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Flags for sale: An empirical assessment of flag of convenience desirability to foreign vessels

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ABSTRACT

Illegal, unreported and unregulated (IUU) fishing costs the global economy tens of billions of US dollars annually, although accurate estimates of the current extent of this activity remain uncertain. Those that break or avoid fisheries management rules often employ tactics, such as registering their vessels under foreign flags (commonly known as "flags of convenience" (FoCs)), to carry out their often illegal activities. The practice of using FoCs by fishing vessels impedes prevention efforts to effectively deter or eliminate IUU fishing. While literature has proposed a large number of factors explaining why certain flags are more desirable than others, an empirical assessment of these proposed factors has not yet been made. This research, therefore, fills this gap by empirically evaluating 38 such factors. Results show that desirable flags are flags of countries that are largely non-cooperative with international efforts to sustainably manage shared fish stocks and prevent IUU fishing, regardless of their ratification of major international agreements. The same flags are easy to acquire and allow fishing vessels access to a large number of countries' exclusive economic zones and areas managed by regional fisheries management organizations. Policy implications are discussed in light of these findings.

1. Introduction

1.1. Background

Fishing is one of the most significant sources of nutrition, income, and livelihood for hundreds of millions of global citizens, particularly of developing countries [1]. Fish comprise 20% of intake of animal protein for over three billion people worldwide [2], and the global fishing industry employs an estimated 57 million fishers and fish farmers, a significant majority of whom are from developing countries [3]. Illegal, Unreported and Unregulated (IUU) fishing, which involves practices that are in contravention of national, regional and international laws, poses a serious threat to the world's fish stocks, and therefore to food security and global sustainability [1,4]. Studying the enablers of IUU fishing, and devising empirically founded and targeted policy instruments to deal with it is, therefore, urgently needed.

IUU fishing vessels often use Flags of Convenience (FoCs) to carry out their activities. A vessel is said to carry an FoC flag if the "beneficial ownership and control of a vessel is found to be elsewhere than in the country of the flag the vessel is flying" [5] 26). In other words, the owner of a vessel flying an FoC holds economic control, or resides in a country different from the country where the vessel is registered. The term 'flag of convenience' became common in the 1950s following the campaigning of the International Transport Workers' Federation (ITF) against FoCs at the ITF Congress in Oslo [6,7]. Nevertheless, the practice of flagging one's vessel under a foreign flag has been carried out for centuries. Since the 16th century, when British vessels used Spanish flags to skirt restrictions in the West Indies trade, the use of FoCs has

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evolved and expanded around the world [6], with the noticeable increase in its use happening in the past fifty years. The use of FoCs by fishing vessels, in particular, has proliferated in the past three decades (EJF [8]. This practice among fishing vessels presents a problem where the flagging country is unable and/or unwilling to effectively monitor and control the vessels registered under their flag,[1] impeding any efforts made by the global community to effectively deal with serious violations of fisheries management regulations.

IUU fishing owes its resilience to the lack of transparency within the global fishing industry, where large vessels that operate on the high seas can be owned by shell companies [9]. This problem is further aggravated by a practice known as "flag hopping," which involves repeated switching from one flag to another, often also while changing a vessel's name. FoCs can facilitate "flag hopping" in situations where the vessel owner aims to avoid legal consequences [10–12].

Generally speaking, most countries with high rates of foreign-owned fishing vessels registered under their flags are developing countries that have ineffective fisheries surveillance capacity and weak enforcement infrastructure [13,35]. This lack of infrastructure in vessel monitoring, control and surveillance capacity not only enables these FoC-flagged fishing vessels to avoid regulations pertaining to vessel insurance, safety gear, licenses, health and safety, taxes, and employment of crew ([14–16,39], but it also provides opportunities for these vessels to carry out other illicit activities, including drug and human trafficking [17], maritime terrorism, and weapons trafficking [14].

Research in the past has suggested various reasons why the use of FoCs by vessel owners has increased in the past fifty years. These studies broadly suggested economic considerations: FoC countries have comparably easy and quick processes of registration [8,15,18,19]; lax tax regulations [6,16,18]; no minimum wage or less minimum wage for crews [10,14,15,19]; lack of ship maintenance regulations [10,12,18]; and weak regulations on labor and environmental laws [7,8,14,20,21]. Owners of IUU fishing vessels specifically have shown a tendency to use flags of certain countries more than others, and research in the past has identified many potential reasons for this. Swan [22]; for example, suggested that fishing vessels registered under FoCs because of the absence of flag State control. When examining the variations in flag preference between a subset of IUU fishing vessels and the global fleet of fishing vessels, Miller and Sumaila [23] found that vessels flying FoCs, as well as the flags of States which were considered to exhibit consistent patterns of failure in compliance with international obligations, defined as 'flags of non-compliance', were more common within the group of IUU vessels. Galaz et al. [24] found that IUU vessels were more likely to use flags of countries that have a tax haven jurisdiction. Ford and Wilcox [25]; in turn, ranked 140 countries based on three risk indicators associated with the likelihood of FoC-associated behavior: (a) the ratio of the fleet nationally flagged to nationally owned (ownership ratio); (b) control of corruption; and (c) fidelity, which is measured by the proportion of time vessels flagged to a nation spend in their home exclusive economic zone. While the Ford and Wilcox [25] study pertained to merchant vessel behavior, the authors suggested that the overall flag level dynamics were not likely to be different for fishing vessels. Drawing from past research, this study, therefore, aims to empirically assess a total of 38 factors associated with the desirability of FoCs to fishing vessels, as well as examine whether these factors have changed over time due to international pressures and other global changes taking place in the past several years, such as changes in policy and governance that may influence changes in flag registration patterns.

2. Overview of the study design

In an attempt to examine the factors associated with the desirability of FoCs, we collected data from a variety of sources on a total of 38 factors (henceforth, variables). The data were collected for two different years, 2013 and 2018, separately, and the analyses were conducted accordingly. The 2018 data were the latest available data at the time of the writing of this research, and the 2013 were retrospectively collected and analyzed in order to assess whether any changes in the factors associated with the desirability of FoCs took place over a five-year period. The section below defines these variables and outlines how these were measured, as well as discusses the sources of data used to gather information on these variables.

2.1. Variables and their data sources[2]

2.1.1. Outcome variable: flag desirability

The *flag desirability* variable was conceptualized as the proportion of all fishing vessels flying an FoC (i.e. a foreign flag) registered under each given country (in 2013 and in 2018). For the purpose of this study, we adopted the Alterton & Winchester (2002) definition of an FoC discussed in the introduction. A given country will, therefore, have a relatively high flag desirability if a large number of all fishing vessels found to be flying FoCs (i.e. flying any foreign flag) were registered under that country's flag relative to other flags.

A total of 115 countries were identified as having at least one FoC fishing vessel registered under its flag in either 2013 or 2018. Two international ship registers were also identified as matching this criterion, however due to the nature of this being a country-level analysis, these two registers were added to the country under whose jurisdiction they fell. This was done to combine Norway and the Norwegian International Ship Register (NIS), as well as Tanzania and the Surface and Marine Transport Regulatory Authority (SUMATRA).

For all countries that were identified as having at least one FoC fishing vessel registered under its flag in 2013 or 2018, vessel ownership data were obtained from the IHS Sea-web database for both of these years (https://maritime.ihs.com). The database contains all maritime vessels over 100 gross tonnes (GT) that have an International Maritime Organization (IMO) number, which is required under the IMO International Convention for the Safety of Life at Sea (SOLAS) for all cargo vessels that are at least 300 GT and for all passenger vessels that are at least 100 GT. Although not mandatory under international law, IHS also assigns IMO numbers to fishing vessels and commercial yachts.

2.1.2. Grouping variables

A literature review was performed to identify an exhaustive list of the factors associated with the desirability of an FoC to foreign fishing vessels (see Appendix A). Quantitative variables were then matched to measure each of these factors, with occasionally more than one variable being utilized for best representation. This resulted in 38 variables (see Appendix A for detailed descriptions and the measurement of these variables). Country-specific data were then collected on these 38 variables each for 2013 and 2018. These 38 variables were placed into 9 groups that include: (1) regulatory instruments, (2) flag performance, (3) engagement in illegal activities, (4) flag accessibility, (5) foreign access to fisheries, (6) taxes, (7) transparency and corruption, (8) country's freedom and development, and (9) fisheries management commitments. Variable groupings are presented in Table 1. Each of the

[1] According to article 94 of the United Nations Convention on the Law of the Sea (and Article five of the 1958 Geneva Convention on the High Seas), "every State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag" (UNCLOS 1982: 59). UNCLOS also requires that each vessel must be registered by a State that regulates its operations on the high seas and in the exclusive economic zones of other countries. A vessel under any given 'flag State' shall comply with the nation's regulations and, in return, gain protection by the State, including diplomatic protections and implicit guardianship against piracy [31].

[2] Detailed descriptions of all the variables and their coding are provided in Appendix B

38 variables was also classified as 'fisheries-' versus 'non-fisheries-related'.

3. Results

3.1. Analysis 1: determining concentrations

Lorenz-plot curves are methods commonly used by researchers to identify concentrations. In the context of the current study, we used this method to examine whether we could identify a small number of countries whose FoCs comprise a disproportionate share of all FoCs. Fig. 1 shows the Lorenz plots for both 2013 and 2018. The left panel shows the Lorenz-plot curve for countries whose flags were used as FoC flags in 2013, while the right panel shows the same for 2018. As seen from these plots, both curves deviate significantly from the line of equality, indicating that a small proportion of countries accounted for a large share of FoCs. In fact, for the year 2013, a total of 31 countries (i.e. 19%) accounted for 80% of such flags, while in 2018, a total of 36 countries (i.e. 22%) accounted for 80% of FoC flags. The Gini coefficient for the 2013 data is 0.783, and for the 2018, it is 0.736, indicating a statistically significant concentration of the choice of FoC flags from a small proportion of countries.

In fact, all but seven countries, namely, Honduras, Cambodia, Namibia, Indonesia, Chile, Comoros and Ireland, were in the top 20% of countries both years. Surprisingly, these countries, especially Honduras, Cambodia and Namibia, which were the top 1, 4, 9, respectively, FoC flags in 2013, did not appear in the top 20% of FoC flags in the year 2018, dropping significantly to lower ranks. Meanwhile, 13 new countries emerged as the top 22% of the countries in 2018 that accounted for 80% of the FoC flags, with Russia, Micronesia and Papua New Guinea making the cut for the top 15 desirable FoC countries in 2018.

Table 2 shows the top 12 most desirable FoC flags in 2013 and in 2018. The table includes the total percent of all vessels flying flags of convenience (i.e. a foreign flag) registered under these countries. Since this table lists the top FoC countries in 2013 and their changes, it does not include countries that experienced an increase in 2018.

In 2013, 98% of fishing vessels flagged to Cambodia, 96% to St Vincent & the Grenadines, 89% to Belize, and 64% to Panama were FoC-flagged vessels (i.e., foreign-owned). In 2018, these countries had similar rates of FoC –flagged vessels, with Cambodia being a noteworthy exception, dropping from having 98% of its vessels as FoC to 0%. The remaining top 12 countries had between 11% and 47% of their vessels under an FoC.

Honduras, Panama, Argentina, and Cambodia collectively had 32% of all FoC vessels flagged to them in 2013, while this number dropped to 15% in 2018. Most notably, none of the FoC vessels in 2018 carried the Honduran or Cambodian flags, and, with the exception of Panama, no countries had more than 9% of all FoC flags registered to them. This may be indicative of a displacement or dispersion of FoC flagging tactics from a handful of countries to more countries, a trend that is also visible from the Lorenz curves discussed earlier.

By way of comparison, Fig. 2 is built to examine the change in the number of FoC-flagged fishing vessels when the years 2013 and 2018 were compared for countries that had more than 20 such vessels during these two years (see Appendix D for countries with less than 20 FoC vessels). While most countries did not exhibit significant changes, a few countries show an extraordinary drop in the number of FoC vessels carrying their flag. Most notably, Honduras and Cambodia, with a drop from 178 to 6 (97% change), and from 61 to 0 (100% change), respectively. Other notable countries included Indonesia (27 → 2, −93%); Namibia (37 → 16, −57%); and Belize (55 → 45; - 18%). However, it must be noted that other changes in the opposite direction also took place. St. Vincent & The Grenadines (45 → 59; +31%) and the United Kingdom (22 → 26, +18%) saw increases in the number of foreign-owned vessels under their flags. Panama, Argentina and Morocco, countries that are ranked in the top 5, all experienced a 11%, 10% and 10% decrease, respectively, but these decreases are small considering in 2013 they had 139, 70 and 58 FoC-flagged vessels, respectively.

Table 1
List of variables (N = 38) and the nine groupings.

GROUPING	VARIABLE	Fisheries Related? Y/N
Regulatory Instruments	UN Law of the Sea	**N**
	UN Law of the Sea Part XI	**Y**
	UN Fish Stocks Agreement	**Y**
	UN Convention on Conditions for Registration of Ships	**N**
	FAO Compliance Agreement	**Y**
	FAO Agreement on Port State Measures	**Y**
	IMO Convention for Safety of Life at Sea (SOLAS)	**N**
	IMO MARPOL I-II/III-VI	**N**
	ILO Work in Fishing Convention	**Y**
	ILO Maritime Labor Convention	**N**
Flag Performance	Paris MoU + Tokyo MoU flag performance	**N**
	EU IUU Carding	**Y**
	USCG Target List	**Y**
Engagement in Illegal Activities	IMO Migrant Smuggling	**N**
	UN Traffic in Persons	**N**
	OECD Non-Cooperative States	**N**
	Major drug producing and transit countries	**N**
	Major money laundering countries	**N**
	UN Convention against Transnational Organized Crime	**N**
	UN Convention against Corruption	**N**
	OECD Convention on Combating Bribery of Foreign Public Officials in International Business Transactions	**N**
	International Convention on Arrest of Ships	**N**
	UN Convention against Illicit Traffic in Narcotic Drugs and Psychotic Substances	**N**
	International Convention on Mutual Administrative Assistance for the Prevention, Investigation and Repression of Customs Offenses	**N**
	Convention on International Trade in Endangered Species of Wild Fauna and Flora	**N**
Flag Accessibility	International ship registries presence	**Y**
Foreign Access to Fisheries	Number of Foreign Fishing Access Agreements	**Y**
Taxes	Tax Exemptions	**N**
	World Bank Tax Revenue	**N**
	World Bank Labor Tax and Contributions	**N**
Transparency and Corruption	Corruption Perception Index	**N**
	WJC Rule of Law	**N**
Country's Freedom/ Development	Human Freedom	**N**
	UN Human Development Index	**N**
	Index of Economic Freedom	**N**
	Gross Domestic Product	**N**
Fisheries Management Commitment	Regional Fisheries Management Organization membership	**Y**
	Number of Treaties and Conventions signed	**N**

3.2. Analysis 2: explaining concentrations

Of the total of nine groups of factors represented by 38 variables, a total of six groups represented by eight variables showed statistically significant differences in the desirability of the FoC flags among the countries examined (Table 3).

Countries that ranked high (poorly) on the Paris/Tokyo MOU ($H(6) = 15.16$, $p < .01$) and received a poor EU carding status ($H(1) = 9.93$, $p < .01$), as well as those that showed negative performance on the US Coast Guard target list ($U = 292$, $z = -1.32$, $p < .05$), had significantly higher proportions of foreign-owned vessels registered under their flags.

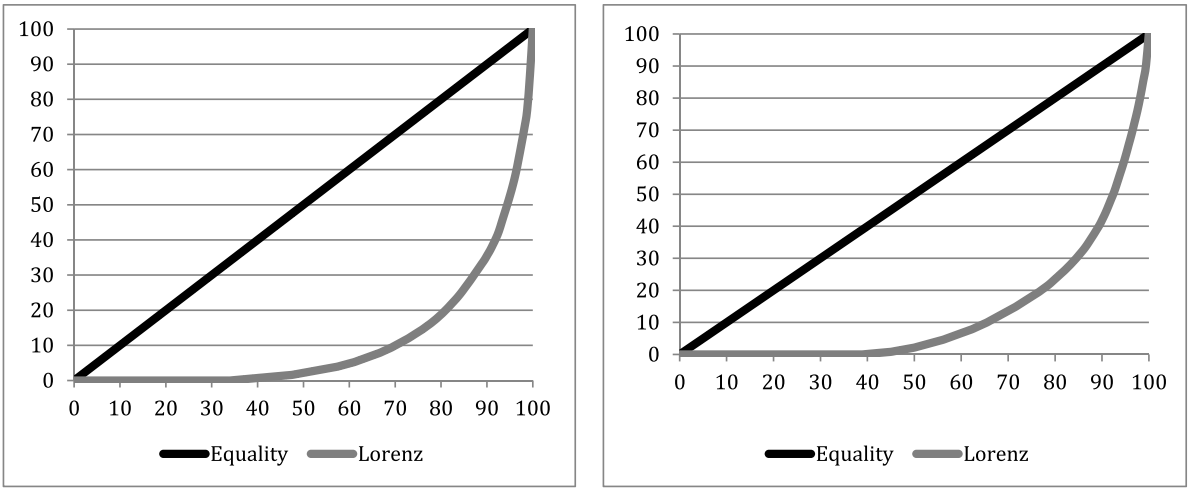

Fig. 1. Lorenz plots showing concentrations for 2013 and 2018.

Table 2
Top 12 FoC-flagged countries in 2013 and in 2018[a].

FLAG	Total vessels		Total FoC vessels		Percent of Country's Vessels as FoC		Percent of All Vessels as FoC	
	2013	2018	2013	2018	2013	2018	2013	2018
Honduras	382	107	178	6	47	6	13	0
Panama	217	200	139	124	64	62	10	10
Argentina	357	381	70	63	20	17	5	5
Cambodia	62	0	61	0	98	0	4	0
Morocco	427	428	58	52	14	12	4	4
Belize	62	51	55	45	89	88	4	4
St Vincent & The Grenadines	47	61	45	59	96	97	3	5
Peru	369	354	40	40	11	11	3	3
Namibia	157	116	37	16	24	14	3	1
Senegal	185	194	35	33	19	17	3	3
Mozambique	99	132	35	37	35	28	3	3
Mauritania	133	133	35	34	26	26	3	3
TOTAL	**2497**	**2157**	**788**	**509**			**58**	**42**
Remaining Countries (n = 153)	**19 756**	**23 012**	**581**	**713**			**42**	**58**
GRAND TOTAL	**22 253**	**25 169**	**1369**	**1222**			**100**	**100**

[a] A full list of FoC countries is available upon request.

Additionally, those countries that did not ratify the UN Convention against Illicit Traffic in Drugs ($U = 660.5$, $z = -1.41$, $p < .10$), as well as had lower tax exemption scores ($\tau = -0.08$, $p < .10$) had significantly higher proportions of foreign-owned vessels registered under their flags. The same countries ranked significantly lower on the Human Development Index ($\tau = -0.08$, $p < .10$), were party to more RFMOs ($\tau = 0.24$, $p < .01$), and had significantly more fisheries access agreements with foreign countries ($\tau = 0.26$, $p < .10$).

Table 4 displays the summary results for the variables that explained to a statistically significant extent, the choice of an FoC flag country in 2018.

Of the total of nine groups of factors represented by 38 variables, a total of seven groups represented by ten variables showed statistically significant results. Specifically, countries that ranked poorly on the EU carding status ($H(3) = 12.01$, $p < .01$), as well as the Paris/Tokyo MOUs ($H(6) = 17.51$, $p < .01$), as well as showed negative performance on the US Coast Guard target list ($U = 202$, $z = -1.61$, $p < .10$), had significantly higher proportions of FoC vessels registered under their flags. Similarly, those countries that did not ratify the UN Convention against Transnational Organized Crime ($U = 486.5$, $z = -2.24$, $p < .01$), the UN Convention against Illicit Traffic in Drugs ($U = 520$, $z = -2.38$, $p < .01$), and the International Convention on Arrest of Ships ($U = 676$, $z = -2.06$, $p < .05$) had significantly higher proportions of FoC vessels registered under their flags. The same countries ranked significantly lower on the Human Development Index ($\tau = -0.13$, $p < .01$), as well as were party to more RFMOs ($\tau = 0.28$, $p < .01$), had significantly more fisheries access agreements with foreign countries ($\tau = 0.16$, $p < .01$), and more of their flags were listed on the www.flagsofconvenience.com website ($U = 722$, $z = -1.47$, $p < .10$).

4. Discussion

4.1. Summary of results

The emergence of new technologies along with improved vessel and gear design over recent decades have made it possible for fishing operations to be carried out nearly anywhere. Fishing vessels operate within coastal waters of foreign countries, as well as far out at sea in internationally shared high seas areas where fisheries monitoring, control, and surveillance activities face greater challenges. Along with the expansion of fishing efforts is the expansion of human populations across the globe and an accompanying demand for food from the sea. Overfishing and the resulting scarcity of local seafood resources have meant that an increasing number of vessels are fishing in distant waters. While our abilities and tendencies to fish farther from shore have increased, our international systems of governance have been playing catch-up to ensure shared resources are exploited sustainably and safely. Currently, weaknesses in these systems still exist, providing

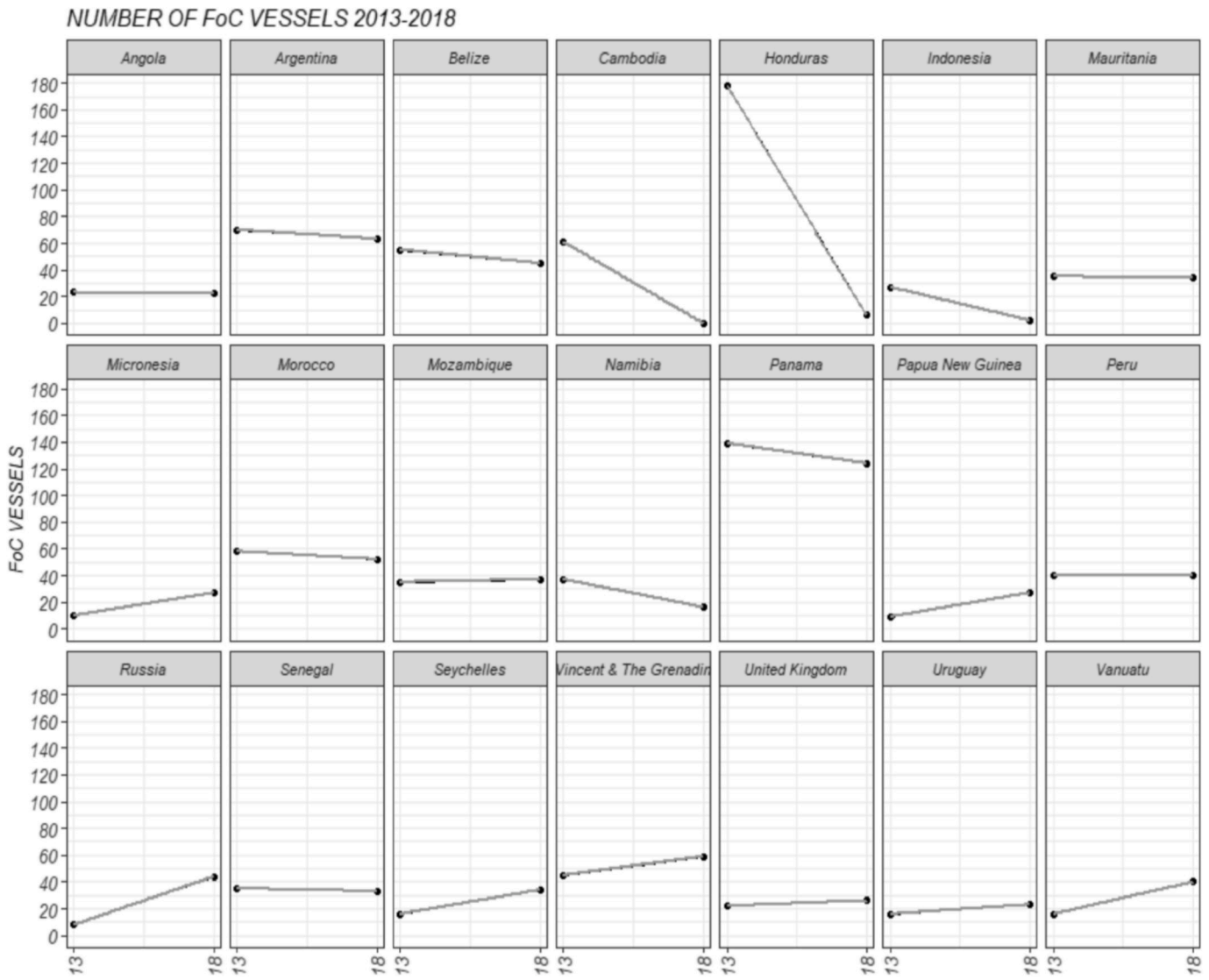

Fig. 2. Countries with more than 20 FoC vessels flagged to them.

opportunities for rogue operators to gain an economic advantage. The ability of fishing vessels to register under FoCs is one of these opportunities that, when abused, facilitates IUU fishing—an issue that may not have been anticipated decades ago when relevant international policies were first drafted.

FoCs are common throughout the entire maritime sector, and their use is thought to be primarily driven by economic pressures [19]. Within the global fishing sector there appear to be two different, main reasons for their use: to gain access to fishing areas and resources; and to avoid rules, oversight and costs [22]. These reasons are not necessarily mutually exclusive, and our analysis suggests that they significantly influence flag preference. Desirable flags were found to be of those countries that are largely non-compliant with fisheries-related regulations, regardless of their ratification of major international agreements. The more popularly flown flags are more easily accessible and afford vessels that register under them greater access to more countries' waters and areas managed by RFMOs. Many of these flags were found to belong to countries that score low on the Human Development Index and some that have undermined international conventions related to transnational organized crime and drug trafficking by not ratifying them. Some of these same countries have also failed to ratify the major international convention that guides the procedures related to the arrest of ships (which is only possible if both states are party to it) at foreign jurisdictions' ports.

If a fishing vessel operator has chosen to register under a foreign flag to gain access to fishing areas and resources, this strategy may be perfectly legal and both socially and economically justifiable in theory, though sometimes controversial in practice [4]. An operator may gain this access by registering their vessel under the flag of the coastal State that has full jurisdiction over the fishing area, often under a 'joint-venture' arrangement (discussed below). Alternatively, they may register their vessel under the flag of a country that has a bilateral fisheries access agreement or is party to a regional access agreement negotiated under the auspices of an RFMO. Our analyses suggest that this is a significant influencing factor in flag choice as the most desirable flags were found to belong to countries that are party to more of these agreements. In order for operations under these arrangements to be sustainable and ethical however, relevant flag States must be capable of, and exercise effective monitoring and control over all vessels flying their flag. In addition, the agreements they are party to must be environmentally sustainable and fair.

If a fishing vessel operator has chosen to register under a foreign flag to avoid rules, oversight, and costs, this strategy also may facilitate illegal activity, unregulated activity, or at best unethical, unsustainable, and/or irresponsible activities. Those that are driven by these incentives are taking advantage of a weak system to the detriment of the

Table 3
Variables determining the choice of FoC flags in 2013[a].

GROUPING	VARIABLE	SIG.	ES
Engagement in Illegal Activities	Has the country ratified the UN Convention against Illicit Traffic in Drugs? (1 = yes; 0 = no)	0.08	0.11
Country's Freedom/ Development	What is the country's Human Development Index (HDI) Score?	0.09	−0.08
Flag Performance	What is the country's status on the Paris/ Tokyo MOU[b] on port State control? (additive; 0 = white listed or not listed - 6 = black listed on both MOUs)	0.01	–
	What is the country's EU IUU carding status? (0 = not carded; 1 = green; 2 = yellow; 3 = red carded)	0.00	–
	What is the country's performance as a US Coast Guard target? (1 = negative performance; 0 = positive performance)	0.05	0.15
Fisheries Management Commitment	How many regional fisheries management organizations (RFMOs) is the country party to?	0.00	0.24
Foreign Access to Fisheries	How many fisheries access agreements has the country signed in 2018?	0.00	0.26
Taxes	Tax Exemption	0.08	−0.08

Note. All analyses are one-tailed due to the nature of the hypotheses tested (i.e. directional).

[a] Due to space limitations, Table 3 only shows statistically significant results.

[b] The Paris MOU, Tokyo MOU, and US Coast Guard Qualtrics 21 are the three principal Port State Control authorities, according to the International Chamber of Shipping. Other MOUs include Acuerdo Latino, Abuja, Black Sea, Mediterranean and Indian Ocean, but these are more local and therefore include fewer signatories [32].

Table 4
Variables determining the choice of FoC flags in 2018[a].

GROUPING	VARIABLE	SIG.	ES
Engagement in Illegal Activities	Has the country ratified the UN Convention against Transnational Organized Crime (1 = yes; 0 = no)	0.01	0.18
	Has the country ratified the UN Convention against Illicit Traffic in Drugs? (1 = yes; 0 = no)	0.01	0.19
Regulatory Instruments	Has the country ratified the International Convention on Arrest of Ships? (1 = yes; 0 = no)	0.02	0.16
Country's Freedom/ Development	What is the country's Human Development Index (HDI) Score?	0.01	−0.13
Flag Performance	What is the country's status on the Paris/ Tokyo MOU on port State control? (additive; 0 = white listed or not listed - 6 = black listed on both MOUs)	0.01	–
	What is the country's EU IUU carding status? (0 = not carded; 1 = green; 2 = yellow; 3 = red carded)	0.00	–
	What is the country's performance as a US Coast Guard target? (1 = negative performance; 0 = positive performance)	0.09	0.18
Fisheries Management Commitment	How many regional fisheries management organizations (RFMOs) is the country party to?	0.00	0.28
Flag Accessibility	Is the country's flag available via www.flagsofconvenience.com for purchase?	0.07	0.12
Foreign Access to Fisheries	How many fisheries access agreements has the country signed in 2018?	0.01	0.16

Note. All analyses are one-tailed due to the nature of the hypotheses tested (i.e. directional).

[a] Due to space limitations, Table 4 only shows statistically significant results.

environment, other fishers, and the food security of vulnerable small island or coastal communities reliant on healthy fish stocks for their livelihood. As the Lorenz curves demonstrated, there is a small proportion of countries from which flags are used. Some of these countries likely provide services as FoCs due to continued demand from vessel operators and the fact that registration for these flags produces income. Further, countries do have differing values and priorities, and not all countries are promoting sustainable fishing to the same degree. Issues of corruption and minimal social consequences may continue to perpetuate their use.

As mentioned, joint-ventures, or other types of private fishing authorizations also represent arrangements where registrations under foreign flags are used to gain access to fishing areas and resources. In joint-ventures, a foreign company partners with a local company or a flag-State government to jointly carry out operations relating to fishing (i.e., research, exploratory fishing, catching, scouting, processing, and marketing) [26]. Vessels owned by joint-ventures may be permitted to apply locally for licenses in some countries, and these arrangements may also qualify them to register under a local flag despite being partially or fully owned by foreign entities. In theory, participation in joint-ventures has been defensible as it can be a means for coastal countries that lack capital, infrastructure, markets, and other capabilities, to develop their own industrial fishing industries. However, in practice, major economic issues have emerged, manifesting at its worst when long-term objectives for sustainable exploitation and development are neglected, or when more experienced foreign partners have used financial manipulations to evade a fair sharing of profits or losses [4,27]. Within the dataset examined, the existence of joint-ventures or other private fishing agreements may explain the popularity of flags that are not known for their ease of accessibility in the maritime domain, and/or are not party to many bilateral or regional fisheries access agreements.

4.2. Differences between the two years analyzed

The non-ratification of the UN-Convention against Transnational Organized Crime was only a significant influencing factor in 2018. This may possibly have something to do with the fact that Papua new Guinea emerged in 2018 as a popular flag, as it is also one of the few countries not a signatory to the Convention (the 9 UN Member States that are not party include Bhutan, Rep of the Congo, Iran, Palau, Papua New Guinea, Solomon Islands, Somalia, South Sudan, Tuvulu).

Flag listing on www.flagsofconvenience.com was only a significant influencing factor in 2018. There appear to be many less flags listed on the site in 2018, which may indicate that fewer countries are offering FoCs due to negative publicity. Still remaining and added to the list is a filtered representation of FoCs that are still confidentially advertising their availability.

The most dramatic changes identified in FoC use were the flags of Honduras, Cambodia, Namibia, Indonesia, Chile, Comoros, and Ireland – Honduras, Cambodia, and Namibia having most significantly dropped in popularity for 2018. A likely key reason for the drop in Cambodian flag use relates to EU intervention. Cambodia has been officially recognized by the EU as a country that is acting insufficiently against illegal fishing and consequently, sanctions were imposed in March of 2014 [28]. Belize and the Republic of Guinea were also sanctioned at the same time, though these sanctions were lifted for both countries after improvements in efforts to combat IUU fishing were made—in December 2014 and October 2016, respectively. As of August 2019, Cambodia still remains sanctioned with imports of fish caught by vessels flagged to Cambodia prohibited from entering the EU—the world's largest seafood market. It is likely that foreign-owned fishing vessels left the Cambodian registry to avoid these trade sanctions. Possible reasons for the drop in Honduran flag use may also relate to EU intervention. The possibility of being issued a warning by the EU followed by the imposition of sanctions may have motivated the Honduran government to demonstrate improved flag State responsibility and remove vessels from their registry. Since 2010, the EU has engaged in dialogues with more than 50 countries in efforts to end IUU fishing and subsequently, many of these countries have made significant reforms to their fisheries management systems [29]. Namibia's observed drop was most probably

due to a number of vessels joining and leaving its register; this includes a number of African vessels becoming Namibian-owned, as well as a group of South African vessels leaving the register. Overall, more vessels left than joined.

Some new countries, however, have emerged from 2013 to 2018. These include Russia, Micronesia, and Papua New Guinea. Potential reasons for the emergence of these new flags include an interest in new fishing areas with the strategic use of flags to gain access; deterrent actions such as EU carding or pressures from the US and other countries causing flag use displacement; the Port States Measures Agreement, which became a legally-binding instrument in 2016; and negative attention on certain flag states through high profile cases, reports, papers, and media attention at conferences, as well as international collaborations and lobbying. Nevertheless, at this point in time, the rate of FoC vessels flagged to these countries has not reached alarming numbers.

5. Conclusion

IUU fishing is environmentally destructive, and it also lowers the resilience of marine ecosystems in the face of other major threats to ocean health, such as overfishing, climate change, and ocean acidification. The path towards tackling IUU fishing, however, is relatively uncomplicated compared to the challenge of addressing these other marine conservation issues. Arguably, the ability to reduce IUU fishing to insignificant levels is well within our grasp, and eliminating or restricting the use of FoCs by fishing vessels could accelerate progress towards achieving this.

Significantly reducing IUU fishing will also require a combination of internationally-aligned trade measures, at-sea, port, and market controls. However, initiatives taking this approach need to be thoughtfully implemented with well-enforced measures; otherwise, a new set of loopholes and weaknesses will emerge, and IUU fishing will continue. Promising economic strategies designed to increase costs or financial risk of involvement in IUU fishing have also emerged within recent years. These efforts have restricted the access that IUU vessels have to services and have mobilized businesses within the seafood supply chain and the global financial sector including, notably, insurance companies [30].

To suggest banning the use of FoCs across the entire maritime sector as a strategy for combatting IUU fishing is perhaps both unnecessary and unrealistic. The use of FoCs is common amongst shipping vessels, and issues with safety throughout the marine transport industry have been dramatically improved by the establishment of the Paris and Tokyo Memoranda of Understanding and other similar agreements worldwide. Within the global fishing sector, however, flag State responsibility—or the lack thereof—appears to be an unaddressed issue leading to the emergence of an FoC market where some of the most desirable flags also facilitate IUU fishing.

Given the known association of FoCs to IUU fishing [23] and the existence of few environmentally, socially or economically defensible reasons to justify their use by the global fishing sector, countries that operate open registers could consider closing these to fishing vessels. In addition, both coastal States and RFMOs could ban the use of FoCs by all fishing vessels authorized to fish within their EEZs and management areas. All forms of access agreements and lists of authorized vessels should be made publicly available by flag States, coastal States and RFMOs; and countries should maintain a public register of their entire fishing fleet, including foreign-flagged vessels (those registered under FoCs) owned by their nationals. These lists should include information (both current and historical) on vessel flags and beneficial ownership. All vessels—including those registered under FoCs—should also be monitored by relevant coastal States (if fishing within an EEZ), flag States, and beneficial owner States through vessel tracking (VMS and AIS), wherever in the world they operate. Governments could also make efforts to stop their nationals from registering the vessels they own and/or operate under FoCs. At a minimum, all countries should have legislation in place preventing their nationals from engaging in, supporting, or otherwise benefiting from the activities of vessels that have been placed on the official IUU vessel list of any RFMO or coastal State. Such legislation is already in place within the EU, and several RFMOs have, in recent years, adopted rules aligned with this approach. All of these management measures would facilitate greater accountability through improved transparency; a general strategy that, if broadly applied on a global scale, could significantly improve ocean governance and reduce IUU fishing, making it harder for unscrupulous operators to hide under the cloak of foreign flags.

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CRediT authorship contribution statement

Gohar A. Petrossian: Conceptualization, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Monique Sosnowski:** Writing - original draft, Formal analysis, Data curation, Writing - review & editing. **Dana Miller:** Conceptualization, Writing - review & editing. **Diba Rouzbahani:** Data curation, Formal analysis, Writing - review & editing.

APPENDIX A. Literature Suggesting Why Countries Use FoC Flags for IUU Fishing

CONSTRUCT MEASURED	Literature Source
Regulatory Instruments	Shaughnessy, T., & Tobin, E [18]. Papaioannou, M. A [19]. Gianni, M., & Simpson, W [10]. Llácer, F. J. M [6]. Gianni, M [12]. Yannopoulos, G. N [20]. Negret, C. F. L [16]. EJF [8] Hamad, H. B [14]. Alderton, T., & Winchester, N [7].
Flag Performance	Llácer, F. J. M [6]. Yang, S., Chung, C., Lee, H. [40] Shaughnessy, T., & Tobin, E [18]. Papaioannou, M. A [19]. Negret, C. F. L [16]. Gianni, M [12].

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(*continued*)

CONSTRUCT MEASURED	Literature Source
Engagement in Illegal Activities	EJF [8] Hamad [14] Corres & Pallis [13] Liddick, D [15]. Shaughnessy, T., & Tobin, E [18]. Papaioannou, M. A [19]. Gianni, M., & Simpson, W [10]. Llácer, F. J. M [6]. Gianni, M [12]. Hamad, H. B [14]. Negret, C. F. L [16]. Ademun-Odeke [21]. Yannopoulos, G. N [20].
Flag Accessibility	Alderton, T., & Winchester, N [7]. Llácer, F. J. M [6]. Yang, S., Chung, C., Lee, H (2014) Shaughnessy, T., & Tobin, E [18]. Papaioannou, M. A [19]. Negret, C. F. L [16]. Gianni, M [12].
Foreign Access to Fisheries	EJF [8] Gianni, M., & Simpson, W [10]. Alderton, T., & Winchester, N [7]. Corres & Pallis [13] Yang, Chung, Lee (2014) Warner-Kramer, D [17].
Taxes	Yang, Chung, Lee (2014) Llacer [6] Shaughnessy, T., & Tobin, E [18]. Negret, C. F. L [16]. Gianni, M [12]. EJF [8] Liddick, D [15]. Llácer, F. J. M [6].
Transparency and Corruption	Yang, S., Chung, C., & Lee, H. (2014) Lueche (n.d.) Corres & Pallis [13]
Country's Freedom/Development	Anderson [41] Negret, C. F. L [16]. Corres & Pallis [13]
Fisheries Management Commitment	Warner-Kramer, D [17].

APPENDIX B. Descriptions of the 38 Factors Grouped Under Nine Categories

Regulatory Instruments

UN Law of the Sea (UNCLOS) (plus part XI). This defines the rights and responsibilities of nations in respect to their use of the world's oceans in order to maintain peace, justice, and progress. **(1 = ratified/acceded; 0 = no)**.

UN Fish Stocks Agreement. This sets out principles for the conservation and management of fish stocks in order to ensure cooperation in conserving and promoting optimum utilization of fisheries resources within and beyond EEZs. **(1 = ratified/acceded; 0 = no)**.

UN Convention on Conditions for Registration of Ships. This promotes the strengthening of the genuine link between a State and ships flying its flag in order to effectively exercise its jurisdiction and control over such ships with regard to identification and accountability. **(1 = ratified/acceded; 0 = no)**.

FAO Compliance Agreement. This agreement is an integral part of the International Code of Conduct for Responsible Fishing and concludes an international agreement within the framework of the Food and Agriculture Organization of the United Nations. It promotes compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. **(1 = accepted/approved; 0 = no)**.

FAO Agreement on Port State Measures. This agreement, formally the FAO Agreement on Port State Measures to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated Fishing, aims to deter and eliminate illegal, unreported, and unregulated fishing through implementation of robust port state measures. **(1 = ratified/acceded; 0 = no)**.

IMO Convention for Safety of Life at Sea (SOLAS. This treaty sets minimum safety standards in the construction, equipment and operation of merchant ships. It requires all signatory states to ensure ships flying their flag comply with these standards. **(1 = ratified/acceded; 0 = no)**.

IMO MARPOL I-II/III-VI. The International Convention for the Prevention of Pollution from Ships (MARPOL) aims to minimize marine pollution, specifically by dumping, oil, and air pollution. Annex 1 pertains to the prevention of pollution by oil and oily water; Annex II pertains to the control of pollution by noxious liquid substances in bulk; Annex III pertains to the prevention of pollution by harmful substances carried by sea in packaged form; Annex IV pertains to the pollution by sewage from ships; Annex V pertains to the pollution by garbage from ships; and ANNEX VI pertains to the prevention of air pollution from ships. **(1 = ratified/acceded; 0 = no)**.

ILO Work in Fishing Convention. Established by the International Labor Organization, this convention aims to ensure that fisher have decent working conditions aboard fishing vessels in regards to minimum work, conditions of service, accommodation and food, occupational safety and health protection, and medical care and social security. **(1 = ratified/acceded; 0 = no)**.

ILO Maritime Labor Convention. This Convention encompasses minimum requirements for seafarers o work, employment conditions,

accommodation, recreational facilities, food and catering, health protection, medical care, welfare, social security protection, and compliance and enforcement. **(1 = in force; 0 = no)**.

Flag Performance

Paris MoU. The Paris MoU "White, Grey, and Black (WGB) list" was obtained from www.parismou.org. This organization, which consists of 27 participating maritime Administrations, aims to eliminate the operation of sub-standard ships through a harmonized system of port State Control. It covers the water of Europe coastal States and the North Atlantic basin from North America to Europe. Each year, a list is prepared on the basis of Paris MoU port State inspection results over a 3-year period. This WGB list categorizes flags from high quality to poor performing flags that are considered high risk. These categorizations are based on the total number of inspections and detentions over a 3-year rolling period with at least 30 inspections per period. **(0 = not on MOU; 1 = white; 2 = grey; 3 = black)**.

Tokyo MoU. The Tokyo MoU "Black, Grey, White list" was obtained from www.tokyo-mou.org. The Tokyo MoU consists of 20 member Authorities in the Asia-Pacific region, whose main objectives are to establish effective port State control regime in the Asia-Pacific region and eliminate sub-standard shipping as to promote safety and environmental protection. Each year, a new "Black, Grey, White list" is established based on inspection and detention history over the preceding 3 calendar years. Flag's whose total number of inspections over the 3 years does not meet the minimum 30 are not included in the final list. **(0 = not on MOU; 1 = white; 2 = grey; 3 = black)**.

Not USCG Target List (Safety). The United States Coast Guard assembles a list of flag Administrations that have been identified as having detention rates higher than the overall average and were associated with more than one detention in the previous three years. This list was obtained from http://www.dco.uscg.mil. **(1 = negative performance; 0 = positive performance)**.

Red/Yellow/Green card status EU IUU. Under the EU IUU Regulation, non-EU9 countries that export fish to the EU or lend their flags to vessels that import into the EU, must meet strict standards for fisheries management and cooperate in the fight against IUU fishing. If these requirements are not met, countries may be "carded," meaning that they could ultimately face exclusion of their fish from the EU market. Card status of select states as determined by the European Commission since the IUU Regulation entered into force in 2010. Carding decisions were obtained from http://www.iuuwatch.eu/. **(0 = none; 1 = green; 2 = yellow; 3 = red)**.

Engagement in Illegal Activities

IMO Migrant Smuggling. The International Maritime Organization maintains an inter-agency platform for information sharing on migrant smuggling by sea. This platform was jointly set up by IOM, UNODC, and the IMO. From this platform, the ***numbers of incidents per country*** detected making unsafe migrations by sea were recorded. This data was obtained from https://gisis.imo.org/Public/Default.aspx.

UN Traffic in Persons. This includes all signatories of the Convention for the Suppression of the Traffic in Persons and of the Exploitation of the Prostitution of Others which was approved by the General Assembly of the United Nations in resolution 317 (IV)2 of 2 December 1949. This data was obtained from https://treaties.un.org/. **(1 = signed; 0 = did not sign)**.

OECD Non-Cooperative States. The Organization for Economic Co-operation and

Development (OECD) identifies jurisdictions as tax havens based on previously established criteria. Specifically, the OECD assessed the standard exchange of information on request (EOIR Standard) in a two-phase, peer-reviewed process. Jurisdictions receive a compliance rating ranging from 'non-compliant' to 'compliant.' This data was obtained from http://www.oecd.org/tax/transparency/exchange-of information-on-request/ratings/. **(1 = compliant; 2 = largely compliant; 3 = partially compliant; 4 = non-compliant)**.

Major drug producing and transit countries. The United States Department of State

International Narcotics Control Strategy (INCS) Report on Drug and Chemical Control is assembled annually pursuant to section 706 of the Foreign Relations Authorization Act. It requires the identification of countries determined to be major drug trafficking or major illicit drug producing countries. This list, obtained at www.state.gov, identifies a drug producing country as one that has at least 1000 ha of illicit opium poppy or coca, or at least 5000 ha of illicit cannabis cultivated or harvested in one year. Major drug transit countries are those that are a significant direct source of illicit narcotics of psychotropic drugs or other controlled substances significantly affecting the US, or ones through which are transported such drugs or substances FAA § 481(e) (5). **(1 = yes; 0 = no)**.

Major money laundering countries. In the same INCS Report on Drug and Chemical Control are identified major money laundering countries. These are identified as ones "whose financial institutions engage in currency transactions involving significant amount of proceeds from international narcotics trafficking" FAA § 481(e) (7). Due to the difficulties in distinguishing narcotics transactions from other serious crimes, as well as the vulnerability of institutions involved in other serious crime money laundering of engagement in narcotics-related money laundering, this list contains countries whose financial institutions engage in transactions involving significant amounts of proceeds from all serious crime. **(1 = yes; 0 = no)**.

UN Convention against Transnational Organized Crime (UNOTC). This is a multilateral treaty adopted by the UN General Assembly in 2000 against transnational organized crime. It is also called the Palermo Convention and has three supplementary protocols: (1) Protocol to Prevent, Suppress, and Punish Trafficking in Persons, especially Women and Children, (2) Protocol against the Smuggling of Migrants by Land, Sea, and Air, and the (3) Protocol against the Illicit Manufacturing and Trafficking in Firearms. These four elements encompass current international law regarding human trafficking, arms trafficking, and money laundering. https://www.unodc.org/unodc/en/organized-crime/intro/UNTOC.html **(1 = ratified; 0 = no)**.

UN Convention against Corruption (UNCAC). This is a legally binding multilateral treaty promoted by the UNODC and negotiated by UN member states on anti-corruption. The goals of this treaty are to reduce corruption across national borders and to strengthen both international law enforcement and judicial cooperation between countries. Parties to this treaty implement measures on anti-corruption focused on five areas: (1) prevention, (2) law enforcement, (3) international cooperation, (4) asset recovery, and (6) technical assistance and information exchange. https://www.unodc.org/unodc/en/treaties/CAC/**(1 = ratified; 0 = no)**.

OECD Anti-Bribery Convention. This treaty is officially known as the *Convention on Combatting Bribery of Foreign Public Officials in International Business Transactions* and is aimed as reducing corruption in developing countries. It encourages sanctions against bribery in international business transactions carried out but its members' countries and requires adherents to criminalize offering and giving bribes. This convention came into force in 1999. A revision was adopted in 2009. http://www.oecd.org/corruption/oecdantibriberyconvention.htm**(1 = ratified; 0 = no)**.

International Convention on Arrest of Ships. Coming into force in 2011, the International Maritime Organization (IMO) intended for this convention to replace the 1952 Arrest Convention/International Convention for the unification of certain rules relating to the Arrest of Sea-going Ships. It is a

multilateral treaty agreeing on rules of arresting ships. These rules include that: (1) states agree to allow foreign jurisdictions to arrest a ship of its nationality that is present in the foreign jurisdiction's port, (2) arrests can be made only after warrant of arrest is issued in the domestic jurisdiction of port state, and (3) the convention applies only if both states involved are parties to this agreement. This is also known as the *Arrest Convention 1999*. Only the 1999 signatories were used for the purpose of this study as these countries represent those who have renewed their commitment to this convention's updated regulations.

http://unctad.org/en/PublicationsLibrary/aconf188d6_en.pdf**(1 = ratified; 0 = no)**.

UN Convention against Illicit Traffic in Narcotic Drugs and Psychotic Substances. This treaty provides legal mechanisms for enforcing the 1961 Single Convention on Narcotic Drugs and the 1971 Convention on Psychotropic Substances. In force as of 1990, it is one of three major drug control treaties in force. https://www.unodc.org/unodc/en/treaties/illicit-trafficking.html **(1 = ratified; 0 = no)**.

International Convention on Mutual Administrative Assistance for the Prevention, Investigation and Repression of Customs Offenses. This agreement aims to provide its contracting parties with administrative assistance for the proper application of Customs law, for the prevention, investigation, and combatting of Customs offenses, and to ensure the security of the international supply chain. http://www.wcoomd.org

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) This agreement aims at ensuring international trade in specimens of wild plants and animals does not threaten their survival. The existence of this agreement ensures sustainability of trade and safeguards certain wildlife species against overexploitation. It uses three Appendices to protect more than 35 000 species of plants and animals as both living and dead specimens. CITES came into force in 1975. www.cites.org**(1 = ratified; 0 = no)**.

Flag Accessibility

Open Registry. A select number of flags are available for purchase online at www.internationalshipregistries.com. These "open registry" countries increase the accessibility of their flags by providing quick and unrestricted purchase to anyone with Internet connectivity. **(1 = yes; 0 = no)**.

Foreign Access to Fisheries

Foreign fishing access. The Sea Around Us derived a database of fishing agreements from the FAO, which contains observed foreign fishing records, as well as fishing agreements and treaties that were signed by fishing countries and the host countries in whose EEZ the foreign fleets were allowed to fish. This database contains start and end years for each agreement and/or observed access. For this analysis, all agreement types were considered, i.e. assumed unilateral, assumed reciprocal, unilateral, or reciprocal, as well as bilateral agreements such as partnership and multilateral agreements. All coastal waters listed are included. Only mainland countries were considered; this excluded islands and other territories held by the state in question. This data was obtained from www.seaaroundus.org. **(# of foreign access agreements)**.

Taxes

Tax Exemption 2003/2009. Sea Around Us records subsidy programs for investment in the fisheries sector that have a direct impact on profit in the form of rebates and other government-funded programs. These include income tax deferral for fishers, crew insurance, duty free imports of fishing inputs, vessel insurance programs, and other economic incentive programs. This data was obtained from www.seaaroundus.org.

World Bank Tax Revenue. Tax revenue is the amount of compulsory transfers to the central government for public purposes. This excludes fines, penalties, and social security contributions. This is expressed in the form of **percent of commercial profit**. This data was obtained from www.data.worldbank.org.

World Bank Labor Tax and Contributions. Labor tax and contributions is the amount of taxes and mandatory contribution on labor paid by the business. This is expressed in the form of **percent of commercial profit**. This data was obtained from www.data.worldbank.org.

Transparency and Corruption

Corruption Perception Index. Transparency International developed a **Corruption Perception Index** (CPI), which scores and ranks countries and territories based on their perceived level of corruption in the public sector. This data was obtained from https://www.transparency.org/.

WJC Rule of Law. The World Justice Project (WJP) **Rule of Law Index** is a quantitative assessment designed to offer a comprehensive representation of a country's adherence to the rule of law. Factors of this index include: Constraints on Government Powers, Absence of Corruption, Open Government, Fundamental Rights, Order and Security, Regulatory Enforcement, Civil Justice, and Criminal Justice. This data was obtained from https://worldjusticeproject.org/our-work/wjp-rule-law-index.

Human Freedom/Development

Human Freedom. The **Human Freedom Index** was developed by the CATO Institute to assess the state of human freedom in the world. This measure encompasses personal, civil, and economic freedom. Although human freedom is a social concept, it is inherently valuable and plays a role in human progress. This Index uses distinct indicators of personal and economic freedom in the following areas: Rule of Law, Security and Safety, Movement, Religion Association, Assembly, and Civil Society, Expression and Information, Identity and Relationships, Size of Government, Legal System and Property Rights, Access to Sound Money, Freedom to Trade Internationally, Regulation of Credit, Labor, and Business. This data was obtained from https://www.cato.org/human-freedom-index.

UN Human Development. The **Human Develop Index** is a summary measure of average achievements of human development, such as a long and healthy life, being knowledgeable, and having a decent standard of living. This data was obtained from http://hdr.undp.org/en/data.

Index of Economic Freedom. This Index, developed by The Heritage Foundation, assessed 12 freedoms, from property rights to financial freedom, to output the economic freedom of any country. For each factor, **countries are scored 0–100**, with 0 being the least free and 100 the most free. This data was obtained from www.heritage.org.

Gross Domestic Product. Gross Domestic Product data was obtained for each flag Administration from www.data.worldbank.org. All values are recorded in **US Dollars**.

Fisheries Management Efforts

Regional Fisheries Management Organizations. Data on the **number** of Regional Fisheries Management Organizations (RFMO) the flag Administration was party to was obtained from www.seaaroundus.org.

Treaties and Conventions. Data on the **number** of Treaties and Conventions the flag Administration was party to was obtained from www.seaaroundus.org.

APPENDIX C. A Brief Note on the Analytical Strategy

Before conducting statistical analyses, pre-analysis diagnostics were performed to assess the distribution and other characteristics of the variables. These pre-analysis revealed that all the variables, both outcome and grouping, were significantly skewed, i.e. not normally distributed.[1] Additionally, most variables grouped under the "regulatory instruments" and "engagement in illegal activities" categories were either nominal (dychotomous) or ordinal. For the above-mentioned reasons, non-parametric tests were selected to examine the variations in flag desirability between the groups of countries. Additionally, due to the variations in sample size for each grouping variable examined (n = 38), and the small sample size of the current study (n = 157), hypotheses were tested by conducting bivariate analyses. Specifically, analyses involving nominal (dychotomous) grouping variables (e.g. 'Has the country ratified the UN Law of the Sea?') were conducted by running the Mann-Whitney non-parametric test. For ordinal-level grouping variables (e.g. EU carding score, which ranged from "0 = not carded" to "3 = red carded"), we used the Kruskal-Wallis non-parametric test. Lastly, for skewed variables measured at the scale level, the Kendall-Tau *b* non-parametric test was utilized.

In this paper, two sets of analyses were performed in order to examine: (a) whether there is a significant concentration of the choice of FoCs on a small group of countries; and if so (b) which of the 38 explanatory variables identified by prior research can explain these concentrations. To measure whether a small group of countries disproportionately account for the *desirable flags*, we created the Lorenz curve plots, as well as calculated their corresponding Gini coefficients. Gini coefficient values range from 0.00 to 1.00, where "0.0" means the distribution is not skewed, i.e. there is perfect equality of distribution, and "1.00" indicates a statistically significantly skewed distribution, i.e. perfect inequality. The calculation is made using the formula below:

$$G = \frac{A}{A + B}$$

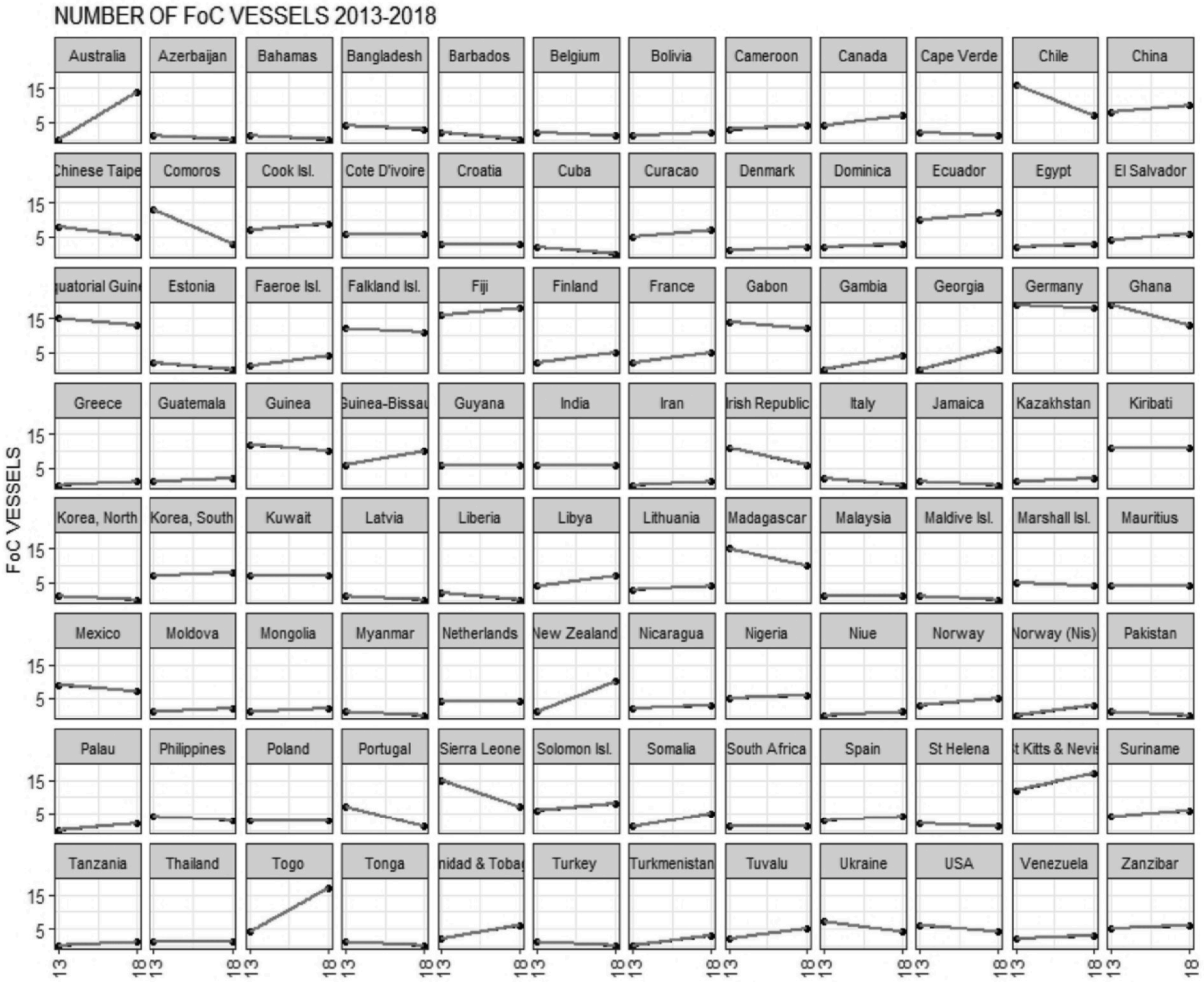
where.

A is the area between the line of perfect equality and Lorenz curve, and

B is the area under the Lorenz curve

Thus, the Gini coefficient, defined by G, is the ratio of the areas on the Lorenz curve diagram.

Appendix C. Countries with Less than 20 FoC Vessels in 2013 and 2018



Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpol.2020.103937.

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