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The Political Economy of Plunder:

Economic Opportunity and Modern Piracy[1]

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*Abstract*

Maritime piracy is a growing scourge on the international community—imposing large costs on maritime states and industries, as well as potentially undermining state capacity and funding terrorism. Using original data on over three thousand pirate attacks, we argue that these attacks are, in part, a response to poor labor market opportunities. To establish this, we take advantage of the strong effect of commodity prices on labor market opportunities in piracy-prone states. Consistent with our theory, we show that changes in the price of labor and capital-intensive commodities have consistent and strong effects on the number of pirate attacks in a country's territorial waters each month. We confirm these results by instrumenting for commodity prices using monthly precipitation levels.

While conjuring images of cannons and tattered sails, piracy is also a modern scourge—and an increasingly costly as well as common one. Besides the costs of theft, sabotage and ransoms from hijackings, piracy delays shipping, drives up security costs, hinders development in coastal states and is a potential source of funding for terrorist groups, insurgents and international criminal organizations (Luft and Korin 2004; Murphy 2007; Lehr 2006). Furthermore, the number of pirate attacks (worldwide) reported by the United Nations' maritime branch—the International Maritime Organization (IMO)—has increased by more than 50% in the past five years.

We argue that economic conditions play an important role in driving this variation. We argue that pirates take into account the rewards they might achieve through labor in alternative, presumably legitimate, activities when deciding whether or not to engage in piracy.

In making this argument, we situate pirate groups within a larger class of predatory groups that include criminal organizations and some insurgent and terrorist groups. Like members of these groups, individual pirates balance the rewards from predatory behavior with benefits of legitimate employment and the risks of capture and punishment (Becker 1968). We therefore expect that the number of pirate attacks is not just a function of how much pirates can earn from predation, but is also a function of how much pirates can earn in other labor-intensive sectors.

This paper offers multiple contributions to an emerging empirical literature on piracy (Hastings 2009; de Groot et al. 2011; Shortland and Vothnecht 2011). While some have suggested poverty plays a role in piracy, this is the first paper to explicitly test the role of labor opportunities in driving the decision to engage in piracy. In addition, this paper is among the first attempts to explain temporal variation in pirate attacks, and to use a causally motivated empirical strategy to test for a link between labor opportunities and piracy.

There is also a growing literature addressing the effect of labor incentives, poverty and resource scarcity on predatory behavior more generally. Financial incentives appear play a role in both the attack and recruitment activities of terrorists, insurgent groups, and organized criminal groups (Collier and Hoeffler 2004; Dube and Vargas 2006; Fearon and Laitin 2003; Humphreys and Weinstein 2008; Kavanagh 2010). Yet despite extensive research, scholars have yet to reach consensus on the underlying mechanisms behind these effects (Blattman and Miguel 2010). We propose one mechanism that appears to hold true for one form of predatory group, pirates, and hope that this research will capture the interest to students of predatory behavior more generally.

We use two approaches to study the effect of labor opportunities on piracy. First, we analyze economic, historic and naval data from Somalia with the goal of assessing competing hypotheses about the causes of the dramatic increase in pirate attacks off the coast of Somalia beginning in late 2008. We show that the initial jump in attacks correlates temporally and geographically with a large shock to the Somali labor and currency market, even after controlling for naval deterrence efforts and temporal trends.

Secondly, we use data on reported pirate attacks (worldwide) between 2000 and 2009 to develop a cross-national test of whether variation in the returns from legitimate, labor-intensive sectors have an effect on the monthly number of reported attacks in a country's territorial waters. We take advantage of the strong effect that commodity prices have on economic opportunities in many piracy-prone states to test for this effect. We show that the price of labor-intensive commodities—which we measure using rice and sugar prices—is negatively correlated with the number of attacks in rice and sugar producing countries. For similar reasons, the price of capital-intensive commodities—which we measure using oil prices—is positively correlated with the number of pirate attacks in oil exporting countries. Furthermore, we are able to establish that this effect is likely causal by using rainfall as an instrument for commodity pricing.

The paper proceeds as follows: first, we provide a brief background on modern maritime piracy. Second, we discuss the emerging literature on the drivers of piracy. Third, we discuss the role of economic opportunities in the decision to engage in piracy. Fourth, we discuss some competing hypotheses about the rise of piracy in Somalia, and assess these hypotheses using sub-national data. We then turn to cross-national hypotheses, methodology and results. We conclude with caveats and questions for future research.

*Background*

Pirate attacks, formally defined, are acts of depredation committed by the crew or passengers of a private ship for private ends that occur either in international waters or in territorial waters claimed by states.[1] Estimating the number of such attacks prior to 2000 is difficult due to the absence of centralized reporting and the extent of missing data for much of this period; however in our sample between 2000 and 2009 the IMO reported an average of 350 pirate attacks each year.

These attacks are global in scope with the areas of greatest concentration being the Straits of Malacca, the Indonesian Archipelago, and the Gulf of Aden. However, attacks are also common in the waters off Nigeria, Bangladesh, Vietnam, the Philippines and Brazil. Our dataset of pirate attacks contains more than thirty countries which report more than one attack a year, and ten countries that report on average at least one attack every two months.[2]

[Figure 1 Here]

While pirate attacks have recently been increasing in number in the Gulf of Aden and the Indian Ocean, this is not true globally. As shown in Figure 1, the highest density of attacks a decade ago was in South East Asia, suggesting that the focus of research should not be exclusively on understanding why attacks occur in some states and not others, but also on why we see variation within already piracy prone countries. This within-country variation is the focus of our study.

Most of these pirate attacks are relatively low technology, labor-intensive events involving loosely organized groups of local men operating from shore with small vessels, armed with knives or small arms. The object of most attacks is the theft of cargo, personal effects, and the vessel's safe. However, a growing number of attacks result in hijackings and kidnappings, particularly in the waters off Somalia. The groups that carry out these attacks appear more organized and connected to international criminal organizations, diaspora networks, and insurgent groups (Liss 2003; Murphy 2007; Hansen 2009; Hansen 2011). These globally connected networks appear to have made it easier for pirate groups to obtain financing, conduct surveillance, and operate far from shore.

The sophistication of some operations is remarkable. According to U.N. reports, Somali pirates often strictly delineate the distribution of returns from hijackings: according to one report, financiers and investors received 30% of the returns from ransoms and local elders received 5-10%. Local militia and support personnel receive a fixed sum of about $15,000 and the remaining returns were distributed among "Class A" shareholders who participated in the actual hijacking. Also, a share of the returns is likely appropriated by government or militia forces, at least in the Puntland area (U.N. Security Council 2010).

The sophistication of these groups suggests that, at least in some areas, pirates are not merely opportunistic individuals, but are more like crime syndicates with a careful division of labor and shrewd profit and loss considerations. In one study, Hastings (2009) argues that pirates are sensitive to the economic opportunities afforded by coastal states. In particular, Hastings demonstrates that pirates engage in more seizures of cargos relative to kidnappings when coastal states contain the necessary markets to absorb stolen cargos.

The costs resulting from piracy are considerable. Bowden (2010) estimates the direct and indirect costs of piracy in 2010 at between USD 7 and 15 billion. The human costs are also considerable. Hurlburt (2011) reports that in 2010 in the waters off Somalia alone, 1,090 seafarers were taken hostage; and, of that number, 60% later reported having been used as human shields or subjected to physical abuse.

Piracy's costs are also borne by particularly vulnerable populations. In 2008, the World Food Program (WFP) announced they would be closing feeding centers in Somalia, largely in response to increased shipping costs (Ploch et al. 2009). Only after EU and NATO naval deployments were assigned to protect these deliveries did the shipments continue.

*Literature Survey*

A newly emerging body of scholarship on piracy has pointed to a number of explanations for variation in attacks. Frequently offered explanations include institutions and rule of law, international cooperation in naval deterrence, favorable geography, as well as poverty.

Empirical studies have provided some support for these explanations. Contrary to some earlier assumptions (e.g., Murphy 2007), piracy does not appear to have a simple relationship with institutions and rule of law. For example, de Groot et al. (2011) offer evidence that pirates are best able to operate where institutions are weak and compliant rather than failed and largely absent.  Likewise, Hastings (2009) argues that more sophisticated attacks (hijackings where the target is the seizure of ships and their cargos rather than simple kidnappings) do not occur as frequently in failed states due to their lack of markets to absorb cargo. Percy and Shortland (2010) similarly argue pirates benefit from improved institutional stability since such stability improves their ability contract for supplies, negotiate ransoms and retain hostages.

Others focus on the role of international cooperation and naval deterrence. When states fail to cooperate in governing shared sea-lanes, pirates can take advantage of this tragedy of the commons to increase attacks. Bradford (2008) argues that this was the case for the Straits of Malacca until littoral states responded to the threat by insurers to declare the region a warzone and raise insurance rates in 2004. Yet, available empirical evidence suggests that even successful international cooperation may yield only limited results in decreasing pirate attacks (Shortland and Vothknecht 2011).

Scholars have also proposed that poverty influences attacks, though empirical results are inconclusive. Vagg (1995) explains the wave of pirate attacks in the Riau Archipelago during the early 1990s as driven by a combination of poverty and opportunity. De Groot et al. (2011) also show a negative relationship between per capita GDP and attacks, conditional on attack type. Percy and Shortland (2010) also look for a link between poverty and attacks by looking at deviation rates in average rainfall on attacks in Somalia, though their results are not conclusive.

These mixed results are not surprising. It is not clear why there should be a simple relationship between aggregate, national wealth (as proxied by per capita GDP) and predatory behavior. Opportunity costs are a function of differences between what a would-be pirate can achieve in piracy and what she can achieve in other employments. While aggregate wealth may have an effect on these costs, the link is at best indirect (Ravallion 2001). National wealth may also better reflect state capacity than opportunity costs

(Fearon and Laitin 2003). In the following section we discuss our theory of economic opportunity and an alternative empirical strategy.

*Economic Opportunity and Piracy*

Why is the number of attacks in a country's territorial waters higher in some periods than in others? We argue some of the month-to-month variation can be attributed to locally changing labor opportunities that face would-be pirates.

In making this argument, we rely on the idea that involvement in piracy places an opportunity cost on individual pirates because involvement in piracy detracts from their ability to engage in other forms of employment. Similarly, from the perspective of organized pirate groups, higher labor prices in legitimate sectors increase the costs of hiring labor and conducting attacks.

Our argument builds upon the well-established economic opportunity cost literature in civil war, terrorism and crime. Our argument borrows from Becker's (1968) classic crime model that posits would-be criminals will choose whether to join a legitimate or criminal sector based upon the net economic returns from involvement in each. When the marginal benefits from engaging in crime outweigh the returns from legitimate activity, would-be criminals will allocate more resources to criminal activity. As a result, criminals are sensitive not just to the returns to criminal activity but also to the opportunity costs associated with engaging in criminal rather than legitimate activity (Gould, Weinberg and Mustard 2002; Mocan and Bali 2010).

Labor cost frameworks have also provided novel insights in the study of civil conflict (Dal Bó and Dal Bó 2010, Dube and Vargas 2006, Blattman and Miguel 2010). We are particularly indebted to Dube and Vargas (2006), who use a similar model to show that insurgent activity in Colombia responds negatively to the price of labor-intensive goods—measured by coffee prices—and positively to the price of capital-intensive goods—measured by oil prices—largely due to the effects of these prices on wages and opportunity costs.

We argue a similar framework can be applied to understand piracy. While there have been few in-depth studies of pirate recruitment, evidence from historical accounts (Pennel 1994; Starkey 1990) as well as contemporary ethnographic accounts suggests that pirate groups the world over recruit locally from among both the unemployed and underemployed including fisherman, sailors, and members of the police and security forces (Burnett 2002; Frecón 2005; Hansen 2009).

This evidence suggests that, much like insurgent groups, pirate groups compete for labor with legitimate labor-intensive sectors. A recent U.N. report claims that a typical Somali pirate group utilizes up to a dozen militia prepared to stay at sea for long periods of time, as well as many logistical personnel, interpreters, investors, and additional militia in case a ship has to be secured on land. In some cases entire villages are involved in pirate operations, either in the role of financiers, militia, suppliers or entertainment (U.N. Security Council 2010). Accounts like these suggest pirates are sensitive to the costs of labor and will find it harder to operate as the returns to labor in legitimate sectors increase.

To test whether labor opportunities affect the number of pirate attacks we rely on the insights of the Stolper-Samuelson theorem (Stolper and Samuelson 1941). This theorem establishes (under certain assumptions) that, in a two-sector economy with labor and capital, an increase in the price of a labor-intensive good will increase the returns to labor and decrease the returns to capital.[3] An increase in the price of capital-intensive goods will have the opposite effect: it will increase the returns to capital and decrease the returns to labor.[4]

From this insight we can derive the effects that changes in the price of capital and labor-intensive goods should have on the number of pirate attacks. Since pirate groups often hire out of labor-intensive sectors, an increase in the price of capital-intensive goods, such as petroleum, will reduce wages and make it cheaper for pirate groups to find recruits. By the same token, such a change may also make the value of capital-intensive shipping more profitable to steal. Similarly, an increase in the price of labor-intensive goods, such as sugar and rice, will increase wages, making it harder to find recruits, and increasing the cost of predation.

While this approach is not without challenges we are able to conduct a more compelling test of our model by using commodity pricing to test for the effect of labor opportunities on pirate attacks than we would by simply examining wage rates or unemployment directly. First, unlike data on labor rates, which are poor and difficult to generalize on a cross-country basis, worldwide commodity prices are precise and available on a daily basis. We therefore believe that our approach provides us a better way to estimate the effect of labor pricing on attacks. Also, since the effect of commodity prices on piracy will vary based upon whether or not a country produces a commodity of interest, as well as which commodity they produce, we can rule out a number of endogeneity issues that would otherwise confound our results. For example, since economic growth and global trade are related to unemployment, as well as to piracy, directly estimating the effects of unemployment might be inconclusive. However, as more direct evidence for our theory, we begin by examining the effect of local unskilled labor prices on the recent increase in attacks off the coast of Somalia.

*The Rise of Piracy in Somalia*

Pirate attacks have been occurring off the coast of Somalia since at least the collapse of the central state in 1990 (Hansen 2009; Hansen 2011), yet the number of attacks increased substantially in late 2008 and has remained elevated since (Figure 3). In 2007, an estimated five out of every thousand ships transiting the Suez Canal reported being attacked by pirates. Yet by 2009 we estimate that nearly 2% chance that a ship transiting through the Suez Canal would be attacked (Figure 3).[5] What accounts for this sudden increase?

We argue that one of the factors behind this increase was a collapse of the Somali currency and labor market in 2008. This collapse, along with fiscal and institutional problems in the Puntland regional government, contributed to low wages and few employment opportunities, which in turn made the potential returns from piracy more attractive.

Existing scholarship has proposed multiple—though not necessarily competing—explanations for the increase in attacks. One common explanation points to the intensity of civil conflict in Somalia. Civil conflict undermines political institutions and increases poverty, potentially fueling attacks (Murphy 2007). Alternatively, some claim there is a negative link between civil conflict and attacks. As evidence, scholars note that most attacks originate from the relatively stable, self-governing region of Puntland in the north rather than the war-torn south, suggesting pirates may avoid operating from active conflict zones (Middleton 2008).

However, this relationship between conflict and attacks remains difficult to substantiate: neither the Puntland ceasefire in 2002, nor the intermittent fighting between Puntland and Somaliland in 2005, nor the intervention by Ethiopia in 2006 coincided with comparable change in attacks. Moreover, while conflict intensified during 2008, this change was constrained to the less piracy prone southern region of the country.[6]

Alternatively, Percy and Shortland (2010) argue that improvements in institutional stability in Puntland may have helped push Somali pirates into an operational "sweet spot" and that some form of stability is needed for pirates to manage the logistics of hostage taking operations, and maintain credible contracts with suppliers.

However, this argument also remains incomplete. While stable but compliant institutions may contribute to a permissive environment for piracy, stability declined during the period preceding the rise in attacks. As Hansen (2009; 2011) points out and our data confirms, the jump in pirate attacks in late 2008 was immediately preceded by institutional and fiscal failure of the regional government in Puntland, where many of the attacks originated.

Deterrence efforts may also help explain variation. Cooperative anti-piracy interventions have been tasked to deter attacks since 2006. There are currently three international efforts operating in the Gulf of Aden and the Indian Ocean: Operation Atalanta (EU), Operation Ocean Shield (NATO) and Combined Task Force 151 (CTF). In order to evaluate whether naval patrols can account for any variation in attacks, we gather data on the size and start dates of these naval deployments and plot them in Figure 2.

[Figure 2 Here]

While we cannot rule out a local deterrent effect, the sharp rise in attacks during 2008 was clearly not associated with a reduction in patrols. Also, despite a rapidly increasing deterrence effort, the growth of naval patrols does not correlate with a reduction in the number of attacks.

This weak effect is not surprising. While naval patrols are increasing, they are still sparse relative to the task: in 2010, there were between 30 and 40 vessels tasked to patrol a coastline the size of the entire west coast of the United States and Canada combined, many of them on an intermittent basis.

This lack of an effect may also be due to the limitations imposed by rules of engagement and international law (Treves 2009). Many of these vessels are limited to escorting duty and have been constrained by rules regarding the holding of suspected pirates (Kontorovich 2010). Recent United Nations efforts have attempted to remedy this problem, however even the adoption of Resolution 1851, which permitted pirates to be pursued on land, has not resulted in a noticeable deterrent effect.[7] In short, given the low costs of engaging in piracy, the easy access to safe havens, and the unlikely possibility of imprisonment, current naval deterrence efforts may be incapable of more than a localized deterrent effect (Shortland and Vothknecht 2011).

A more compelling explanation for the rise of piracy during 2008 is economic opportunity. Prior to 2008, the Somali economy appeared to have been on the rise (Leeson 2007; Powell et al. 2008). However in 2008 Somalia experienced a record increase in both food prices and inflation, due to the confluence of drought, high world food prices, and currency counterfeiting.[8] In some cases, food prices increased by as much as 400%, resulting in food riots and deaths.[9] At the same time, unemployment was high and unskilled wage rates hit record lows, according to U.N. Food and Agriculture Organization figures (authors' calculations). If economic opportunities influence the decision to engage in piracy, this drop in labor rates and reduction in economic opportunities should correlate with a rise in attacks.

We plot both the price of labor and attacks in Figure 3. It seems likely that the timing of the economic crisis and changing labor market conditions were linked. The hyperinflation and the drop in wage rates both occurred during the months of February and March 2008, which predated the largest increase in attacks to-date. The fact that this increase occurred so soon after the crisis suggests that the condition of the Somali economy played a role in motivating the increase in attacks.

[Figure 3 Here]

To further validate these results we estimate a negative binomial regression of monthly attacks on unskilled labor rates in Table 1. To account for confounding factors, we control for state fragility (Marshall and Cole 2010), naval patrols (authors' calculations), battle events (Raleigh et al. 2010), GDP (World Bank 2009), population (*ibid*), time trends, shipping (Suez Canal Authority 2009), a binary variable for the Southern Indian Ocean cyclone season (Cornell 2002), as well as month fixed effects. Labor prices remain highly significant during the crucial 2008 period. Also, the number of naval vessels appears to have no significant deterrent effect on total attacks.

[Table 1 Here]

Our argument is also supported by geographic variation in attacks. Particularly in 2008, most attacks originated from the Puntland region in northern Somalia (Middleton 2008). This region was also more heavily impacted by the crisis: In Puntland, economic malaise was compounded with a series of budgetary problems related to the support of the Transitional Federal Government (TFG) project (Hansen 2009). This resulted in a collapse of many public services in April 2008, as well as a general increase in insecurity, corruption and crime.[10] In addition, the Puntland government dissolved the police force during this period, creating a large number of potential well-armed recruits into piratical activities (Hansen 2009; 2011).

These events also suggest that economic opportunity and low levels of governance may act as complements. The collapse of the Puntland government not only decreased labor opportunities and public services, it also contributed to a more permissive institutional environment. Based upon these events and the evidence from Table 1, we conclude that there is a plausible link between Somalia's economic and political malaise and the rise of piracy. This account also provides anecdotal motivation for our principal argument; piracy responds to the opportunity cost of engaging in attacks rather than legitimate activity. To test our hypothesis more generally, we turn to a cross-national empirical test.

*Cross-National Predictions*

Our empirical predictions are based upon the opportunity cost model outlined earlier: when the prices of labor-intensive commodities increase, there will be an increase in unskilled wages which will place higher opportunity cost on engaging in piracy. When the prices of capital-intensive commodities increase, wage rates will drop and piracy will be more attractive. To test for these effects, we gather data for two labor-intensive commodities, rice and sugar, and one capital-intensive commodity, petroleum.[11]

Rice and sugar are particularly good commodities for testing a labor opportunity mechanism. First, rice and sugar are highly labor intensive and employ a large portion of the population in many pirate-prone states such as Indonesia, Malaysia and Cambodia. As a result variation in the price of these commodities should have a strong effect on labor conditions in these regions (Deaton 1989; Rashid 2002). Moreover, unlike other labor-intensive commodities, such as fisheries, there is little regional variation in price, allow us to largely assume away country-specific price effects.

Petroleum should capture the effects of capital in pirate prone states in a similar fashion. Many petroleum-exporting states have high levels of piracy, including Nigeria, Indonesia and Angola. Moreover the effect of petroleum on labor pricing and unemployment is well established by the resource-curse literature (Keane and Prasad 1996). For example, Keane and Prasad (1996) establish using U.S. employment data that oil price shocks have a substantial effect on wage rates, particularly for unskilled labor.

Using these commodities, we test the following hypotheses:

*H1: An increase in the price of labor-intensive commodities—measured by rice and sugar prices—will cause a reduction in the number of attacks in regions that produce rice and sugar intensely.*

*H2: Due to the effects of capital on the returns in labor-intensive sectors, an increase in the price of capital-intensive commodities—measured by petroleum prices—will increase the number of attacks in regions that produce petroleum intensely.*

These hypotheses rely on a few assumptions. First, we assume pirates can and will substitute working as a pirate for working in a legitimate sector. If the returns to piracy are great enough that everyone would prefer to be a pirate, then it would be unlikely that the number of pirate attacks would be sensitive to labor costs in other sectors.

This is not an unreasonable assumption. First, the returns from most successful attacks are often small. Vagg (1995) calculates the payouts from successful attacks in Indonesia's Riau Archipelago and finds that in over 70% of cases, the return from an attack was less than five thousand dollars. In 31% of cases, the value was less than one hundred dollars. Moreover while the returns to piracy can be great, they must be balanced against the risk of capture, the costs of supplies, and the chances of a successful action.

However, note that this assumption does not mean that all pirates were once rice or sugar farmers. One advantage to our approach is that as long as there is mobility between unskilled sectors and as long as rice and sugar farming employ a large portion of the labor force, then the price of rice and sugar will affect labor rates across the economy (Deaton 1989; Rashid 2002).

Finally, our logic relies on the assumption that labor is a greater limiting factor than capital on piracy operations. In highly complex hijackings or cargo seizures, this may not be the case since the human and physical capital required in these operations may be considerable (Hastings 2009). This is not true of most attacks, however. Most pirate groups utilize large pools of labor and have few equipment costs. In fact many groups will only recruit individuals who already have weaponry (U.N. Security Council 2010). Later we will relax this labor intensity assumption in order to demonstrate that the effect of labor does in fact appear to vary with the level of attack sophistication.

*Data on Pirate Attacks*

Our dependent variable is the number of reported pirate attacks in a country's territorial waters in a given month. We collected and coded this variable from MSC.4 Circulars issued on a monthly basis by the Maritime Safety Committee (MSC) of the International Maritime Organization (IMO), the maritime arm of the U.N. These data originate from reports made by ship operators who experience an actual or attempted attack.

We code all available monthly data, providing us with a sample of 3284 attacks between 2000 and 2009. To code attacks to countries, we first look at whether an attack occurs in a particular country's port areas or territorial waters. For attacks that occur in international waters, we instead take advantage of data on the latitude and longitude of the event and attribute the attack to the country with the nearest territorial waters.[12] In our analysis these data are collapsed into a count of the number of attacks in each country and year. Since our interest is in within-country variation, if a country had no attacks in our sample period, we exclude it from our analysis.[13]

*Estimation Methodology*

To identify the effects of commodity pricing on pirate attacks, we utilize a difference-in-differences type strategy that exploits the fact that the effect of commodity prices should hold only for countries that produce that commodity intensely. The idea behind this strategy is that we can rule out potential confounds and isolate treatment effects by comparing the effect of commodity prices on piracy across multiple countries which vary on the intensity of rice, sugar and petroleum production (Angrist and Krueger 1999). We expect that increases to rice and sugar prices will have a negative effect on the number of attacks disproportionately in countries that produce rice and sugar more intensely. We expect that increases to petroleum prices will have a positive effect disproportionately in states that produce petroleum more intensely.

We measure production intensity as the average level of rice, sugar and petroleum production for a country between 2000 and 2009. For this *AvgProduction* variable, we use data reported to the U.S. Department of Agriculture and the U.S. Energy Information Administration.[14] Since our interest is in the effect of production as a proportion of the total economy, we divide this variable by annual GDP for each state.

Our explanatory variable is the globally adjusted commodity price of rice, sugar and petroleum. While our results remain largely insensitive to the small regional differences in commodity market prices, we rely on the international market closest to the majority of relevant attacks. Rice prices come from the Thailand market, sugar prices come from the Philippines market, and petroleum prices are averaged across all markets. For rice and sugar data we rely on the International Financial Statistics (IFS) database from the

International Monetary Fund. Petroleum data comes from the U.S. Energy Information Administration. Summary statistics for all variables can be seen in Table 2.

[Table 2 Here]

In order to test whether these commodity variables affect attacks as predicted, we estimate the following equation for each country *i* and month *t:*

$$\lambda(\text{MonthlyAttacks}_{it}) = \exp(\alpha_i + \gamma_y + \beta_1 \text{CommodityPrice} * \text{AvgProduction}_{it} + \beta_2 \text{AvgProduction}_i + \beta_3 \text{CommodityPrice}_t + \Phi(X_{it}) + \varepsilon_{it})$$

Here $\alpha_i$ and $\gamma_y$ are year and country fixed-effects and *X* is a vector of covariates which include population (World Bank 2009), GDP (*ibid.*) and vessel traffic (Suez Canal Authority 2010; Maritime and Port Authority of Singapore 2010).

By including year and country fixed effects we difference out any heterogeneity correlated with a particular country or year. Since there may be remaining seasonal effects or trending unaccounted for in this approach, we also estimate this model with seasonal effects, month effects and time trends. We are primarily interested in the coefficient $\beta_1$ which captures the effect of commodity prices on attacks after differencing out any effect of commodity prices on non-producing states. We estimate this equation using a negative binomial event count model, which has become standard in the event count literature, and is able to handle the typical over-dispersion issues in our data (Greene 2003). In our supplementary appendix, we also show that our results are robust to a linear specification.

One concern with this estimation approach is that the effect of commodity prices might affect attacks by other means than a labor opportunity mechanism, resulting in biased or misleading results. It is likely, for example, that commodity prices have an effect on the number of ships available for attack. Alternatively, piracy itself might increase the cost of shipping and thereby affect commodity prices.  We address these issues as an estimation problem.

First, in the robustness section, we account for any effect of commodity prices on shipping levels by excluding attacks on ships that transport particular commodities from our analysis. Since the effect of commodity prices on shipping has the greatest potential to confound the findings of our second hypothesis, we exclude attacks on oil shipments from our models. As an additional check we also control for shipping through the two largest piracy hotspots: the Gulf of Aden and the Straits of Malacca.

We also more directly address the endogeneity of commodity pricing using an instrumental variable approach. By instrumenting for the price of commodities with a variable unrelated to piracy save through their effect on commodity prices, we can be reasonably sure that commodity prices are affecting piracy independent of any confounding effects of piracy on shipping. While we lack an instrument for petroleum prices, we instrument for rice and sugar prices using levels of precipitation in rice and sugar producing regions.[15]

### *Results*

The results lend credibility to our proposed mechanism (Table 3). Labor-intensive commodity prices (rice and sugar) have a negative effect on piracy in rice and sugar producing countries. Capital-intensive commodity prices, or petroleum prices, have a positive effect on piracy in petroleum producing countries. These results suggest that variation in labor opportunities, as driven by commodity pricing, has an effect on the decision to engage in pirate attacks.

[Table 3 Here]

These effects are substantial. For countries with the maximum level of rice and sugar production, a standard deviation increase in price would decrease the rate of attacks by a factor of 0.39 and 0.51 respectively. In real terms, a USD 180 per ton increase in the price of rice is associated with about a 10 percent reduction in the monthly rate of attacks for the average rice producer and a 60 percent reduction for the highest rice producers. Similarly, a standard deviation increase in the price of oil (USD 18.6) is associated with about a 50 percent increase in the rate of attacks in the highest oil producing states (Figure 4).

[Figure 4 Here]

In Table 4, we take the additional step of dividing our dependent variable into counts of robberies, kidnappings for ransom, and hijackings. For these estimates we take advantage of additional data from Hastings (2009). We are unfortunately forced to exclude more than 30% of observations due to ambiguities in attack descriptions. Nevertheless, our results remain compelling.

While this missing data leads us to be cautious in our interpretation, the results suggest that attacks may differ on the extent to which labor opportunity costs are a limiting factor. Our estimates suggest that labor opportunity costs play a role in robberies and kidnappings for ransom, but they may play less of a role in hijackings. This result is consistent with other scholars, such as Hastings (2009) and Liss (2003), who point out that hijackings with the intent of seizing ships and cargo are more logistically sophisticated due to the need to access markets and resell cargo. As a result, these operations may be more constrained by access to capital and resale markets rather than access to unskilled labor.

There are some potential objections to our estimation approach. First, we may not have fully accounted for the effect of petroleum on shipping. Since shipping levels track oil prices, it is possible that our result is an artifact of the fact that oil prices increase the number of vessels available for attack. While we control for the amount of vessels transiting the Suez Canal, this may not account for the entire effect in places like Nigeria or Indonesia whose traffic is not readily captured with Suez traffic.

To address this objection, we exclude oil tankers from our data (about 7% of our data). Excluding these data has negligible effects on our coefficients, suggesting that our results are not driven by unmeasured shipping density (Table 5). We include a control for shipping traffic data in the Singapore Straits (Maritime and Port Authority of Singapore 2010), which we use as an estimate of the amount of traffic in the straits of Malacca. We only have limited coverage for these data and our results are inconsistent. We conclude this difference is due to change in sample size rather than confounding effects of shipping levels.[16]

A second objection stems from seasonal patterns. Some of our effect might be explained by seasonal weather changes that affect both pricing and attacks. In some places, monsoon seasons bring hurricanes and high winds making it difficult to send out small vessels. Alternatively, harvest seasons may have an effect on pricing and labor supply. Our instrumental variable approach rules out many of these possibilities, however we also include month level fixed-effects and a dichotomous variable for the East Asian Monsoon (frequently December through May; Cornell 2002). These do not alter our substantive findings (Table 5).

It is possible that additional factors, such as state fragility, governance or civil conflict, are correlated with both prices and attacks. Most potential avenues of such an effect are accounted for as a consequence of our country-level fixed effects and our difference-in-differences approach. However, it is possible that something like civil conflict could confound our results if oil prices are systematically related to conflict (Ross 2006). As a result, we take the additional step of controlling for an index of state stability from the State Fragility Index (Marshall and Cole 2010), civil conflict from the Major Episodes of Political Violence dataset (Marshall 2010), and governance from the Polity IV project (Marshall et al. 2010). We also include polynomials of these instability and governance variables to account for any non-linearity (de Groot et al. 2011). Our results again remain consistent (Table 5).

Finally, we also address the objection that our results might be sensitive to the inclusion of Somalia, or common trends in both pricing and piracy. Since Somalia accounts for a large proportion of attacks in our dataset, it is important to verify that our results are not the artifact of Somalia specific factors. Excluding Somalia and including polynomial time trends does not change the significance of our results (Table 5).

[Table 5 Here]

*Instrumenting for Commodity Prices*

These results suggest that commodity prices have a significant effect on the rate of pirate attacks in commodity producing countries. However, as with all non-experimental research, we cannot rule out the possibility that this correlation is due to unobserved confounds that affect both piracy and commodity prices.

Taking this step is important in a number of respects. Global demand, taxes, and insurance rates are all likely have an effect on shipping, prices, as well as local production levels. Alternatively, we could be picking up an effect of piracy on shipping or prices, rather than the effect of prices on piracy. If piracy imposes significant costs on shipping, then the causal connection could go from attacks to commodity prices rather than from prices to attacks.

We use monthly precipitation levels as an instrument for monthly commodity prices to address these issues. Since rice, in particular, is dependent upon abundant water, there is a consistent correlation between rainfall in rice producing regions and prices. Moreover, since precipitation levels are independent of attacks and most confounding factors, this technique provides strong evidence for a causal link between prices and piracy. By using precipitation as an instrument, we join an expanding political economy literature that uses weather and geography to demonstrate causal effects (Angrist and Krueger 2001; Acemoglu, Johnson and Robinson 2001; Bruckner and Ciccone 2008; Miguel, Satyanath and Sergenti 2004).

Some have criticized precipitation as an instrument since the effect of rainfall may be heterogeneous across countries and may be correlated with economic and geographic features (Dunning 2008; Sovey and Green 2011). We are optimistic that our approach addresses many of these issues. Unlike others, we instrument for commodity prices, not growth, and only use precipitation levels in states that produce the commodity of interest. As a result, the effect of precipitation should be mostly consistent across our treatment group. Additionally, since our goal is to predict global prices, correlations between rainfall and country or region-specific features are less likely to violate exclusion restrictions.

The U.N. Food and Agriculture Organization reports monthly precipitation levels for a number of collection points around the globe (U.N. Food and Agriculture Organization 2010). Using these data we construct two variables containing the average monthly precipitation levels for countries that produce high levels of rice and sugar.[17] In constructing this variable, we exclude rice producing countries that have reported cases of piracy. While this is not possible for sugar producing countries, which are almost all prone to piracy, this provides us additional insurance that precipitation has no independent effect on attacks. For example, this rules out the possibility that conducting attacks is more difficult in high precipitation months. Following Stock and Watson (2003), we test whether these instruments are sufficient using an F-test in which the sum of the squared residuals from the model is compared to a model without instruments (Table 6). Precipitation appears to be a good instrument for both sugar and rice prices.[18]

In our model both commodity pricing and the interaction between price and production are endogenous variables requiring instruments. We follow the advice of Wooldridge 2010 and instrument for both for *RicePrice* and *SugarPrice*, as well as the interaction between prices and production. In order to obtain accurate standard error estimates we bootstrap the combined system of equations using a fixed block bootstrapping method appropriate for time series data (Canty 2002). Since bootstrapped estimates can be sensitive to certain violations of independence and normality (Horowitz 2001), we also include more traditional two-stage least squares estimates. A detailed discussion of both techniques is in the supplementary appendix.

Our instrumented results remain consistent with our previous results, supporting our claim that prices have an independent effect on the number of attacks. In both the bootstrapped poisson estimates and the two-stage least squares estimates, the interaction coefficient remains negative and significant. In both cases our standard error estimates for sugar are large, however this may be due to the weaker effect of precipitation on sugar pricing.

[Table 4 Here]

## *Conclusion*

Piracy is an increasingly common and costly problem. Yet we have little quantitative research on how pirate groups operate, and existing efforts to deter pirate groups have had little measurable effect.

We make a number of novel contributions. First, we extend a growing literature on the drivers of piracy by providing both an original theory and novel empirical test of the role of labor opportunity costs on pirate attacks. By doing so, we also contribute to a larger literature on the role of labor opportunities in the behavior of predatory groups. Our primary finding—that labor opportunity costs constrain pirate behavior—demonstrates that conclusions from this existing literature can be more generally applied.

Using an original dataset, we establish that the number of attacks in piracy-prone states is sensitive to returns in labor and capital-intensive sectors. We establish that, in countries that produce rice and sugar, the global price of rice and sugar is negatively correlated with attacks. In oil-producing countries, oil prices are positively correlated with attacks. We take this as evidence that attacks decrease as wages in unskilled sectors rise. Using rainfall as an instrument for commodity prices, we can suggest a plausible causal link.

Finally, we also contribute to our understanding of the evolution and deterrence of Somali piracy. Using data on deterrence efforts in the Gulf of Aden and the Red Sea, we show that these efforts have had an ambiguous effect on the overall number of attacks. In addition we show that the recent increase in attacks in 2008 coincided with a collapse of the Somali currency and a sharp reduction in the average wage rate for unskilled labor. These results reinforce our contention that labor opportunities constrain pirate activity.

Unfortunately current trends in both poverty and attacks suggest that both are only likely to worsen.[19] Many questions await further research, but one possible implication of our findings is that an effective response to these attacks should take into account coastal development, and, in particular, wage trends among less skilled laborers. However, addressing these root causes is both difficult and costly, and will require significant coordination among the international community.

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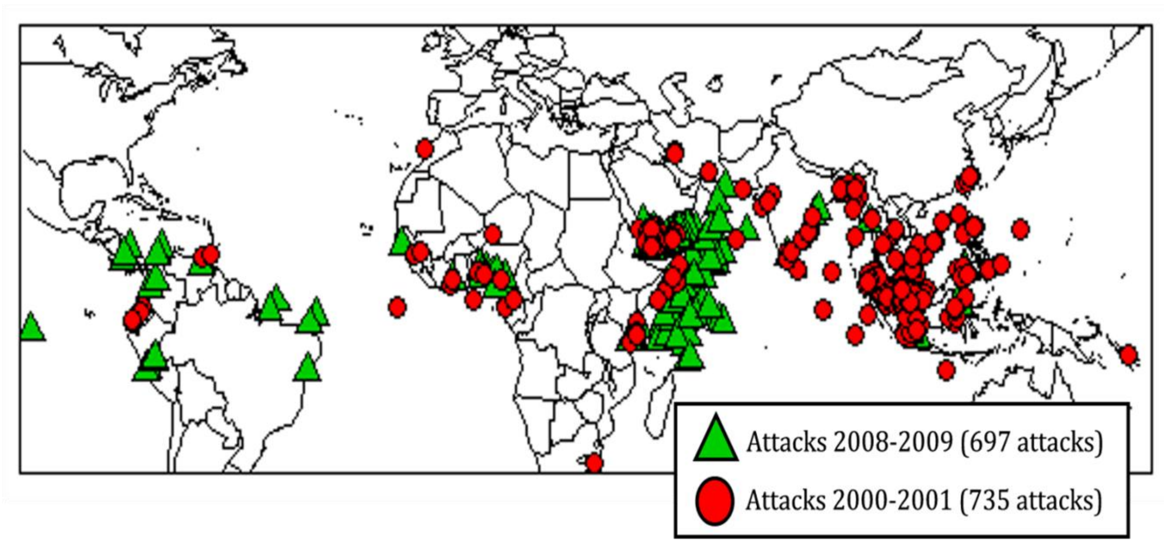
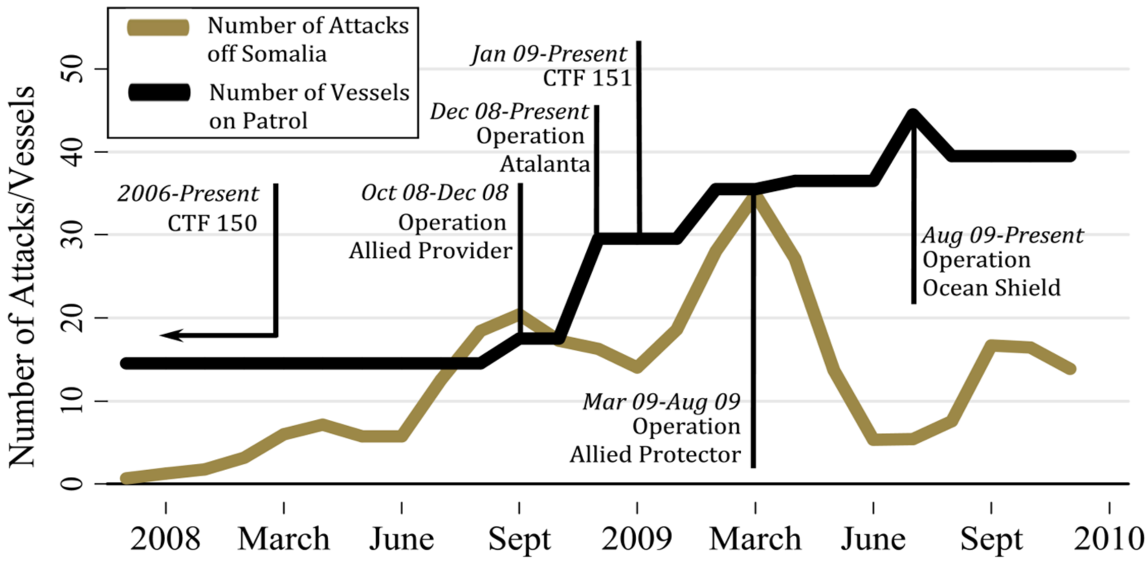
Figure 1: The Geography of Piracy



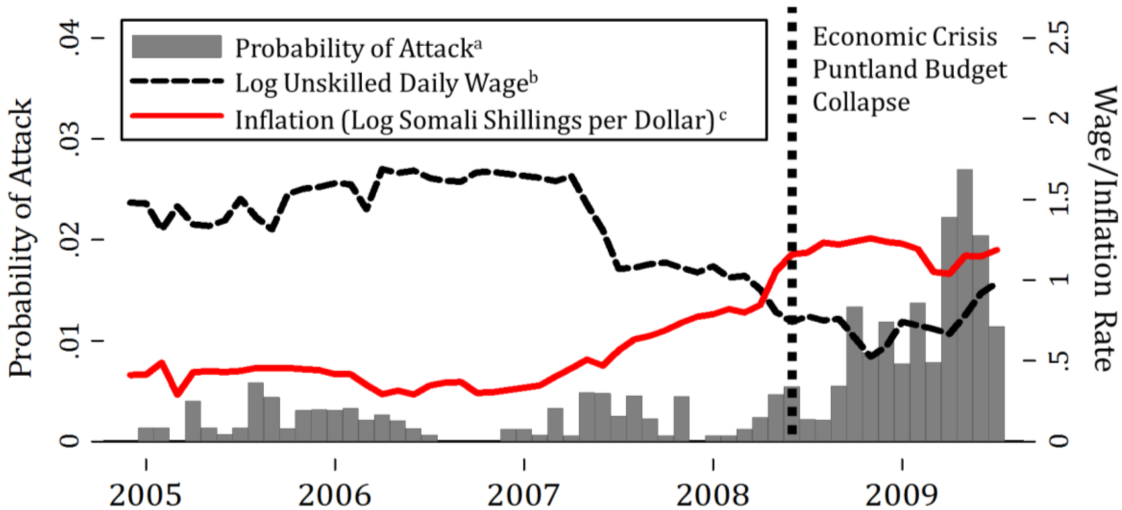

Each dot indicates the location of a pirate attack. These coordinates are based upon location information provided to the International Maritime Organization (IMO) at the time of the attack.

Figure 2: International Piracy Deterrence Efforts



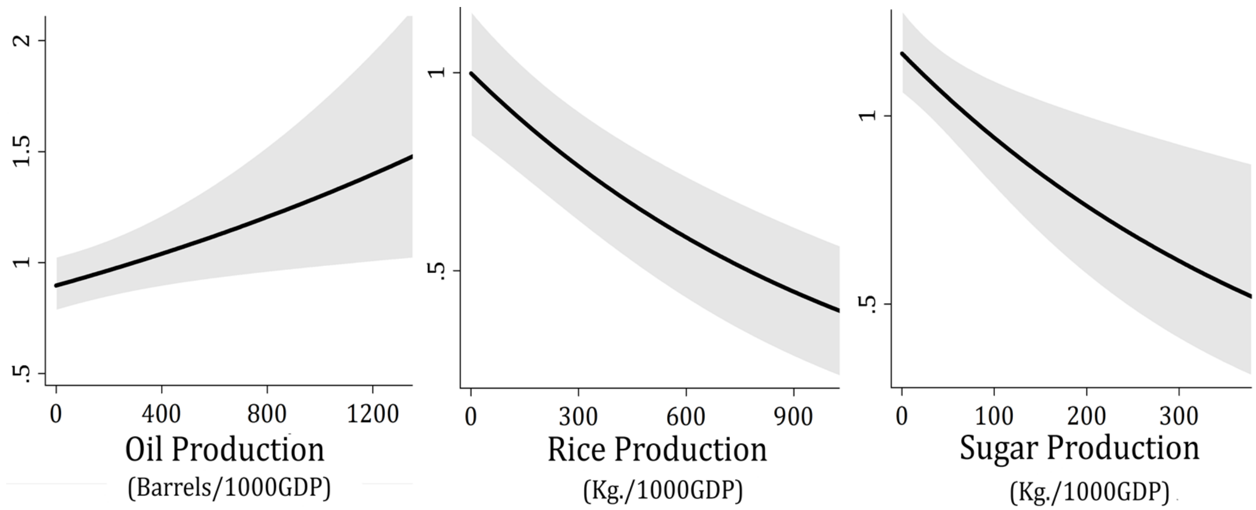

The beginning dates and force levels come from the official websites for each naval operations. In some cases, force levels vary on a regular basis, in which case we use the average vessel count. Data and sources are available in the supplementary appendix.

Figure 3: Labor Rates, Inflation and the Rise of Somali Piracy




[a] The probability of attack equals the number of attacks in a month by the number of vessels transiting the Suez Canal (Suez Canal Authority 2010).
[b] Somali unskilled daily labor rates (normalized to 2000 USD) are from the Food Security Analysis Unit (FSAU) for Somalia.
[c] The Somali exchange rate (in 10,000 shillings) is calculated using data from the Food Security Analysis Unit (FSAU) for Somalia.

Figure 4: Effect of Commodity Prices on Pirate Attack Incident Rates




These incident ratios provide the effect on a standard deviation increase in price on the rate of attacks for each level of production. These ratios are calculated as IRR = $\exp(b_1 * \text{Production} + b_2)$, following Hilbe (2007). The shaded areas show 95% confidence intervals.

Table 1: Effect of Unskilled Labor Prices on Somali Attacks [a]

| | |
|---|---|
| Unskilled Labor Price * 2008 | -2.5 (0.85)*** |
| Year 2008 | -7.2 (1.9)*** |
| Unskilled Labor Price | 0.09 (0.23) |
| Conflict Events | -0.37(0.23) |
| Naval Vessels | 0.83 (0.44)* |
| State Fragility | 2.8 (1.7) |
| Vessel Traffic (Suez) | -0.24 (0.59) |
| Cyclone Season | 1.6 (0.81)* |
| Observations | 93 |
| Log Likelihood | -164.9 |

Standard errors in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

[a] The dependent variable is the monthly count of attacks from 2000-2009. Estimated using a negative binomial regression with time trends (month and month$^2$), yearly GDP, yearly population levels, and month fixed effects as additional controls.

Table 2: Data Summary

| | Mean | SD | Min | Max | Mean Rice Producer | Mean Sugar Producer | Mean Oil Producer |
|---|---|---|---|---|---|---|---|
| Monthly PirateAttacks | 0.67 | 2.1 | 0.0 | 40.0 | 0.73 | 0.71 | 0.78 |
| NonTanker Attacks | 0.61 | 1.9 | 0.0 | 40.0 | 0.68 | 0.66 | 0.72 |
| Oil Price (USD/Barrel) | 39.28 | 18.6 | 16.5 | 102.5 | n/a | n/a | n/a |
| Avg Oil Production (Bls/1000 GDP) | 127.0 | 269.3 | -0.8 | 1629 | 110.06 | 97.68 | 183.09 |
| Rice Price (USD/Ton) | 316.1 | 178.3 | 162.1 | 1015 | n/a | n/a | n/a |
| Avg Rice Production (Kg./1000 GDP) | 111.2 | 209.5 | 0.00 | 1527 | 127.20 | 125.00 | 126.39 |
| Sugar Price (US Cents/Pound) | 2.2 | 0.25 | 1.8 | 3.0 | n/a | n/a | n/a |
| Sugar Production (Kg./1000 GDP) | 21.7 | 60.7 | 0.0 | 482 | 24.21 | 24.92 | 11.41 |
| Vessel Traffic (Suez Canal) | 1415 | 229.9 | 1010 | 1993 | n/a | n/a | n/a |
| Vessel Traffic (Singapore) | 10832 | 412.4 | 9604 | 11744 | n/a | n/a | n/a |
| GDP (Billion USD) | 134.9 | 381.0 | 0.6 | 3925 | 474.77 | 10.42 | 87.86 |
| Population (Millions) | 98.89 | 256.7 | 0.8 | 1326 | 403.44 | 10.90 | 56.31 |
| Precipitation Rice (mm) | 78.43 | 23.98 | 40.4 | 136.3 | n/a | n/a | n/a |
| Precipitation Sugar (mm) | 75.37 | 20.01 | 40.4 | 141.8 | n/a | n/a | n/a |

In all regressions the independent variables are standardized to deviations from the mean to simplify interpretation.

Table 3: Effect of Commodity Prices on Piracy Attacks by Production Levels[a]

*Regression Results*

| | Rice Model1 | Sugar Model2 | Oil Model3 | All Model4 |
|---|---|---|---|---|
| Rice Price* Rice Production | -0.19*** (0.04) | | | -0.18*** (0.04) |
| Rice Price | -0.10 (0.08) | | | -0.07 (0.09) |
| Rice Production | -0.24** (0.11) | | | -0.24** (0.11) |
| Sugar Price* Sugar Production | | -0.13*** (0.04) | | |
| Sugar Price | | 0.11** (0.05) | | |
| Sugar Production | | -0.11 (0.12) | | |
| Oil Price * Oil Production | | | 0.09*** (0.04) | 0.05 (0.04) |
| Oil Price | | | -0.06 (0.07) | -0.06 (0.07) |
| Oil Production | | | 0.19 (0.23) | 0.01 (0.22) |
| Vessel Traffic (Suez) | 0.16* (0.08) | 0.09 (0.08) | 0.17* (0.09) | 0.19** (0.09) |
| GDP | -0.78*** (0.16) | -0.57*** (0.14) | -0.56*** (0.14) | -0.77*** (0.17) |
| Population | 2.65*** (0.38) | 2.14*** (0.33) | 2.14*** (0.33) | 2.66*** (0.39) |
| *Observations* | 4662 | 4662 | 4662 | 4662 |
| *Log Likelihood* | -3462 | -3467 | -3473 | -3461 |
| Year Fixed Effects | Yes | Yes | Yes | Yes |
| Country Fixed Effects | Yes | Yes | Yes | Yes |

*Incident Ratios at Varying Levels of Production*

| | Rice Price | Sugar Price | Oil Price |
|---|---|---|---|
| Max Production | .39 (.08) | .52 (.14) | 1.49 (.29) |
| Mean Production | .90 (.07) | 1.12 (.05) | .94 (.06) |
| Min Production | 1.00 (.08) | 1.17 (.06) | .90 (.06) |

Standard errors in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

[a] Negative binomial regression with yearly GDP, yearly population levels, and monthly shipping levels through the Suez Canal as controls. Also includes year and country fixed effects.

[b] These incident ratios provide the effect on a standard deviation increase in price on the rate of attacks for each level of production. These ratios are calculated as IRR = exp($\beta_1$ *

Production + $\beta_2$), following Hilbe (2007).

Table 4: Effect of Commodity Prices on Piracy Attacks by Type[a]

| | Robberies | Hijackings | Kidnappings |
|---|---|---|---|
| | *Rice Model* | | |
| Rice Price * Rice Production | -0.10** (0.04) | -0.33 (0.29) | -2.05*** (0.79) |
| Rice Price | 0.04 (0.09) | 0.53 (0.47) | -1.09** (0.47) |
| Rice Production | 0.08 (0.16) | -0.89 (0.61) | -2.83*** (0.65) |
| *Observations* | 4,662 | 4,662 | 4,662 |
| *Log Likelihood* | -2587 | -275.4 | -283.9 |
| | *Sugar Model* | | |
| Sugar Price * Sugar Production | -0.12*** (0.05) | 0.43 (0.48) | 0.82 (1.29) |
| Sugar Price | -0.12* (0.07) | -0.17 (0.29) | 0.25 (0.43) |
| Sugar Production | -0.11 (0.12) | -1.06 (1.22) | -1.88 (2.85) |
| *Observations* | 4,662 | 4,662 | 4,662 |
| *Log Likelihood* | -2584 | -276.7 | -301.1 |
| | *Oil Model* | | |
| Oil Price * Oil Production | 0.06 (0.04) | -0.18 (0.39) | -0.04 (0.14) |
| Oil Price | 0.01 (0.08) | -0.12 (0.38) | -0.52** (0.23) |
| Oil Production | -0.11 (0.17) | -0.70 (0.77) | -0.17 (0.64) |
| *Observations* | 4,662 | 4,662 | 4,662 |
| *Log Likelihood* | -2589 | -277.3 | -299.3 |

Standard errors in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

[a] Estimated using a negative binomial regression with yearly GDP, yearly population levels, and monthly shipping levels through the Suez Canal as controls. Also includes year fixed effects and country random effects.

Table 5: Additional Specifications for the Effect of Commodity Pricing on Attacks[a]

| | Monsoon[b] | State Fragility[c] | Malacca Shipping[d] | No Somalia[e] | No Tanker[f] |
|---|---|---|---|---|---|
| | | *Rice Model* | | | |
| Rice Price * Rice Production | -0.19*** | -0.12** | -0.13*** | -0.13*** | n/a |
| | (0.04) | (0.05) | (0.05) | (0.04) | |
| Rice Price | -0.07* | -0.09 | 0.02 | -0.06 | n/a |
| | (0.04) | (0.08) | (0.08) | (0.08) | |
| Rice Production | -0.20* | -0.27** | -0.29 | -0.27** | n/a |
| | (0.11) | (0.14) | (0.21) | (0.12) | |
| *Observations* | 4,662 | 4,248 | 2,148 | 4,554 | |
| *Log Likelihood* | -3467 | -3228 | -1404 | -3218 | |
| | | *Sugar Model* | | | |
| Sugar Price*Sugar Production | -0.12*** | -0.12*** | -0.13 | -0.12*** | n/a |
| | (0.04) | (0.04) | (0.10) | (0.04) | |
| Sugar Price | -0.05* | 0.16*** | -0.11 | 0.05 | n/a |
| | (0.03) | (0.05) | (0.08) | (0.05) | |
| Sugar Production | -0.10 | -0.18 | -0.11 | -0.15 | n/a |
| | (0.13) | (0.12) | (0.24) | (0.12) | |
| *Observations* | 4,662 | 4,248 | 2,148 | 4,554 | |
| *Log Likelihood* | -3476 | -3222 | -1407 | -3221 | |
| | | Oil Model | | | |
| Oil Price * Oil Production | 0.09** | 0.11** | 0.01 | 0.13*** | 0.08** |
| | (0.04) | (0.05) | (0.06) | (0.04) | (0.04) |
| Oil Price | -0.05 | -0.06 | -0.01 | -0.07 | -0.05 |
| | (0.06) | (0.07) | (0.07) | (0.08) | (0.07) |
| Oil Production | 0.17 | 0.07 | -0.11 | -0.03 | 0.25 |
| | (0.22) | (0.29) | (0.26) | (0.22) | (0.26) |
| *Observations* | 4,662 | 4,248 | 2,148 | 4,554 | 4,662 |
| *Log Likelihood* | -3479 | -3230 | -1409 | -3221 | -3357 |
| Year Fixed Effects | No | Yes | Yes | Yes | Yes |
| Seasonal/Month Effects | Yes | No | No | No | No |
| Time Trends | No | No | No | Yes | No |
| Fragility Controls | No | Yes | No | No | No |
| Country Fixed Effects | Yes | Yes | Yes | Yes | Yes |

*p<10%; **p<5%; ***p<1%. Standard errors in parentheses.

[a] Estimated using a negative binomial regression with yearly GDP, yearly population levels, and monthly shipping levels through the Suez Canal as controls.

[b] Includes controls for civil war, state fragility, and governance.

[c] Includes a dummy variable for monsoon season in South Asia as well as month fixed

effects.

[d] Excludes attacks in Somali waters. . Also includes time trends include (time and time squared in months.

[e] Excludes all attacks reported on oil tankers.

Table 6: Instrumental Variable Results for the Effect of Commodity Pricing on Attacks

| | *Poisson Bootstrap*[a] | | *Two-Stage Least Squares* | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| RicePrice* $\widehat{\text{Rice}}$Production | -0.19** | | -0.11*** | |
| | (0.08) | | (0.02) | |
| $\widehat{\text{RicePrice}}$ | 0.34 | | 0.10 | |
| | (0.25) | | (0.18) | |
| Rice Production | -0.07 | | | |
| | (0.07) | | | |
| SugarPrice*$\widehat{\text{Sugar}}$Production | | -0.14* | | -0.02 |
| | | (0.08) | | (0.03) |
| $\widehat{\text{SugarPrice}}$ | | -0.01 | | 0.05 |
| | | (0.16) | | (0.14) |
| Sugar Production | | -0.05 | | |
| | | (0.06) | | |
| Num Obs | 4030 | 4030 | 3831 | 3831 |
| Year Fixed Effects | Yes | Yes | Yes | Yes |
| Country Fixed Effects | No | No | Yes | Yes |
| Country Random Effects | Yes | Yes | No | No |

*p<10%; **p<5%; ***p<1%. Standard errors in parentheses. Included but not shown are controls for population, GDP, vessel traffic and a binary variable for the East Asia Monsoon Season.

[a] Estimated using a Poisson model with corrections for over dispersion and country random effects. Standard errors are bootstrapped. Additional details on our estimation technique are listed in the supplementary appendix.

[1] This definition corresponds to the IMO's *de facto* definition of piracy. This differs from the *de jure* definition under the UN Convention on the Law of the Sea (1982) which restricts the definition of piracy to acts in international waters.

[2] A summary of countries in our dataset is provided in the supplementary appendix.

[3] This assumes perfect competition (factors move without cost between sectors) and constant returns to production.

[4] For evidence see  Krugman and Obstfeld 2008

[5] Estimate is based upon the monthly number of attacks and the monthly number of vessels transiting the Suez Canal. Since we cannot account for non-transiting traffic, the actual ratio (including non-transiting traffic) is likely lower.

[6] The number of battle events increased from 511 to 593 in 2008 and dropped to 347 in 2009, though only a few dozen of these attacks were located in northern Somalia (Raleigh, Linke, Hegre, Karlsen 2010). Fatality eestimates for these years are 1393, 1483 and 1471, respectively (Harbom and Wallensteen 2010).

[7] United Nations Dept. of Public Information. (2008). "Security Council authorizes states to use land-based operations in Somalia." Retrieved from http://www.un.org/News/Press/docs/2008/sc9541.doc.htm.

[8] "Inflation adds more hardship to war-weary Somalis." *Reuters*. April 28, 2008.

[9] "Humanitarian situation in Somalia worsens." *USA Today.* April 11, 2008; "Somali Capital Reportedly on the Brink of Starvation." *Voice of America*. March 4, 2008; "Somali Food Protest 'Turns Ugly'." *Associated Press*. May 7, 2008.

[10] "Somalia: Irresponsible policies leading to the destruction of a fragile economy." *GaroweOnline (Puntland).* April 20, 2008; "Somalia: Islamic clerics in Puntland propose private security force." *GaroweOnline (Puntland).* April 19, 2008.

[11] We select these two commodities since most piracy is concentrated in East Asia, North Africa, and West Africa – regions which consistently produce high levels of rice, sugar and/or petroleum. A list of production levels by country is in the supplementary appendix.

[12] In a very few cases (approximately 1% of reports), the nearest country of attack cannot be coded due to missing information or disputed territory. We exclude these cases from analysis.

[13] Since attacks are self-reported these data may underreport less significant cases or cases in which victims feel threatened. This bias will prejudice us against a finding if attacks on smaller vessels are more sensitive to labor costs.

[14] One objection is that production levels are not independent of price. This issue is difficult to address without monthly production levels and due to time-to-market delays. However this issue is addressed in our instrumentation technique.

[15] The need for an instrument for petroleum is less crucial since an effect of piracy on oil prices implies a negative relationship between price and attacks. We predict a positive relationship.

[16] We validate this is the case by omitting the Singapore shipping variables, but retaining the same sample. The coefficients and standard errors on our treatment variables remain largely identical.

[17] We define high production countries as those in the top 50% of production. Also note that since FAO does not have complete coverage for our entire sample, we drop some observations from the analysis.

[18] Stock and Watson (2003) suggest that an F-statistic under 10 suggests a problem of weak instruments. Since we use multiple instruments, a larger F-statistic is preferred.

[19] Survey evidence suggests that poverty increased by 20% in Somalia in 2010. Post Deyr 2010/11 Analysis. FSNAU. February 2011. http://www.fsnau.org/products/quarterly-briefs (accessed February 17, 2011). Piracy attacks have similarly increased 40% during 2010.