIA$	.645	.479
$YEAR$	5.44	2.62
$TONNAGE$	16.8	21.6
$GDPCAP$	7595	39803
$POLITY$	4.26	4.35
$MTRADECAP$	1.15	1.12
$CUMSUCCESS$	122	170
CUM_REGION	591	475

	SCS	AFR	$ASIA$	$YEAR$	$TONN$	$GDPC$	POL	$MTPC$	$CSCS$
$SUCCESS$	1	...	...	...	...	...	...	...	...
$AFRICA$	.023	1	...	...	...	...	...	...	...
$ASIA$	$-.005$	$-.681$	1	...	...	...	...	...	...
$YEAR$	$-.021$	.113	$-.106$	1	...	...	...	...	...
$TONN$	$-.127$	$-.072$	.083	$-.002$	1	...	...	...	...
$GDPCAP$	$-.062$	$-.072$	.068	$-.040$	$-.023$	1	...	...	...
$POLITY$	.069	$-.343$	.195	.024	.057	$-.113$	1	...	...
$MTPC$	.030	$-.339$	.028	.079	$-.017$	.013	.155	1	...
$CUMSCS$	.073	$-.256$	.418	.314	.137	$-.053$	.345	.053	1
CUM_REG	.015	$-.344$	.596	.634	.047	.009	.157	.059	.588

Table 3.1 b: Descriptive Statistics and the Correlation Matrix

1998 – 2007		
$n = 3362$	*Mean*	*St. Dev.*
$SUCCESS$	.744	.436
$WATER$	1.80	.780
$GDPCAP$	7595	39804
$POLITY$	4.26	4.35
$CREWHARM$	.528	.499
$DEATH$	.019	.135
$RANSOM$	.028	.165
$VESSEL$	.045	.208
$CUMSUCCESS$	122	170
CUM_REGION	591	475

$n = 3362$	SCS	WTR	$GDPC$	POL	$HARM$	DTH	$RNSM$	$VESL$	$CSCS$
$SUCCESS$	1	...	...	...	...	...	...	...	...
$WATER$	−.358	1	...	...	...	...	...	...	...
$GDPCAP$	−.062	.116	1	...	...	...	...	...	...
$POLITY$	.069	−.128	−.113	1	...	...	...	...	...
$CREWHARM$	.399	−.051	.038	−.016	1	...	...	...	...
$DEATH$	.051	.061	.030	.013	.130	1	...	...	...
$RANSOM$	.100	.148	−.012	−.062	.160	.003	1	...	...
$VESSEL$	.127	.088	.018	.002	.202	.128	−.036	1	...
$CUMSUCC$	.073	−.190	−.053	.345	.071	−.050	−.054	.053	1
CUM_REG	.015	.029	.009	.157	.052	−.001	.003	.079	.588

3.2.2 Main Results

3.2.2.1 Reduced-Form Estimates

We derive our baseline empirical results by estimating the following reduced-form equation:

$$\begin{aligned} OUTCOME_{it} &= \alpha_1 \times SUCCESS_{it} + \alpha_2 \times CUMSUCCESS_{it-1} \\ &+ \Gamma_{it}\boldsymbol{\beta} + \Omega_{it}\boldsymbol{\gamma} + \sum_{j=1998}^{2007} \psi_j \times I_j + \sum_{k=1}^{29} \lambda_k \times I_k + \varepsilon_{it} \ , \end{aligned} \tag{25}$$

where $OUTCOME_{it}$ is an outcome of the piracy act that took place in location i at time t; it is based on the type of violence or the nature of the appropriation involved, which we shall explain further below.

$SUCCESS_{it}$ is a dummy variable that takes on the value of one if pirates succeeded in boarding the vessel; $CUMSUCCESS_{it-1}$ is the cumulative count of successful attacks that occurred at location i up to and including year $t-1$; Γ_{it} represents incident-specific explanatory variables related to the vessel or geographic location where the incident occurred; Ω_{it} represents economic or political variables associated location i at time t; I_j and I_k represent controls for time fixed effects and location fixed effects, with the latter being based on the 29 locations in our database where piracy incidents were reported.[25]

[25]On this basis, we end up with ten year fixed effects for 1998 through 2007; five regional fixed effects for Asia, Africa, Oceania, Europe, and the Americas; and 29 location fixed effects that cover Bangladesh, Brazil, Cameroon, Colombia, Dominican Republic, Ecuador, Ghana, Guinea, Guyana, India, Indonesia, Ivory Coast, Jamaica, Kenya, Malaysia, Nigeria, Peru, Philippines, Somalia, Sri Lanka, Tanzania, Thailand, Venezuela, Vietnam, the Malacca Strait, the South China Sea, the Gulf of Aden, the Singapore Strait and the Red Sea.

The 29 locations covered in our dataset account for 3,039 observations out of the total of 3,362, corresponding roughly to 90 percent of our data points. Since a key variable in our analyses is the cumulative local histories of successful piracy raids, in all of the empirical work below, we are constrained by these 3,039 observations for which we were able to identify the location of attack.

In alternative specifications, our dependent variable $OUTCOME_{it}$ is either one of three main outcomes: whether the crew were subject to some physical harm, denoted as $CREWHARM_{it}$; the crew were used for ransom demands, $RANSOM_{it}$; or the attack culminated with the pirates' seizure of the vessel, $VESSEL_{it}$.[26] All of these dependent variables are binary indicator variables, which is why our baseline empirical specifications involve Probit estimates.

In terms of the incident-specific economic or political explanatory variables in the matrix Ω_{it}, we have per-capita GDP, its growth rate between 1998 and 2007, and the unemployment rate at time t in location i, $GDPCAP_{it}$, $GROWTH_{it}$, and $UNEMP_{it}$, respectively. This matrix also includes measures of polity quality, $POLITY_{it}$, and autocracy, $AUTOCRACY_{it}$, respectively.[27] The matrix of vessel-specific and geographic explanatory variables, Γ_{it}, includes the month, year and time of day (am or pm) of the incident, its geographic location, as well as the gross tonnage, flag and the type of vessel.[28]

[26] Although we chose to focus on three specific outcomes of piracy in particular, we were able to explore other outcomes too. These include, but are not confined to, whether the attack culminated with some or all crew members being taken hostage; the attack involved at least one crew member being killed; whether or not the pirates stole cash from the crew or the vessel; and a more general measure of economic damage.

[27] Other variables we experimented with but chose not to include in the baseline specifications discussed below include measures of political rights, civil liberties, democracy and political freedoms.

[28] We have dummies for the flags of 20 countries under which the targeted vessels sailed. The incidents involving ships under these country flags account for more than 75 percent of our data. The countries for which we have flag dummies include: Antigua, Bahamas, Cyprus, Denmark, Greece, Hong Kong,

In Tables 3.2, 3.3 and 3.4, we report our baseline, reduced-form Probit estimates. All regressions in these tables include economic as well as political and institutional measures, in addition to a variety of basic vessel characteristics and geographic variables. There are no fixed effects in the specifications reported in column (1) regressions, but the subsequent three regressions in all three tables respectively add attack location, year and regional fixed effects.

As for vessel characteristics and geographic variables that are controlled for in Tables 3.2 through 3.4, we include $SUCCESS$ because the extent to which pirates can inflict physical or material harm ought to be highly conditional on pirates successfully boarding the vessel. We include the $TONNAGE$ of the vessels because the damage pirates can inflict could be systematically different for larger vessels due to size-related characteristics that make larger ships more or less vulnerable to piracy acts. Whether or not the incident took place when the ship was anchored at port, or cruising in the open territorial or international seas could also have made it logistically easier or more difficult for pirates to exact some cost. Hence, we have the inclusion of $WATER$ as a basic right-hand side control. We also include a measure of the volume of maritime trade per capita of the region where the attack occurred, $MTRADECAP$, based on the idea that maritime trade volumes could, independently, affect the kinds of damage the pirates inflicted.

The set of our basic economic variables as well as those for political stability and institutional controls are self-explanatory. In any case, the main economic variables are income per capita, $GDPCAP$, economic growth, $GROWTH$, and the unemployment

Indonesia, India, Liberia, Malaysia, Malta, the Marshall Islands, the Netherlands, Norway, Panama, Saint Vincent, Singapore, Thailand, United Kingdom, and the United States. We also have six carrier-type dummies: liquid containers, tankers, bulk carriers, general cargo ships, fishing boats and chemical tankers.

rate, $UNEMP$. And our main controls for political stability and institutional quality are the polity score, $POLITY$, and an index of whether or not the government in power is authoritarian, $AUTOCRACY$.

In Table 3.2, our dependent variable is whether or not the crew was physically harmed, $CREWHARM$.[29] As shown, the likelihood of the crew being harmed during a piracy incident depends strongly on whether or not the pirates successfully got on board. But controlling for that, the crew can still escape unharmed when larger vessels are involved or the attacks occur closer to shores and harbors. Economic factors do come in with the predicted signs — with GDP per capita and economic growth reducing the likelihood of crew harm and unemployment raising it. Adding fixed effects for the location of attacks, their year and geographic region, respectively in columns (2), (3) and (4), does reveal that GDP per capita is a strongly negative and statistically significant determinant of the extent to which the crew was harmed during a pirate raid. The impact of income on the incidence of piracy attacks that culminate with some physical harm to the crew is quantitatively meaningful. Taking the average of the coefficients on $GDPCAP$ in columns (2) through (4), we get a roughly one percent decline in attacks with crew harm for every \$10,000 increase in per-capita income. It is worthwhile to point out, however, that this impact is not that of incomes on acts of piracy but, rather, that of incomes on undertaking piracy which inflict harm on the crew, conditional on the success of the act.

In our column (2) specification, we see that the volume of maritime trade per capita in the region of the attack negatively and significantly influences the chances of the crew being harmed. But when all fixed effects are controlled for, as we do in columns

[29]This is an indicator variable that attains the value of one if the pirates either threatened, physically assaulted, kidnapped or killed someone on the crew, and is zero otherwise.

(3) and (4), this effect switches sign and turns insignificant. As for the impact of state authority on the impact of piracy incidents that are harmful to the crew, we get somewhat mixed results. On the one hand, polity scores come in with positive signs in three regressions although they are never significant. On the other hand, more authoritarian regimes produce fewer piracy incidents as implied by $AUTOCRACY$ yielding negative and significant effects in the first three columns. Once location fixed effects are introduced, as we do in column (4), this latter effect disappears which is indicative of the fact that authoritarian regimes had staying power (at least over the period between 1998 and 2007), thereby the role of $AUTOCRACY$ being absorbed by our location fixed effects.

Most importantly, the cumulative number of successful piracy attacks, denoted as $CUMSUCCESS$, comes in with positive and statistically significant effects in three of the four specifications. In essence, we find here that a history of successful piracy attacks at a given location significantly improves the odds of a future attack in which the crew is physically harmed. This effect, too, is independent of any impact local piracy experience has on how successful pirates are in successfully boarding vessels. Thus, an interesting question is the extent to which the local piracy experience has an indirect impact on crew safety via pirate attacks that become more *successful* over time due to experience. We shall address this issue further below.

Table 3.2: Probit Estimates with Location-Specific LBD & Crew Assaults Outcomes

VARIABLES	(1)	(2)	(3)	(4)
CUMSUCCESS	0.000827***	0.000397	0.000647*	0.000945*
	(0.000182)	(0.000243)	(0.000338)	(0.000523)
GDPCAP	-7.15e-07*	-4.10e-07	-8.31e-07***	-1.60e-06***
	(3.89e-07)	(4.10e-07)	(2.98e-07)	(3.06e-07)
GROWTH	0.000357	-0.00190	0.000845	0.000973
	(0.00395)	(0.00293)	(0.00291)	(0.00285)
UNEMP	0.0410**	0.0321**	0.0337**	0.0132
	(0.0167)	(0.0164)	(0.0158)	(0.0279)
AUTOCRACY	-0.0115***	-0.00804*	-0.00886**	0.00447
	(0.00388)	(0.00422)	(0.00404)	(0.00288)
POLITY	-0.00184	0.00871	0.000965	0.00699
	(0.0157)	(0.0170)	(0.0159)	(0.0158)
SUCCESS	1.510***	1.558***	1.489***	1.597***
	(0.105)	(0.112)	(0.122)	(0.110)
WATER	0.173***	0.208***	0.270***	0.180***
	(0.0648)	(0.0617)	(0.0538)	(0.0581)
TONNAGE	-1.14e-05***	-1.06e-05***	-1.06e-05***	-1.06e-05***
	(1.71e-06)	(1.67e-06)	(1.69e-06)	(1.78e-06)
MTRADECAP	-0.198	-0.378*	0.408	0.267
	(0.181)	(0.197)	(0.511)	(0.562)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	3039	3039	3039	3039

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Table 3.3, we present the impact of our explanatory variables on the extent to which pirates successfully sought ransom. As seen, most of the effects we already unearthed in Table 3.2 remain in play here, although, most conspicuously, local piracy experience seems to have lead to a shift away from piracy incidents involving ransom demands, with only the final specification yielding statistically significant negative influence.

In Table 3.4, we explore the determinants of ship seizures by pirates. Our results with vessel capture are mostly in line with those in Table 3.2, with favorable economic factors being consistently associated with fewer attacks, which culminated in the vessel being turned over to the pirates. One exception here appears to be the positive — and, in the first two regressions, significant — role of economic growth in leading to more incidents that culminated with vessel seizures. *AUTOCRACY* still suppresses acts that culminated in vessel seizures. Most importantly, local piracy experience exerts a positive and statistically significant impact on ship seizures in three of our four regressions. All in all, these findings suggest that pirates were becoming more successful in capturing vessels in their entirety as they accumulated more local experience in launching successful pirate attacks.

Table 3.3: Probit Estimates with Location-Specific LBD & Ransom Demands

VARIABLES	(1)	(2)	(3)	(4)
CUMSUCCESS	-1.81e-05	-0.000859	-0.000792	-0.00380**
	(0.000827)	(0.000945)	(0.00111)	(0.00188)
GDPCAP	-2.18e-06**	-9.02e-07	-1.36e-06	0.000125**
	(9.48e-07)	(1.02e-06)	(9.21e-07)	(5.48e-05)
GROWTH	0.00443*	0.00174	0.00403	-0.00531
	(0.00246)	(0.00553)	(0.00608)	(0.00944)
UNEMP	-0.000402	-0.00675	0.00108	0.304*
	(0.0376)	(0.0410)	(0.0463)	(0.157)
AUTOCRACY	-0.0189***	-0.0156***	-0.0166***	-0.0147
	(0.00368)	(0.00518)	(0.00455)	(0.0108)
POLITY	0.0128	0.00885	-0.00656	-0.0626
	(0.0293)	(0.0312)	(0.0313)	(0.0457)
WATER	0.664***	0.678***	0.728***	0.763***
	(0.117)	(0.119)	(0.101)	(0.147)
TONNAGE	-9.62e-05***	-0.000102***	-0.000104***	-0.000106***
	(2.63e-05)	(2.71e-05)	(2.79e-05)	(3.54e-05)
MTRADECAP	-0.458	-0.688**	0.0681	-0.267
	(0.397)	(0.309)	(1.191)	(1.732)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	2270	2270	2270	1608

Standard errors clustered by location in parentheses;
SUCCESS dropped; predicts outcomes perfectly.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Probit Estimates with Location-Specific LBD & Ship Seizures

VARIABLES	(1)	(2)	(3)	(4)
CUMSUCCESS	0.00178***	0.00183***	0.000411	0.00162**
	(0.000399)	(0.000445)	(0.000507)	(0.000792)
GDPCAP	-2.19e-06*	-2.29e-06**	-2.74e-06**	-8.54e-06
	(1.24e-06)	(1.07e-06)	(1.17e-06)	(4.15e-05)
GROWTH	0.00537**	0.00780**	0.00895	0.00904
	(0.00267)	(0.00394)	(0.00568)	(0.00890)
UNEMP	0.00306	-0.0107	0.0700*	0.0443
	(0.0288)	(0.0303)	(0.0425)	(0.0863)
AUTOCRACY	-0.00519*	-0.00739**	-0.0130**	0.274
	(0.00299)	(0.00364)	(0.00569)	(0.419)
POLITY	-0.00568	0.00292	0.00306	0.0596
	(0.0174)	(0.0174)	(0.0163)	(0.193)
WATER	0.396***	0.458***	0.333***	0.291***
	(0.0922)	(0.0914)	(0.0823)	(0.0716)
TONNAGE	-5.26e-05	-4.92e-05	-4.85e-05	-4.81e-05
	(3.34e-05)	(3.15e-05)	(3.17e-05)	(3.22e-05)
MTRADECAP	-0.0974	-0.0839	-0.399	-0.483
	(0.202)	(0.190)	(0.775)	(1.118)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	2270	2270	1974	1820

Standard errors clustered by location in parentheses;
SUCCESS dropped; predicts outcomes perfectly.
*** p<0.01, ** p<0.05, * p<0.1

3.2.2.2 IV Estimates

One problem with the reduced-form estimates we discussed above stems from the fact that three of our explanatory variables are endogenous and outcomes of the piracy acts themselves. In particular, the variables $TONNAGE$ and $WATER$ are choices that the pirates have full control over because they can — and do — decide on which ships to attack and where. $SUCCESS$ is not fully in control of the pirates, because whether the latter can be successful in boarding a ship depends on many factors. But, by deciding on the timing and logistics of and the resources devoted to each attack, the pirates do have some influence over this outcome too. This is why we now turn to two-stage least squares estimates (*2SLS*) in which we shall instrument for these endogenous variables.

Our instrument choice is a set of (twelve) dummies for the month of attack. The idea is that weather conditions not only are highly seasonal, but also significantly influence whether or not attacks in the open seas or harbors succeed. The success of piracy attacks plausibly do depend on weather conditions. This in turn might not only shift the location of attacks closer to the shores and away from the open seas, but also make it more or less easy to defend ships based on their size. On this basis, we shall instrument for $SUCCESS$, $WATER$ and $TONNAGE$. The working assumption required here is that the incidence of pirate attacks by month is not only orthogonal to the kinds of damage pirates inflict conditional on the success rate of attacks, but also orthogonal still to any omitted variables we might have in predicting the types of damage inflicted due to piracy.

We derive our baseline *2SLS* results by estimating the following first-stage regressions:

$$\left.\begin{array}{c} SUCCESS_{it} \\ WATER_{it} \\ TONNAGE_{it} \end{array}\right\} = \sum_{m=1}^{12} \gamma_m \times I_m + \Gamma_{it}\boldsymbol{\beta} + \Omega_{it}\boldsymbol{\gamma} + \sum_{j=1998}^{2007} \psi_j \times I_j + \sum_{k=1}^{29} \lambda_k \times I_k + \upsilon_{it} \ , \quad (26)$$

We then run this second-stage equation:

$$OUTCOME_{it} = \alpha_1 \times \widehat{SUCCESS}_{it} + \alpha_2 \times \widehat{WATER}_{it} + \alpha_3 \times \widehat{TONNAGE}_{it} + \Gamma_{it}\boldsymbol{\beta} + \Omega_{it}\boldsymbol{\gamma} + \sum_{j=1998}^{2007} \psi_j \times I_j + \sum_{k=1}^{29} \lambda_k \times I_k + \varepsilon_{it} \ , \quad (27)$$

where $\widehat{SUCCESS}$, $\widehat{WATER}$ and $\widehat{TONNAGE}$ are the predicted values of $SUCCESS$, $WATER$ and $TONNAGE$ but all other variables are identical to the ones in the reduced-form specifications we presented above.

Tables 3.5.a, 3.5.b and 3.5.c present our first-stage estimates for $SUCCESS$, $WATER$ and $TONNAGE$ respectively. As reported by the F-statistics, our instruments are very strong for $WATER$ and, for the most part, acceptable for $SUCCESS$ with two specifications involving $SUCCESS$ producing F-statistics above the threshold of 10. With $TONNAGE$ our instruments are clearly weaker with none of our F-statistics registering above five.

In any event, what these first-stage results indicate is that, as the pirates gained experience in launching successful attacks, their success rates rose significantly and they launched fewer attacks in the open seas, targeting larger vessels. All of these effects are

statistically significant in ten of the twelve regressions for $SUCCESS$, $WATER$ and $TONNAGE$.

Table 3.5.a: 2SLS IV Estimates — First Stage Results with *SUCCESS*

VARIABLES	(1)	(2)	(3)	(4)
CUMSUCCESS	0.000171***	0.000197***	0.000513***	0.000132
	(0.00005)	(0.000053)	(0.000066)	(0.000122)
GDPCAP	-8.01e-07***	-7.99e-07***	-9.08e-07***	-5.45e-07***
	(2.17e-07)	(2.18e-07)	(2.11e-07)	(2.29e-07)
GROWTH	0.000254	0.000563	0.00197***	0.00124
	(0.00047)	(0.00052)	(0.00055)	(0.00085)
UNEMP	-0.0123***	-0.0130***	-0.0184***	-0.00548
	(0.0023)	(0.0023)	(0.0028)	(0.0050)
AUTOCRACY	0.00343***	0.00318**	0.00300***	-0.000140
	(0.0005)	(0.00059)	(0.00059)	(0.0012)
POLITY	0.00272	0.00427*	-0.00279	0.000669
	(0.0024)	(0.00025)	(0.00252)	(0.00465)
MTRADECAP	0.0324	0.0364	0.217**	0.229*
	(0.022)	(0.0239)	(0.103)	(0.121)
JANUARY	0.0349	0.0362	0.0393	0.0520
	(0.0382)	(0.0381)	(0.0367)	(0.0362)
MAY	-0.0599*	-0.0597*	-0.0360	-0.0374
	(0.0374)	(0.0374)	(0.0361)	(0.0354)
AUGUST	-0.0628**	-0.0576	-0.0549	-0.0389
	(0.0384)	(0.0383)	(0.0370)	(0.0363)
DECEMBER	-0.0527	-0.0593*	-0.0517*	-0.0413
	(0.0386)	(0.0384)	(0.0371)	(0.0365)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	3039	3039	3039	3039
R-squared	0.053	0.065	0.130	0.179
F-statistics	9.31	7.70	14.95	11.40

Standard errors clustered by location in parentheses;
FEBRUARY, *MARCH*, *APRIL*, *JUNE*, *JULY*, *SEPTEMBER*, *OCTOBER*, *NOVEMBER* included but not shown.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5.b: 2SLS IV Estimates — First Stage Results with $WATER$

VARIABLES	(1)	(2)	(3)	(4)
$CUMSUCCESS$	-0.0008***	-0.0008***	-0.0020***	-0.00016
	(0.000085)	(0.00009)	(0.00011)	(0.00016)
$GDPCAP$	1.9e-06***	2.0e-06***	2.11e-06***	-3.22e-08
	(3.75e-07)	(3.7e-07)	(3.41e-07)	(3.0e-07)
$GROWTH$	0.0048***	0.0026***	-0.000159	-0.00107
	(0.00081)	(0.0009)	(0.0009)	(0.0011)
$UNEMP$	0.0175***	0.0203	0.0541***	0.00887
	(0.004)	(0.004)	(0.0046)	(0.00657)
$AUTOCRACY$	-0.0109***	-0.0089***	-0.010***	-0.000653
	(0.0009)	(0.001)	(0.001)	(0.00156)
$POLITY$	-0.0108***	-0.013***	0.00291	-0.00414
	(0.0042)	(0.004)	(0.0041)	(0.0061)
$MTRADECAP$	0.0552	0.0106	0.202	-0.411***
	(0.0380)	(0.041)	(0.166)	(0.159)
$APRIL$	0.197***	0.191***	0.149***	0.0637
	(0.064)	(0.062)	(0.057)	(0.046)
MAY	0.0953*	0.0838	0.0257	0.0141
	(0.0650)	(0.063)	(0.0582)	(0.0463)
$AUGUST$	0.178***	0.158**	0.156***	0.0860**
	(0.0662)	(0.065)	(0.060)	(0.0475)
$NOVEMBER$	0.150**	0.139**	0.148**	0.0585
	(0.066)	(0.065)	(0.059)	(0.0473)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	3039	3039	3039	3039
R-squared	0.119	0.162	0.292	0.559
F-statistics	22.71	21.63	41.30	66.37

Standard errors clustered by location in parentheses;
$FEBRUARY$, $MARCH$, $APRIL$, $JUNE$, $JULY$, $SEPTEMBER$, $OCTOBER$, $NOVEMBER$ included but not shown.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5.c: 2SLS IV Estimates — First Stage Results with $TONNAGE$

VARIABLES	(1)	(2)	(3)	(4)
$CUMSUCCESS$	14.43***	17.90***	20.10***	18.70***
	(2.464)	(2.65)	(3.43)	(6.43)
$GDPCAP$	-0.00913**	-0.0112	-0.00902	-0.0103*
	(0.0109)	(0.011)	(0.011)	(0.0120)
$GROWTH$	64.49***	85.15***	65.84**	20.40
	(23.52)	(26.17)	(28.34)	(44.50)
$UNEMP$	340.1***	416.6***	259.2*	167.9
	(115.7)	(117.8)	(148.0)	(263.6)
$AUTOCRACY$	-17.59	-43.44	-24.20	-94.74
	(26.65)	(29.66)	(30.65)	(62.56)
$POLITY$	208.5*	162.6	205.1	-156.4
	(120.6)	(125.2)	(131.4)	(244.5)
$MTRADECAP$	-585.8	647.9	-8,613	-11,428*
	(1,099)	(1,200)	(5,349)	(6,374)
$JANUARY$	-2,902*	-2,439	-2,452	-3,694**
	(1,915)	(1,916)	(1,915)	(1,902)
$JUNE$	-4,179**	-3,578*	-3,534*	-2,911
	(1,941)	(1,944)	(1,942)	(1,922)
$OCTOBER$	-3,268**	-3,197*	-3,391*	-3,447*
	(1,864)	(1,866)	(1,865)	(1,848)
$NOVEMBER$	-2,378	-2,287	-2,279	-2,132
	(1,918)	(1,918)	(1,916)	(1,898)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	3039	3039	3039	3039
R-squared	0.028	0.034	0.037	0.074
F-statistics	4.77	3.98	3.89	4.16

Standard errors clustered by location in parentheses;
$FEBRUARY$, $MARCH$, $APRIL$, $JUNE$, $JULY$, $SEPTEMBER$, $OCTOBER$, $NOVEMBER$ included but not shown.
*** p<0.01, ** p<0.05, * p<0.1

Our second-stage results are shown in Tables 3.6 and 3.7, with harm to the crew and vessel capture as our dependent variables, respectively.[30] As shown in Table 3.6, the predicted success of attacks and whether or not they occur in the open seas have positive impact on harm to the crew in all four estimates, but none of the estimates enter significantly. The economic and politico-institutional measures enter these estimates in consistence with their roles in our reduced-form specifications, although they show statistical significance in only a few cases. The local histories of successful piracy incidents exert positive effects in all four estimates, and when no fixed effects are controlled for, they enter significantly as well. In Table 3.7, we see that the results are mostly in line with those in Table 3.6, although none of the explanatory variables have statistically significant impact on the extent to which piracy incidents culminated with ship seizures.

All in all, these results are indicative of the fact that piracy experience has altered the outcome of attacks mainly by raising the likelihood of pirates getting on board, successfully targeting larger vessels and launching attacks closer to land. Beyond that, however, it seems to not have impacted the extent to which attacks led to more physical harm to the crew or the vessels' seizure.

[30] We have chosen not to report the second-stage findings for $RANSOM$ here as they were very much line with those for $VESSEL$. Of course, all results discussed but not shown are available upon request.

Table 3.6: 2SLS IV Second-Stage Estimates with Crew Assaults as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)
$\widehat{SUCCESS}$	0.141	0.335	0.243	0.265
	(0.539)	(0.560)	(0.635)	(0.545)
$\widehat{WATER}$	0.0439	0.0861	0.0587	0.00968
	(0.204)	(0.212)	(0.198)	(0.242)
$\widehat{TONNAGE}$	-2.45e-05	-2.11e-05	-2.02e-05	-1.31e-05
	(1.61e-05)	(1.76e-05)	(1.80e-05)	(1.58e-05)
$CUMSUCCESS$	0.000618**	0.000499	0.000627	0.000529
	(0.000231)	(0.000326)	(0.000455)	(0.000403)
$GDPCAP$	-6.05e-07*	-4.39e-07	-5.13e-07	-6.12e-07
	(3.38e-07)	(4.10e-07)	(4.69e-07)	(4.88e-07)
$GROWTH$	0.00174	0.00114	0.00211	0.000895
	(0.00273)	(0.00267)	(0.00289)	(0.00134)
$UNEMP$	0.0169*	0.0156*	0.0127	0.00332
	(0.00916)	(0.00858)	(0.00990)	(0.00667)
$AUTOCRACY$	-0.00259	-0.00225	-0.00242*	0.000204
	(0.00153)	(0.00137)	(0.00138)	(0.00202)
$POLITY$	0.00506	0.00712	0.00344	0.00107
	(0.00847)	(0.00751)	(0.00628)	(0.00614)
$MTRADECAP$	-0.0664	-0.105	0.0856	0.0277
	(0.0681)	(0.0784)	(0.181)	(0.200)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	3039	3039	3039	3039
R-squared	0.056	0.061	0.065	0.084

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.7: 2SLS IV Second-Stage Estimates with Ship Seizures as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)
$\widehat{SUCCESS}$	0.219	0.227	0.229	0.150
	(0.159)	(0.170)	(0.190)	(0.190)
$\widehat{WATER}$	0.00920	0.00173	0.0127	0.00744
	(0.115)	(0.125)	(0.105)	(0.108)
$\widehat{TONNAGE}$	5.13e-06	5.78e-06	4.67e-06	1.33e-06
	(6.05e-06)	(7.33e-06)	(5.81e-06)	(8.73e-06)
$CUMSUCCESS$	-1.11e-05	-6.16e-05	-0.000207	5.19e-05
	(0.000165)	(0.000223)	(0.000318)	(0.000172)
$GDPCAP$	1.64e-07	2.15e-07	1.72e-07	-2.32e-07
	(3.38e-07)	(3.99e-07)	(3.56e-07)	(1.82e-07)
$GROWTH$	-0.000179	-0.000290	-0.000583	-0.000195
	(0.000511)	(0.000816)	(0.000820)	(0.000744)
$UNEMP$	-7.33e-05	-0.00119	0.00488	0.00115
	(0.00254)	(0.00253)	(0.00532)	(0.00248)
$AUTOCRACY$	-0.00110	-0.00106	-0.00126	0.000429
	(0.00144)	(0.00128)	(0.00123)	(0.000968)
$POLITY$	-0.00214	-0.00200	-0.000623	-0.00343
	(0.00333)	(0.00394)	(0.00274)	(0.00264)
$MTRADECAP$	0.000169	-0.0116	0.0103	-0.0377
	(0.0215)	(0.0280)	(0.0938)	(0.102)
YEAR FE	N	Y	Y	Y
REGION FE	N	N	Y	Y
LOCATION FE	N	N	N	Y
Observations	3039	3039	3039	3039
R-squared	0.002	0.003	0.003	0.009

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.2.2.3 Alternative Specifications & Robustness

While our results suggest that a history of successful piracy aided pirates in becoming more successful or, perhaps to some extent, altering their objectives too, they do not fully corroborate the idea that this history is a pure manifestation of learning by doing. The reason for this is that resources devoted to piracy might have evolved over time as well.

The descriptions of modern-era piracy leave little doubt that it is a labor- and capital-intensive activity. With our broad sample of 3,362 observations we do not have data to control for such inputs. But for roughly 70 percent of all incidents in our dataset, we have a record of the number of pirates involved in the attack. Hence, for a restricted subsample of our observations, we can control for piracy labor input. For the 2,300 observations for which we have data on the number of pirates, we see that each attack involved roughly six pirates, although with high variance. Most attacks took one audacious pirate, but close to ten percent of these attacks involved more than ten pirates, and 43 were reported to take more than twenty. We have five incidents in which there were more than 80 pirates involved with a maximum of 200 pirates in one case.

Controlling for changes in the pirates' physical capital stock is also a daunting challenge. Nevertheless, recall that our dataset includes information on the extent to which the piracy acts culminated with the appropriation of spare parts and equipment from the vessels or the latter's seizure. Thus, ignoring depreciation, one could take the cumulative sum of the incidents in which the pirates stole spare parts and equipment or seized ships at a given location up to the time of the incident as a crude proxy of the amount of physical capital available to the pirates.

This is exactly what we have done in producing the results we report in our

next table, where $PIRATES$ denotes the number of pirates involved in the attack and $KAPITAL$ represents our proxy for the physical capital pirates employed in carrying out their raids. As shown in Table 3.8, the number of pirates typically exerts a positive impact on the likelihood that the crew is harmed during the attack as well as the odds that the vessel is taken full control of by the pirates. However, in only one specification — that in column (2) where $CREWHARM$ is the dependent variable — does this effect enter statistically significantly. More interestingly, we see that, when we control for the labor and capital inputs, the local history of successful piracy acts once again starts to positively and significantly influence harm inflicted upon the crew. And although we have chosen not to report our first-stage estimates that correspond to the second-stage outcomes reported in Table 3.8, the history of the local piracy experience still mainly manifests itself through three channels: Even after one controls for the number of pirates and proxies for piracy physical capital, local piracy experience produces higher odds of attack success in general, and more success against larger vessels and in attacks closer to land. These results suggest to us that the impact of learning-by-doing on the part of the pirates is generally robust to the inclusion of controls for labor input and proxies for the stock of physical capital at the disposal of pirates.

Table 3.8: 2SLS IV Estimates with Number of Pirates & Proxies for Capital Stock

VARIABLES	(1) $CREWHARM$	(2) $CREWHARM$	(3) $VESSEL$	(4) $VESSEL$
$\widehat{SUCCESS}$	0.471	0.450	-0.00749	-0.0893
	(0.585)	(0.478)	(0.118)	(0.0884)
$\widehat{WATER}$	0.172	0.0175	-0.0874	-0.0687
	(0.175)	(0.180)	(0.0966)	(0.0809)
$\widehat{TONNAGE}$	-2.09e-05	-1.66e-05	-1.22e-06	-5.64e-06
	(1.37e-05)	(1.09e-05)	(4.76e-06)	(5.35e-06)
$CUMSUCCESS$	0.00132*	0.00152**	-0.000711	0.000561
	(0.000766)	(0.000570)	(0.000533)	(0.000460)
$PIRATES$	-6.28e-05	0.00346**	0.00317	0.00205
	(0.00242)	(0.00156)	(0.00258)	(0.00227)
$KAPITAL$	-0.00466	-0.00532**	0.00409	-0.00263
	(0.00426)	(0.00244)	(0.00243)	(0.00194)
$GDPCAP$	-5.64e-07	-6.96e-07**	4.76e-08	-2.35e-07**
	(3.50e-07)	(3.05e-07)	(1.85e-07)	(9.53e-08)
$GROWTH$	0.000642	0.00146	0.00125**	0.000113
	(0.00255)	(0.00148)	(0.000548)	(0.000522)
$UNEMP$	0.0154*	0.000297	-0.000761	0.000979
	(0.00860)	(0.00581)	(0.00300)	(0.00220)
$AUTOCRACY$	-0.00221	3.83e-05	-0.00146**	-0.000670
	(0.00142)	(0.00206)	(0.000688)	(0.000945)
$POLITY$	0.00542	8.28e-05	-0.000253	0.000776
	(0.00952)	(0.00628)	(0.00284)	(0.00173)
$MTRADECAP$	-0.0420	0.0699	0.0112	-0.0481
	(0.0751)	(0.200)	(0.0231)	(0.0882)
YEAR FE	Y	Y	Y	Y
REGION FE	N	Y	N	Y
LOCATION FE	N	Y	N	Y
Observations	2083	2083	2083	2083

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note that our dependent variables predominantly include binary outcomes data. As such, the distribution of these variables could lend themselves most appropriately to Probit or Poisson (negative binominal) estimation techniques. With this in mind we ran our baseline regressions with Probit regressions. In any event, we also ran the Probit specifications in Tables 3.2, 3.3 and 3.4 using linear probability models as well. We have elected not to report on those findings, but our qualitative results were very similar to — in fact, in many cases stronger than — those we show in Tables 3.2 through 3.4.

Next, we investigated the extent to which the cumulative history of piracy experience influenced future acts of piracy at a higher level of aggregation regionally. To this end, we used our alternative series of cumulative piracy experience that tracks the total number of successful piracy attacks at the regional level. This variable, denoted $CUMSUCCESS\_REGION_{i(I)t-1}$, is the sum of attacks (in which the perpetrators came onboard.) up to time $t-1$ in geographic region I (where i is located).[31] We replicated the regressions in the second and fourth columns of Tables 3.5, 3.6 and 3.7, this time also including $CUMSUCCESS\_REGION$ as an additional control. Our first-stage results with $SUCCESS$, $WATER$ and $TONNAGE$ are not shown. But they are similar to those we report in Tables 3.5.a through 3.5.c in that successful local piracy experience, $CUMSUCCESS$, helps to influence the odds of success, $SUCCESS$, and leads to more incidents closer to the shores, $WATER$, and aimed at larger vessels, $TONNAGE$, whereas experience at the regional level, $CUMSUCCESS\_REGION$, is not as important. Our second-stage regressions are listed on Table 3.9. As shown, the inclusion of regional piracy history does not alter our findings for ship seizures, with the main influence of piracy experience stemming from its first-stage role in $SUCCESS$, $WATER$

[31] Rceall that we have five regions in our sample: Asia, Africa, Oceania, Europe, and the Americas.

and $TONNAGE$. But, as columns (1) and (2) attest, the local piracy experience matters positively in the extent to which the crew is physically harmed whereas the regional experience does not, even after controlling for the first-stage roles of local and regional piracy experience.

Table 3.9: Estimates with Location- and Region-Specific LBD & Outcomes

VARIABLES	(1) $CREWHARM$	(2) $CREWHARM$	(3) $VESSEL$	(4) $VESSEL$
$\widehat{SUCCESS}$	0.405	0.527	0.0111	-0.0881
	(0.629)	(0.480)	(0.105)	(0.0883)
$\widehat{WATER}$	0.201	0.0738	-0.0743	-0.0692
	(0.195)	(0.188)	(0.0980)	(0.0860)
$\widehat{TONNAGE}$	-2.22e-05	-1.56e-05	-1.79e-06	-5.65e-06
	(1.37e-05)	(1.05e-05)	(4.79e-06)	(5.23e-06)
$CUMSUCCESS$	0.00187**	0.00168***	-0.000780	0.000521
	(0.000895)	(0.000554)	(0.000648)	(0.000521)
$CUMSCS\_REGION$	-0.000236*	-0.000115	0.000115	2.70e-05
	(0.000131)	(0.000197)	(8.79e-05)	(6.29e-05)
$PIRATES$	-0.000174	0.00310*	0.00268	0.00204
	(0.00226)	(0.00152)	(0.00246)	(0.00228)
$KAPITAL$	-0.00576	-0.00598**	0.00372	-0.00248
	(0.00412)	(0.00261)	(0.00244)	(0.00215)
$GDPCAP$	-6.22e-07	-6.86e-07**	1.63e-08	-2.31e-07**
	(3.71e-07)	(2.79e-07)	(1.79e-07)	(9.97e-08)
$GROWTH$	0.000794	0.00150	0.00111**	9.63e-05
	(0.00248)	(0.00138)	(0.000508)	(0.000503)
$UNEMP$	0.00480	0.00105	0.00456	0.000804
	(0.0105)	(0.00670)	(0.00294)	(0.00227)
$AUTOCRACY$	-0.00112	0.000173	-0.00175**	-0.000667
	(0.00177)	(0.00197)	(0.000846)	(0.000928)
$POLITY$	0.00560	-6.78e-06	0.000231	0.000661
	(0.00990)	(0.00610)	(0.00284)	(0.00168)
$MTRADECAP$	0.0158	0.234	-0.0161	-0.0847
	(0.0836)	(0.316)	(0.0287)	(0.101)
YEAR FE	Y	Y	Y	Y
REGION FE	N	Y	N	Y
LOCATION FE	N	Y	N	Y
Observations	2083	2083	2083	2083
R-squared	.003	0.028	.005	.005

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In our next set of tables, 3.10.a through 3.10.e, we carry out our IV investigations at the regional subsample level for Asia and Africa.[32] As these findings indicate, the role of learning-by-doing in the odds of success, place and target of attacks as well as outcomes, such as physical harm on the crew and vessel seizures, is primarily an Asian phenomenon. The successful Asian piracy experience influences the odds of success and leads to more incidents closer to the ports and focuses on larger vessels whereas the successful African piracy experience tends to launch more attacks farther from seashore and also aims at larger vessels.

[32]Recall that 85 percent of our data cover these two continents. The remainder of our observations were scant enough for each of the other three regions of Europe, Oceania and the Americas that we were only able to carry out region-level analyses only for Africa and Asia.

Table 3.10.a: Estimates with LBD & Outcomes by Region — First-Stage with *SUCCESS*

VARS.	(1) *ASIA*	(2) *ASIA*	(3) *ASIA*	(4) *AFRICA*	(5) *AFRICA*	(6) *AFRICA*
CUMSUCCESS	0.001***	0.001***	0.0003*	0.0004	0.0005	0.00022
	(0.00008)	(0.00008)	(0.00015)	(0.0006)	(0.0006)	(0.0000)
GDPCAP	-8e-08***	-8e-08***	-6e-08***	3e-05**	4e-05***	3.0e-05**
	(2.0e-08)	(1.9e-08)	(2.1e-08)	(1.3e-05)	(1.3e-05)	(1.6e-05)
GROWTH	0.00082	0.0008	0.0018	0.00025	0.0001	-0.0003
	(0.0009)	(0.0009)	(0.0011)	(0.0009)	(0.0009)	(0.0011)
UNEMP	-0.044***	-0.046***	-0.0173**	-0.008**	-0.01**	-0.011**
	(0.0043)	(0.0043)	(0.008)	(0.0040)	(0.0041)	(0.0051)
AUTOCR.	-0.007***	-0.007***	-0.007***	0.004***	0.004***	0.001
	(0.0016)	(0.0017)	(0.0018)	(0.0006)	(0.0007)	(0.0011)
POLITY	-0.009***	-0.008***	-0.005	-0.006*	-0.005	-0.01
	(0.003)	(0.003)	(0.0045)	(0.005)	(0.005)	(0.0067)
JANUARY	0.095**	0.094**	0.099**	-0.0295	-0.0230	-0.0286
	(0.046)	(0.046)	(0.0455)	(0.0755)	(0.076)	(0.0758)
APRIL	.0193	0.0162	0.0675	-0.133*	-0.140*	-0.144*
	(0.0435)	(0.0434)	(0.0432)	(0.078)	(0.079)	(0.078)
JULY	0.0540	0.0525	0.0485	-0.116	-0.113	-0.0950
	(0.0453)	(0.0451)	(0.0448)	(0.080)	(0.080)	(0.079)
NOVEMBER	.0178	0.0148	0.0346	-0.098	-0.096	-0.071
	(0.0447)	(0.0446)	(0.0444)	(0.078)	(0.078)	(0.079)
YEAR FE	N	Y	Y	N	Y	Y
LOCAT. FE	N	N	Y	N	N	Y
Observations	2165	2165	2165	686	686	686
R-squared	0.082	0.093	0.117	0.144	0.157	0.198
F-statistics	10.6	8.39	7.42	6.25	4.72	4.44

Standard errors clustered by location in parentheses;
MTRADECAP, *FEBRUARY*, *MARCH*, *MAY*, *JUNE*, *AUGUST*, *SEPTEMBER*, *OCTOBER*, *DECEMBER* included but not shown.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10.b: Estimates with LBD & Outcomes by Region — First-Stage with $WATER$

VARS.	(1) $ASIA$	(2) $ASIA$	(3) $ASIA$	(4) $AFRICA$	(5) $AFRICA$	(6) $AFRICA$
$CUMSUCCESS$	-0.003***	-0.003***	-0.0004**	0.003***	0.0023**	0.0029**
	(0.00012)	(0.0001)	(0.0002)	(0.001)	(0.001)	(0.0014)
$GDPCAP$	2e-06***	2e-06***	8e-06***	-6e-05**	-7e-05**	-6e-05***
	(3.1e-07)	(3.0e-07)	(2.6e-06)	(3.0e-05)	(3.0e-05)	(3.1e-05)
$GROWTH$	0.004***	0.0033**	-0.006***	-0.004**	-0.0028*	-0.0011
	(0.0014)	(0.0013)	(0.0015)	(0.002)	(0.0015)	(0.0016)
$UNEMP$	0.115***	0.122***	-0.019*	0.0035	0.0097	0.012
	(0.069)	(0.007)	(0.010)	(0.0065)	(0.0063)	(0.0075)
$AUTOCR.$	0.012***	0.012***	0.010***	-0.01***	-0.01***	0.0002
	(0.0027)	(0.0026)	(0.0022)	(0.001)	(0.001)	(0.002)
$POLITY$	0.030***	0.029***	0.019***	-0.0122	0.000878	0.0157
	(0.004)	(0.0042)	(0.0057)	(0.0081)	(0.008)	(0.010)
$APRIL$	0.033	0.033	0.050	0.237*	0.238*	0.239**
	(0.070)	(0.068)	(0.055)	(0.127)	(0.122)	(0.115)
$JULY$	-0.171**	-0.158**	-0.151***	0.0676	0.0832	0.0215
	(0.073)	(0.071)	(0.057)	(0.130)	(0.124)	(0.116)
$AUGUST$	0.191**	0.165**	0.097	0.145	0.201	0.133
	(0.073)	(0.072)	(0.057)	(0.130)	(0.124)	(0.118)
$NOVEMBER$	0.169**	0.160**	0.048	0.212*	0.216*	0.130
	(0.072)	(0.070)	(0.056)	(0.127)	(0.122)	(0.114)
YEAR FE	N	Y	Y	N	Y	Y
LOCAT. FE	N	N	Y	N	N	Y
Observations	2165	2165	2165	686	686	686
R-squared	0.255	0.301	0.557	0.262	0.338	0.436
F-statistics	40.81	35.34	70.34	13.13	12.96	13.92

Standard errors clustered by location in parentheses;
$MTRADECAP$, $JANUARY$, $FEBRUARY$, $MARCH$, MAY, $JUNE$, $SEPTEMBER$, $OCTOBER$, $DECEMBER$ included but not shown.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10.c: Estimates with LBD & Outcomes by Region — First-Stage with *TONNAGE*

VARS.	(1) *ASIA*	(2) *ASIA*	(3) *ASIA*	(4) *AFRICA*	(5) *AFRICA*	(6) *AFRICA*
CUMSUCCESS	10.64***	10.87***	15.38**	41.6*	46.3*	85.6**
	(4.07)	(4.11)	(8.00)	(25.0)	(25.7)	(38.3)
GDPCAP	-0.015	-0.013	-0.0095	0.202	0.116	-0.282
	(0.010)	(0.011)	(0.012)	(0.516)	(0.524)	(0.693)
GROWTH	96.4**	84.80*	25.39	58.65	52.50	5.278
	(46.0)	(46.4)	(62.4)	(37.8)	(38.6)	(43.0)
UNEMP	1,042***	1,082***	576.4	184.0	212.3	253.8
	(232.3)	(235.3)	(436.0)	(164.0)	(166.7)	(211.6)
AUTOCRACY	-246.1***	-218.0**	-176.2*	-29.3	-27.70	-93.7**
	(89.10)	(90.3)	(98.0)	(26.4)	(26.9)	(46.9)
POLITY	-30.09	-6.367	-56.16	317.6	212.3	99.40
	(137.5)	(143.1)	(243.7)	(205.4)	(166.7)	(278.4)
JANUARY	-3,243	-2,897	-4,087*	-3,730	-4,072	-4,156
	(2,485)	(2,486)	(2,479)	(3,088)	(3,129)	(3,143)
MARCH	-1,601	-1,104	-1,059	-549.2	-762.5	-1,128
	(2,447)	(2,454)	(2,443)	(3,305)	(3,359)	(3,404)
APRIL	-1,348	-1,167	-1,316	-2,074	-2,542	-2,919
	(2,359)	(2,361)	(2,355)	(3,192)	(3,241)	(3,252)
OCTOBER	-5,276**	-5,372**	-5,479	2,280	1,800	-2,231
	(2,337)	(2,339)	(2,449)	(3,216)	(3,248)	(3,229)
YEAR FE	N	Y	Y	N	Y	Y
LOCAT. FE	N	N	Y	N	N	Y
Observations	2165	2165	2165	686	686	686
R-squared	0.040	0.046	0.066	0.061	0.066	0.095
F-statistics	4.98	3.98	3.98	2.41	1.80	1.90

Standard errors clustered by location in parentheses;
MTRADECAP, *FEBRUARY*, *MAY*, *JUNE*, *JULY*, *AUGUST*
SEPTEMBER, *NOVEMBER*, *DECEMBER* included but not shown.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10.d: Estimates with LBD & $CREWHARM$ by Region — Second-Stage

VARIABLES	(1) $ASIA$	(2) $ASIA$	(3) $ASIA$	(4) $AFRICA$	(5) $AFRICA$	(6) $AFRICA$
$\widehat{SUCCESS}$	1.103**	1.278**	1.338**	0.304	0.377	0.224
	(0.498)	(0.524)	(0.508)	(0.677)	(0.479)	(0.578)
$\widehat{WATER}$	0.172	0.251	0.264	0.397	0.297*	0.288
	(0.149)	(0.173)	(0.178)	(0.268)	(0.158)	(0.211)
$\widehat{TONNAGE}$	-3.9e-06	-1.7e-06	1.65e-06	1.2e-05**	7.7e-06	8.5e-06
	(7.8e-06)	(7.3e-06)	(6.8e-06)	(5.2e-06)	(5.5e-06)	(7.93e-06)
$CUMSUCCESS$	-0.00022	-0.00018	3.1e-05	0.0027	0.0027*	-0.00081
	(0.00038)	(0.00039)	(0.00021)	(0.0015)	(0.0013)	(0.0013)
$GDPCAP$	2.66e-07	2.58e-07	-2.21e-07	7.32e-05	6.28e-05	-8.61e-06
	(4.3e-07)	(4.1e-07)	(1.9e-07)	(4.2e-05)	(4.3e-05)	(0.00021)
$GROWTH$	-0.00290	-0.00269	0.000561	-0.00365	-0.00246	0.00364
	(0.00314)	(0.00254)	(0.00129)	(0.00274)	(0.00309)	(0.00504)
$UNEMP$	0.0439*	0.0358	0.00945	-0.0106	-0.0133*	-0.00443
	(0.0218)	(0.0205)	(0.0173)	(0.00989)	(0.00707)	(0.0141)
$AUTOCRACY$	-0.0457	-0.0296	0.258***	0.00199	0.000320	0.00484
	(0.0445)	(0.0522)	(0.0674)	(0.00198)	(0.00315)	(0.00383)
$POLITY$	-0.0221	-0.0120	0.120***	0.00553	0.00279	-0.0108
	(0.0151)	(0.0226)	(0.0280)	(0.0143)	(0.00957)	(0.0207)
$MTRADECAP$	0.215	0	0	-3.654*	0	0
	(0.133)	(0)	(0)	(1.641)	(0)	(0)
YEAR FE	N	Y	Y	N	Y	Y
LOCAT. FE	N	N	Y	N	N	Y
Observations	2063	2063	2063	551	551	551

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10.e: Estimates with LBD & $VESSEL$ by Region — Second-Stage

VARIABLES	(1) $ASIA$	(2) $ASIA$	(3) $ASIA$	(4) $AFRICA$	(5) $AFRICA$	(6) $AFRICA$
$\widehat{SUCCESS}$	0.0180	-0.0501	0.0136	0.190	0.243	0.334
	(0.378)	(0.377)	(0.282)	(0.179)	(0.166)	(0.187)
$\widehat{WATER}$	-0.0182	-0.00738	-0.0342	0.0906	0.111	0.0952
	(0.0900)	(0.108)	(0.120)	(0.0709)	(0.0917)	(0.145)
$\widehat{TONNAGE}$	2.9e-06	2.3e-06	1.4e-06	6.7e-07	7.1e-07	4.5e-07
	(3.0e-06)	(2.7e-06)	(3.3e-06)	(1.4e-06)	(1.3e-06)	(2.2e-06)
$CUMSUCCESS$	-0.00018	-0.00010	7.2e-05	-0.00055	-0.00056	-0.0011
	(0.00015)	(0.00015)	(0.00011)	(0.00052)	(0.00052)	(0.00081)
$GDPCAP$	4.6e-09	-7.6e-08	-3.3e-07**	-7.6e-06	-7.1e-06	-4.2e-05
	(2.0e-07)	(1.7e-07)	(1.3e-07)	(1.5e-05)	(1.5e-05)	(0.00013)
$GROWTH$	0.00054	0.00083	-0.00040	0.00075	0.00068	0.0022
	(0.0013)	(0.0013)	(0.0013)	(0.00084)	(0.00073)	(0.0020)
$UNEMP$	0.0120	0.0068	-0.0035	-0.0018	-0.0014	-0.0012
	(0.007)	(0.0064)	(0.017)	(0.0015)	(0.0016)	(0.0061)
$AUTOCRACY$	-0.022	-0.019	0.015	-0.0008	-0.00081	-0.00055*
	(0.020)	(0.027)	(0.050)	(0.00098)	(0.00095)	(0.00029)
$POLITY$	-0.0088	-0.0075	0.0013	0.0034	0.004	0.0116
	(0.0089)	(0.011)	(0.024)	(0.0023)	(0.0026)	(0.00642)
$MTRADECAP$	0.0820	0	0	-0.104	0	0
	(0.0660)	(0)	(0)	(0.874)	(0)	(0)
YEAR FE	N	Y	Y	N	Y	Y
LOCAT. FE	N	N	Y	N	N	Y
Observations	2063	2063	2063	551	551	551

Standard errors clustered by location in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Although we have chosen to report a subset of the analyses we conducted, we also experimented with a variety of alternative specifications to test the robustness of our qualitative results. For example, besides the three institutional and polity measures we have included in the tables above, we have other related measures such as democracy, civil liberties, political freedoms and property rights indices. We have utilized these variables in conjunction with or in lieu of $POLITY$ and $AUTOCRACY$ in a variety of alternative regressions. Our key results did not alter in any meaningful way. Although the measures we reported on above generally produced the most significant effects on outcomes, the signs of their coefficients were not always consistent with predictions.

While we primarily focused on and reported results for a subset of our dependent variables (that is, $CREWHARM$, $RANSOM$, $VESSEL$, $SUCCESS$, $WATER$ and $TONNAGE$), we also examined the role of our standard explanatory variables in explaining variations in other dependent variables as well. These included specific outcomes such as incidents that resulted in crew deaths or cargo stolen from the vessels. But we also had at our disposal broader measures of violence or material damage, which aggregate various outcomes we discussed above into instances of violence or material damage.[33] With our broad violence or material damage measures, we got results that were fairly in line with what we have already reported, with learning-by-doing effects typically producing more violent outcomes and more material damage in reduced-form estimates and working through first-stage effects in our IV specifications. With other specific outcomes, the results regarding the impact of learning-by-doing were sometimes

[33]For example, our general $VIOLENCE$ measure attains values of zero when the crew escaped unharmed; one if the crew were threatened with physical violence; two if they were physically assaulted; three if they were kidnapped and four if at least one crew member was killed. The variable $GOODS$, in similar fashion, rank orders material damage inflicted, ranging from none to the vessel being commandeered away.

mixed and sometimes weaker. With respect to other explanatory variables, we did find, however, that both higher incomes per capita and polity scores produced fewer cases of cash robberies. And higher incomes per capita also accounted for fewer threats to the crew.

Finally, we also explored if there were non-linear time trends, but did not detect any when our year fixed effects were included. However, when the latter were removed most, if not all, of our specifications showed statistically significant negative but declining time trends. That is, until around 2005, we found declining incidents, but roughly sometime around then the net effect of the time trends usually turned positive.

3.3 Conclusion

Modern pirates are learning. As a result, the nature of contemporary piracy attacks is evolving.

We reach this conclusion on the basis of empirical work using a dataset which includes 3,362 modern-day piracy incidents that occurred globally between 1998 and 2007. It records detailed information on the location, timing and success of each attack, as well as the material damage and violence inflicted upon the crew and the cargo. There are also peripheral data on macroeconomic and aggregate measures of per-capita incomes, rates of economic growth and institutional quality.

On this basis, we highlighted three main findings: First, economic factors play a role in the sustenance of modern maritime piracy: higher per-capita incomes and employment dampen both the physical violence and material damage of modern-day piracy. For example, higher par-capita incomes are associated with fewer successful attacks that culminated with cash robberies and ransom demands, while they are related more fre-

quently with cases in which the crew escaped unharmed. Second, political institutions and legal enforcement are also important, although not as much nor consistently as economic factors. For instance, incidents that occur in the harbors of territorial waters of countries with more effective polities tend to involve fewer cases in which pirates captured the vessel, robbed the crew of their cash and more incidents in which the crew escaped safely.

Most importantly, however, we document significant learning-by-doing and skill accumulation among the pirates that have helped modern piracy evolve over time into a more potent ordeal. In particular, we find that, over the period between 1998 and 2007, a history of successful piracy attacks locally improved the odds of future success, making it more likely that pirates launched successful raids aimed at larger vessels closer to land. The learning-by-doing effects are detectable even after controlling for our proxies for capital use and labor input (the number of pirates).

CONCLUSION

This dissertation project has both theoretically and empirically studied the real root causes of modern maritime piracy, which began making a return in the mid-1990s. The feature of this research is utilizing the most comprehensive and novel modern-era piracy dataset in the empirical chapters. The dataset are mainly constructed from the annual reports on Piracy and Armed Robbery against ships by the International Maritime Bureau (IMB) and the International Maritime Organization (IMO). It covers 3,362 modern-day piracy incidents that occurred internationally between 1998 and 2007. For each incident of piracy attack, the data includes detailed information on location, date, vessel characteristics and the numbers of pirates involved in each incident. There is also information on the material damage and violence imposed upon the crew and the cargo. These incident-based data are then paired with macroeconomic and aggregate measures of per-capita incomes, rates of economic growth and institutional quality of the countries whose territorial waters either witnessed these piracy incidents or were in closest proximity to them. The contribution of this research is offering a new empirical work in which the quantitative work in Economics hypothesizing the reemergence of maritime piracy is skimp.

This dissertation consists of three main essays focused on the study of three aspects of worldwide modern maritime piracy: (1) Extralegal Appropriation Model, (2)

Determinants of Modern Maritime Piracy, and (3) Maritime Pirates's Learning Skill Accumulation.

(1) Modeling the Root Causes of Modern Maritime Piracy

The first chapter begins with a brief discussion on the root causes of modern maritime piracy, which mostly takes place in two regions of the world: Somalia and the Southeast Asia. The fact that a state is failed or weak is commonly known as a root cause of the existence of piracy due to its poor economic condition. To explain the root causes hypothetically, I extend the theoretical framework of extralegal appropriation and production model applied to modern piracy where the economic opportunity cost of working in extralegal ventures can be viewed as wage employment in the formal production sector. The main results of this model are that, in equilibrium, the time that the average family allocates to extralegal activity is increasing in its effectiveness, in the resource endowment, in the price of the good and in the proportion of exports but decreasing in the number of families, in the wage of productive activity, and in the number of cargo ships.

(2) Understanding the Root Causes of Modern Maritime Piracy

The second chapter is a reduced-form empirical application of the first-chapter theory on modern maritime piracy. In it, I find evidence in favor of the extralegal appropriation framework in that economic factors do play a role in the number of pirates involved in attacks and the probability of the successful attack. But economic factors also seem to alter the outcome of modern piracy attacks; accordingly, higher per-capita incomes are associated with fewer successful attacks that culminated with cash robberies

and vessel hijackings, while they are related more frequently with cases with cargo goods robbery and ransom demand. I also find that political institutions and legal enforcement are also important, although not as much nor consistently as economic factors.

(3) Learning Piracy on the High Seas

This last chapter is coauthored with my dissertation advisor. We focus on the evolution of piracy attacks over time due to learning-by-doing and skills accumulation. The central result is that, even after controlling for geographic, economic and sociopolitical factors as well as a variety of fixed effects, learning-by-doing and skills accumulation among the pirates seems to have played an important role in maritime piracy turning into a more potent threat over time. In particular, we find that a history of successful piracy attacks locally improves the odds of future success in piracy, making it more likely that pirates launch successful raids aimed at larger vessels closer to land. The learning-by-doing effects are detectable even after controlling for our proxies for capital use and labor input (the number of pirates).

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