Security in the Absence of a State:
Traditional Authority, Livestock Trading, and Maritime Piracy in Northern Somalia

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Abstract

Without a strong state, how do institutions emerge to limit the impact of one group’s predation on another’s economic activities? Motivated by the case of northern Somalia, we develop a model that highlights the monitoring challenges that groups face in making cooperation self-enforcing, and two key parameters that influence their likelihood of overcoming this challenge: the ratio of economic interests across productive and predatory sectors, and the existence of informal income-sharing institutions. We argue that the model helps explain why conflicts between pirates and livestock traders can be resolved in the region of Somaliland, where the ratio of economic interests favors the productive sector and traditional institutions promote income sharing between groups, but not in the region of Puntland, where these conditions do not hold. Our theory accounts for empirical patterns in the relationships between piracy, livestock exports, and conflict in both regions.

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1 Introduction

An important function of the state is to promote cooperation among groups, limiting the inefficient externalities that one group’s predation creates for the productive activities of another.\footnote{Hobbes (1651) in \textit{Leviathan} argued that the state’s authority derives from a social contact to maintain order and avoid a collapse to the disorderly and violent “state of nature.” The idea that the state has a role in protecting property rights, and fostering development, was further developed in several literatures, notably by Olson (2000), Evans (1995) and others in the literature on the “developmental state.” In recent work, Tyson (2015) studies challenges to the endogenous emergence of such states.} To provide this function, the state requires the institutional capacity to maintain law and order, enforce contracts, and engender peace. In some states, the formal institutions that support cooperation are insufficient or even absent entirely, and it is up to rival groups to locate and implement a \textit{self-enforcing agreement} that finds peace between them.\footnote{Prior work has argued that self-governance or private governance can lead to welfare improvements when the state is absent, even though it may not achieve first-best outcomes (Dixit, 2003, Leeson, 2009).}

Existing work, particularly the literature on repeated games, provides some answers to when and how cooperation can be made self-enforcing. Much of this theory is abstract, however, and does not provide specific insights into how cooperation is sustained in particular applications. As Kandori and Obayashi (2014) have argued, empirical case studies motivated by the theory of cooperation, such as those in Ostrom (2015), provide detailed studies of particular cases without developing models that engage the existing theory.\footnote{Kandori and Obayashi (2014) fill the gap by studying the mode of cooperation between labor union members in Japan, and showing that it fits the model of an overlapping generations repeated game. Other detailed studies of cooperation in specific examples include Igami and Sugaya (2017), who study collusion among vitamin producers in the 1990s, and Chassang and Ortner (2015), who study collusion among bidders in procurement auctions in Japan. To our knowledge, there is no such study in political economy.}

This paper contributes to filling the gap by studying conflict and cooperation in northern Somalia, where formal state institutions have been largely absent. In this region of Africa, traditional clan-based authorities operating locally at the level of sub-clans or lineage groups (hereon simply “clans”) have been able to discover and support a system of cooperation between their members with varying degrees of success.

For the past twenty years, and throughout much of Somalia’s history, the provision of basic public goods such as economic governance and security has been the purview of clan leaders who rely on the informal institutions of traditional clan authority (LeSage, 2005). Somalia’s longtime ruler, Siad Barre, sought to dismantle traditional institutions and limit the authority of clan leaders, but clan structures were resilient to his efforts and the country reverted to these institutions after his regime and the Somali state collapsed in 1991. Clanship remains the fundamental basis of security in Somali society (Gundel, 2006, Lewis, 2004).

As the key providers of local governance in northern Somalia, clan leaders have grappled with the dramatic rise in maritime piracy in the Gulf of Aden that took place after 1991. In addition to damaging international trade, this increase in piracy has affected the terms of Somalia’s crucially important livestock sector. Even when pirating attacks are not directed
at ships transporting Somali livestock abroad (as they typically are not), piracy hurts the livestock trade because it increases shipping and insurance costs. The income of Somalia’s livestock herders is thus inversely related to the frequency and scale of pirating attacks off the Somali coast, creating the potential for conflict between clans that vary in the extents to which piracy and the livestock trade contribute to their income. Without a state to enforce cooperation, clan leaders have had to find peaceful ways to resolve their differences.

Clans in the two northern Somali regions of Somaliland and Puntland have shown markedly different levels of success in their ability to find peace. Clan leaders in Somaliland have been able to find ways of cooperating, building an agreement that has begun to resemble a formal state. They have done so by promoting a traditional system of cooperative income sharing that goes back to pre-colonial times. Puntland, in contrast, remains an economically fragmented, conflict-ridden society, with high levels of violence and weak state institutions.

Motivated by the differences between Somaliland and Puntland, we develop a model that explains why cooperation would be more plausible in Somaliland than in Puntland. The model highlights two key features of the relationship between livestock traders and pirates. The first is that the livestock traders have incentives to sanction piracy when they have evidence that it is on the rise. The second is that it is difficult to monitor piracy. The traders cannot know just how much piracy is taking place, and must infer it from noisy signals of pirate activity such as their own revenues and the observable income of the pirates. This feature makes it impossible to sustain a self-enforcing agreement in which there is perpetual cooperation between the two groups; but some cooperation may be possible with the help of these noisy signals.

In times when livestock exports are up, clans that rely comparatively more on livestock income cooperate with those that rely relatively more on piracy income by sharing part of their income from the livestock trade in exchange for the pirates reducing their overall level of piracy. This benefits the livestock group because it mitigates the negative externality that piracy has on the livestock trade. However, to provide the pirates with the incentive to lower their piracy, the livestock traders must (credibly) threaten the pirating clans with conflict when they have evidence that piracy is on the rise. Because the evidence for piracy is noisy, conflict will sometimes take place even though the pirates are not cheating.

For this mode of cooperation to be self-enforcing, two conditions must be met: (i) the punishment to pirates for cheating should be sufficiently great so as to deter it—which happens when livestock interests overwhelm pirating interests—and (ii) the rewards to pirates for cooperating must be sufficiently great—which happens when clan leaders can successfully encourage existing practices of income sharing in society. Both of these conditions are met in Somaliland but not in Puntland.

Our model helps make sense of three patterns that we see in the data from Somalia. The first is that piracy is lower off the coast of Somaliland when livestock export levels are high, but there is no relationship between piracy and livestock exports in Puntland. The second is that
increases in conflict appear to follow increases in piracy in both regions, but this relationship is subject to more noise in Somaliland. The third is that export price drops appear to be followed by periods of conflict in Somaliland, but not in Puntland.

Our paper contributes to the literature on inter-group cooperation and political order under anarchy. In this literature, Bates, Greif and Singh (2002) develop a theory in which property rights can emerge in stateless societies, provided that "citizens ... also invest in the capacity for violence" (p. 624). Skaperdas (1992) argues that cooperation can result if one group can dominate the other, consistent with our argument that the dominance of the livestock sector helps explain why we see greater cooperation in Somaliland. Fearon and Laitin (1996) study the role of in-group social sanctioning in enforcing cooperation across groups, suggesting that group leaders (in our case, clan elders) play a role in encouraging cooperation.\footnote{Fearon and Laitin (1996) also relates to our work in that it studies cooperation under moral hazard. Other papers in the political economy literature that also study cooperation under moral hazard include Yared (2010), Padró i Miquel and Yared (2012) and Shapiro and Siegel (2012).}

Our paper also relates to prior studies of the consequences of statelessness in Somalia, and the divergent development trajectories of Somaliland and Puntland.\footnote{One recent contribution in this literature that is relevant to our work is that of Leeson (2007), who suggests that because of statelessness, governance institutions have developed from the bottom up in a self-enforcing manner. He argues that Somalia has been "better off stateless" after the fall of the Barre regime.} Eubank (2012), for example, attributes the success of Somaliland to the absence of a foreign aid curse. Hansen (2009) focuses on formal institutions in Somaliland and their conspicuous absence in Puntland. Like us, Azam (2006, 2010) emphasizes the importance of income sharing in Somaliland, and suggests that ethnic heterogeneity and fiscal institutions play a key role in explaining the differences between Somaliland and Puntland. However, in his model, ethnic heterogeneity has made Puntlanders relatively myopic, which, combined with the weaker ability of the Puntland government to raise revenue and discipline bandits, has hindered cooperation.

Finally, our paper relates to work on the effects of economic shocks on conflict (e.g. Dal Bó and Dal Bó, 2011, Dube and Vargas, 2013, Bazzi and Blattman, 2014). This literature has focused on the effects of economic structure through a traditional "resource curse" channel and an alternative "opportunity cost" channel. In particular, if predation is more labor intensive than production, predation rises with positive shocks to capital intensive industries but declines with positive shocks to labor intensive ones. Our work suggests a different possibility: price shocks affect conflict by acting as noisy signals of cheating and cooperation.

2 Background to Northern Somalia

Our model simplifies the northern Somali economy into two sectors, livestock trading and piracy, and Somali society into two groups based on clan heritage —those that rely comparatively more on the livestock trade for income and those that rely comparatively more on
piracy. In this section, we justify this approach. We first provide a brief background to the two main economic sectors of our focus, the livestock trade and piracy. We then describe how clan structures and authority vary across Somaliland and Puntland. The key differences are that (i) clans with relatively greater interest in livestock trading, as opposed to piracy, are more predominant in Somaliland than in Puntland, and (ii) although clan authority is important in both regions, clan leaders are a significantly stronger source of authority in Somaliland, especially when it comes to promoting cooperation through income sharing across groups.

2.1 The Livestock Trade

The largest economic sector in northern Somalia is the livestock trade, which accounts for about a third of GDP in northern Somalia. Majid (2010, p. 11) reports that the northern Somali livestock trade involves the export of more than US$200 million worth of live animals across the Gulf of Aden each year. Livestock exports through the port of Bosasso in Puntland alone brought in $113 million in 2011 (Oliver, Jablonski and Hastings, 2014).

The main foreign buyer of Somali livestock is Saudi Arabia, and the main export among varieties of livestock is goat, though camels and cattle are also common. Saudis prefer Somali livestock to alternatives from other major providers such as Australia, due to its provenance from a Muslim country. This is especially the case during the Hajj season when demand is high.

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See, e.g., the World Bank’s January 29, 2014 press release “New World Bank GDP and poverty estimates for Somaliland,” and the Somali Ministry of Planning and Statistics press release titled, “Puntland Facts and Figures 2003,” which also reports that the livestock trade accounts for 60% of employment opportunities in Puntland, and 80% of foreign exchange earnings.
due to the sharp increase in pilgrims visiting Mecca. Somali livestock traders employ shipping companies to move livestock across the Gulf of Aden with the majority of these companies owned by businessmen from Somalia, Yemen, Saudi Arabia, and Pakistan, who typically start their shipments at the two main shipping ports of Berbera in Somaliland and Bosasso in Puntland. Local sellers at these ports are often middlemen who buy livestock from nomadic pastoralists and bring them to the ports, which are linked to the hinterland through a series of clan-based networks that manage the transportation and trade of livestock (Majid, 2010). These trade networks are of ancient origin, with clan-based protection for livestock caravans noted from the fourteenth century (Umar and Baulch, 2010, p. 16).

Clan authority is critical to the operation of the livestock trade. The clan-based insurance system mitigates risk for herders and traders in a context where clan arrangements provide the only form of security against issues such as infringements of grazing rights, animal theft, and reneging on loan agreements (Umar and Baulch, 2010, p. 18). For example, dispute resolution falls under the purview of clan leaders who act as judges in an ad hoc court known as guddi in which traditional xeer law is expected to prevail. This is a form of customary law, which has evolved to maintain a set of principles that are applicable to any type of situation or conflict, and as such is almost never silent on any given conduct (van Notten, 2005). This system of informal local economic governance provides strong disincentives against economic misconduct through a norm of collective liability known as the diya system, under which the entire clan becomes liable for a breach of contract by any one of its members.

Our main data on the livestock trade are depicted in Figure 1, which shows livestock exports over time from the two ports of Berbera and Bosasso, measured as the number of heads of livestock (summing over camels, cattle, and goats) exported monthly from each of the two ports. The data reveal three patterns worth noting. First, there is a seasonality in trade with exports rising sharply during the Hajj. Second, there has been a gradual increase in exports since November 2009 after the removal of a Saudi ban on Somali livestock that started in 2000 following an outbreak of Rift Valley Fever in Yemen and Saudi Arabia. Third, exports from Berbera have been higher after 2009 than exports from Bosasso.

2.2 Piracy

There is a long history of predation against foreign vessels around the Somali coast, and of piracy directed against the dhow (shipping) trade that plies the Gulf of Aden (de Wijk, 2003). Modern application of the law accommodates certain aspects of shariʿa law as well, though when the two might conflict shariʿa law is typically subordinated to clan traditions (Gundel, 2006).

Summary statistics for these data, and all other data used in this paper, are given in Table 3 in the appendix.

During the ban, exports to Saudi Arabia from Berbera were severely limited, though unofficial exports and indirect exports continued to hold (with livestock being first exported to Djibouti, quarantined and checked for illness before being sent to Saudi Arabia).
Anderson and Haines, 2010). While these predatory activities were restricted under the Barre regime, maritime piracy off the Somali coast exploded after the regime collapsed in 1991. Figure 2 shows monthly counts of piracy incidents from February 2000 to December 2012 within a 250 kilometer radius of the ports of Berbera and Bosasso. The figure highlights the significant variation in rates of piracy, both spatial and temporal, across the northern Somali coast. In terms of spatial variation, the key notable pattern is the greater number of pirate attacks off the coast of Bosasso than off the coast of Berbera.

The World Bank estimates that ransom payments from piracy have brought in an annual average of $53 million to the Somali economy since 2005, and ransom payments in 2011 alone from pirate attacks in the Gulf of Aden generated $163 million in revenue. These numbers indicate that although piracy is a smaller sector than the livestock trade, it is still a large income generator in northern Somalia. At the same time, it has the potential to produce negative spillover effects on the wider Somali economy, including the livestock trade. For example, during periods of intense piracy the number of ships willing to ply the routes between northern Somalia and the Arabian Peninsula declines, often leading to an over-supply of livestock at Somali ports, which in turn drives down the prices received by traders and herdsmen.

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10See the World Bank report titled “The Pirates of Somalia: Ending the Threat, Rebuilding the Nation.” Similarly large figures are estimated by Besley, Fetzer and Mueller (2015), who report that Somali piracy has produced revenues for pirates of approximately $120 million, but the global welfare loss from this piracy (mainly in the form of shipping, monitoring and insurance costs) exceeds $630 million.
Another channel by which piracy hurts the livestock trade is by increasing shipping and insurance costs. Agreements between traders and shipping agents factor in some potential losses that may occur during the sea journey, with exporters bearing up to 1% of loss of sheep and goats, and 2% of cattle. Any losses exceeding these are typically compensated by the shipping company (Umar and Baulch, 2010, p. 35). As a result, increases in piracy that make sea journeys across the Gulf of Aden more dangerous increase the risks that shipping companies face, raise transportation costs and driving down their value from trade. Besley, Fetzer and Mueller (2015) estimate that the upsurge in Somali piracy in 2008 led to an 8-12% increase in international shipping costs, which they attribute mostly to higher insurance and security costs. Therefore, although the vessels attacked by pirates might not themselves always represent local victims, Somali piracy is harmful to the livelihoods of many Somalis if it negatively affects the terms of the Somali livestock trade.\footnote{Oliver, Jablonski and Hastings (2014) suggest yet another by which Somali piracy hurts the Somali economy. They estimate that ransom earnings from Somali piracy had the effect of appreciating the local currency and reducing export competitiveness.}

We lack direct quantitative evidence on the harmful effects of piracy on the terms of the livestock trade. However, some qualitative evidence is borne out by local news reports that highlight the increased shipping costs, as trade ships charge higher transportation costs due to greater security expenses.\footnote{See for example “The Real Costs of Piracy on Locals”, \textit{SomaliaReport}, 03/27/2011, and “Life in Bosaso”, \textit{SomaliaReport}, 03/01/2012.} Although the international media tends only to report the most audacious attacks on international tankers and container ships, for many years Somali pirates have targeted the cargo dhows and light coastal freighters that make up the bulk of the area’s maritime trade.\footnote{“Somalia Pirates’ Last Stand”, \textit{African Business}, 01/03/2000.} This includes vessels of different sizes transporting livestock to the Arabian peninsula out of both Berbera and Bossaso.\footnote{“Somalia: Puntland force prepares to rescue livestock boat from pirates”, \textit{Garowe Online}, 04/03/2010; “Pirates Hijack UAE Vessel, Says Official”, \textit{SomaliaReport}, 07/14/2011; “Weekly Piracy Report”, \textit{SomaliaReport}, 08/12/2011; “Daily Media Roundup”, \textit{SomaliaReport}, 08/15/2012.} In 2011, for example, pirates captured a livestock ship in the runup to the Hajj, the most lucrative part of the year for the livestock trade, and were reportedly killed within hours by “irate traders and herders.”\footnote{“Hope is four-legged and wooly”, \textit{The Economist}, 10/15/2011.}

As a result of its negative externalities for the livestock trade, piracy has the potential to invoke sanctions from different parts of Somali society. When pirate attacks are successful the pirates typically route the captured vessel to a private port, which in the face of potential sanctions requires protection and support from local accomplices. In order to function effectively, therefore, pirate groups require the complicity of groups onland, in particular local clan leaders. Interestingly, these leaders, in an attempt to allow both the livestock and pirating sectors to flourish, provide both support for and sanctioning against piracy. Shortland and Varese (2012) describe how clan complicity facilitates piracy, with some clans providing “protection” to pirates. At the same time, since \textit{xeer} law forbids criminal activities such as
abduction, theft, extortion, and fraud (and many clan leaders view piracy as belonging to this category, in addition to being haraam, i.e. forbidden, under shari’a law), clans leaders are able to provide a meaningful source of disincentives against piracy.16

The influence of clan elders over pirates is reinforced by the fact that pirate gangs tend to organize within rather than across clans, maintaining these “familial” ties by transferring “Qaaraan” (“livestock or money for the needy,”) to the clan (Hansen, 2009, p. 25-26).17 Reports of clan elders pressuring pirates to release vessels in Puntland, and mediating conflicts involving pirates in both Puntland and the central region of Galmudug, also suggest that clan leaders often have authority over pirates that formal authorities lack.18

2.3 Clan Structure and Authority in Somaliland and Puntland

Despite the importance of clan structures and authority in both Somaliland and Puntland, clan interests and composition vary considerably across the two regions. We focus on the two key differences highlighted by our model: the ratio of interests, and income sharing.

Ratio of Economic Interests In Somaliland, the Isaaq clan-family makes up the vast majority of the population. The Isaaq contains a number of confederacies, themselves consisting of various sub-clans. The largest of these in Somaliland is the Habr Awal, a merchant class that has benefited from proximity to Somaliland’s crucial trading port of Berbera. Despite their various tribal delineations, the Isaaq are unified by the fact that they are almost entirely nomadic pastoralists (Lewis, 1969, p. 23-24). In this regard they are very similar to the Esa and Gadabursi sub-clans in the furthest north-west part of Somaliland, who belong to the Dir clan-family. Much like their Isaaq neighbors, the Esa and Gadabursi are pastoral nomads (Lewis, 1969, p. 25), who rely heavily on the livestock trade as a source of income.

A very small proportion of Somaliland’s population come from the Dulbahante and Warsangeli sub-clans, concentrated in the north-eastern province of Sanaag (Lewis, 2008, p. 99). Both the Dulbahante and Warsangeli are primarily pastoralist groups, though the Warsangeli “are much given to seafaring and compose the bulk of the crews manning the dhows which ply between Aden and Somaliland” (Lewis, 1969, p. 21). Because of their comparative advantage at sea, members of this group have also been known to engage in piracy, and a major pirate network operated for some time out of Las Qoray in north-eastern Somaliland (Murphy, 2011, Palmer, 2014). Thus, piracy represents a small part of the economic interests of Somaliland,

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16 For example, clan elders pressured for the release of eight pirates who had been arrested by Ahlu Sunna Waljama’a, a paramilitary group allied to the Somali government. “Pirates Get Ready for More Attacks, Confusion Over Possible Oil Tanker Hijack”, SomaliaReport, 02/17/2012.

17 Backhaus (2010) notes the importance of pirate leaders being well established and connected in the local community through clan ties, and suggests that Somali pirates actively avoid attacking ships which belong to fellow clan members.

and “pirate clans” are a very small minority in the region. Since the majority of clans rely on pastoralism, the ratio of economic interests in Somaliland favors the livestock trade.

Clan structure and authority in Puntland is considerably different. Although most clans fall under a single clan-family (the Darod), the distribution of economic preferences across these clans has made governance more difficult. As noted above, the Darod contains numerous confederacies and sub-clans, including the Dulbahante and Warsengeli, which straddle the border between Somaliland and Puntland. Far more numerous in Puntland, however, are the Mijerteen, another Darod sub-clan. As with the Warsengeli, the Mijerteen have traditionally engaged in both pastoralism and seafaring activities, and a sizable proportion of the Mijerteen (roughly 12%) are fishermen and sailors (Lewis, 1969, p. 20).

The Mijerteen actually also have a long history of engagement in maritime predation dating back to the early nineteenth century (Durrill, 1986). This was true for communities across the north-eastern and eastern coastlines of Puntland, with ships being lured onto the rocks to be pillaged and shipwreck survivors being taken hostage for ransom. Pirates, moreover, were linked to a broader political system of predation (de Wijk, Anderson and Haines, 2010, p. 44-5). These predatory activities resurfaced in the 1990s, with pirate gangs operating out of a number of locations around the Puntland coast.

The relevant fact is that the piracy business is much larger in Puntland than it is in Somaliland, both in absolute and in relative terms. While the various Darod sub-clans all have sizable interests in pastoralism, many of them also have an interest in piracy, much more so than any of the groups in Somaliland. As a result, the ratio of economic interests in Puntland is more balanced between piracy and the livestock trade.

**Cooperative Income Sharing** The differences between Somaliland and Puntland in terms of clan influence are not just limited to the numerical composition of clans groups and interests in these regions. Clans are much more a part of the governance structure of Somaliland, and their role in society has been recognized even somewhat formally by the Somaliland state. Starting in 1991 a series of congresses and peace talks involving clan elders were held in northern Somalia, bringing together all the major clans in the region (Farah and Lewis, 1997, Huliaras, 2002, Walls, 2009). By 1993 this led to a National Charter establishing a government, rights, and basic national institutions. Key to this development was the formation of the Guurti assembly of clan elders as a chamber of Somaliland’s bicameral legislature to facilitate cooperation across clan groups. This assembly has, to a large extent, succeeded in promoting cooperation across groups through the guarantee of national revenue-sharing, including export revenues from the port of Berbera and those from the national airport at Hargiesa, which include air taxes and landing charges (Lewis, 2008, p. 95-96). And, in general, the numerous confederacies of clans and their constituent sub-clans in Somaliland have been able to negotiate competing interests to settle both inter- and intra-clan disputes.
Groups in Puntland have attempted to form clan-based agreements akin to those in Somaliland, but with almost no success. Attempts to form a unified state have been less successful, in large part due to inter-clan conflicts and a relatively unconstrained executive after Colonel Abdilliahi Yusuf emerged as an iron leader of Puntland, who showed an interest in emulating the attempt by Siad Barre to limit the influence of clan elders and stamp out “clannism” (Hesse, 2010). A key implication of this has been the lack of any broad-based commitment to national revenue-sharing along the lines of that seen in Somaliland.

3 Model

Our model simplifies the northern Somali economy into the two sectors that we have highlighted, livestock trading and piracy, and Somali society into two groups based on clan heritage—those that rely comparatively more on the livestock trade for income and those that rely comparatively more on piracy. While our discussion above recognizes that economic interests and occupational choices do not perfectly delineate along clan boundaries, we will for simplicity refer to these groups as “livestock traders” and “pirates.”

The population share of the traders is $\lambda$ while the share of the pirates is $1 - \lambda$. The parameter $\Lambda = \lambda/(1 - \lambda)$ denotes the ratio of these population shares. The two groups interact repeatedly over time. Time is discrete with an infinite horizon and indexed by $t$. Both groups discount future payoffs with a common discount factor $\delta < 1$.

3.1 Fundamentals

In each period the two groups move simultaneously, deciding whether or not to cooperate with each other.

At the start of each period $t$ a state $s_t \in \{0, 1\}$ is drawn to determine whether trade is productive, with $s_t = 1$ indicating the realization of the high productivity state. We assume that $s_t$ is independently drawn across periods and that the probability that $s_t = 1$ is a constant $\theta$ for all $t$. When the traders cooperate, they make peace with the pirates and each trader shares a fraction $\phi_t$ of his income with the pirating group, where $0 \leq \phi_t \leq \bar{\phi}$ and $\bar{\phi}$ is an exogenous parameter. When the traders do not cooperate, they do not share any of their income, and conflict takes place between the two groups. Under conflict, each member of the pirating group incurs a cost $k\Lambda > 0$ while each member of the trading group incurs a cost $k\Lambda > 0$.

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19 As we have noted, members of a Somali clan are likely to be engaged in a variety of economic activities. The claim here is simply that some groups have a comparatively greater economic interest in the livestock trade, while others have more in piracy. For simplicity, we refer simply to trading groups and pirate groups, but this should not be taken to imply that all members of the group are engaged in that single activity.
The key feature of this assumption is that the cost that one group can inflict upon each member of the other group is larger the more the first group outnumbers the second.

When the pirates cooperate, they self-regulate the number of pirate attacks that they launch. By doing this, they are foregoing some of the returns from piracy, but they may be providing considerable benefits to the traders by creating a safer trading environment during periods of highly productive trade. When the pirates choose not to cooperate, they engage in unregulated piracy, creating a negative externality on productive trade in these periods.

More precisely, suppose that when productivity is low the income of each trader from productive trade is 0 regardless of what the pirates do. When productivity is high, the income of each trader is a random variable $R_t$ which can be high or low, and whose distribution is determined by the pirating group’s choice of whether or not to regulate piracy. In particular, we assume that $R_t \in \{0, R\}$ with $0 < R$, and the probability that $R_t$ will equal 0 is $\gamma > 0$ if the pirates self-regulate in period $t$, and $\overline{\gamma} > \gamma$ if they do not. $R_t = R$ with complementary probability in either case, and $R_t$ is realized at the end of the period.

To capture the idea that the self-regulation of piracy is costly for the pirates, we assume that the pirates have a lower chance at making a high return from piracy if they self regulate. In each period, each pirate receives a return of $d_t \in \{0, d\}$ from piracy in period $t$, where $0 < d$. When they do not self regulate in period $t$, each pirate makes the high return of $d_t = d$ with probability $\overline{\mu}$ and the low return of $d_t = 0$ with probability $1 - \overline{\mu}$. The expected return from not self regulating is thus $\overline{\mu}d$. When they do self-regulate, each pirate receives the high return $d_t = d$ with probability $\mu$, and the normalized low return of $d_t = 0$ with probability $1 - \mu$. The expected return from self-regulation is thus $\mu d$. The assumption that $\mu < \overline{\mu}$ says that self-regulation lowers the probability that the pirates will receive the high return $d_t = d$.

### 3.2 Monitoring Structure

We assume that the model has one-sided moral hazard: the pirates’ decision to regulate piracy is not directly observed by the traders. This assumption is motivated by the fact that piracy is often, but not always, an activity that is planned and carried out in a way that may not be publicly observable. In particular, it is difficult for the trading group based on land to always know how much piracy is going on at sea, and where it is being targeted.

In our model, the traders have access to two noisy public signals of whether or not the pirates are self regulating: the pirates’ period $t$ income from piracy, and the traders’ own period $t$ revenue from trade, both of which are observed at the end of the period. Since the low revenue $R_t = 0$ is more likely when the pirates don’t self regulate than when they do, it

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20To motivate these costs, imagine that each individual can produce a cost $k$. There are $\lambda$ traders, so the traders together produce $\lambda k$. This cost is equally divided among all members of the pirating group, so the cost incurred by each member of the pirating group is $\lambda k/(1 - \lambda) = k\Lambda$. Similarly, the pirates produce a total cost of $(1 - \lambda)k$ and each trader incurs cost $(1 - \lambda)k/\lambda = k/\Lambda$. 

is evidence of unregulated piracy. Similarly, the high return $d_t = d$ is more likely when the pirates do not self-regulate than when they do, and is also evidence of unregulated piracy.

We define $\omega_t \in \{0, 1\}$ to be the period $t$ indicator of a high income from piracy in the previous period, $d_{t-1} = d$. Thus $\omega_t = 1$ with probability $\mu$ if the pirates self-regulated in the previous period, and with probability $\overline{\mu}$ if they did not. $\omega_t = 0$ with complementary probability in either case. Finally, we assume that if the traders learn that the pirates did not self-regulate in the previous period ($\omega_t = 1$), then by choosing conflict each trader receives an additional payoff worth $g$, while each pirate incurs a loss of $l$. If $\omega_t = 0$ then there are no additional gains or losses to either group. For example, we could set $g = h + \beta d / \Lambda$ and $l = (\alpha - \beta) d$ with the following interpretation. If a pirate earns $d$ from piracy in the previous period, then the traders loot $\beta d \geq 0$ of this income, dividing it equally among themselves. $\alpha d > 0$ is the value of the previous period return in the current period. $h \geq 0$ represents any social motives for sanctioning unregulated piracy. We set $\omega_0 = 0$.

### 3.3 Payoff Structure and Assumptions

The expected payoffs per individual in each group have the following structure, where the row player is the trading group and the column player is the pirate group:

<table>
<thead>
<tr>
<th></th>
<th>self-regulate</th>
<th>don’t self-regulate</th>
</tr>
</thead>
<tbody>
<tr>
<td>peace</td>
<td>$(1 - \phi_t)(1 - \gamma)s_t R, \mu d + \phi_t (1 - \gamma)s_t R\Lambda$</td>
<td>$(1 - \phi_t)(1 - \gamma)s_t R, \overline{\mu} d + \phi_t (1 - \gamma)s_t R\Lambda$</td>
</tr>
<tr>
<td>conflict</td>
<td>$(1 - \gamma)s_t R + \omega_t g - k / \Lambda, \mu d - \omega_t l - k \Lambda$</td>
<td>$(1 - \gamma)s_t R + \omega_t g - k / \Lambda, \overline{\mu} d - \omega_t l - k \Lambda$</td>
</tr>
</tbody>
</table>

These payoffs are subject to the assumptions above as well as some additional assumptions, two of which are as follows.

(A1) $g - k / \Lambda > 0$

(A2) $d > l + k \Lambda$

We use the first assumption to establish that the traders have short-run incentives to sanction piracy despite the costs of conflict if they expect the pirates to not self-regulate. We use the second one to establish that if piracy is successful, then the income that it generates is high in comparison to the potential costs of being punished for it; this gives myopic pirates a short run incentive to not self-regulate.

21Since we allow $h = 0$ or $\alpha = 0$ we are agnostic as to whether the traders have short run incentives to choose conflict after evidence of piracy in order to obtain a share of the pirate income, or to sanction the pirates for anti-social / immoral behavior; or, for both reasons.
3.4 Social States

We have described a stochastic game with imperfect public monitoring. If the players are patient ($\delta$ is high) then the game has a large set of equilibria exhibiting varying degrees of cooperation between the two groups (Hörner et al., 2011). However, in all equilibria, periods of conflict take place. In addition, the structure of efficient equilibria can be quite complex.\footnote{See, e.g., Abreu, Pearce and Stacchetti (1990) for an analysis of repeated games with imperfect monitoring, and Hörner et al. (2011) for an analysis of stochastic games with imperfect monitoring in case of $\delta \to 1$.}

Therefore, instead of seeking a characterization of the socially optimal self-enforcing agreement, we focus on particular modes of cooperation that help us make sense of our case.

Our strategy for analyzing the game will be to take an approach that focuses on particular kinds of social agreements. We characterize conditions that make these agreements incentive compatible. The equilibrium concept, as usual, is perfect public equilibrium (PPE).

We characterize social agreements using three categories of “automaton states” and derive conditions that are necessary and sufficient to sustain particular “path automata” in equilibrium. Informally, a path automaton specifies actions that are chosen only on the path of play.\footnote{Kandori and Obara (2010) give a formal definition of path automata.}

As such, it is an incomplete description of a strategy profile. Our approach is to characterize conditions under which there exists a way to complete the description of the strategy profile such that it becomes an equilibrium of the game for high values of the discount factor.\footnote{We follow the literature on cooperation in repeated games by focusing on high values of the discount factor. To support the path automata that we study here for lower values of the discount factor, we typically require stronger conditions.}

The following describes the three categories of automaton states.

1. \textit{Conflict} : In these states, the traders choose conflict and therefore they do not share any of their income with the pirates. Note that there are several possible automaton states in this category, depending on whether the payoff relevant signal $\omega_t$ equals 0 or 1, whether $s_t$ equals 0 or 1, and whether the pirates self-regulate or don’t.

2. \textit{Peace and no self-regulation} : In these states, the traders make peace with the pirates but the pirates do not self-regulate. If $s_t = 1$, then this creates a negative externality on productive trade because it lowers the probability that the traders will obtain the high return ($R_t = R$) from $1 - \gamma$ to $1 - \gamma$. If $s_t = 0$ then unregulated piracy has no externality on productive trade (since $R_t = 0$ for sure). Note that there is a continuum of such states depending on the fraction $\phi$ of income that is shared.

3. \textit{Peace and self-regulation} : In these states, the traders make peace with the pirates and the pirates self-regulate. The pirates are forgoing some of the expected returns from piracy by lowering their chance of obtaining the high return ($d_t = d$) from $\overline{\mu}$ to $\mu$. During high productivity periods ($s_t = 1$) they are conferring a benefit to the traders by
increasing the traders’ chances of earning the high return \( R_t = R \) from \( 1 - \gamma \) to \( 1 - \gamma \).

During low productivity periods \( s_t = 0 \) they are conferring no benefit upon the traders, since \( R_t = 0 \) independent of what they do. Again, there is a continuum of such states depending on the fraction \( \phi \) of income that is shared.

### 3.5 Cooperation and No Cooperation Regimes

We now describe two types of regimes—one that we call the “No Cooperation Regime” (NCR) in which the pirates do not self-regulate, and another that we call a “Some Cooperation Regime” (SCR) in which they do. These correspond to different classes of path automata.

**NCR** Suppose that the players are myopic \( (\delta = 0) \) and consider a situation in which no income is ever shared \( (\phi_t = 0 \text{ for all periods } t \text{ in which the traders make the choice}) \). The pirates would never self-regulate, due to the fact that \( \underline{\mu} - \mu > 0 \). This results in a negative externality on productive trade during the high productivity periods. The traders would then choose peace when \( \omega_t = 0 \) and conflict when \( \omega_t = 1 \), by assumption (A1). Transitions between automaton states in this regime are depicted in Figure 1. Society begins in a *Peace and no self-regulation* state. In any period \( t > 0 \), if \( \omega_t = 0 \) then society is in a *Peace and no self-regulation* state; but if \( \omega_t = 1 \) then society is in a *Conflict* state in which the pirates choose not to self-regulate. This describes the NCR. In the appendix, we show that under assumption (A2) the NCR describes a path automaton that is supported by a PPE for all values of \( \delta \).

**SCR** Now we describe two versions of the SCR, both of which are represented in Figure 2. In both versions, the following describes which of the three categories of states society is in for any period \( t \). (Note that these are only rules governing on-path play.)
Consider the following situations: (i) \( t = 0 \) and \( s_t = 1 \), (ii) \( R_{t-1} = R \), \( \omega_t = 0 \), \( s_t = 1 \) and society was in a Peace and self-regulation state in period \( t - 1 \), and (iii) \( \omega_t = 0 \), \( s_t = 1 \) and society was in a Conflict state in period \( t - 1 \). In all of these situations, the pirates choose to self regulate and the traders make peace, sharing a fraction \( \phi_t = \bar{\phi} \) of their income. Thus, society is in a Peace and self-regulation state in period \( t \).

Consider the following situations: (i) \( t = 0 \) and \( s_t = 0 \), (ii) \( R_{t-1} = R \), \( \omega_t = 0 \), \( s_t = 0 \) and society was in a Peace and self-regulation state in period \( t - 1 \), and (iii) \( \omega_t = 0 \), \( s_t = 0 \) and society was in a Conflict state in period \( t - 1 \). In all of these situations, the pirates choose to not self regulate and the traders make peace with the pirates. (They share any fraction of their income since they are guaranteed to have \( R_t = 0 \).) Thus, society is in a Peace and no self-regulation state in period \( t \).

Consider the following situations: (i) \( R_{t-1} = 0 \) or \( \omega_t = 1 \) and society was in the Peace and self-regulation state in period \( t - 1 \), and (ii) \( \omega_t = 1 \) and society was in a Conflict state in period \( t - 1 \). In both situations, society is in a Conflict state in period \( t \).

Thus in both versions of the SCR, there is maximal revenue sharing at the level \( \bar{\phi} \) whenever society is in Peace and self-regulation. The two versions of the SCR differ only in whether the Conflict states that are reached involve the pirates self-regulating their pirate activities or not. In one version of the SCR, which we will call SCR[SR], the pirates self-regulate on the path of play whenever the traders choose conflict. In the other version, which we call SCR[nSR], the pirates choose to not self-regulate on the path of play whenever the traders choose conflict.
3.6 Supporting the Regimes in Equilibrium

In an equilibrium, neither the pirates nor the livestock traders have a profitable one-time deviation from any of the automaton states that occur on the path of play. Deviations by the livestock traders are perfectly observable, so their incentive to not deviate from the SCR can be provided by a switch to the NCR provided that the NCR gives a lower payoff to them than the SCR. To focus our attention on the monitoring problems that complicate the incentives of the pirates to not deviate, we make an assumption that guarantees that the livestock traders’ payoff from either SCR exceed their payoff from the NCR for all values of \( \delta \) high enough. This is our third assumption:

\[
(A3) \theta \left[ (1 - \bar{\phi})(1 - \gamma)R - \left( 1 + \frac{1}{1 - \mu} \right)(1 - \bar{\gamma})R \right] \geq [1 + \gamma(1 - \mu)\theta]g + k/\Lambda
\]

Since the right side of (A3) is positive, this implies that the left side is positive. Therefore, the ex ante expected income to livestock traders when they share the maximum amount under Peace and self-regulation (i.e., the quantity \( \theta(1 - \bar{\phi})(1 - \gamma)R \)) exceeds the ex ante expected income from Conflict in the NCR (i.e., the quantity \( \theta(1 - \bar{\gamma})R \)). When this is the case, assumption (A3) is more likely to hold when \( R \) is high in comparison to \( g \) and \( k/\Lambda \). That is, the assumption implies that revenue from the livestock trade is important to the traders in comparison to their other payoff considerations.

The following proposition the summarizes our main result.\(^{25}\)

**Proposition 1.**

1. There is a PPE that supports the NCR for all values of the discount factor \( \delta \).

2. There exist three continuous real valued functions \( f_C, f_{nSR} \) and \( f_{SR} \) over the parameters of the model with the following properties: (i) there is a PPE that supports the SCR\([nSR]\) for all high values of \( \delta \) if and only if \( f_{nSR} > 0 \) and \( f_C > 0 \), (ii) there is a PPE that supports the SCR\([SR]\) for all high values of \( \delta \) if and only if \( f_{SR} > 0 \) and \( f_C < 0 \), and (iii) \( f_{nSR} \) and \( f_{SR} \) are both increasing in \( \Lambda \) and \( \bar{\phi} \) and decreasing in \( d \).

We prove this proposition in the appendix. In what follows here, we interpret it and briefly remark on its implications.

Parts (i) and (ii) imply that either the SCR\([nSR]\) or the SCR\([SR]\) can be supported in equilibrium for high values of the discount factor, but not simultaneously both. In the proposition, \( f_C > 0 \) represents the condition that says that the pirates have no profitable one-time deviations from any of the Conflict states of the SCR\([nSR]\) that arise on the path of play. If \( f_C < 0 \), they have no profitable one-time deviations from any of the Conflict states that arise on the path of the SCR\([SR]\).

\(^{25}\)The proposition refers to the parameters of the model, which are \( \theta, \bar{\mu}, \mu, \bar{\gamma}, \gamma, \Lambda, \bar{\phi}, g, l, d, k \) and \( R \).
Similarly, $f_{nSR} > 0$ represents the condition that says that the pirates have no profitable one-time deviations from the *Peace and self-regulation* state that arises on the path of play of the SCR$[nSR]$ and $f_{SR} > 0$ is the condition that says that the pirates have no profitable one-time deviations from the *Peace and self-regulation* state that arises on the path of play of the SCR$[SR]$. Since part (iii) says that $f_{nSR}$ and $f_{SR}$ are both increasing in $\Lambda$ and $\bar{\phi}$, it is easier to provide incentives to the pirates to not deviate from the *Peace and Self Regulation* state on the path of play of either SCR$[nSR]$ or SCR$[SR]$ when the traders significantly outnumber the pirates, and when they are able to share higher fractions $\bar{\phi}$ of their income from trade. These functions are also decreasing in $d$, so as piracy becomes more lucrative the pirates have greater incentive to deviate from self-regulating in both the SCR$[nSR]$ and SCR$[SR]$.

### 3.7 Putting the Model into Context

Our explanation for the different development trajectories of Somaliland and Puntland is that the two regions of Somaliland and Puntland differ in terms of the fundamental parameters of the model, notably $\bar{\phi}$ and $\Lambda$. The ratio of economic interests favors the livestock trade more in Somaliland, thus $\Lambda$ is higher in Somaliland than in Puntland. Similarly, as we argued previously, there is a greater degree of revenue sharing among clans in Somaliland than in Puntland, making it likely that $\bar{\phi}$ is higher in Somaliland than it is in Puntland. This suggests, in light of the comparative statics of the previous section, that it is harder to provide the pirates of Puntland with the incentive to self-regulate their piracy than it is to provide the pirates of Somaliland with these incentives. Consequently, our theory is that the SCR better describes the relationship between traders and pirates in Somaliland while the NCR better describes the relationship between these two groups in Puntland.\(^{26}\)

We now compare the two regimes in terms of their predictions for Somaliland and Puntland. We focus on explaining the variation in piracy and conflict.

**Piracy** Piracy takes place in an unregulated way under the NCR and the pirates are able to make successful attacks with probability $\bar{\mu}$ in each period. We take this to represent the frequency of piracy under the NCR. Under either SCR, on the other hand, piracy is self-regulated in the *Peace and self-regulation* state, so on average pirates make successful attacks with probability smaller than $\bar{\mu}$ in each period. Thus, the frequency of attacks is strictly lower under either of the two SCRs than under the NCR. This comports with the fact reported in Section 2.2 that there is more piracy off the coast of Bosasso in Puntland than there is off the coast of Berbera in Somaliland.

---

\(^{26}\)Furthermore, it may not be possible to replicate the cooperative agreement that is in place in Somaliland in Puntland since the differences in $\Lambda$ and $\bar{\phi}$ across the regions suggest that the Somaliland agreement may not be self-enforcing in Puntland.
In addition, under the SCR pirating attacks are more frequent when livestock exports are low and less frequent when livestock exports are high, whereas under the NCR there is no relationship between livestock exports and the timing of pirating attacks. The reason is that the SCR represents a social agreement that is designed to mitigate the externality caused by pirating attacks on the livestock trade. When trade is low, there is almost no externality so there is no reason for the livestock traders to want the pirates to self-regulate, and for the pirates to do so. Given this, we expect to see a negative relationship between livestock exports and piracy off the coast of Berbera in Somaliland. By contrast, the relationship between livestock exports and pirate attacks off the coast of Bosasso in Puntland should be much weaker, because the distribution of interests in Puntland is such that groups are unable to reach an agreement whereby piracy will always be regulated in periods when livestock revenues are high.

Conflict  What fraction of time do the two societies spend in the Conflict automaton states in the long run? This quantity can also be derived by finding the stationary distribution of the Markov process governing state transitions when players implement the paths associated with the NCR and either of the SCRs. The quantity is given by $\mu$ under the NCR, by $\theta \kappa / (1 - \mu + \theta \kappa)$ under the SCR[nSR], and by $\theta \kappa / (1 - \mu + \theta \kappa)$ under the SCR[SR], where $\kappa := \mu + \gamma (1 - \mu)$. Therefore, if $\gamma$ is small enough, society spends less time in conflict under either of the SCRs than it does under the NCR. The assumption that $\gamma$ is small (i.e. society is relatively unlikely to enter conflict as a result of a downward income shock for the livestock traders) is natural, and comports with our empirical findings. See, for example, Figure 3 below, which shows less overall conflict in Somaliland than in Puntland.

As well as differing with regard to the amount of conflict that occurs, the NCR and SCR also differ in terms of when conflict starts. Under the NCR conflict takes place after pirating attacks since the pirates bring back income that creates a windfall of resources to compete over, and/or because of the social incentives to sanction piracy. Under both SCRs, there is also a relationship between conflict and pirating attacks but because attacks are less frequent, the relationship is subject to more noise. If pirating attacks occur only when piracy does not hurt the livestock trade, for example, there should be only a weak relationship between pirating attacks and conflict. Conflict does take place, however, after a sharp decline in livestock revenue since the livestock traders use conflict as a means to provide incentives to not launch too many pirate attacks. As a result, we expect that in both Puntland and Somaliland, conflict increases after pirating attacks, but the relationship is clearer in Puntland. We also expect that in Somaliland, conflict takes place after a sharp decline in livestock revenue, while in Puntland there is no relationship between livestock revenue and conflict.
4 Other Empirical Patterns

Our theory helps make sense of three additional empirical patterns that we see in the data from Somalia. The first is that piracy tends to be lower off the coast of Somaliland when livestock export levels are higher, but there appears to be no relationship between piracy and livestock exports off the coast of Puntland. The second is that in each region, conflict appears to rise after increases in pirate attacks off its coast but this relationship is measured with much greater noise in Somaliland than in Puntland. The third is that drops in the export price of Somali livestock trigger conflict in Somaliland but not in Puntland. We present these patterns in three successive subsections, and conclude the section with a discussion of why our theory provides a better account of these patterns than alternative theories.

4.1 Piracy and the Livestock Trade

To examine the relationship between piracy and the livestock trade, we estimate negative binomial regression models in which the dependent variable is a count of pirate attacks and the the main independent variable is the (logged) number of heads of livestock exported monthly from each port. Livestock export data are the same data depicted in Figure 1 and piracy data are the data depicted in Figure 2 (see the notes below these tables for more details on these data and their sources).

Because pirate attacks closer to ports are likely to have a greater impact on shipping and insurance costs, we use a spatially-smoothed version of the piracy variable, down-weighting those attacks that occur further away from the ports.\(^\text{27}\) We estimate separate models for pirate attacks off the two ports, Berbera and Bosasso. In addition, given the importance of the Saudi ban on Somali livestock that we noted in Section 2, and which is depicted clearly in Figure 1, we also examine the relationship prior to November 2009 separately from the relationship after this date when the ban was lifted. This takes into account the possibility of a statistical regime change taking place as a result of the removal of the ban.

In all models, we include a lag of the dependent variable, as well as year fixed effects. In an effort to control for seasonal effects, we also include a dummy variable for monsoon months to capture whether the month falls in one of Somalia’s two monsoon periods.\(^\text{28}\) Finally, we include monthly data on the average daily unskilled wage rate for each region, taken from the Food Security and Nutrition Analysis Unit - Somalia (the same source as our livestock data in Figure 1), to account for the possibility that the relationship between piracy and the livestock trade is driven by changes in local labor market opportunities (Jablonski and Oliver, 2012).

\(^{27}\)The spatially weighted variable is rounded to integers, to enable estimation of the negative binomial models.

\(^{28}\)There are two monsoon seasons in the Gulf of Aden. The summer monsoon occurs from June through August, and the winter monsoon occurs during December through February. Using two separate variables for these two monsoon seasons makes no difference to any of the results in this paper.
Table 1: Negative Binomial Estimates of Pirate Attacks

<table>
<thead>
<tr>
<th>DV = Pirate Attacks</th>
<th>Somaliland (Berbera)</th>
<th>Puntland (Bosasso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All During Ban After Ban</td>
<td>All During Ban After Ban</td>
</tr>
<tr>
<td></td>
<td>(1) (2) (3)</td>
<td>(4) (5) (6)</td>
</tr>
<tr>
<td>Lagged Pirate Attacks</td>
<td>0.0536 (-0.0581 0.0707)</td>
<td>-0.0121 (0.00630 -0.229)</td>
</tr>
<tr>
<td></td>
<td>(0.0386 (0.0789 (0.0446))</td>
<td>(0.0378 (0.0391 (0.156))</td>
</tr>
<tr>
<td>Exports (log)</td>
<td>-0.241** (-0.273** -0.580†)</td>
<td>-0.0769 (0.0788 (0.496)</td>
</tr>
<tr>
<td></td>
<td>(0.0762 (0.0935 (0.342))</td>
<td>(0.122 (0.132 (0.490))</td>
</tr>
<tr>
<td>Unskilled Wage Rate</td>
<td>-0.490 (0.125 -0.296)</td>
<td>-0.285 (0.419 -0.281)</td>
</tr>
<tr>
<td></td>
<td>(0.312 (0.536 (0.416))</td>
<td>(0.325 (0.479 (0.455))</td>
</tr>
<tr>
<td>Monsoon</td>
<td>0.200 (0.00779 0.479)</td>
<td>-0.222 (0.306 -0.159)</td>
</tr>
<tr>
<td></td>
<td>(0.224 (0.295 (0.329))</td>
<td>(0.204 (0.231 (0.453))</td>
</tr>
<tr>
<td>Constant</td>
<td>4.999** (3.248* 7.467*)</td>
<td>2.202 (3.300* -3.274)</td>
</tr>
<tr>
<td></td>
<td>(1.384 (1.557 (3.103))</td>
<td>(1.438 (1.447 (4.637))</td>
</tr>
</tbody>
</table>

Observations 128 90 38 143 105 38
Pseudo $R^2$ 0.143 0.135 0.108 0.141 0.183 0.038
Log-Likelihood -175.1 -96.72 -74.20 -201.3 -141.9 -56.51
AIC 388.2 231.4 186.4 440.7 321.8 151.0

Note: Negative binomial estimates of pirate attacks. All models include year fixed effects. Robust standard errors in parentheses. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

The results, which are consistent with our theory, are presented in Table 1. The table shows that in Somaliland, the coefficient for livestock exports is negative whether we look at the whole time period or look separately during and after the Saudi ban. However, the coefficient is more than twice the size in the period after the ban was lifted. The implied effect of a one standard deviation increase in livestock exports is therefore a reduction in the number of pirate attacks by 0.59 per month during the period in which the ban was in place, and by 1.27 per month after the ban was lifted. By contrast, in Puntland the coefficient on livestock exports is closer to zero (or positive).29,30

4.2 Piracy and conflict

We now estimate the relationship between piracy at sea and conflict on land separately for Somaliland and Puntland. To measure conflict in these regions, we use geo-referenced con-
flict data from the Armed Conflict Location and Event Data Project (ACLED) and generate monthly conflict counts in Somaliland and Puntland from these geo-references (Raleigh et al., 2010). These data are depicted in Figure 3, which plots the cumulative number of violence counts in Somaliland (dotted line) and Puntland (solid line) between 2000 and 2012. During this period, Puntland saw 45% more ACLED-reported conflict incidents overall, experiencing on average eight incidents per month compared to Somaliland’s five. This is consistent with our model and qualitative accounts of the on-ground situation in these two regions.

To examine the relationship of interest we take a monthly count of conflict incidents between 2000 and 2012, estimated separately for Puntland and Somaliland, as our dependent variable and a lagged monthly count of pirate attacks within a 250 kilometer radius of the ports of Berbera for Somaliland and Bosasso for Puntland as our main explanatory variable. Lagging this variable enables us to evaluate whether conflict occurs as a result of pirate attacks. As a control, each model also includes a lagged version of the conflict variable to deal with the fact that conflict instances may be correlated over time. We also include the monsoon dummy and year fixed effects.

Columns (1) and (4) of Table 2 present estimates of negative binomial regression models of the relationship between pirate attacks and conflict in Somaliland and Puntland respectively. Column (4) shows that there is a significant and positive relationship between pirate attacks and conflict in Puntland. Column (1) shows that there is also a positive relationship...
Table 2: Conflict, Piracy and Meat Prices

<table>
<thead>
<tr>
<th>DV = Conflict Incidents</th>
<th>Somaliland</th>
<th>Puntland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Lagged Conflict Incidents</td>
<td>0.009</td>
<td>0.00804</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.0140)</td>
</tr>
<tr>
<td>Lagged Pirate Attacks</td>
<td>0.038</td>
<td>0.0540</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.0401)</td>
</tr>
<tr>
<td>Local Sheep/Goat Price Change</td>
<td>-0.264*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td></td>
</tr>
<tr>
<td>Int’l Lamb Price Change</td>
<td>-0.358*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.143)</td>
<td></td>
</tr>
<tr>
<td>Monsoon</td>
<td>-0.142</td>
<td>-0.193</td>
</tr>
<tr>
<td></td>
<td>(0.123)</td>
<td>(0.133)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.658</td>
<td>-0.856</td>
</tr>
<tr>
<td></td>
<td>(0.418)</td>
<td>(0.555)</td>
</tr>
<tr>
<td>Observations</td>
<td>154</td>
<td>125</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td>0.282</td>
<td>0.241</td>
</tr>
<tr>
<td>Log-Likelihood</td>
<td>-272.0</td>
<td>-252.8</td>
</tr>
<tr>
<td>AIC</td>
<td>580.0</td>
<td>539.5</td>
</tr>
</tbody>
</table>

**Note:** Negative binomial estimates of conflict instances. All models include year fixed effects. Robust standard errors in parentheses. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

between piracy and conflict in Somaliland, but it is noisy.\textsuperscript{31} Nevertheless, these results are consistent with our theoretical model, which predicts a positive relationship between conflict and piracy in both regions, but greater noise in the relationship in Somaliland.

### 4.3 Export price shocks and conflict

Columns (2), (3), (5) and (6) in Table 2 also speaks to the role of the livestock economy in the relationship between conflict and piracy. Our theoretical model predicts that a drop in livestock revenue serves as a signal of cheating from the cooperative agreement in place in Somaliland, and hence should increase conflict in that region but not in Puntland, where no such agreement is in place. Columns (2) and (5) explore this possibility by adding local goat prices to the models estimated in columns (1) and (4). For ease of interpretation, and to capture the effect of substantial price changes, this variable is operationalized as a variable equal to

\textsuperscript{31}Although the coefficient on pirate attacks in Somaliland is smaller than that in Puntland, we cannot reject the hypothesis that the two coefficients are equal. We note, however, that our measurement of the conflict variable includes incidents that are unrelated to piracy, causing variation in the data over the intensity as well as the nature and causes of conflict incidents. As such, these data are generally very noisy, and the estimates of our standard errors should be interpreted with this in mind.
1 if the month-to-month percent change in price was greater than one standard deviation above the mean, −1 if month-to-month percent change in price was greater than one standard deviation below the mean, and zero otherwise. The data for this variable are again from the Food Security and Nutrition Analysis Unit - Somalia. Missing data require us to truncate the start of the time-series so the number of observations slightly declines after we introduce it to the model. The two columns confirm that a drop in revenue leads to a rise in conflict in Somaliland but not in Puntland.

While drops in local livestock prices may be most relevant signals of cheating in a setting of imperfect monitoring, herders may adjust their market behavior in the face of low prices. This raises the possibility of endogeneity in these estimates. In order to avoid this kind of endogeneity, we also use a source of exogenous variation in international lamb prices from the International Monetary Fund.\textsuperscript{32} Specifically, these data refer to the price in US cents per pound of frozen lamb carcasses at London’s Smithfield market. Somali livestock herders are price-takers in the international market, so London sheep prices serve as an exogenous source of variation in local livestock revenues in Somalia. The idea is that sheep and goats are close substitutes in the world market, so their prices are positively correlated.\textsuperscript{33} Thus, the London price data reflect fluctuations in international meat prices and at the same time are unlikely to be affected by the actions of pirates or herders in northern Somalia. We operationalize the international price data in the same way as the local price data: the variable takes a value of 1 if the month-to-month percent change in price was greater than one standard deviation above the mean, −1 if month-to-month percent change in price was greater than one standard deviation below the mean, and zero otherwise. Columns (3) and (6) confirm that major drops in London lamb prices increase conflict in Somaliland but not in Puntland.\textsuperscript{34}

Results for both the local and international prices are substantively very similar. As expected, substantial drops in livestock prices are negatively related to conflict in Somaliland.\textsuperscript{35} These results provide support for the expectation that conflict in Somaliland occurs at least in part in response to imperfect signals about levels of piracy that traders in Somaliland receive from changes to meat prices. Thus, to provide the pirates with incentives to self-regulate during the high trade season, the traders in Somaliland respond to a drop in prices with conflict in order to provide a deterrent for piracy.

\textsuperscript{32}The data can be accessed at www.imf.org.
\textsuperscript{33}For example, we find that the London sheep prices from the IMF are positively correlated with the local Somali goat prices ($\rho = 0.10$ for Somaliland and $\rho = 0.08$ for Puntland).
\textsuperscript{34}One estimation strategy that we do not present is that of instrumenting local prices with the international prices, given that they are positively correlated. We instead report the results of the reduced form approach because the local prices are very patchy (making the time series shorter) and because our goal is not to estimate the precise effect of changes in local prices but rather to provide evidence consistent with our mechanism.
\textsuperscript{35}At the same time, note that the estimates of the relationship between conflict and piracy in Puntland are unaffected by including price shocks.
4.4 Alternative Explanations

We conclude the empirical part by arguing that our theory does a better job at explaining the full set of empirical patterns than alternative accounts.

One popular explanation for the relationship between downward price shocks and conflict, of the kind we see in columns (2) and (3) of Table 3, is the simple theory that says conflict rises when people become poorer as a result of the downward shock to prices. This could be because of labor market effects: when the income from productive activity goes down, criminal occupations involving theft, extortion and fraud become more attractive, leading to greater social conflict. A similar kind of labor market substitution story could also explain why piracy is greater during periods of low trade in Somaliland, as Tables 1 and 2 reveal. Similarly, the fact that conflict is higher in both regions following increases in piracy could be explained by a “resource curse” argument: pirate attacks bring more conspicuous wealth to society, so fighting rises after pirate attacks because there is more to fight over.\(^{36}\)

The problem with explanations that rely on labor market effects is that they fail to account for why we see the relationship between piracy and livestock exports, and price shocks and conflict, in Somaliland but not in Puntland. If the livestock trade constitutes a substantial share of the economy in both regions, then shocks to the industry should result in discernible labor market effects in both areas.

More importantly, studies such as Majid (2010), Eid (2014) and Umar and Baulch (2010) stress the importance of clan and family ties in the livestock trade, suggesting that labor markets do not work in the way that the labor market substitution theory posits. In fact, these studies show that herders tend to follow their herds throughout the year, and that the actual shipping business is in the hands of a few specialized traders. Put another way, one does not just quit piracy, buy a herd and start being a herder when short term livestock prices go up. There are considerable fixed costs that prevent this kind of labor market substitution. A more plausible possibility is that pirates are switching between piracy and working as laborers at the ports during the high trade season, but the lack of a significant relationship between piracy and the unskilled wage rate suggests that this is not the case.

Similarly, the resource curse argument fails to account for why the relationship between pirate attacks and conflict is noisier in Somaliland than in Puntland.\(^{37}\) Moreover, while the resource curse argument may make sense of the relationship between conflict and piracy, its predictions run counter to the pattern we see in the relationship between price shocks and conflict. Downward shocks lower the overall income of society, reducing the aggregate value of wealth that is contestable. Therefore, according to this explanation we should less conflict.

\(^{36}\)Such explanations are investigated by the extant literature on conflict. See, for example, Dal Bó and Dal Bó (2011), Dube and Vargas (2013) and Bazzi and Blattman (2014).

\(^{37}\)Since there is less conflict overall in Somaliland, the resource curse explanation might posit that the relationship is, if anything, noisier in Puntland.
after steep price drops in both regions, whereas we see the opposite in Somaliland and no discernible relationship in Puntland.

Our model, in contrast to these theories, provides a unified explanation for the data patterns. These data patterns and qualitative evidence that we discussed in the background section suggest that the structure of cooperation between clans is fundamentally different in Somaliland than it is in Puntland. Resource curse and labor market substitution arguments do not take into consideration these social differences, whereas our explanation does. According to our theory, the differences between the two regions are attributable to the fact that clans with diverse interests have discovered a way (albeit imperfect) to cooperate in Somaliland whereas they have not discovered an analogous self-enforcing mode of cooperation in Puntland.

5 Concluding Remarks

A key contribution of this paper is to characterize the conditions under which cooperation—like the one that appears to be in place in Somaliland—can be maintained informally through pre-existing social arrangements. In particular, we address the question of how restraint of predatory economic activities like piracy can be obtained via decentralized social contract in the absence of an exogenous “protector state”—conditions that we see in both Somaliland and Puntland. Our theory suggests that piracy is best controlled by expansion of alternative economic activity like livestock trading, and improving the social and political institutions that promote income-sharing in society.

Although our model is particular to the Somali case, its main features may be portable to other settings in which the predatory sector has an indirect negative externality on the productive sector. Take for example the increased operating costs faced by oil producers in Nigeria, which due to security challenges including frequent kidnapping and armed robbery, Alike (2017) estimates to be between 15-35% higher than in other countries, with over $500 million spent on security services in 2016. Importantly, even if the nefarious activities of the predatory group are not aimed directly against those operating in the productive sector, criminal activities may still have negative externalities that are detrimental to productivity, which makes the setup of our model relevant to that case as well.\footnote{Olalere et al. (2015) notes that security threats from activities such as drug or people smuggling reduce the operational efficiency of Nigerian ports, thereby increasing transportation costs for businesses operating in the country. Reports have also noted heightened security costs for enterprises operating across a wide variety of sectors. “Private Security in Nigeria: Rent-a-cop”, The Economist, 10/17/2015.}

Other settings to which our model may apply are the drug trades Colombia and Mexico, and other organized crime syndicates such as those operating in Italy, Japan and Hong Kong.

From a methodological perspective, our paper demonstrates the value of the theory of cooperation under imperfect monitoring in describing real-world social equilibria in specialized settings. By specifying an exact theoretical relationship between piracy, livestock trading, and
land-based conflict, we were able to generate a number of predictions that rationalize a set of empirical patterns specific to a particular case, suggesting new ways of integrating theory with case analysis. This could be especially valuable in contexts where data are limited.

References


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Appendix

A. Summary Statistics and IV Results

Table 3 presents summary statistics for the data used in this paper. In the remainder of this section, we present the instrumental variables estimation strategy for estimating the relationship between livestock exports and piracy attacks mentioned in footnote 30.

<table>
<thead>
<tr>
<th>Table 3: Summary statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Somaliland</strong></td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Pirate attacks</td>
</tr>
<tr>
<td>Conflict incidents</td>
</tr>
<tr>
<td>Livestock exports</td>
</tr>
<tr>
<td>Local meat prices</td>
</tr>
<tr>
<td>Int’l meat prices</td>
</tr>
</tbody>
</table>

| **Puntland**               |
| Mean | Std. Dev. | Min | Max | Obs. |
| Pirate attacks | 1.32 | 2.15 | 0  | 14  | 157 |
| Conflict incidents | 5.75 | 7.93 | 0  | 44  | 155 |
| Livestock exports | 9.27 | 1.93 | 0  | 10.9 | 156 |
| Local meat prices | 0.09 | 0.45 | -1 | 1  | 136 |
| Int’l meat prices | 0.02 | 0.55 | -1 | 1  | 175 |

Estimating the relationship between livestock exports and piracy attacks is difficult since many unmeasured factors may affect both export volume and piracy attacks. One such factor is current weather conditions, which might not be sufficiently controlled for by our monsoon dummy, and which may simultaneously decrease the ability of pirates to carry out attacks while decreasing the volume of livestock offered for export. For example, in periods of plentiful rainfall and ample grazing forage, pastoralists face less pressure to sell their animals to purchase food. At the same time, heavy rains make it harder to undertake pirate attacks. If both livestock exports and pirate attacks are higher in periods of limited rainfall, this unobserved factor may lead us to underestimate the negative relationship between exports and piracy.

To address the possibility of such confounding, we examine how exogenous variation in demand for livestock due to the annual Hajj affects exports and, in turn, piracy. Since the Hajj is scheduled by reference to the Islamic lunar calendar, which is shorter than the Gregorian calendar, its timing is plausibly exogenous to pirate attacks as well as longer term seasonal
Table 4: Instrumental Variables Estimates of Pirate Attacks

<table>
<thead>
<tr>
<th>Second Stage IV Results</th>
<th>Somaliland (Berbera)</th>
<th>Puntland (Bosasso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV = Pirate Attacks</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>During Ban</td>
<td>After Ban</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Lagged Pirate Attacks</td>
<td>0.0370 (0.0429)</td>
<td>-0.0922 (0.0827)</td>
</tr>
<tr>
<td>First Stage Residuals</td>
<td>0.401 (0.246)</td>
<td>0.274 (0.304)</td>
</tr>
<tr>
<td>Exports (log)</td>
<td>-0.568* (0.230)</td>
<td>-0.492† (0.288)</td>
</tr>
<tr>
<td>Monsoon</td>
<td>0.205 (0.227)</td>
<td>0.0802 (0.315)</td>
</tr>
<tr>
<td>Unskilled Wage Rate</td>
<td>-0.261 (0.337)</td>
<td>0.375 (0.546)</td>
</tr>
<tr>
<td>Constant</td>
<td>7.380** (2.216)</td>
<td>4.422 (2.783)</td>
</tr>
<tr>
<td>Observations</td>
<td>127</td>
<td>89</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.147</td>
<td>0.137</td>
</tr>
<tr>
<td>Log-Likelihood</td>
<td>-173.7</td>
<td>-96.02</td>
</tr>
<tr>
<td>AIC</td>
<td>387.3</td>
<td>232.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First Stage IV Results</th>
<th>Somaliland (Berbera)</th>
<th>Puntland (Bosasso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV = Exports (log)</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>During Ban</td>
<td>After Ban</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Lagged Exports (log)</td>
<td>0.786** (0.0901)</td>
<td>0.839** (0.0888)</td>
</tr>
<tr>
<td>Hajj</td>
<td>0.521* (0.212)</td>
<td>0.227 (0.209)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.639† (0.872)</td>
<td>1.477† (0.855)</td>
</tr>
<tr>
<td>Observations</td>
<td>155</td>
<td>117</td>
</tr>
<tr>
<td>R²</td>
<td>0.778</td>
<td>0.787</td>
</tr>
</tbody>
</table>

Note: Two stage IV results. Second stage results, reported in the upper panel, are negative binomial estimates of pirate attacks. These models include year fixed effects, and robust standard errors are reported in parentheses. OLS estimates of livestock exports. All models, both first and second stage, include year fixed effects and robust standard errors are reported in parentheses. † p < 0.10, * p < 0.05, ** p < 0.01.

weather that may affect piracy. This makes it a reasonable candidate as an instrument for exports, albeit with some caveats. In particular, the exclusion restriction – that piracy incidents are affected by the Hajj via the livestock export route alone – may be violated in other ways. For example, one might argue that, given Somali pirates are Muslim, they may reduce the organization of piracy activities during particularly salient religious periods. Although this “pious pirate” argument does not appear to find support elsewhere in our data (in particular,
pirate attacks are no less likely on Fridays) we cannot rule out this possibility so we must interpret the results of this strategy with equal caution.\footnote{For example, one might argue that the lack of any Friday effect may be not rule out the pious pirate argument, if the Hajj is a more important religious commitment than Friday prayers. We do not find this explanation compelling since Muslims are only expected to undertake Hajj at most once during their lifetime, and only a small number of Somalis actually perform the Hajj each year (less than 7,500 did so in 2015, “Somali Hajj pilgrims reluctant to return home”, Saudi Gazette, 10/15/2015). So it seems unlikely that any significant proportion of Somali pirates are observing Hajj each year, but since we cannot rule it out, it is important to err on the side of caution in interpreting these estimates as causal.}

Table 4 shows the results from this instrumental variables estimation strategy. All models include lagged exports and year dummies to control for changes in export volumes across time. The first notable result is the positive coefficient of the Hajj indicator on export volumes across all first stage models in the lower panel. As expected, the Saudi livestock ban attenuated the relationship between the instrument and exports during the ban, which can be seen by comparing the coefficient estimates during and after the ban for each port. This attenuation is particularly acute for Somaliland, demonstrating the importance of the Saudi livestock market for Somaliland’s Berbera port.

We report the second stage estimates in the upper panel of Table 4. Given that we use a negative binomial model for the pirate attack count data, we use the second-stage residual inclusion method for non-linear models, which provides a way to control for unmeasured confounders in the second stage. Our interest is in the coefficient of the log of exports (third row). The upper panel shows how the estimates for each region follow our expectation. There is a negative relationship between exports and pirate attacks in Somaliland, consistent with the argument that pirates self-regulate their piracy therein. This relationship is especially strong after the Saudi ban ended and Somaliland’s export market expanded. The larger size of the estimates in Table 2 as compared to Table 1 in the main text indicate that unobserved factors do lead us to underestimate the negative relationship between exports and piracy in the first Table. In Puntland, there is no evidence of such a relationship, consistent with the lack of coordination between Puntland’s diverse economic interests.

B. Proof of Proposition 1

A PPE supports a path automaton if, on the path of play, the PPE prescribes the same action choices that are prescribed by the path automaton.

We organize the proof as follows. We first characterize the payoffs for each group in each automaton state of the NCR, SCR, SCR\[nSR\] and SCR\[SR\]. Second, we prove part 1 of the proposition. Third, we define the functions \(f_C\), \(f_S\) and \(f_{nSR}\). In so doing, we establish the comparative statics reported in part 2(iii). Finally, we prove parts 2(i) and 2(ii).
B.1. Payoffs

We characterize all payoffs as solutions to a recursive system of equations. In each case, the system of equations has a unique solution so all payoffs are unique.

**NCR payoffs** Let $V^p_{NCR}(PnSR)$ denote the value function for the pirates at the *Peace and no Self Regulation* state and $V^p_{NCR}(C)$ their value function at the *Conflict* state when $\omega = 1$. Under the NCR these value functions satisfy the following recursive system of equations

$$
\begin{align*}
V^p_{NCR}(PnSR) &= (1 - \delta)(\overline{\pi}d) + \delta V^p_{NCR} \\
V^p_{NCR}(C) &= (1 - \delta)(\overline{\pi}d - l - k\Lambda) + \delta V^p_{NCR}
\end{align*}
$$

where

$$V^p_{NCR} := (1 - \overline{\pi})V^p_{NCR}(PnSR) + \overline{\pi}V^p_{NCR}(C)$$

is the continuation value from each state. Similarly, to compute the values of the livestock traders, let $V^\ell_{NCR}(PnSR|s)$ denote their value in the *Peace and no Self Regulation* state when $s_t = s$ and $V^\ell_{NCR}(C|s)$ their value under the *Conflict* state when $s_t = s$. These values solve the following system of equations

$$
\begin{align*}
V^\ell_{NCR}(PnSR|0) &= (1 - \delta)(0) + \delta V^\ell_{NCR} \\
V^\ell_{NCR}(PnSR|1) &= (1 - \delta)((1 - \overline{\tau})R) + \delta V^\ell_{NCR} \\
V^\ell_{NCR}(C|0) &= (1 - \delta)(g - k/\Lambda) + \delta V^\ell_{NCR} \\
V^\ell_{NCR}(C|1) &= (1 - \delta)[(1 - \overline{\tau})R + g - k/\Lambda] + \delta V^\ell_{NCR}
\end{align*}
$$

where

$$V^\ell_{NCR} \equiv \theta \left[\overline{\pi}V^\ell_{NCR}(C|1) + (1 - \overline{\pi})V^\ell_{NCR}(PnSR|1)\right] + (1 - \theta) \left[\overline{\pi}V^\ell_{NCR}(C|0) + (1 - \overline{\pi})V^\ell_{NCR}(PnSR|0)\right]$$

is the continuation value from each state.

**SCR[nSR] payoffs** Now consider the SCR[nSR] and let $V^p_{SCR[nSR]}(PnSR|\omega)$ denote the value of the pirates in the *Conflict* state when the payoff relevant signal realization is $\omega \in \{0, 1\}$, $V^p_{SCR[nSR]}(PnSR)$ their value in the *Peace and no Self Regulation* state, and $V^p_{SCR[nSR]}(PSR)$ their value in the *Peace and Self Regulation* state. These value functions satisfy the following
recursive system of equations:

\begin{align*}
V_{SCR}^{p}(C \mid 0) &= (1 - \delta)(\mu d - k\lambda) + \delta [(1 - \mu)\nu_{SCR}^{p} + \mu V_{SCR}^{p}(C \mid 1)] \\
V_{SCR}^{p}(C \mid 1) &= (1 - \delta)(\mu d - l - k\lambda) + \delta [(1 - \mu)\nu_{SCR}^{p} + \mu V_{SCR}^{p}(C \mid 1)] \\
V_{SCR}^{p}(PnSR) &= (1 - \delta)(\mu d) + \delta\nu_{SCR}^{p} \\
V_{SCR}^{p}(PSR) &= (1 - \delta)[\phi(1 - \gamma)R\Lambda + \mu d] + \delta [(1 - \mu)\nu_{SCR}^{p} + \mu V_{SCR}^{p}(C \mid 1)] \\
& \quad + (1 - \mu)\gamma V_{SCR}^{p}(C \mid 0) + \mu V_{SCR}^{p}(C \mid 1) \quad (3)
\end{align*}

where

\[ \nu_{SCR}^{p} \equiv \theta V_{SCR}^{p}(PSR) + (1 - \theta)V_{SCR}^{p}(PnSR) \]

is the expected value of continuing to a peaceful automaton state. Similarly, we let \( V_{C}^{\ell}(C \mid s, \omega) \) denote the value of the traders in the Conflict state when \((s, \omega) \in \{0, 1\} \times \{0, 1\}\), and \( V_{C}^{\ell}(PnSR) \) and \( V_{C}^{\ell}(PSR) \) their values in the Peace and no Self Regulation and Peace and Self Regulation states respectively. These value functions satisfy the following recursive system of equations:

\begin{align*}
V_{SCR}^{\ell}(C \mid 0, 0) &= (1 - \delta)(-k/\lambda) + \delta [(1 - \mu)\nu_{SCR}^{\ell}(P) + \mu \nu_{SCR}^{\ell}(C \mid 1)] \\
V_{SCR}^{\ell}(C \mid 0, 1) &= (1 - \delta)(g - k/\lambda) + \delta [(1 - \mu)\nu_{SCR}^{\ell}(P) + \mu \nu_{SCR}^{\ell}(C \mid 1)] \\
V_{SCR}^{\ell}(C \mid 1, 1) &= (1 - \delta)(1 - \gamma)R + g - k/\lambda) + \delta [(1 - \mu)\nu_{SCR}^{\ell}(P) + \mu \nu_{SCR}^{\ell}(C \mid 1)] \\
V_{SCR}^{\ell}(C \mid 1, 0) &= (1 - \delta)(1 - \gamma)R - k/\lambda) + \delta [(1 - \mu)\nu_{SCR}^{\ell}(P) + \mu \nu_{SCR}^{\ell}(C \mid 1)] \\
V_{SCR}^{\ell}(PnSR) &= (1 - \delta)(0) + \delta \nu_{SCR}^{\ell}(P) \\
V_{SCR}^{\ell}(PSR) &= (1 - \delta)[(1 - \phi)(1 - \gamma)R] + \delta [(1 - \mu)\nu_{SCR}^{\ell}(P) + \mu \nu_{SCR}^{\ell}(C \mid 1)] \\
& \quad + (1 - \mu)\gamma \nu_{SCR}^{\ell}(C \mid 0) + \mu \nu_{SCR}^{\ell}(C \mid 1) \quad (4)
\end{align*}

where

\[ \nu_{SCR}^{\ell}(P) \equiv \theta V_{SCR}^{\ell}(PSR) + (1 - \theta)V_{SCR}^{\ell}(PnSR) \]

\[ \nu_{SCR}^{\ell}(C \mid 1) \equiv \theta \nu_{SCR}^{\ell}(C \mid 1, 1) + (1 - \theta)\nu_{SCR}^{\ell}(C \mid 0, 1) \]

\[ \nu_{SCR}^{\ell}(C \mid 0) \equiv \theta \nu_{SCR}^{\ell}(C \mid 1, 0) + (1 - \theta)\nu_{SCR}^{\ell}(C \mid 0, 0) \]

are the expected values of continuing to a peaceful automaton state and a conflictual automaton state with \( \omega = 1 \) and \( \omega = 0 \), respectively.
**SCR[SR] payoffs** The systems of recursive value functions for the SCR[SR] are the same as above but with

\[
\begin{align*}
V^p_{SCR}(C|0) &= (1 - \delta)(\mu d - k\Lambda) + \delta[(1 - \mu)V^p_{SCR}(P) + \mu V^p_{SCR}(C|1)] \\
V^p_{SCR}(C|1) &= (1 - \delta)(\mu d - l - k\Lambda) + \delta[(1 - \mu)V^p_{SCR}(P) + \mu V^p_{SCR}(C|1)]
\end{align*}
\]

(5)

replacing the first two lines of (3), and

\[
\begin{align*}
V^t_{SCR}(C|0,0) &= (1 - \delta)(-k/\Lambda) + \delta[(1 - \mu)V^t_{SCR}(P) + \mu V^t_{SCR}(C|1)] \\
V^t_{SCR}(C|0,1) &= (1 - \delta)(-g - k/\Lambda) + \delta[(1 - \mu)V^t_{SCR}(P) + \mu V^t_{SCR}(C|1)] \\
V^t_{SCR}(C|1,1) &= (1 - \delta)[(1 - \gamma)R + g - k/\Lambda] + \delta[(1 - \mu)V^t_{SCR}(P) + \mu V^t_{SCR}(C|1)] \\
V^t_{SCR}(C|1,0) &= (1 - \delta)[(1 - \gamma)R - k/\Lambda] + \delta[(1 - \mu)V^t_{SCR}(P) + \mu V^t_{SCR}(C|1)]
\end{align*}
\]

(6)

replacing the first four lines of (4).

**B.2. Proof of Part 1**

Note that under the NCR we have \(\phi_t = 0\) in every period \(t\) in which society is not in a Conflict state, as assumed in the main text. Consider a strategy profile in which the players play according to the NCR after every possible history of play. We claim that this strategy profile is a PPE. It is clear that the trading group has no profitable deviations: this follows from assumption (A1). It is also clear that if the players are sufficiently myopic (\(\delta\) is equal to or close to 0) the strategy profile is a PPE. For higher values of \(\delta\), however, this need not be the case since the pirates may want to deviate from the Peace and no Self Regulation state or from the Conflict states to lower their next period probability of entering the Conflict states. These deviations would entail switching from no self-regulation to self-regulation.

To find conditions under which such one-time deviations are not profitable, we first compute the value functions of the pirates at each of the states. The solution to (1) is

\[
\begin{align*}
V^p_{NCR}(PnSR) &= \overline{\mu}d - \delta\overline{\mu}(l + k\Lambda) \\
V^p_{NCR}(C) &= \overline{\mu}d - (1 - \delta(1 - \overline{\mu}))(l + k\Lambda)
\end{align*}
\]

(7) (8)

The pirates’ payoff to a one-time deviation from the automaton state \(S \in \{PnSR, C\}\) is

\[
V^p_{dev}(S) = (1 - \delta)v^p_{dev}(S) + \delta[(1 - \mu)V^p(PnSR) + \mu V^p(C)]
\]

(9)
where \( v_{dev}^p(PnSR) = \mu d \) and \( v_{dev}^p(C) = \mu d - l - k\Lambda \). Such deviations are unprofitable if \( V_{dev}^p(S) \leq V^p(S) \) for \( S \in \{PnSR, C\} \), or in other words
\[
v_{dev}^p(S) \leq \frac{1}{1-\delta} [V^p(S) - \delta [(1 - \mu) V^p(PnSR) + \mu V^p(C)]] \quad S \in \{PnSR, C\}
\] (10)
which follows from substituting (9) and rearranging. Substituting the values of \( V^p(PnSR) \) and \( V^p(C) \) from (7) and (8) into (10) and then taking the derivative of the right hand side of the inequality with respect to \( \delta \) yields \(-(\bar{\mu} - \mu)(l + k\Lambda)\) for both states \( S \). Thus the right hand side of (10) is decreasing in \( \delta \) for both states. This implies that if the inequality holds when \( \delta \) goes to 1 then the NCR is supported by the PPE for all values of \( \delta \).

Substituting \( v_{dev}^p(S) \) and the values from (7) and (8) into (10), taking \( \delta \) to 1 on the right hand side, and then rearranging the inequalities for both \( S \in \{PnSR, C\} \) yields the same inequality for both states: \((\bar{\mu} - \mu)(d - l - k\Lambda) \geq 0\). This is satisfied by assumption (A2), which states that \( d - l - k\Lambda > 0\). Therefore, deviating at either state is unprofitable.

B.3. Candidates for \( f_C, f_SR \) and \( f_{nSR} \) (and Proof of Part 2(iii))

Let
\[
f_C = [1 - (1 - \theta)\bar{\mu} + \theta \gamma(1 - \mu)]d - [1 + \theta \gamma(1 - \mu)]l - k\Lambda - \theta \phi(1 - \gamma)\Lambda R\Lambda
\] (11)

Define
\[
\mu[a] = \begin{cases} 
\bar{\mu} & \text{if } a = nSR \\
\mu & \text{if } a = SR 
\end{cases}
\]
and for \( a \in \{nSR, SR\} \) define a vector of payoffs \( v[a] \) by
\[
v[a] = \begin{pmatrix} v_{PSR}[a] \\
v_{PnSR}[a] \\
v_{C1}[a] \\
v_{C0}[a] \\
v_{dev}[a]
\end{pmatrix} = \begin{pmatrix} \mu d + \phi(1 - \gamma)\Lambda R\Lambda \\
\bar{\mu}d \\
\mu[a]d - l - k\Lambda \\
\mu[a]d - k\Lambda \\
\bar{\mu}d + \phi(1 - \gamma)\Lambda R\Lambda
\end{pmatrix}
\]
Similarly, define a vector of weights \( w[a] = (w_{PSR}[a], w_{PnSR}[a], w_{C1}[a], w_{C0}[a], w_{dev}[a]) \) by
\[
w_{PSR}[a] = 1 - \mu[a] + \theta [\bar{\mu} + \gamma(1 - \bar{\mu})]
\]
\[
w_{PnSR}[a] = (1 - \theta) [(\bar{\mu} + \gamma(1 - \bar{\mu})) - (\bar{\mu} + \gamma(1 - \bar{\mu}))]
\]
\[
w_{C1}[a] = - \bar{\mu} - \mu[a]\gamma(1 - \bar{\mu}) - \gamma(1 - \mu)] - \theta [\bar{\mu}\gamma(1 - \mu) - \mu\gamma(1 - \bar{\mu})]
\]
\[
w_{C0}[a] = - (1 - \mu[a])\gamma(1 - \mu) - \gamma(1 - \mu)] + \theta [\bar{\mu}\gamma(1 - \mu) - \mu\gamma(1 - \bar{\mu})]
\]
\[
w_{dev}[a] = - [1 - \mu[a] + \theta (\bar{\mu} + \gamma(1 - \bar{\mu})]
\]

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We then define the functions $f_{SR}$ and $f_{nSR}$ by

$$f_{SR} = w[SR] \cdot v[SR] \quad \text{and} \quad f_{nSR} = w[nSR] \cdot v[nSR]$$

We show below that for both $a = nSR, SR$, the weighted average of flow payoffs represented in vector $v[a]$ where weights are given by $w[a]$ must be positive for the pirates to have no profitable deviation at the Peace and Self Regulation state. Note that the components of the vector of weights $w[a]$ sum to 1 for each $a = nSR, SR$. Moreover, for both $a = nSR, SR$ the weight $w_{dev}[a]$ is negative meaning that as the flow payoff from one time deviation becomes more attractive, it is harder to support the path automaton in equilibrium.

Second, note that in the product $w[a] \cdot v[a]$, $a = nSR, SR$, the parameter $\tilde{\phi}$ appears only in a product with $R \Lambda$ and the parameter $\Lambda$ appears either as a product with $\bar{\phi}R$ or with $k$. The coefficient of $k \Lambda$ in $w[a] \cdot v[a]$ is $-(w^{[1]}[a] + w^{[0]}[a])$, which is positive for both $a = nSR, SR$. The coefficient of the term $\bar{\phi}R \Lambda$ in the product $w[a] \cdot v[a]$ is $(1 - \gamma)w^{PSR}[a] - (1 - \sigma)w_{dev}[a]$, which is also positive for both $a = nSR, SR$. Therefore $w[a] \cdot v[a]$ is increasing in $\Lambda$ and $\bar{\phi}$ for both $a = nSR, SR$.

Finally, the coefficient of $d$ in $w[a] \cdot v[a]$ is negative for both $a = nSR, SR$ so when $d$ increases it is harder to provide incentives to the pirates to not deviate from the Peace and Self Regulation state on the path of play of either SCR$_{nSR}$ or SCR$_{SR}$.

These observations establish the comparative statics reported in part 2(iii) of the proposition. We now prove the remainder.

**B.4. Proof of Part 2(i)**

Consider a PPE under which the players play according to the SCR$_{nSR}$ and any deviation by livestock traders is met by switching to the NCR forever after. As is well-known, the payoff for each group $i = \ell, p$ in the limit as $\delta \to 1$ is the same across all automaton states and equals a weighted average of flow payoffs for each state with weights being the corresponding components of the stationary distribution of the Markov process governing automaton state transitions. Let $V_{NCR}^{\ell}$ denote this limiting value for the traders respectively in the NCR and $V_{SCR}^{\ell}$ the limiting values the traders in the SCR$_{nSR}$. Since the NCR can be supported in equilibrium for all values of the discount factor, the livestock traders have no profitable one-time deviations for all high enough values of $\delta$ if and only if $V_{SCR}^{\ell} - V_{NCR}^{\ell} > 0$. To show that this holds, we compute that for a positive constant $\zeta := [1 - \mu + \theta \mu + \gamma \theta (1 - \mu)]/(1 - \mu)$

$$\frac{1}{\zeta} (V_{SCR}^{\ell} - V_{NCR}^{\ell}) = \theta [(1 - \bar{\phi})(1 - \gamma)R - (1 - \sigma)R] - (\bar{\mu} - \theta \mu)(g - k/\Lambda) - \gamma \theta (1 - \mu)(k/\Lambda)$$

$$\geq \theta \left[ (1 - \bar{\phi})(1 - \gamma)R - \left( 1 + \frac{1}{1 - \mu} \right)(1 - \sigma)R \right] - [1 + \gamma (1 - \mu) \theta] g - k/\Lambda > 0$$

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where the first inequality follows because \( g - k / \Lambda > 0 \) by (A1) and the second inequality follows from assumption (A3). Therefore, it is sufficient for us to examine only the no profitable one-time deviation condition for the pirates.

The solution to the recursive system of equations in (3) is unique and follows from straightforward algebra. To save space, we do not report it. In what follows we consider one-time deviations by the pirates from the two Conflict states, the Peace and Self Regulation state and the Peace and no Self Regulation state, characterizing conditions under which these one-time deviations are unprofitable.

1. We start by showing that when \( \delta \) is high, the pirates have no incentive to deviate from the Conflict state when \( \omega_t = \omega \). If the pirates deviate from this state, then with probability \( \mu \) we have \( \omega_{t+1} = 1 \) and society returns to a Conflict state with \( \omega_{t+1} = 1 \). With probability \( 1 - \mu \) society exits the Conflict states, entering the Peace and Self Regulation state with probability \( \theta \) and the Peace and no Self Regulation with probability \( 1 - \theta \). Thus, the deviation is unprofitable if and only if

\[
 v_{\text{dev}}^P(C|\omega) \leq \frac{1}{1 - \delta} \left[ V_{\text{SCR}}^P(C|\omega) - \delta \left( (1 - \mu)V_{\text{SCR}}^P + \mu V_{\text{SCR}}^P(C|1) \right) \right]
\]

for \( \omega \in \{0, 1\} \), where \( v_{\text{dev}}^P(C|0) = \mu d - k \Lambda \) and \( v_{\text{dev}}^P(C|1) = \mu d - l - k \Lambda \). Substituting the values of \( V_{\text{SCR}}^P(C|\omega) \) and \( V_{\text{SCR}}^P(PSR) \) solved from the system above, and the value of \( v_{\text{dev}}^P(C|\omega) \), rearranging and taking \( \delta \to 1 \) yields the same inequality for both values of \( \omega \in \{0, 1\} \). The inequality is

\[
 \frac{\bar{p} - \mu}{1 - \bar{p} + \theta (\frac{\bar{p}}{\mu} + (1 - \mu))} \left( [1 - (1 - \theta)\bar{p} + \theta \gamma (1 - \mu)]d - [1 + \theta \gamma (1 - \mu)]l - k \Lambda - \theta \phi (1 - \gamma) R \Lambda \right) \geq 0
\]

Since the coefficient of the term in large square brackets is positive, the term in large square brackets must be positive to guarantee no profitable deviations for all high values of \( \delta \). This gives the inequality \( f_C > 0 \) where \( f_C \) is defined in (11). Since this inequality is satisfied by assumption, one-time deviations from either of the Conflict states are unprofitable.

2. Now consider a deviation for the pirates from the Peace and Self Regulation state. The deviation yields an instantaneous expected payoff of \( \bar{p} d + \bar{\phi} (1 - \gamma) R \Lambda \). After the deviation, the players enter the Conflict state with \( \omega_t = 1 \) with probability \( \bar{p} \), the Conflict state with \( \omega_t = 0 \) with probability \( \bar{\gamma} (1 - \bar{p}) \) and they exit the Conflict states entering the Peace and Self Regulation state with probability \( (1 - \bar{p}) (1 - \bar{\gamma}) \theta \) and the Peace and no Self Regulation state with probability \( (1 - \bar{p}) (1 - \bar{\gamma}) (1 - \theta) \). Therefore, the deviation is
unprofitable if and only if
\[
\bar{\mu} d + \phi (1 - \bar{\pi}) R A \leq \frac{1}{1 - \delta} \left[ V^{p}_{SCR}(PSR) - \delta (1 - \bar{\pi})(1 - \bar{p}) V^{p}_{SCR} \right.
\]
\[
\left. + \bar{\pi} (1 - \bar{p}) V^{p}_{SCR}(C| 0) + \bar{p} V^{p}_{SCR}(C| 1) \right]\]

Substituting $V^{p}_{SCR}(PSR)$, $V^{p}_{SCR}$, $V^{p}_{SCR}(C| 0)$, and $V^{p}_{SCR}(C| 1)$ solved from the system of recursive equations, taking the limit as $\delta \to 1$, and rearranging yields
\[
\frac{1}{1 - \bar{\mu} + \theta (\mu + \gamma (1 - \mu))} (w[nSR] \cdot v[nSR]) \geq 0
\]

where $w[nSR]$ and $v[nSR]$ are the vectors defined in Section C. Since the coefficient of the product of these vectors is positive, the product of vectors must be positive to guarantee no profitable deviations for all high values of $\delta$. This gives the inequality $f_{SR} > 0$ where $f_{SR}$ is given by (12).

3. If the pirates do not deviate at the Peace and no Self Regulation state, then they receive $V^{p}_{SCR}(PnSR) = \delta (1 - \mu d) + \delta V^{p}_{SCR}$ but if they do deviate then they receive only $(1 - \delta)(\mu d) + \delta V^{p}_{SCR}$. Therefore, the deviation is not profitable.

B.5. Proof of Part 2(ii)

This time let $V^{fs}_{SCR}$ denote the the limiting payoff of the livestock traders in the SCR[SR]. These traders have no profitable one time deviation for all high values of $\delta$ if and only if $V^{fs}_{SCR} - V^{fs}_{NCR} > 0$. We compute, as before, that for a positive constant $\xi := [1 - \mu + \theta \mu + \gamma \theta (1 - \mu)]/(1 - \mu)$
\[
\frac{1}{\xi} (V^{fs}_{SCR} - V^{fs}_{NCR}) = \theta \left[ (\xi - \bar{\phi}) (1 - \gamma) R - \xi (1 - \bar{\pi}) R \right] - [1 + \gamma \theta (1 - \mu)] g - k/\Lambda
\]
\[
\geq \theta \left[ (1 - \bar{\phi})(1 - \gamma) R - \left( 1 + \frac{1}{1 - \mu} \right) (1 - \bar{\pi}) R \right] - [1 + \gamma (1 - \mu) \theta] g - k/\Lambda > 0
\]

where the first inequality follows because $1 + \frac{1}{1 - \mu} > \xi > 1$ and the second inequality follows from assumption (A3). Therefore, it is sufficient for us to examine only the no profitable one-time deviation condition for the pirates.

As before, the solution to the recursive system of equations defining the pirates payoffs in the SCR[SR] is unique, and again we do not report it to save space. We consider one-time deviations by the pirates from the two Conflict states, the Peace and Self Regulation state and the Peace and no Self Regulation state, characterizing conditions under which these one-time deviations are unprofitable.
1. If the pirates deviate from a Conflict state, then with probability $\bar{\mu}$ we have $\omega_{t+1} = 1$ and society returns to a Conflict state with $\omega_{t+1} = 1$. With probability $1 - \bar{\mu}$ society exits the Conflict states, entering a Peace and Self Regulation state with probability $\theta$ and a Peace and no Self Regulation with probability $1 - \theta$. Thus, the deviation is unprofitable if and only if

$$v_{dev}^{p}(C|\omega) \leq \frac{1}{1 - \delta} \left[ V_{SCR}^{p}(C|\omega) - \delta[(1 - \bar{\mu})V_{SCR}^{p} + \bar{\mu}V_{SCR}(C|1)] \right]$$

for $\omega \in \{0, 1\}$, where $v_{dev}^{p}(C|0) = \bar{\mu}d - k\Lambda$ and $v_{dev}^{p}(C|1) = \bar{\mu}d - l - k\Lambda$. Substituting the values of $V_{SCR}^{p}(C|\omega)$ and $V_{SCR}^{p}(PSR)$ solved from the system above, and the value of $v_{dev}^{p}(C|\omega)$, rearranging and taking $\delta \to 1$ yields the same inequality for both values of $\omega \in \{0, 1\}$. The inequality is

$$\frac{\bar{\mu} - \mu}{1 - \bar{\mu} + \theta(\bar{\mu} + \gamma(1 - \mu))} \left[ [1 - (1 - \theta)\bar{\mu} + \theta\gamma(1 - \mu)] \cdot d - [1 + \theta\gamma(1 - \mu)] l - k\Lambda - \theta \bar{\phi}(1 - \gamma)R\Lambda \right] \leq 0$$

Since the coefficient of the term in large square brackets is positive, the term in large square brackets must be negative to guarantee no profitable deviations for all high values of $\delta$. This produces $f_{C} < 0$.

2. Now consider a deviation for the pirates from the Peace and Self Regulation state. The deviation yields an instantaneous expected payoff of $\bar{\mu}d + \bar{\phi}(1 - \gamma)R\Lambda$. After the deviation, the players enter the Conflict state with $\omega_{t} = 1$ with probability $\bar{\mu}$, the Conflict state with $\omega_{t} = 0$ with probability $\gamma(1 - \bar{\mu})$ and they exit the Conflict states entering a Peace and Self Regulation state with probability $(1 - \bar{\mu})(1 - \gamma)\theta$ and a Peace and no Self Regulation state with probability $(1 - \bar{\mu})(1 - \gamma)(1 - \theta)$. Therefore, the deviation is unprofitable if and only if

$$\bar{\mu}d + \bar{\phi}(1 - \gamma)R\Lambda \leq \frac{1}{1 - \delta} \left[ V_{SCR}^{p}(PSR) - \delta[(1 - \gamma)(1 - \bar{\mu})V_{SCR}^{p} + \gamma(1 - \bar{\mu})V_{SCR}(C|0) + \bar{\mu}V_{SCR}(C|1)] \right]$$

Substituting $V_{SCR}^{p}(PSR)$, $V_{SCR}^{p}$, $V_{SCR}^{p}(C|0)$, and $V_{SCR}^{p}(C|1)$ solved from the system of recursive equations above, taking the limit as $\delta \to 1$, and rearranging yields

$$\frac{1}{1 - \mu + \theta(\mu + \gamma(1 - \mu))} (w[SR] \cdot v[SR]) \geq 0$$

where $w[SR]$ and $v[SR]$ are the vectors defined in the statement of the proposition. Since the coefficient of the product of these vectors is positive, the product of vectors must be
positive to guarantee no profitable deviations for all high values of $\delta$. This produces the inequality $f_{SR} > 0$.

3. Finally, if the pirates do not deviate at a Peace and no Self Regulation state, then they receive $V_{SCR}^{p}(PnSR) = (1 - \delta)(\bar{\mu}d) + \delta V_{SCR}^{p}$ but if they do deviate then they receive only $(1 - \delta)(\bar{\mu}d) + \delta V_{SCR}^{p}$. Therefore, the deviation is not profitable.