

We estimate a 29% probability that there will be more than 20 acts of piracy or armed robbery against ships in March 2020

Key Judgments

1. The probability that there will be more than 20 acts of piracy and acts of armed robbery (as defined and reported by the International Maritime Organization), committed or attempted against ships in March 2020, is estimated to be 29%.
2. That the recent relatively low level of incidents will persist into March 2020; if there is a change, it will be downwards.
3. That the likely reduction in trade caused by the coronavirus outbreak is unlikely to cause significant reduction in the incidence of piracy and armed robbery at sea in the Asian region in the immediate future (probability 70%)

Reasoning

Question interpretation

The question asks: "What is the probability that acts of piracy and acts of armed robbery (as defined and reported by the International Maritime Organization), committed or attempted, against ships in March 2020 will be greater than 20?". We've interpreted this as "estimate the probability that the count of all reported incidents will exceed 20 in the month of March, 2020.

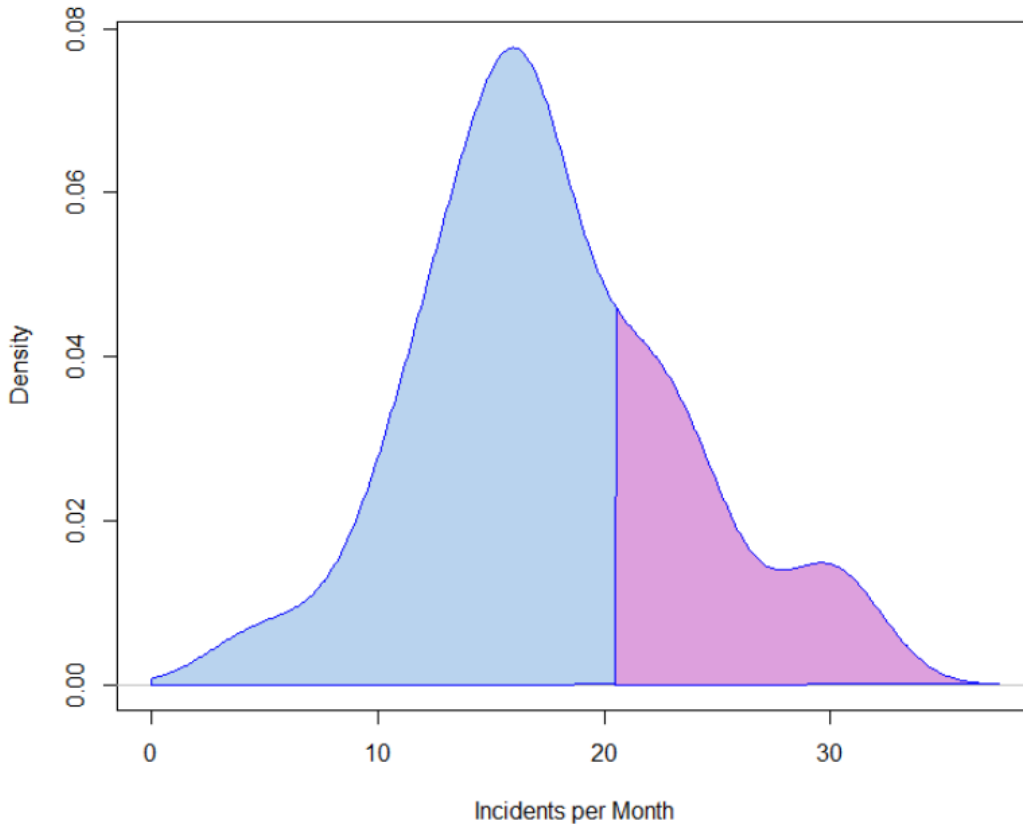
We note that the United Nations International Maritime Organization defines piracy as being "an act of violence, etc. against a ship on the high seas, while armed robbery occurs in a nation's territorial waters". We are not here differentiating between these: all reported attacks on and/or theft from (or of!) ships, whether in port or at sea, minor or major, successful or otherwise, are counted equally.

It is somewhat unclear whether the phrase "as defined and reported" should be taken as indicating we are interested in predicting only the probability of reported "acts of piracy and armed robbery" (hereafter **PAR**); there is a definite suspicion of under-reporting; but no hard data as to its prevalence. We accordingly note the possibility that the true number of PAR incidents may be higher than both that predicted and reported, but do not attempt to quantify the (potential) discrepancy.

Methodology

1. The IMO "all incidents" data was aggregated into a monthly timeseries and examined for evidence of underlying patterns (see Fig. 1). The data is extremely volatile, as might be expected, but most notable is the clear indication of multiple "regime shifts", in which the level, trend or variability of the monthly data was clearly different. Clearly the distribution of PAR incidents varies over time, in response to social, economic and political circumstances in the coastal states, and suppressive and punitive actions undertaken by trading nations.
2. However, the monthly worldwide "all incidents" count for the period from the start of 2016 (ie, the most recent 50 months), while volatile, displays no discernable trend or cycle, leading us to conclude that the distribution of this variable is currently stable, and so might be regarded as predictive, at least in the short run.
3. The 2016–2020 data was therefore made the basis for prediction of the distribution of the count of incidents for March 2020.
4. The March 2020 distribution of the count of PAR incidents was accordingly predicted by computing a "kernel density" estimate (KDE) of the distribution of monthly counts based on the data from Jan-2016 to Feb-2020.
5. The estimated probability of the number of PAR incidents exceeding 20 in March 2020 is computed as the sum of the area over the "count > 20" region (see Fig. below).

Estimated distribution of PAR incidents, 2016-2019



[kde1.png]

Notes

1. Because we require a numeric estimate of a probability, rather than a point prediction of the count itself, we need to estimate/predict the distribution of the number of PAR incidents in the next month.
2. The KDE may be thought of as a "smoothed" histogram; and probability estimates can be obtained by summing the area increments in the implied "bins" in a very similar way.
3. The KDE treats the data as if it were continuous, while the underlying variable is of course discrete. Hence the area is in fact computed as $\Pr(\text{count} > 20.5)$.

Supporting arguments

Data description

The GISIS data <<https://gisis.imo.org/Public/PAR/Default.aspx>> consists of a database of information extracted from PAR incident reports as published in the GSC circulars. The extracted information typically includes the date of the incident, the name of the ship, whether the incident occurred in international waters, territorial waters, or the port area, the geographic region in which the incident occurred; the original description of the incident; and whether it was reported or not (I assume this last actually means "reported to the IMO", since at least some of the 22% of incidents flagged as "not reported" clearly were reported, at least to the local authorities).

It may also include information on the type of ship, the longitude and/or latitude; whether the ship was boarded (and if so, the parts of the ship raided); the number of attackers, and the outcome and response.

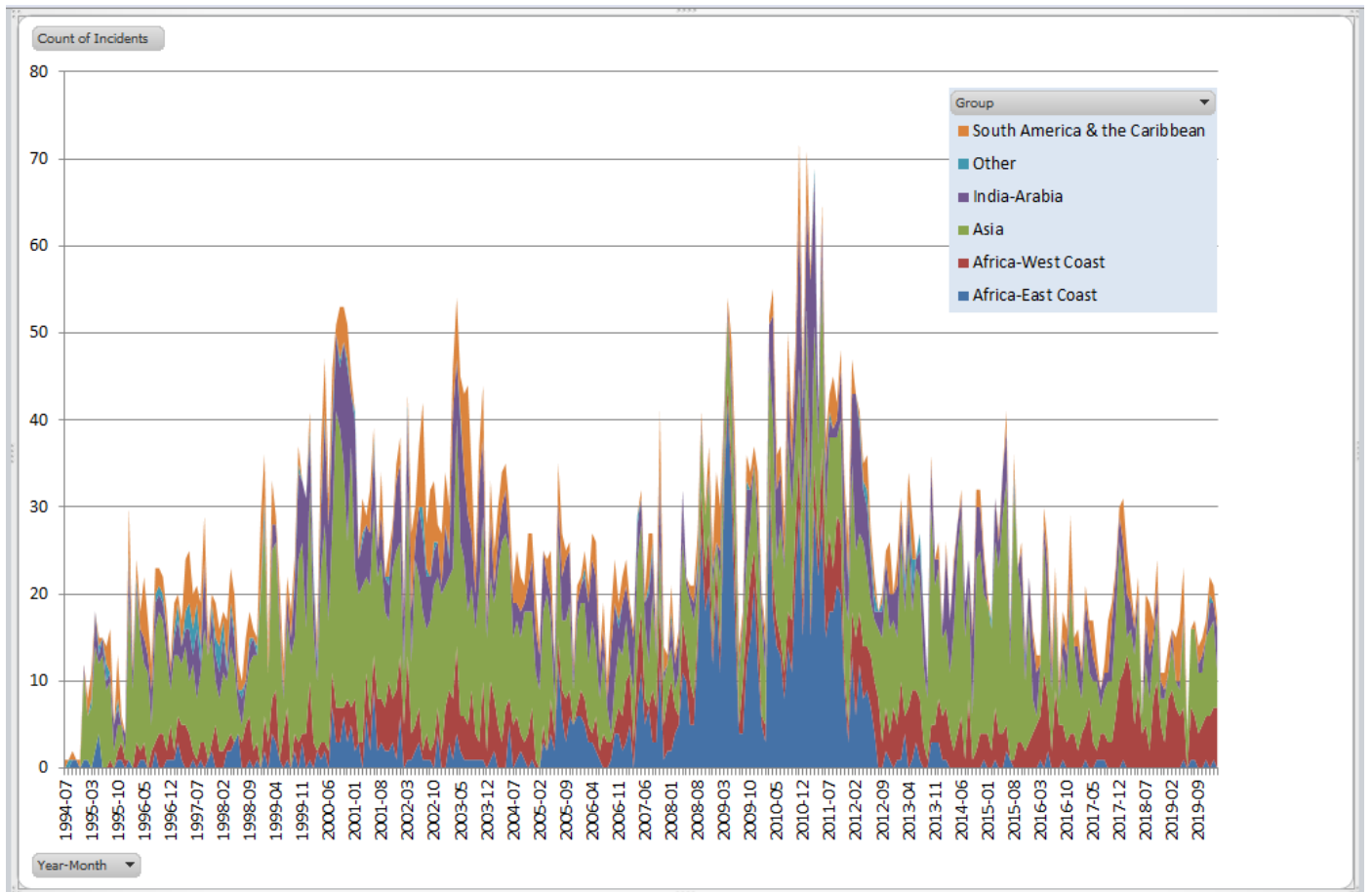
After discarding the handful of incidents for which the date was missing we have a table of 7895 incidents, beginning in July 1994, and ending in February 2020. A certain amount of cleaning was undertaken with respect to the "geographic region" information, after which we have the following breakdown of incidents by location and region (see Fig. below)

| Count of Incidents Region | Location | | | | Total |
|--|-------------------------|-----------------------|--------------|------------|-------------|
| | In international waters | In territorial waters | In port area | Not stated | |
| Africa | | | | | |
| East Africa | 943 | 148 | 104 | 1 | 1196 |
| West Africa | 304 | 373 | 516 | | 1193 |
| India-Arabia | | | | | |
| Arabian Sea | 143 | 28 | 24 | | 195 |
| Indian Ocean | 198 | 374 | 488 | 5 | 1065 |
| Persian Gulf | 4 | 12 | 4 | | 20 |
| South America & the Caribbean | | | | | |
| Caribbean | 16 | 53 | 177 | 1 | 247 |
| South America | 3 | 17 | 55 | | 75 |
| South America (Atlantic) | 4 | 30 | 83 | | 117 |
| South America (Pacific) | 9 | 63 | 106 | | 178 |
| South America and the Caribbean | 4 | 113 | 60 | | 177 |
| Asia-Pacific | | | | | |
| China-other | 2 | 2 | 2 | | 6 |
| Indonesia-Philippines | 4 | 4 | 6 | | 14 |
| Malacca Strait | 296 | 359 | 179 | | 834 |
| Oceania | 4 | 7 | | | 11 |
| South China Sea | 496 | 990 | 974 | 2 | 2462 |
| Yellow Sea | 1 | 9 | 8 | | 18 |
| Other | | | | | |
| Black Sea | | 1 | | | 1 |
| Caspian Sea | | 1 | | | 1 |
| Mediterranean | 8 | 18 | 34 | | 60 |
| North Atlantic | | | 7 | | 7 |
| North Sea | | | 3 | | 3 |
| Unknown | 3 | 13 | 1 | | 17 |
| Total | 2442 | 2615 | 2831 | 9 | 7897 |

[counts.png]

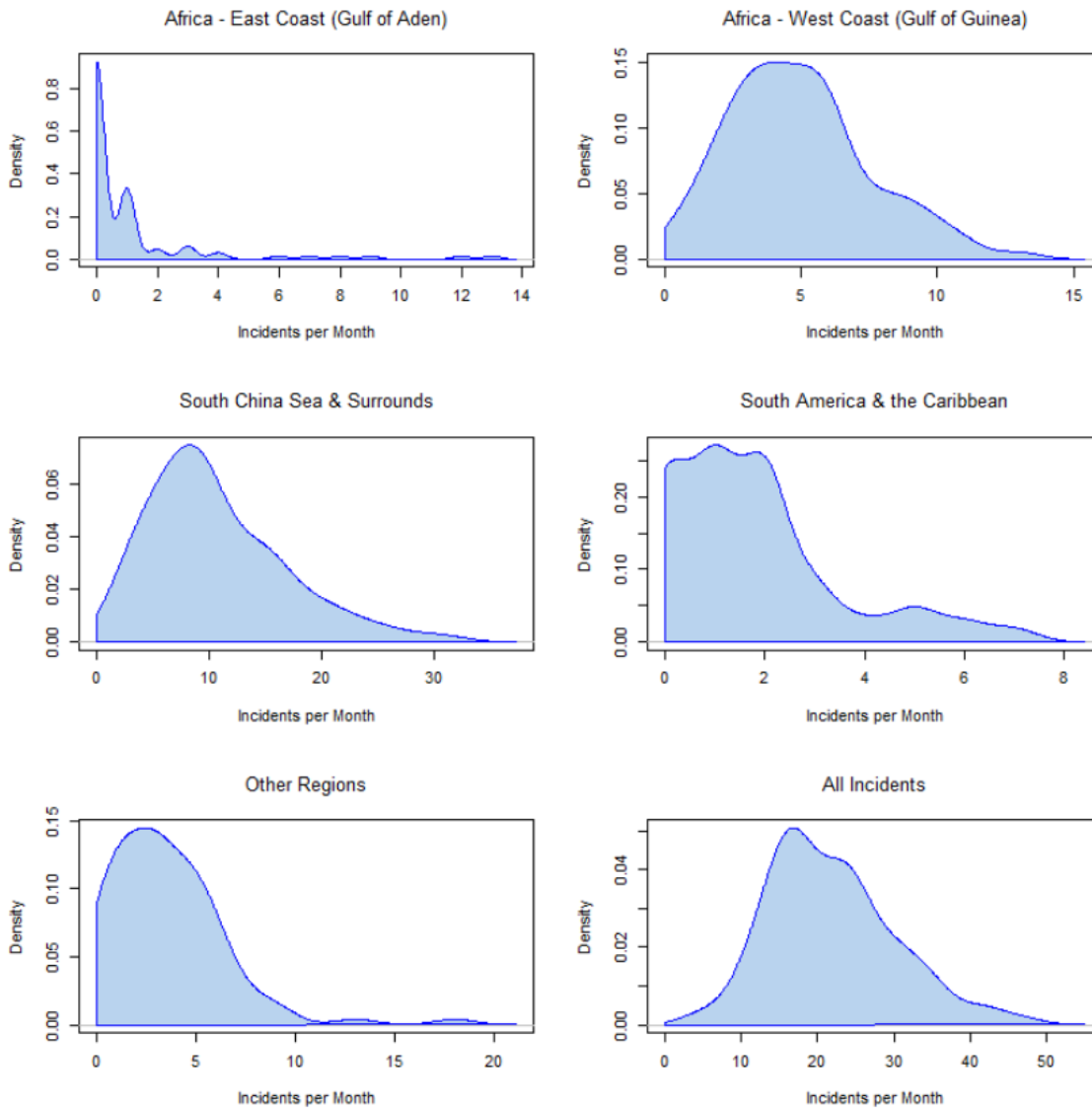
Data analysis

The requirement is for a prediction of the distribution of incidents in a given month; it was therefore decided to begin by assembling a series comprised of the count of incidents in each month. This produced a series of 308 monthly observations on the number of PAR incidents per month, starting in July 1994 and ending in February 2020.



[bv-month.png]

- The data is highly volatile, with several periods of very high activity; most notable of course being the "Somali Piracy Crisis" of 2009--2012. However, the Somali's have been quite thoroughly suppressed, to the extent that this area is now one of the least prone to PAR incidents (the new hotspot, of course, is on the the other side of the continent, in the Gulf of Guinea; this has not, however, reached anywhere near the levels of the Gulf of Aden in 2011). The spike in 2000--2001, on the other hand, is due to high levels of PAR in the South China Sea and Malacca Strait; this is a perennial problem that seems to ebb and flow in 10-15 year cycles.
- The data is therefore subject to multiple "regime shifts" over the period for which it is available; which is to say; the series falls into several periods with quite different characteristics. While a complex model that accounts for the external factors that drive these differences could be constructed, it is unlikely to be especially useful for the very short-term forecast required here, and we accordingly confined our attention to the post-Somali Crisis period (ie, from 2012 onwards).
- The incident data is available for 17 different regions, though only 5 of these see a large enough number of incidents to be separately useful. Plotting the distribution of the monthly PAR count for each of these regions shows them to be quite different (see Fig. below) The very long tail in the Africa-East distribution reflects the tail-end of the Somali Crisis; this had expired entirely by July 2012; and the number of incidents per month in this region never again exceeded 4; indeed, the average rate for this region is now around 4 incidents per year.



[regionkde.png]

Evaluation of information and sources

The primary source for this analysis is the IMO Piracy and Armed Robbery incident database [<https://gisis.imo.org/Public/PAR/Default.aspx>]

While this data naturally exhibits the usual issues inherent in hand-entered data (duplicate entries, records that have been allocated to the "wrong" geographic location, and similar), I would nonetheless rate its credibility as high, and the more recent data as very high.

We note however that we only see the incidents that are **reported**. There are most certainly many small incidents that are never reported; there is, for instance, a paucity of the fishing boats and yachts that seemed to be a feature of the earlier data; one wonders if these incidents are simply not being reported to the IMO.

There is also suspicion that under-reporting in the Gulf of Guinea is a significant problem (see the references in the "Under-reporting" section of the Appendix); but again, we are interested here in reported incidents, and so do not pursue this further.

Caveats

With respect to the procedure as outlined above, we note in particular:

1. The final result is highly dependent on careful selection of the estimation window (have we erroneously included data from a different regime?)

2. Assuming the estimation window is correctly confined to our stable "regime", we now require this regime to persist into the prediction period. If it doesn't our predictive distribution will be incorrect. (Naturally, if we were fortunate enough to have advance information regarding the possibility of such an impending "regime shift" we could use it to adjust the location and/or dispersion of our distribution.)
3. The approach described above takes no account of trends (or non-stationarity in general), and was feasible only because the last 3 years of data appeared to be stationary.
4. Dividing the PAR incidents according to region and constructing monthly series in the same fashion as for the worldwide data showed at least some of these to have markedly different characteristics; implying that our procedure might be sensitive to changes in the regional share of PAR incidents, even if the overall totals appear unchanged.

Key assumptions

1. As noted above, we've assumed the as-yet unobserved data in the prediction period (March 2020) be generated by the same underlying processes and factors as were operative in the estimation period. If this turns out to be incorrect our predicted probability will be more likely to be too high, or too low, depending.
2. In particular this means we are assuming that the factors discussed in the next section do not have a significant impact on the incident rate in the very short run (ie, in the next month)

Limitations and key unknowns

The key unknown is that flagged above: Will the as-yet unobserved data in the prediction period (March 2020) be generated by the same underlying processes and factors as were operative in the estimation period?

This is essentially a question about the potential impact of systemic changes, and/or the possibility of sudden shocks.

Systemic changes relate both to increased effort on the part of maritime and local authorities to suppress PAR -- the coalition assembled to stamp out piracy in the Gulf of Aden is the most notable, and successful example of such action in the recent past -- and socio-economic and political developments in the coastal states.

Two notable and very recent developments in the former category are the initiatives in Nigeria and Singapore:

Nigeria

The launch of the federal government's Integrated National Security and Waterways Protection Infrastructure, or Deep Blue Project, the agency said, would drastically reduce piracy and other crimes within Nigeria's maritime domain and the Gulf of Guinea once fully operational. Giving a breakdown of the assets being installed under the Deep Blue Project, Mr Dakuku revealed that a good number of the assets had arrived the country, including six interceptor boats and a special mission vessel, saying a second one will come in before the end of February.

<https://www.von.gov.ng/nigeria-set-to-deploy-integrated-architecture-for-maritime-security/> (dated 04/02/2020)

Singapore

Singapore Plans to restructure its Maritime Security Task Force (MSTF) and beef up its assets to deal with piracy in the Straits of Malacca, a crucial waterway connecting Asia to the rest of the world.

"Most recently, at the 14th Malacca Straits Patrol (MSP) Joint Coordination Committee meeting, the navies of Indonesia, Malaysia, Singapore and Thailand revised the MSP standard operating procedures to enhance the region's ability to tackle sea robbery in the Straits of Malacca and Singapore," he said.

On Tuesday, the Indonesian Navy (TNI AL) also upped the security by deploying a Helly BO 105 helicopter to support marine security operations in the Malacca Strait and Singapore Strait.

https://www.defenseworld.net/news/26274/Singapore_to_Beef_up_Maritime_Security_Task_Force_to_Deal_with_Piracy#.Xl76VqgzaHt (dated 03/02/2020)

Finally, we should consider the possibility that any direct action made on the basis of this report that (for instance) resulted in a decrease in PAR activity would itself invalidate the in defined hot spots or as a reaction to emerging trends based on this analysis is likely to directly impact the probability and introduce an unknown variable.

Sudden shocks are events such as the bursting of the housing bubble in the USA, resulting in a sudden catastrophic economic downturn. The current case in point is of course the appearance and rapid spread of COVID-19 (*aka* the "coronavirus"). This is already affecting travel and shipping; however its potential to impact the PAR rate is less apparent. If reduced trade leads to fewer ships, we could see a reduction due to fewer opportunities; if reduced trade leads to an economic downturn we could see an increase due to increased need. This point is discussed in more detail in the next section.

Alternative approaches

1. An obvious alternative to the "non-parametric" KDE procedure outlined above would be to fit one of the parametric distributions typically used to model "count" data. The go-to probability mass function for count data is of course the Poisson; this was trialed, but was an unsurprisingly dreadful fit: the monthly data is simply too variable for this to serve as a useful approximation. A better candidate is the Negative Binomial; with parameters estimated by matching the sample mean and variance. This was a reasonable fit; and gave very similar results to the KDE.
2. The approach outlined above is based on a selected subsample of the data, and so depends at least in part on the judgement of the researcher. The alternative would be to use a longer estimation timeframe, but allow for trend and/or cycle components. (see discussion below)
 - Only the Asian PAR data shows a definite cycle; if this persists into the future then the most recent minimum would have occurred in 2018, implying ship attacks in this region are again on the upswing.
 - The possibility of a seasonal (monthly or quarterly) cycle was considered (in both the by-region data, where there was sufficient of this, and overall), but was not found to be significant.
 - Expanding on (2), it seems reasonable that if the categories have differing characteristics that is might be worth modelling them separately. In particular, since the data includes information on the location of the attacks, and we've already noted that the Asian data behaves markedly different from the rest (see Fig. in the Appendix), we might at least consider modelling the Asian region separately. However, this approach is most useful when doing so results in sufficiently enhanced accuracy to compensate for the increased probability of large errors when the separately-obtained predictions are combined. It also raises the issue of how the individual forecast distributions are to be combined to produce a worldwide probability. The obvious methods of performing this distributional "aggregation" all require at the very least that the subcategories in the analysis (the geographic regions, in our case) be statistically independent of each other. This could be justified if the regions are carefully defined; but does impose another layer of assumptions and complexity.

Contending analysis: modelling trend

As noted above, the predictive distribution used to obtain our probability estimate has been obtained by noting the lack of trend in the most recent 3 years, and accordingly basing the analysis on that data alone. If we look at a slightly longer timeframe (while still avoiding the Somali crisis period) we do observe a (small negative) trend. An alternate estimate can therefore be produced by estimating the trend, then fitting a distribution to the de-trended data, using the KDE approach outlined above. If this is done we obtain our estimated probability of more than 20 PAR incidents in March 2020 falls to 20%.

This approach obviously assumes that it is the **negative trend over the period 2012 to the present** that will persist into the next month, rather than the **zero trend of the period 2016 to the present**.

A summary of this analysis can be found in the Appendix.

Impact of external "shocks"

- Regarding the possible impact of the coronavirus crisis on the PAR rate: we initially expected that, if there is an impact, it would be negative, caused by the reduction of shipping and restrictions on ship movements in the Asian region. However this is not supported by the available data on previous global downturns: there is little to no correlation between the volume of trade worldwide and PAR incidents generally; and while there may be correlation between the volume of trade worldwide and PAR incidents in the Asian region, its direction is ambiguous.
- We therefore rate the likelihood of the coronavirus crisis causing a fall in the PAR rate over and above the current downward trend to be low: of the order of 20-30%.
- The likelihood of the crisis causing a rise in PAR in the immediate future is rated very low: $\leq 5\%$; though this may change in the longer term if the crisis escalates as compounding factors come into play.

Assumptions/judgements

1. That the incidence of piracy and armed robbery at sea is driven primarily by local factors in certain coastal states.
2. That the coronavirus crisis will have a negative impact on world trade (99% likely)
3. That the global volume of merchandise exports is highly correlated with the volume of shipping, both worldwide, and in the Asian region in particular (80% likely)

Argument

Re the correlation (or lack of it) between the volume of shipping and PAR:

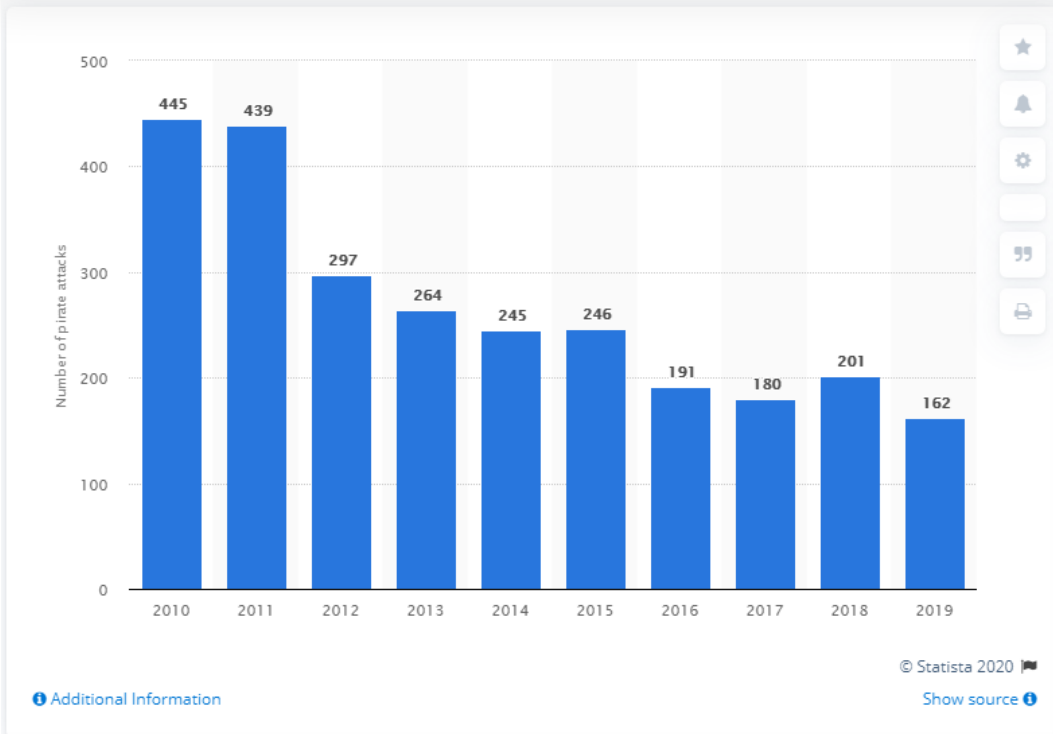
1. this could not be confirmed, as I was not able to obtain detailed data for shipping. However the WTO (World Trade Organization) publishes monthly data on exports and imports (see Fig.); this shows an extraordinary fall in 2009, following the "Global Financial Crisis" of 2008; and another notable decrease in 2015--2016.
2. While neither downturn appeared to be followed by notable falls (or rises) in PAR worldwide, this was not the case in the Asian region --- here there was a huge spike in the PAR rate in 2015, followed by a marked drop at the start of 2016. 2006--2009 was also a "quiet" period, but the PAR rate did start to rise as trade increased in 2010.
3. The correlation between monthly world trade volume and PAR in the Asian region over the period from 2006 is positive, but not particularly high: 19% -- not surprising given the volatility in PAR. In contrast, the correlation between monthly world trade volume and PAR worldwide is negative, and small: -9% (and even less in the 2012--2019 period)
4. On the other hand, the trend in Asian PAR has been slightly negative since 2012, while world trade has been rising for most of that period (ie, the correlation is now negative).
5. The Asian region accounts for around 40% all all PAR incidents, so a large spike (or fall) there should show in the worldwide PAR rate.
6. PAR in the Asian region is already in a "quiet" period, leaving less scope for reductions caused by external factors generally.

Limitations

1. We did not have detailed data for shipping, nor by-region data on trade generally; and so have used the WTO "volume of merchandise exports" data as a proxy.

Appendices

Piracy and Armed robbery worldwide

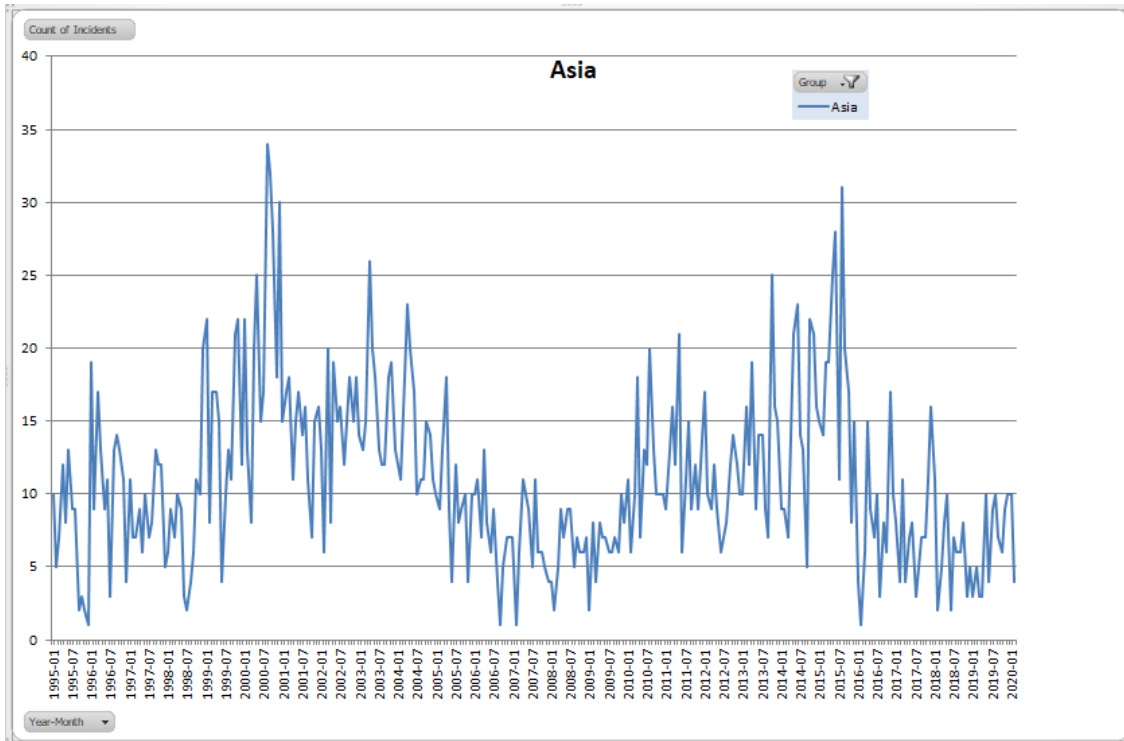


[Number of pirate attacks against ships worldwide from 2010 to 2019]

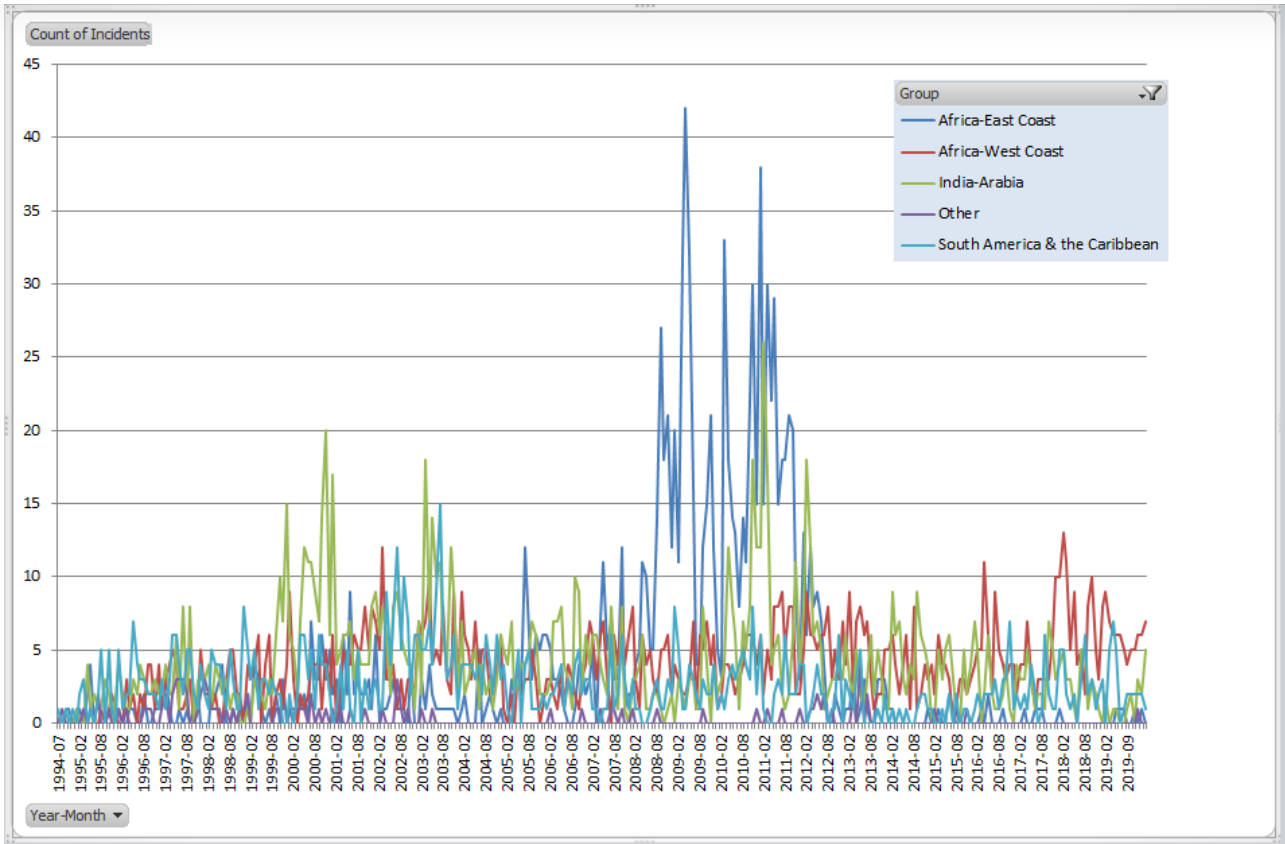
Source: <https://www.statista.com/statistics/266292/number-of-pirate-attacks-worldwide-since-2006/>

Piracy and Armed robbery in the Asian region vs the rest of the world

[Underlying data source: IMO-GISIS]



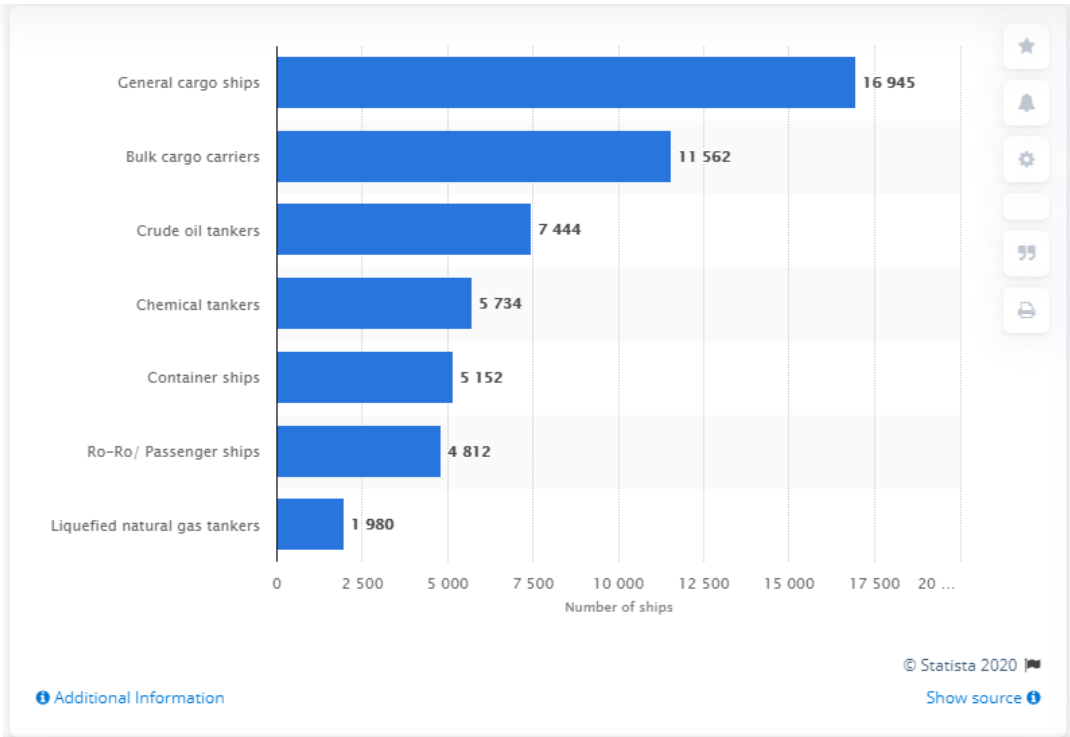
[asia.png]



[the-rest.png]

Global Shipping and Trade

- World general cargo ship fleet capacity has been almost constant since 2015 at around 74 million metric tons deadweight (a significant decrease from the average of around 104 million tons for 1980--2010).
- Source --- Capacity of general cargo vessels in seaborne trade from 1980 to 2019 --- <https://www.statista.com/statistics/267604/capacity-of-general-cargo-vessels-in-seaborne-trade-since-1980/>
- Notes:
 1. Deadweight tonnage (dwt) is the carrying capacity of a merchant ship.
 2. The term "cargo ship" refers to freighters with dwt capacity of 100 tons or more.
- In 2019 there were around 53,000 merchant ships trading internationally. Of these some 11,000 ships were bulk carriers. General cargo ships accounted around 32% of ships in the world merchant fleet as of January 1, 2019.
- Source --- Number of ships in the world merchant fleet as of January 1, 2019 --- <https://www.statista.com/statistics/264024/number-of-merchant-ships-worldwide-by-type/>



[Number of ships in the world merchant fleet as of January 1, 2019, by type]

This summary data was obtained from Statista <<https://www.statista.com>>; unfortunately the detailed data is paywalled.

Effect of the Coronavirus

The outlook for global trade

The WTO had been predicting growth of around 3.0% in 2020, up slightly from 2.6% in 2019; in view of the current coronavirus crisis this seems unlikely.

- From the WTO: " - World trade will continue to face strong headwinds in 2019 and 2020 after growing more slowly than expected in 2018 due to rising trade tensions and increased economic uncertainty. WTO economists expect merchandise trade volume growth to fall to 2.6% in 2019 --- down from 3.0% in 2018. Trade growth could then rebound to 3.0% in 2020..."
- Source: Global trade growth loses momentum as trade tensions persist --- https://www.wto.org/english/news_e/pres19_e/pr837_e.htm

Effect on shipping

Global shipping has certainly been hit by the coronavirus --- see for instance

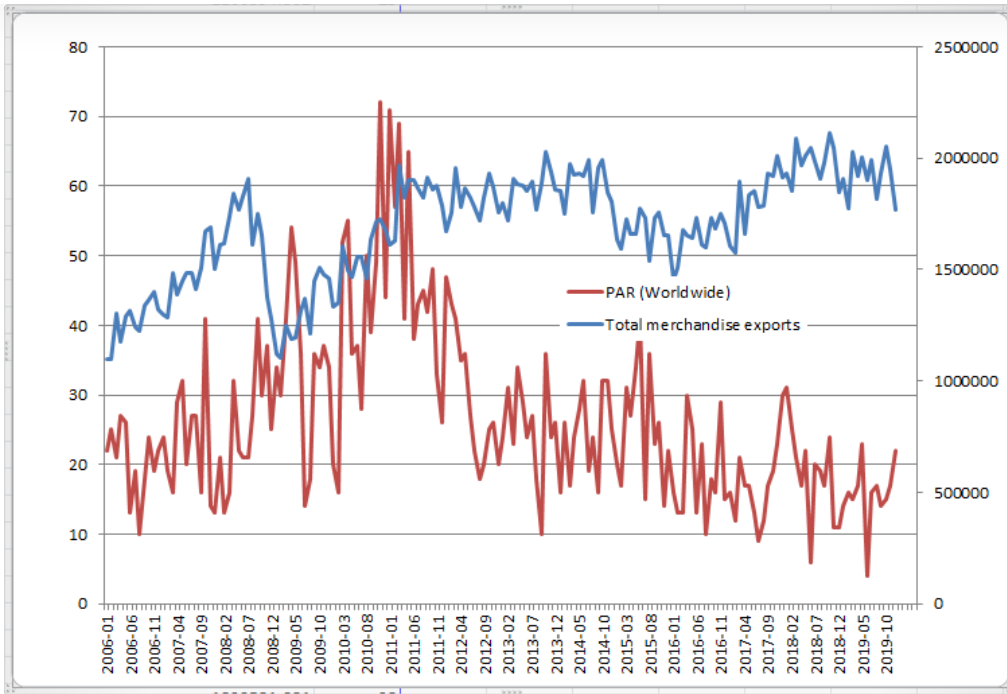
<https://edition.cnn.com/2020/02/05/business/shipping-coronavirus-impact/index.html/>

Data

Monthly merchandise exports (in US\$ billions) for all reporting countries from 2006 was obtained from <https://data.wto.org/> ; resulting (after totalling across countries) in the series seen below. The impact of the GFC is clearly visible; as is the downturn in 2016.

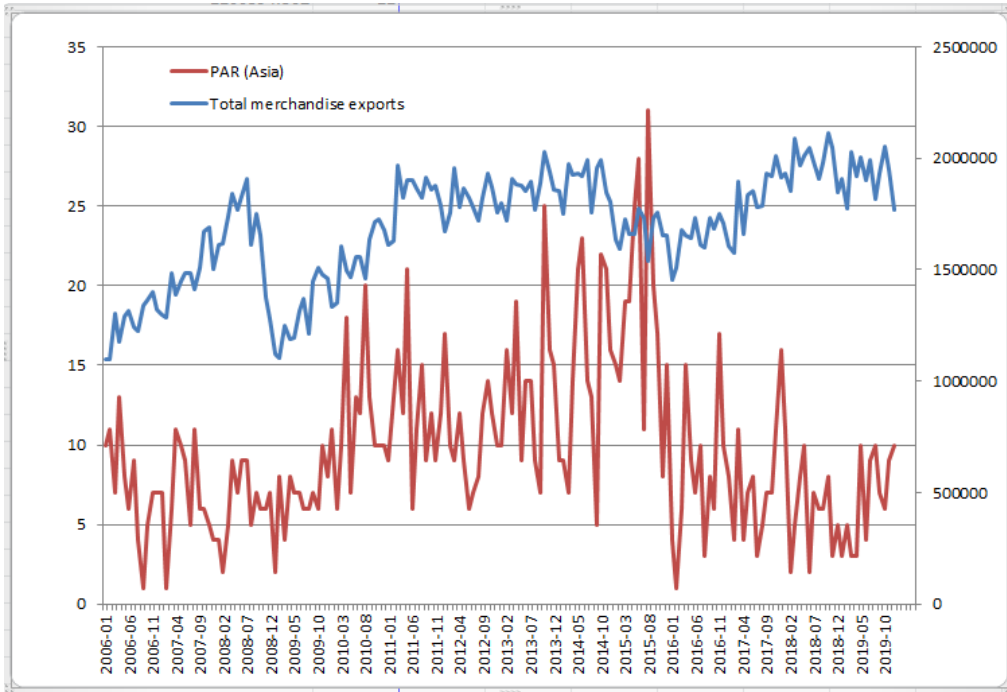
(Monthly merchandise imports was also downloaded; unsurprisingly this is almost identical to exports)

PAR incidents worldwide vs. World Trade



[Figure]

PAR in the Asian Region vs. World Trade



[Figure]

Sources

Recent PAR reports

- The ONI publishes weekly and yearly reports on piracy and maritime crime --- most recent reports here: <https://www.oni.navy.mil/News/Shipping-Threat-Reports/>
- The United Nations International Maritime Organization also publishes monthly and yearly reports --- <http://www.imo.org/en/OurWork/Security/PiracyArmedRobbery/Pages/Default.aspx>

Other sources:

- Office of Naval Intelligence (ONI) Shipping threat reports -- <https://www.oni.navy.mil/News/Shipping-Threat-Reports/>
- The Hellenic Shipping News -- <https://www.hellenicshippingnews.com/category/shipping-news/piracy-and-security-news/>
- ICC-CCS News -- <https://www.icc-ccs.org/news>

The 2019 IMB report (Summary)

There has been a nearly 20% fall in incidents worldwide (201 incidents in 2018 vs 162 in 2019); there have, however, been increases in The Gulf of Guinea and the Singapore Straits.

The situation in the Gulf of Guinea is of increasing concern:

The number of crew kidnapped in the Gulf of Guinea increased more than 50% from 78 in 2018 to 121 in 2019. This equates to over 90% of global kidnappings reported at sea with 64 crew members kidnapped across six separate incidents in the last quarter of 2019 alone. The region accounted for 64 incidents including all four vessel hijackings that occurred in 2019, as well as 10 out of 11 vessels that reported coming under fire.

Similarly, the Singapore Straits experienced a rise in armed robbery attacks with 12 reported incidents in 2019, including 11 in the last quarter of 2019; 10 of these incidents resulted in successful boardings. (The same region accounted for just three incidents for the entirety of 2018).

On the other hand, armed robbery attacks in Indonesian ports are down from 36 incidents in 2018 to 25 in 2019, and Bangladesh and Somalia reported zero incidents.

Source: <https://www.sail-world.com/news/225693/2019-Annual-IMB-Piracy-Report>

PAR in the Gulf of Guinea

Maritime piracy incidents down in Q3, yet Gulf of Guinea remains a hot spot

<https://www.icc-ccs.org/index.php/1282-maritime-piracy-incident-down-in-q3-yet-gulf-of-guinea-remains-a-hot-spot>

Unprecedented number of crew kidnappings in the Gulf of Guinea despite drop in overall global numbers

<https://icc-ccs.org/index.php/1286-unprecedented-number-of-crew-kidnappings-in-the-gulf-of-guinea-despite-drop-in-overall-global-numbers>

Heightened Risk of Crew Kidnapping in Gulf of Guinea

<https://www.nepia.com/industry-news/heightened-risk-of-crew-kidnapping-in-gulf-of-guinea/>

Pirate Attacks: World shipping groups threaten to report Nigeria to UN

<https://www.hellenicshippingnews.com/pirate-attacks-world-shipping-groups-threaten-to-report-nigeria-to-un/>

The Gulf of Guinea is now the world's worst piracy hotspot

<https://www.economist.com/international/2019/06/29/the-gulf-of-guinea-is-now-the-worlds-worst-piracy-hotspot>

Chronic Under-Reporting of Piracy

<https://www.maritime-executive.com/article/chronic-under-reporting-of-piracy>

What is happening to Africa's pirates?

<https://www.economist.com/the-economist-explains/2018/01/16/what-is-happening-to-africas-pirates>

On the issue of under-reporting

The IMO has done some work on this in the Gulf of Guinea (though its a couple of years old now) and concluded that the under-reporting rate is of the order of 60-70%. The available documents give no indication as to how this figures was arrived at, but if accurate this would seem imply that for every 30 reported incidents there are between 60 and 70 unreported; in which case the average per-month PAR incident rate for this regions is not 5, but 15 or more. This compares to the 10 incidents per month in the South China Sea/Malacca Strait/Indonesian archipelago region (though we must assume that this also has a non-zero under-reporting rate).

Reporting Of Incidents Of Piracy And Armed Robbery Against Ships In The Gulf Of Guinea (pdf, 5/7/2017)

<http://www.imo.org/en/OurWork/Security/PiracyArmedRobbery/Guidance/Documents/MS-Circ.1585.pdf>

Chronic Under-Reporting of Piracy (6/10/2015)

<https://www.maritime-executive.com/article/chronic-under-reporting-of-piracy>

The South China Sea and the Malacca Straits

The most dangerous waters in the world (undated; published sometime in 2014)

<https://time.com/piracy-southeast-asia-malacca-strait/>

Troubled waters: piracy and maritime security in Southeast Asia -- August 22, 2019

<https://kontinentalist.com/stories/troubled-waters-piracy-and-maritime-security-in-southeast-asia>

The Somali Crisis

Broadly agreed to have been initially motivated by the plundering of local fisheries and toxic waste dumping by foreign nationals after the collapse of the Somali government and the disbanding of its Navy, and accordingly a prime example of the impact of the collapse of "failed states". It has been observed that some of the same underlying factors are coming into play in the Gulf of Guinea, with the pillaging of local fisheries by unregulated commercial trawlers.

What is happening to Africa's pirates? (16/1/2018)

<https://www.economist.com/the-economist-explains/2018/01/16/what-is-happening-to-africas-pirates>

Causes of Maritime Piracy in Somalia Waters (13/10/2019)

<https://www.marineinsight.com/marine-piracy-marine/causes-of-piracy-in-somalia-waters/>

Somalia: Understanding Somali Piracy on Land and Sea (28/11/2018)

<https://www.globalpolicy.org/security-council/index-of-countries-on-the-security-council-agenda/somalia/52111-somalia-understanding-somali-piracy-on-land-and-sea.html>

On the impact of "Exogenous" events

COVID-19: Coronavirus Outbreak - Impact on Shipping *Update* (02/03/2020)
<https://www.nepia.com/industry-news/coronavirus-outbreak-impact-on-shipping/>

Venezuela Sanctions Update (19/02/2020)
<https://www.nepia.com/industry-news/venezuela-sanctions-update/>

Timeline of relevant world events

- 2008--2012 --- Somali piracy "crisis"
- 2007--2008 --- Global Financial Crisis
- 2008--2009 --- World trade fell around 22% compared to its 2008 peak
- 2015--2016 --- World trade down ~10% on its previous level
- 2017--present --- Piracy increasing in the Gulf of Guinea

Contending Analysis - incorporating a trend

Briefly, the procedure is as follows:

1. We fit a linear* trend to the monthly data for July 2012 to Feb 2020 and use the fitted values to "de-trend" the data
2. A trend prediction was produced for March 2020 -- call this "xhat"
3. We add "xhat" to the detrended data and fit a KDE - this gives us the estimated distribution of the count of incidents in March 2020, taking into account the shift downwards that we've estimated using the trend.
4. The final probability was calculated from the new KDE as described above.

Notes

- Log-linear and quasi-Poisson trend fits were also trialed, but made no substantive difference to the result; and so were abandoned in favour of simplicity.
- Use of the linear model does mean that the KDE had to be truncated at zero on the left -- see the Figure below

Estimated trend

| | Estimate | Std. Error | t value | Pr(> t) |
|-------------|-----------|------------|-----------|--------------|
| (Intercept) | 29.627393 | 1.42945605 | 20.726341 | 3.241855e-37 |
| trend | -0.157387 | 0.02507239 | -6.277305 | 9.957038e-09 |

The estimated $\Pr(X > 20)$ is 0.1980579

Forecast distribution of PAR incidents, March 2020

