Flag Choice Behaviour in the World Merchant Fleet

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Flag selection is not just a crucial decision with regard to ship operation, but also plays an important role in national and international maritime policy. This study uses individual ship registration data to analyze flag selection behaviour, including flagging out decision using a binary choice model, and final flag choice by applying a nested logit model. Operators from traditional maritime countries are found to flag out high quality vessels, whereas those from open-registry countries tend to flag out low quality ones. Flag preferences are more sensitive to the registration fee than to the annual due; full-open flags are more elastic than quasi-open ones; and substitution among flags within the same group is higher than across different groups. Port State Control, Flag State Control and safety records have opposite impacts on flag choice for ships from closed registry countries and those from open registers.

Keywords: Ship registration; binary choice model; nested-logit model; flag preference

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1. Introduction

Selecting a nationality for a ship has always been the first decision for her owner, ever since it became possible for a ship to have a nationality different from that of its owner. The motivations for selecting a flag have also evolved from simply seeking protection from maritime powers and avoiding hostile trade partners, to a complicated chemical cocktail: Avoiding strict regulations, increasing competitive advantages, escaping national taxation and hiding identities (Metaxas, 1981; Thuong, 1987; Bertaintino & Marlow, 1998). Open register—making the national flag readily available to foreign owned or operated vessels—has also become a revenue generating measure for some countries (Li & Wonham, 1999a). As a result, the proportion of vessels flying a flag that is different from the nationality of their owners or operators (subsequently referred to as foreign-flagged vessels) has grown continuously from 21.6% in the 1970s to 67% in 2008 (UNCTAD 1997-2008).

This high proportion of foreign-flagged vessels in the world fleet, together with changing behaviour in flag selection, has significant implications, not only for public maritime policies at both national and international levels, but also for business strategies in the private sector. Traditional maritime countries are concerned about the shrinking of their national fleet, declining tax revenues, falling employment in the maritime sector and adverse effects on national security. For example, according to the Lloyd's Register database, 59.2% of the US vessels by number, or 76% in DWT (deadweight ton, a measure of cargo carrying capacity), are under a foreign flag. Faced with a similar problem, the Chinese government has initiated a tax-exemption policy to attract foreign-flagged vessels back to Chinese registration.[2] However, will such a policy have the desired effect?

Flag State Control (FSC) — the regulatory control of the state over the vessels flying its flag — is supposed to enforce various national and international conventions on shipping. However, most of the open registry countries do not seriously enforce these conventions. This provides ship operators/owners with opportunities to avoid requirements, which can lead to unseaworthy vessels and thus impaired safety in maritime transportation. Realizing this problem, the International Maritime Organization and the coastal states initiated Port State Control (PSC) as a supplement to FSC, with a view to controlling the standard of ships. However, due to limited resources for conducting vessel inspections, the PSC assigns priorities to those ships whose flag states have bad reputations, mostly those of open registers that have very loose shipping standards. Given that owners or operators will also try to avoid vessel inspection and potential detention in ports, how can the PSC/FSC effectively influence their flag choice behaviour?

From the perspective of private business, the selection of a flag is a primary step for a successful shipping operation. Competition in the international shipping market mandates that the ship owner/operator has to cut costs in all ways possible, and open register is simply the magic wand that has made such dreams come true. Moreover, this wand has also opened a door that can lead to lax enforcement in ship safety regulation, which may

[2] www.jrj.com, Feb. 25, 2009

provide further cost savings, but may also lead to a higher frequency of PSC inspection. How do ship owners/operators make tradeoffs between cost savings and flexibility, with the resulting potential safety hazards and possible inconvenience?

A review of previous studies of flag selection behaviour, provided in section two, reveals some important issues. Firstly, neither the flag selection decision makers, nor the open registers, are homogeneous, and the same policy of an open registry country may have different implications for vessels from different countries. At the same time, the decision maker for the ship's flag may not have the same probability of choosing any of the open registers. Therefore, the statistical model applied to analyze flag selection behaviour has to accommodate both non-homogeneous decision makers and non-homogeneous open registers. Secondly, having decided to flag out, the decision makers also have to decide which flag to choose from among all the potential open registry countries—bearing in mind that they each provide different services and have different requirements.

This study addresses the above-mentioned issues by applying a binary choice model to the flag-out decision, and a nested logit model to the flag choice for foreign-flagged vessels in the world merchant fleet. A major advantage of this study is that it uses observable data to reveal the preference of the decision maker for the flag country. Therefore, it is free from the bias that is a common problem when using survey data. Besides this, logit models are consistent with the random utility framework. Therefore, it is possible to estimate tradeoffs between certain non-monetary policies, such as requirements for crews' nationalities, with financial motivations, such as savings in registration fees and taxes. This provides an economic valuation of maritime policies, an important factor in policy analysis. In short, the findings from this paper contribute to the understanding of a) how the private companies select a flag for their vessels based on the trade-off between economic and safety attributes of the flag, and b) how the choice differs when the operators are from a traditional maritime country (or a closed registry) and when they are from open-registry countries.

In the next section, we will first discuss existing literature on open registries, as well as on the methodology used in our research. Section three introduces the development of the statistical model; section four describes the data processing; section five reports on the model estimation results and discussions; and section six concludes.

2. Literature review

Due to the popularity of open registry, and its significant impact on the maritime industry from the perspectives of both private business operation and public policy, numerous studies have discussed the issue. Early research into open registration focused on the economics of such a practice. Metaxas (1981) reviewed the history of FOC (Flags of Convenience, a term used by many for "open registry"), and discussed benefits and costs from three different perspectives—the world community, and the national economies of both traditional maritime states and countries of registration. He concluded that the costs of the FOC institution far outweighed its benefits. Yannopoulos (1988) studied labour cost factors in traditional maritime countries and foreign-flagged vessels, using a two-sector general equilibrium model. The policy recommendation was that the real labour costs should be reduced for vessels flying the national flag of a traditional maritime country.

Major public concerns at the international level pertain to the safety standards of vessels under open resisters, and the fair treatment of seafarers (Gianni, 2008; Coles & Watt, 2009). Concerning the impact of open-registration on maritime safety, existing studies have tried to identify the correlation between a vessel's flag and its safety record. Alderton and Winchester (2002) examined the casualty rates of flag states in the Lloyd's casualty database from 1997 to 1999, and found that FOCs do have a worse safety record. Li and Wonham (1999b) also found that open-registry ships are more likely to be substandard. However, they also pointed out that not all open-register ships are the same, and some open registers have an acceptable safety record. On the effectiveness of PSC, Cariou et al. (2008) used 4080 observations from the Swedish Maritime Administration during 1996-2001 and found that PSC inspections can reduce the number of deficiencies.

Regarding the possible choices for ship registration, Coles & Watt (2009, p.55) stated that there are three alternatives: (1) the ship register of a country with which the ship owner has some genuine connection; (2) an open registry; or (3) the second/international register. Alternatives (1) and (3) are similar in terms of the genuine economic link, because second registers are not open to foreign vessels. Therefore, we merged them into one group in this study. In addition, we divided the open registers into two groups, to take into account the possible heterogeneity among the open registers.

To understand the major factors involved in a vessel's flag-out decision, many different approaches have been applied in existing research, including the Markov chain model for the flag-out process in the Netherlands shipping fleet (Veenstra & Bergaintino, 2000), the discrete choice model on surveyed data (Bertaintino & Marlow, 1998), and the fuzzy set theory on surveyed data (Haralambides & Yang, 2003). Although a well-designed survey can solicit unobservable data by asking the participants' opinions, the flag hanging on each ship is the best indicator of the preference of its decision maker. In this regard, Hoffmann et al. (2005) applied a binominal probit model to analyze ship operators' flagging out behaviour, using actual ship registration data for 47,740 commercial vessels from the Lloyd's Register database, and a binary choice model for flag choice for eight specific Latin American and Caribbean open registries.

This study applies a binary choice model to study the flagging out behaviour, and a nested logit model for the selection of a specific flag from among many potential alternatives, all under the random utility framework. Nested logit models have been widely used in many different areas, including marketing (Kannan & Wright, 1991; McFadden, 1980), transportation (Lo et al., 2004), and resource economics (Carson et al., 2009), where the potential alternatives exhibit structural differences. Kannan and Wright (1991) applied a nested logit model to study how consumers select coffee products, following a decision tree of three levels: Caffeinated or decaffeinated at the first level; types of coffee at the second level (regular, drip or electric perk); and brand-size combinations at the third level. In a transportation study, Lo et al. (2004) used the nested logit approach to modelling combined-model choices of travellers, following a three-level nested logit structure: Mode choice, transfer mode choice and route choice. In resource economics, Carson et al. (2009) applied the nested logit model in studying the behaviour for fish site selection, when analyzing the recreational fishing demand in

Alaska. They assumed that the decision tree for resident anglers to select where to go for fishing includes four levels: Whether or not to go sport fishing; what the targeted fish type is; what the targeted fish species is; and which site to go to. In our study, we assume that the ship registration decision maker will first decide whether or not to flag-out, followed by a decision on which type of foreign flag to choose, and finally the choice of a flag. The next section introduces the formulation of the model.

3. Model formulation

This section explains the model specification based on the decision making process of selecting a nationality for a vessel. Through a discussion on the decision-making process of flag choice, we first present the binary choice model for the flagging out decision, then the formulation of the nested logit model for flag choices.

3.1. Flag choice behaviour

In this paper, we assume that decision makers have three choices with regard to ship registration. The first is to fly a "national flag", i.e., to register the vessel in a country with which the ship owner has some genuine connection by way of national or economic ties. This choice reflects that the decision maker weights the "genuine link" more than the benefits of the open registration system.

Open registries are not homogeneous. While many treat ship registration simply as a vehicle for increasing national income, some do impose a high standard on ships flying their flags (Toh & Phang, 1993; Hill Dickinson LLP, 2008). We define the former group as "full-open" registries, and the latter one as "quasi-open" registers. Full-open registers provide maximum cost saving possibilities, will accept all vessels regardless of their current vessel classification, and will provide total flexibility with regard to the enforcement of safety, environmental and labour regulations. Examples of such open registers include Panama and Liberia; virtually all ships can fly their flags. Selecting this option implies that the decision maker assigns a high weight to the flexibility and cost savings provided by open register. Quasi-open registers, on the other hand, offer most of the flexibility of an open register, while at the same time imposing high requirements on the quality of the ships flying their flags. Such open registers include Hong Kong and Singapore. Choosing this alternative indicates that the decision maker seeks to enjoy certain cost savings offered by open registry while at the same time avoiding the poor safety reputation associated with open registers.

Those who make flagging out decisions are not homogeneous either. They come to the decision with experience of different environments and regulations and hence will naturally have different considerations when deciding to choose a foreign flag. Furthermore, not all ship owners are the actual operators, and there is no information available regarding who actually selected the flag. In cases where the ship owner is just an investor, it is unlikely that he or she will be the decision maker. In addition, since the Lloyd's ship register database indicates that 79.4% of vessels have operators who are from the same country as the owners, in this research the operator's country is considered the ship's country of origin.

To test the possible differences between the operators from different countries (both closed registry countries and open registry countries), the sample data is organized into two different groups according to the property of the country (closed or open), of the operator. For each group, we analyze the flag-out and flag selection decision following the decision tree depicted in Figure 1. The upper part analyzes the flag-out decision using a binary choice model, while the lower part uses a nested logit model to analyze how to select a flag from among all the major open registries. We put the flag-out decision at the top in order to show the hierarchical structure of the alternatives. When deciding whether or not to flag out, the decision maker is assumed to be in possession of all information about all possible alternatives, and is able to calculate the expected utility of flagging out. Finally, two separate models are applied to these two sections. These are introduced next.

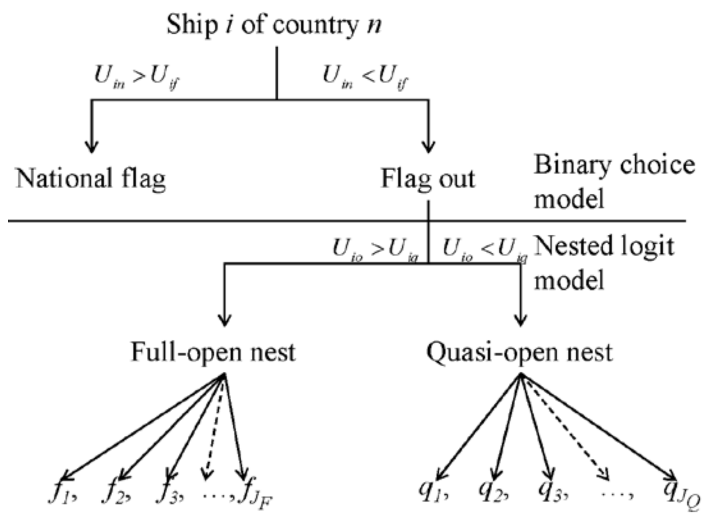

Figure 1. Decision tree for vessel flag choice

3.2 The binary choice model for a flagging out decision

We model the decision for flag-out using a binary choice logit model. The model assumes utility maximization in the operator's flag decision. The specification of the utility function is the key to the estimation process, because it leads to the specification of the probability. Following Greene (2008), the utility for ship *i* to select flag *n* can be written as $U_{in}=V_{in}+\varepsilon$, where V_{in} is the observable utility based on a set of observable factors. These factors include the policies and economic and geographical conditions of both the national country and other flag countries. The last part, ε, is an unobservable random variable with extreme value distribution (Train, 2003, p.80). Using dummy variable y_i for flying a foreign flag, and U_{if} and U_{in} to represent the utility for flying a foreign flag and national flag respectively, if $U_{if}>U_{in}$, then y_i=1; otherwise, y_i=0.

Then the probability for a ship i to fly a foreign flag is:

$$prob(y_i = 1) = \frac{\exp(V_{if})}{\exp(V_{in}) + \exp(V_{if})}\ .$$

This follows the standard definition of a binary choice logit model. From this probability function, the likelihood function can be specified. The parameters in the observable utility function can then be estimated using maximum likelihood estimation.

3.3 The nested logit model for flag choices

The behaviour of decision makers in selecting a particular foreign flag from among many open registries (the lower part in Figure 1) is analyzed using a nested logit model. This assumes that the decision makers will select the foreign flag that can provide the highest utility, and that there are possible structural differences among the open registry countries.

Having determined to flag out, the decision maker for the i^{th} vessel is now facing J potential open registry countries to choose from, with J_F flags in the full-open nest and J_Q flags in the quasi-open nest, as shown in the lower part of Figure 1. The utility for ship i of country n to choose flag j includes two parts: The nest specific utility W_{ik}; and the choice specific utility Y_{ij}, where $k \in \{F,Q\}$ is the index for a specific nest. The probability to choose a nest k is

$$p_k = \frac{\exp(W_{ik} + \tau_k I_k)}{\sum_k \exp(W_{ik} + \tau_k I_k)},$$

where $I_k = \ln \sum_j \exp(Y_{ij} / \tau_k)$ is the inclusive value, $1 \leq j \leq J_k$, J_k is the number of alternatives in nest k, and τ_k the coefficient to be estimated. The inclusive value is designed to capture the influence of the alternative specific attributes in each nest on the selection of the nest. The $\tau_k I_k$ is actually the expected utility of nest k (Train, 2003). The conditional probability for the i^{th} ship to select flag j in group k is

$$p_{ij|k} = \frac{\exp(Y_{ij} / \tau_k)}{\sum_j \exp(Y_{ij} / \tau_k)}$$

Then the likelihood of all the ships to choose the flag that they are actually flying can be written as $L(\beta,\tau,\sigma \mid y_{ij}, x) = \prod_{i=1}^{N} \prod_j (p_{ij|k} p_k)^{y_{ij}}$. From this, it is possible to apply the maximum likelihood method to estimate the parameters, including β, τ, and σ.

One criterion for choosing the nested logit model is the IIA (Independence of Irrelevant Alternatives) property of the alternatives. If IIA holds, the decision between two alternatives is independent of the existence of more (or fewer) alternatives. This statistic is $\chi^2 = (\hat{\beta}_s - \hat{\beta}_f)'[\hat{V}_s - \hat{V}_f]^{-1}(\hat{\beta}_s - \hat{\beta}_f)'$, where s indicates the estimators based on the restricted subset, f indicates the full set of choices, and $\hat{V}_S$ and $\hat{V}_f$ are the estimates of the covariance matrices separately (Hausman & McFadden, 1984; Greene, 2008). This statistic has a χ^2-distribution with degrees of freedom being the rank of $(\hat{V}_S - \hat{V}_f)$.

The advantage of using a nested logit model is that it does not require IIA (Train, 2003) for the alternatives across nests. Therefore, it can capture the higher probability of substitution for the open registries with similar attributes (for example, in the quasi-open nest), which can better reflect the decision making process behind flag choice in the real world.

4. Data description

The data source for all the commercial cargo vessels is the PC Register of ships from Lloyd's Register, which consists of 120,000 vessels of 100 GT (Gross Tonnage) and above. In our analysis, 48,477 vessels of more than 400GT were selected, as smaller vessels are mainly engaged in coastwise trade, and are seldom flagged out. Figure 2 summarizes the composition of the selected ships by the decision makers' country of origin and the nature of the flag. It indicates that more than 86% of the ships are from closed registry countries. Of these, 45% per cent are flying their national flag, while 48% of ships from open registry countries are flying a foreign flag.

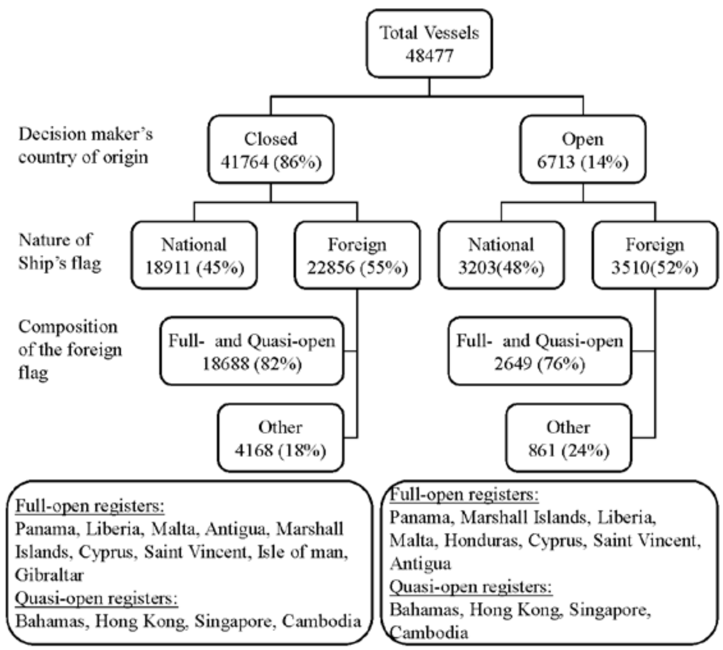

Figure 2. Distribution of ship nationalities and flag nationalities for selected vessels.

Among the selected vessels, 54% (26,366), from both closed and open registry countries, are flagged out. Table 1 lists the open registers and their fleet nationality distribution by number of ships. It shows that the top 14 open registers have around 93% of the open-registered vessels. These 14 countries are the main focus of this study. Ships that are flying the second register of their own country are considered to be flying their national flag, while those registered in other countries' second ship registers are considered flagged out.

For foreign-flagged vessels originating from closed registry countries, 82% are concentrated in the top 13 registry countries, namely Panama, Liberia, Malta, Antigua, Marshall Islands, Cyprus, Saint Vincent, Isle of Man, Gibraltar, Bahamas, Hong Kong,

Table 1: Distribution of fleet nationality (by ship number) for world open registers

	Countries	National	Foreign	Cumulative		Countries	National	Foreign	Cumulative
1	Panama	464	7494	32.5%	18	Philippines	541	150	96.3%
2	Liberia	72	2964	45.4%	19	Cayman Islands	1	142	96.9%
3	Malta	23	1734	52.9%	20	Netherlands Antilles	22	121	97.4%
4	Marshall Islands	119	1569	59.7%	21	Bermuda	7	117	97.9%
5	Antigua	4	1469	66.1%	22	France (FIS)		101	98.4%
6	Bahamas	28	1276	71.7%	23	Mongolia		94	98.8%
7	Hong Kong	585	1091	76.4%	24	Barbados		92	99.2%
8	Singapore	808	924	80.4%	25	Vanuatu		55	99.4%
9	Cyprus	187	920	84.4%	26	Korea (North)	136	43	99.6%
10	Cambodia	15	665	87.3%	27	Bolivia	2	26	99.7%
11	St Vincent	16	516	89.5%	28	Jamaica	1	25	99.8%
12	Isle of Man	11	325	90.9%	29	Sri Lanka	22	15	99.9%
13	Gibraltar	5	307	92.3%	30	Tonga	1	15	100.0%
14	Honduras	73	192	93.1%	31	Sao Tome et Principe	4	5	100.0%
15	Belize	9	222	94.1%	32	Lebanon	35	4	100.0%
16	Georgia	5	189	94.9%	33	Equatorial Guinea	2	2	100.0%
17	Comoros	3	169	95.6%	34	Mauritius	2		100.0%

Source: Compiled from Gianni (2008) *and Lloyd's Fairplay 2009.*

Singapore and Cambodia. For foreign-flagged vessels originating from open registry countries, 76% are flying the one of the above flags, except Gibraltar.

Table 2 lists all the variables used for analyzing both the flag-out decision (with the dependent variable FC) and the flag choice (with the dependent variable CHOICE). It includes four groups: Vessel attributes, characteristics for the country of origin, characteristics of open registers, and the variables representing the difference between the country of origin and the open registers.

In vessel attributes, the dummy variable BUILTOPER is included to check if the flagging-out behaviour of a ship is correlated to where it is built. The 48,477 vessels in our analysis were built in 79 countries. Among them, 70% were built in four major shipbuilding countries, namely Japan, China, Korea (South) and Germany. Of these, 46% are operated by a company in the same country.

The variable LDWT is used to test whether bigger ships are more likely to flag out than smaller ones. Among all the ships in this analysis, 48% are smaller vessels of less than 10,000 DWT. The current database shows that fewer smaller vessels (38%) are flagged out compared with larger vessels (69%).

The REAGE is devised to test whether older vessels are more likely to flag-out than newer ones. The data shows that both new ships (less than 10 years of age) and old ships (older than 20 years) have more than a 50% flagging out rate in each age class. However, ships between 10 and 20 years of age have less than a 50% flagging-out rate.

The ship-type dummy variables BULK, TANKER and CONTAINER are included to test whether ships of different type have different flag selection behaviours. The reference ship type is dry cargo vessel, which includes roro, reefer, combination and miscellaneous vessel types. According to our analysis, container vessels have the highest flag-out ratio (76%), followed by bulkers (63%), tankers (50%), and dry cargo vessels (46%).

Table 2: Variable definitions

	Measurement
Dependent variables	
FC	1 if vessel flag country is foreign, 0 otherwise
CHOICE	1 if vessel chooses the particular flag, 0 otherwise
Independent variables	
Vessel attributes	
BUILTOPER	1 if the vessel operator's country is where the vessel was built, 0 otherwise
LDWT	Log of the vessel carrying capacity in DWT
REAGE	Vessel age when registered, in years
BULK, TANKER and CONTAINER	Dummy variables for bulk, tanker and container respectively. Dry cargo is the base dummy.
CNIK, CGEL, CLLR, CBUV, CDNV, CABS, CCCS, CRUS, CSKR and CREI	Dummy variables for Nippon Kaiji Kyokai, Germanischer Lloyd, Lloyds Registry, Bureau Veritas, Det Norske Veritas, American Bureau of Shipping, China Classification Society, Russian Maritime Register of Shipping, South Korean Register, and Registro Italiano, respectively. All non-IACS are treated as base dummy.
Characteristics for the country of origin	
TOPMARTAX[1]	The top marginal tax rate imposed by the government on high income levels. Average from 2000-2006.
LGDPCAP	Log of the GDP per capita of the vessel's national country
AFRICA, ASIA, EUROPE, AMERICA, and OCEANIA	Dummy variables for vessels from Asia, Europe, America, and Oceania respectively.
Characteristics for open registers	
LRFEE	Log of vessel's registration fee
LAFEE	Log of vessel's annual due fee
Panama, Liberia, Malta, Antigua, Marshall Islands, Bahamas, Hong Kong, Singapore, Cyprus, Cambodia, St Vincent, Isle of Man, Gibraltar, Honduras	Dummy variables representing each open register
Difference variables between the country of origin and the open registry country	
DFSPERFORM[2]	Sum of the black 'blobs' indicated by the table (except the No. of non-IACS bodies) for each vessel operator's country. The higher the value, the worse the performance of the country.
DLOSSRATE[3]	The average marine loss rate from 1998 to 2007, 1/100
DINSPECT[4]	Flag country's inspection rate for different vessels
DAREA	1 if the country of origin and flag country are in the same area
DCOMPANY[5]	Vessel registration requirement for the holding company share, scaled from 1 to 5
DCREW[5]	Vessel registration crew requirement, scaled from 1 to 5

Note:

1. *Source: Economic Freedom of the World: Annual Report Economic Freedom Network 2000-2006.*
2. *Source: Shipping Industry Flag State Performance Table (BIMCO 2009).*
3. *Source: World Casualty Statistics* (*Lloyd's fairplay 1998-2007*).
4. The average annual inspect times by Tokyo MOU from 2000 to 2008 and Paris MOU from 2005 to 2008.
5. The detailed requirements for company equity and crew nationality are listed in Table 3.

Information on the classification society of a ship is used to check how the quality of a ship is related to the flag-out decision. The dummy variable indicates 10 members of the International Association of Classification Society (IACS). These members impose high standards when granting vessel certificates. Therefore, ships bearing their classification certificate are generally believed to be high quality vessels (Hoffmann et al., 2005; Li et al., 2009). Our data shows that around 70% of the ships are under IACS classification. Of these IACS classified vessels, 66% are in closed registry countries and 55% are in open registry countries.

In the variable groups that represent the characteristics of country of origin, the average TOPMARTAX is about 42% for closed registers and 25% for open registers. This indicates that, on average, the tax rates for closed registers are higher than for open registers. The average GDPCAP in closed registry countries (US$18,706) is also higher than that in open registers (US$18,012). The high value of GDPCAP may be due to the fact that most of the large shipping countries have a high Gross Domestic Product (GDP) per capita.

For the characteristics of open registers, the registration fee and annual due are included so as to test the substitution among different flags. They are not used in the flag-out decision analysis because complete information concerning these two variables is not available for the closed registry countries.

Finally, for the difference variables between the country of origin and the open registry country, we included two policy factors, COMPANY and CREW, because these are perceived to exert significant influence on vessels' flag choices. These two variables represent a flag country's requirements with regard to the equity of the company and the nationalities of the crew of the ships flying its flag. Table 3 lists the values of these two variables. Due to their direct impact on a ship's operating costs, these two variables have important implications when selecting a flag. For example, China's ship registration imposes very strict requirements on the equity of the company and the nationality of its crew. It is one of the most stringent in the world (Li & Wonham, 1999b; Hill Dickinson LLP, 2008). To register a ship under the Chinese flag, the owning company's foreign investment should be less than 50%, and all the crew members should be Chinese. Another strict registration is that of the United States. For a ship to fly a US flag, the owning company should have at least 50% US equity. The officers and 75% of the crew onboard should be US citizens. In contrast to the closed registers, open registry countries do not usually impose restrictions on equity or crew nationality, or they impose very low restrictions.

In order to capture the impact of FSC, PSC and vessel safety record on flag choice, our model also uses three variables on FSC performance, PSC inspection rate and the loss rate between the country of origin and the open registers. In our dataset, the average score for the FSC performance of closed registry countries is 2.96, which is greater than that for open registers (2.56). This indicates that, on average, open registry countries may have better FSC performance than closed ones. Regarding loss rate, the average for closed registry countries is 0.087%, which is lower than for open registers at 0.135%. For the PSC inspection rate of each individual country, we use data from Paris and Tokyo MoUs,[3] the two largest MoUs in the world accounting for approximately 75-80% of the world's PSC inspections. The inspection record shows that the top 10 most frequently inspected countries are all open registers, which accounts for around 74% of the total inspections in these two MoUs.

[3] MoU stands for Memorandum of Understanding. These two MoUs are the agreements among maritime administrations in Asia and Europe regarding the inspection of foreign-flagged vessels calling at their ports according to international conventions. The USA is not a member country of the PSC.

Table 3: Flag country's requirements on the equity of the company and the nationality of the crew

Country	A	B	Country	A	B	Country	A	B
Antigua and Barbuda	1	1	Norway NIS	1	1	Maldives	4	.
Australia	1	5	Panama	1	1	Netherlands	4	2
Bahamas	1	1	Sri Lanka	1	3	Suriname	4	2
Barbados	1	1	St Vincent	1	1	Dominican Republic	4	4
Belize	1	1	Syria	1	4	Thailand	4	4
Bermuda	1	2	United Kingdom	1	2	Austria	4	1
Cambodia	1	1	Vanuatu	1	1	India	4	5
Cayman Islands	1	1	Bulgaria	3	3	Morocco	4	5
Cyprus	1	2	Gabon	3	5	Papua New Guinea	4	4
Denmark	1	2	Luxembourg	3	1	Switzerland	4	1
Egypt	1	5	Madagascar	4	5	Ethiopia	5	5
France	1	2	Poland	3	5	Ghana	5	.
Gibraltar	1	1	Togo	3	5	Iraq	5	5
Honduras	1	1	Iran	3	3	Mexico	5	5
Hong Kong	3	1	Qatar	3	.	Russia	5	5
Isle of Man	1	1	Saudi Arabia	3	3	Yemen	5	.
Italy	1	5	Senegal	3	5	Bangladesh	4	.
Jamaica	1	1	Tunisia	3	5	Belgium	4	5
Japan	1	1	Argentina	4	4	China	4	5
Jordan	1	1	Brazil	4	4	Greece	4	4
Liberia	1	1	Colombia	4	4	Malaysia	4	5
Madeira	1	1	Iceland	4	.	Sweden	4	4
Malta	1	1	Korea (South)	4	.	United States of America	4	4
Marshall Islands	1	1	Nicaragua	4	4	Finland	4	2
Mauritius	1	1	Norway	4	4	Germany	5	5
Netherlands Antilles	1	1	Philippines	4	5	Singapore	3	3

Note: The numerical value for company and crew are calculated from requirements for company equity (A) and crew nationality (B): 1 for no requirement, 5 for the strictest requirement.
Sources: Compiled from *Li* and *Wonham* (1999) and *Hill Dickinson LLP* (2008).

5. Empirical results

This section presents and explains the statistical results for the flag-out and flag-choice analyses. Following the assumptions regarding the decision making process, the flag-out decision is explained first. After that, the factors involved in determining the flag choice are outlined. The results for operators from open registry countries are presented alongside those from closed registry countries, and a further explanation is given if they are significantly different.

5.1. Results from the binary choice model of the flag-out decision

Table 4 presents the estimated coefficients of the binary-choice logit model for the flag-out decisions of ship operators from closed and open registries separately. The goodness of fit statistics (χ^2) are all well above 46.963, the critical value for significance at the 0.01 level for 27 degrees of freedom.

Most of the estimated coefficients of the two models are significant. There are significant differences in the sign of some variables between these two models, suggesting that when deciding flagging-out, operators from closed register countries and those from the open registers think differently. The results are explained next.

Table 4: Estimation of flag-out decision (binary choice model)

	Operators from closed registers			Operators from open registers		
Parameter	**Estimate**	**P-Value**	**Marginal Probability**	**Estimate**	**P-Value**	**Marginal Probability**
INTERCEPT	-5.899	<.0001		-7.304	0.011	
Vessel characteristics						
BUILTOPER	-0.700	<.0001	-0.173	-1.340	<.0001	-0.269
LDWT	0.479	<.0001	0.119	0.191	<.0001	0.047
REAGE	0.028	<.0001	0.007	0.037	<.0001	0.009
BULK	-0.455	<.0001	-0.113	-0.076	0.485	-0.018
TANKER	-0.611	<.0001	-0.151	-0.136	0.162	-0.033
CONTAINER	-0.068	0.210	-0.017	-0.233	0.070	-0.056
CNIK	2.078	<.0001	0.414	-0.600	<.0001	-0.141
CGEL	1.785	<.0001	0.366	-0.235	0.128	-0.056
CLLR	0.617	<.0001	0.148	-0.970	<.0001	-0.213
CBUV	0.839	<.0001	0.196	-0.549	0.000	-0.127
CDNV	0.596	<.0001	0.143	-0.449	0.006	-0.105
CABS	0.717	<.0001	0.169	-0.851	<.0001	-0.190
CCCS	-0.112	0.116	-0.028	-0.986	<.0001	-0.212
CRUS	0.481	<.0001	0.116	0.747	0.029	0.184
CSKR	-0.237	0.002	-0.059	-0.749	0.000	-0.167
CREI	-0.116	0.306	-0.029	-0.443	0.195	-0.103
Characteristics for the country of origin						
TOPMATAX	0.010	<.0001	0.002	-0.050	0.284	-0.012
LGDPCAP	0.088	<.0001	0.022	0.690	0.004	0.169
AFRICA	1.066	<.0001	0.236	-0.484	0.782	-0.112
ASIA	0.047	0.820	0.012	-1.249	0.136	-0.303
EUROPE	-0.268	0.189	-0.067	0.061	0.914	0.015
AMERICA	0.056	0.801	0.014			
Difference between the country of origin and the open registry country						
DINSPECT	0.584	<.0001	0.145	-0.4470	0.6508	-0.109
DFSPERFORM	-0.296	<.0001	-0.074	-0.0661	0.6773	-0.016
DLOSSRATE	1.819	<.0001	0.453	-2.867	0.362	-0.701
DCOMPANY	-0.064	<.0001	-0.016	0.080	0.782	0.019
DCREW	0.103	<.0001	0.026	0.218	0.121	0.053
Observations	35614			4939		
χ^2	13764			857		

Note: The results from taking the shipowner as the decision maker are similar, hence omitted.

- BUILTOPER

The coefficient is negative, indicating that vessels built in an operator's country are less likely to flag out, and those built in a foreign country are more likely to. This may be because of the requirements involved in securing government subsidies in shipbuilding; ships built using subsidies have to use the national register. It may also be because of the huge import tax that prevents ships built in a foreign shipyard from flying a national flag. The marginal probability indicates that if the shipbuilding country is the same as the operator's country, the probability of flag-out will decrease by 0.17.

- LDWT

The positive coefficient suggests that large vessels are more likely to choose a foreign flag: most large vessels deployed on international trade routes are in close competition, and flying a foreign flag helps to cut the costs.

- REAGE

The positive coefficient implies that older vessels are likely to flag-out. When a ship becomes old, it costs more to maintain the ship to a high standard. To reduce costs, it may have to register in an open register where the requirements are low.

- BULK, TANKER and CONTAINER

The negative coefficients suggest that bulk and tanker vessels are less likely to flag out compared with dry cargo vessels. The coefficient for CONTAINER is not significant, suggesting that the flag-out behaviour for container vessels and dry cargo vessels is similar. For all vessel types, tankers show the least possibility of flagging out. This may be because tankers carry energy resources such as crude oil or gas, which are typically controlled by the government and can only be carried by the national fleet. Being registered under a national flag may therefore confer certain privileges. Another reason may be that tankers are less likely to have an accident (Hoffmann et al., 2005), especially since the stringent vetting process developed by the Oil Companies International Marine Forum came into force in 1989. Therefore, tankers are less motivated to flag out to enjoy flexible requirements on safety.

- Dummy variables for IACS members

The estimated coefficients are the opposite for operators from closed registry countries and those from open ones. Also, most of the coefficients are significant. However, for the former, most of the coefficients are positive, whereas for the latter group most are negative. These results indicate that closed registry countries tend to flag-out IACS classified vessels. Normally, these vessels are also high quality and comply with international safety and environmental standards. They are flagged-out for operational cost savings and flexibilities, not for lower quality or safety requirements. However, for open registry countries, ships with IACS classification are less motivated to flag-out than those with non-IACS classification. In other words, the statistical results reveal that open registry countries tend to flag-out lower quality vessels.

- Characteristics of the country of origin

The coefficients for TOPMARTAX and LGDPCAP indicate that a high tax rate and GDP per capita motivate operators to flag out, in order to save on operating costs. This is also reflected in previous research by Hoffmann et al. (2005). The coefficients for the country location dummies are not significant, except for Africa, indicating that there is no significant difference in flagging out decisions among ship operators in different regions, except on that continent.

- Differences between the country of origin and the open registry country

All the coefficients are significant for ships from closed registry countries, but not for those from open registry countries. This may be due to the fact that for the variables in this group there are no significant differences between open registers. For ships from the closed registry countries, the DINSPECT is positive, indicating that the high PSC inspection rate in the country of origin increases the probability of flag-out. In other words, ship operators prefer to register in a country with a low PSC inspection rate.

The negative coefficient on DFSPERFORM indicates that ships whose country of origin has a higher FSC performance value (that is, worse FSC enforcement) will not flag out. This in turn indicates that ship operators prefer to register in a country that does not enforce relevant international laws and regulations strictly.

However, ship operators do care about the safety of the ship. This can be inferred from the coefficient of the loss rate, DLOSSRATE. The estimated coefficient is positive and significant, revealing that if the ship's country of origin has a high loss rate then the operator will flag out. If it has a lower loss rate, the operator will fly the national flag. In other words, the effort spent on improving the safety record of a country could have a positive impact on retaining ships in its national fleet.

The negative coefficient on DCOMPANY indicates that stringent requirements on the ownership of company shares will actually reduce flagging out, which goes against the feeling that stricter regulations will motivate the operator to flag out. This is because those countries that have higher requirements (the value for column 4 in Table 4) are also the largest ship controlling countries, such as the US, China and Greece. Therefore, the number of ships flagged-out from these countries is also high. The coefficient of DCREW suggests that the stricter the nationality requirement on the crew in the operator's country, the more likely it is that the vessel will flag out.

In conclusion, the statistical results indicate that owners of vessels from closed registry countries make flag-out decisions differently to those from open registry countries. For the former, the vessel type, characteristics of the country of origin, and policy differences between the country of origin and the open registers are the key factors in making a flagging out decision. While the operators prefer a flag state with lower PSC inspections and flexible FSC, they still prefer flags with a lower loss rate. This implies that effort expended maintaining quality shipping pays off. For the open registry group, the differences between the country of origin and the open registers are not significant. The closed registry countries tends to flag out good quality vessels, while the open registry group often puts lower quality vessels under foreign flags.

5.2. Results from the nested logit model of flag choice

In determining which flag to choose from among all the open registers, we adopt the Nested Logit model, which assumes that there are structural differences among all the alternatives. Open registers are not homogeneous—some enforce national and international maritime policies, while others just treat the register as a source of revenue. According to previous research (Hill Dickinson LLP, 2008), four open registers are identified as not completely FOC countries, namely the Bahamas, Cambodia, Hong Kong and Singapore. These are treated as a 'quasi-open' group. Other open registers are classified under 'full-open' group.

To justify the application of the nested model, we examined the IIA property using the Hausman-McFadden test (Greene, 2008; Hausman & McFadden, 1984) introduced in section three. The test statistics are 3291.0 and 75.0 for vessels from closed and open registry countries respectively, these being larger than the critical value of 38.93($\chi^2_{0.99}(21)$) and 37.57 ($\chi^2_{0.99}(20)$). Therefore, the IIA assumption is rejected, and the conditional logit model is not appropriate for modelling the flag choices.

Ships from both closed registry and open registry countries may choose to flag out. Do they behave in the same way? To test this, we also ran two separate regression analyses—one for ships originating from closed registry countries, the other for those from open ones. The closed registry group includes 82% of the ships in this analysis, and has 13 flags to choose from; while the open registry group comprises only one tenth of the sample size (foreign flagged vessels, 26,366), and has only 12 flags to choose from. In the event that the ship's country of origin is one of the 12 alternatives, it is reduced to 11 choices.

For each analysis, we assume that the decision maker will first decide which nest to choose from—the 'full-open' group or the 'quasi-open' one. The next step is to choose a specific flag within that nest by comparing the choice-specific characteristics of each alternative. Table 5 shows the results from the nested logit model.

Table 5: Estimates of the nested logit model

	Operators from closed registers		Operators from open registers	
Parameter	**Estimate**	**P-value**	**Estimate**	**P-value**
Panama_L1	2.254	<.0001	2.923	<.0001
Liberia_L1	1.384	<.0001	1.721	<.0001
Malta_L1	0.373	<.0001	0.923	<.0001
Antigua_L1	1.781	<.0001	0.473	0.034
Marshall Islands_L1	0.148	0.030	1.234	<.0001
Bahamas_L1	-3.011	0.000	0.526	0.535
Hong Kong_L1	-5.025	<.0001	-1.569	0.092
Singapore_L1	-2.881	0.001	-0.456	0.596
Cyprus_L1	-0.477	<.0001	0.219	0.276
Cambodia_L1	-6.496	<.0001	-2.793	0.003
Isle of Man_L1	-5.137	<.0001		
Gibraltar_L1	-2.883	<.0001		
Honduras_L1			-0.310	0.126
LRFEE_L1	-0.873	<.0001	-0.893	<.0001
LAFEE_L1	-0.260	<.0001	-0.277	<.0001
DAREA_L1	0.761	<.0001	0.833	<.0001
OPEN×BULK_L2G1	0.407	<.0001	0.468	0.016
OPEN×TANKER_L2G1	0.100	0.103	0.468	0.011
OPEN×CONTAINER_L2G1	0.684	<.0001	0.553	0.035
OPEN×REAGE_L2G1	-0.004	0.078	0.006	0.297
OPEN×DINSPECT	-0.279	<.0001	1.314	0.001
OPEN×DFSPERFORM	-0.336	<.0001	0.353	0.001
OPEN×DLOSSRATE	1.197	<.0001	-4.177	0.001
INC_L2G1C1	0.648	<.0001	0.934	0.001
INC_L2G1C2	0.481	<.0001	0.776	0.000
Observations	17202		2107	
χ^2	16735		2354	
Log L	-35755		-3875	

The coefficients of the inclusive variables (INC_L2G1C1 and INC_L2G1C2) are between 0 and 1. This indicates that the nested specification is consistent with flag selection behaviour. The likelihood ratio between the conditional logit model and the nested one is used to test the null hypothesis that the nested logit model is not significantly different from the conditional logit model. The test statistics for operators from closed registry countries is 88 (= – 2[–35,799 – (–35,799)])[4]. The 1% critical value from the χ^2-distribution with 2 degrees of freedom is 9.21. Therefore, we can conclude that the nested logit model is statistically different from the conditional logit model. The test statistics for ships from open registers are similar.

For vessels from closed registry countries, with St. Vincent as the reference flag, the countries with positive coefficients suggest that, all other things being equal, the probability of choosing that flag is larger when compared to St. Vincent, whereas negative coefficients indicate that the probability of choosing that flag is smaller. All the coefficients for the quasi-open registers are lower, indicating the relatively low probability compared with St. Vincent. The Marshall Islands is not significant, probably because there is not much difference between this flag and St. Vincent's.

The negative coefficients of LRFEE and LAFEE suggest that an increase in the registration fee or annual due of a flag will reduce the attractiveness of that flag. A 1% increase in the registration fee for a particular country will decrease the probability of choosing that flag by 0.582% (1-*exp*(-0.873)). Similarly, a 1% increase in the annual due of a country will decrease the probability by 0.228%. It is logical that the preference for a flag will decrease with its registration fee and annual tonnage due. However, it is not obvious that the preference is more sensitive to the registration fee than to annual dues. This implies that the decision maker cares more about the up-front costs at the time of registration than any future costs. Regarding the geographical indicator, the positive coefficient on the variable DAREA indicates that the ship operator is more likely to choose a flag if the flag country is in the same continent.

The variables with an OPEN prefix are nest-specific variables for selecting a nest—a positive coefficient implies that it will increase the probability of choosing the full-open nest. Our result shows that, compared with dry cargo vessels, all other ship types prefer a full-open nest. For ships originating from a closed registry country, the negative coefficient on REAGE suggests that newer vessels are more likely to choose full-open registers than older ones are.

With respect to the comparison of PSC, FSC and safety records between vessels' countries of origin and open registers, there are significant differences in nest preference between operators from closed registry countries and those from open registers. Most of the countries in the former group have lower PSC inspection rates, stricter FSC (lower DFSPERFORM), and better safety records, but there are still variations among these countries. The negative coefficient of DINSPECT means that if the operator's country of origin has a lower inspection rate, it will prefer a full-open group. The negative coefficient of DFSPERFORM indicates that if the country of origin has stricter FSC, or the full-open flag has flexible FSC, it will prefer a full-open nest. The positive coefficient

[4] The two numbers in the square brackets are the log-likelihood values. The first one is from the conditional logit model, while the second one is from the nested logit one.

of DLOSSRATE indicates that if the country of origin has a high loss rate, it will prefer a full-open group. In short, vessels originating from closed registry countries with a lower PSC inspection rate, stricter FSC and a worse safety record will prefer a full-open group.

The sign for the same three variables for operators from open registry countries are just the opposite of those stated above. This may be because these ships are already in open registry countries. The reason for them to flag out is to find a particular register that has lower requirements, as they cannot maintain the standards of their countries of origin. Therefore, ships whose country of origin has a higher PSC inspection rate, a loose FSC and a better safety record will still register in some other full-open registers.

Owing to the substitution effect, a change in the registration fee of one flag will also affect the probability of selecting other flags. The level of substitution can be measured by elasticity, which is the percentage change of the chosen probability *w.r.t.* (with respect to) a one percent change in a variable. This elasticity can be calculated using the next equation, following Greene (2008):

$$\frac{\partial LnP(j,k)}{\partial LRFEE\ of\ (j^*,k^*)} = \{1(k=k^*)[1(j=j^*)-P_{j^*|k^*}]+\tau_{k^*}[1(k=k^*)-P_{k^*}]P_{j^*|k^*}\}\beta_{LRFEE},$$

where (j^*, k^*) indicates the alternatives with a registration fee change, and (j, k) for any other alternatives impacted by the registration fee change in (j^*, k^*). Table 6 summarizes the estimated elasticity of the probabilities *w.r.t.* the registration fee in all the open-registers, based on the operators from closed registry countries.

Each column in Table 6 contains the elasticity of the probability for all the open registry countries *w.r.t.* the registration fee of one country identified in the header. For example, the first column is the elasticity of all the countries *w.r.t.* the registration fee in Panama. Defining own-elasticity as the elasticity of one particular flag with its own registration fee change, cross-elasticity as the elasticity of that country for the registration fee change of a flag in the same nest, and cross-nest elasticity as that for a registration fee change in another nest, the results of this table can be summarized as follows:

1. Negative own-elasticity: An increase in the registration fee of a flag country will always decrease its preference. All of them are inelastic.
2. Positive cross-elasticity and cross-nest elasticity: Increasing the registration fee in one country will increase the preference for all other countries. A registration fee change for large open registers will result in higher cross-elasticity.
3. All cross-elasticities and cross-nest elasticities are equal. This conforms with the IIA requirement of the nested logit model: IIA only holds within a nest, not across nests (Train, 2003).
4. Cross-elasticity is always larger than cross-nest elasticity: Flags in the same nest are closer substitutes than those in a different nest. For example, it is relatively difficult for Hong Kong to attract vessels that are currently registered in Panama, as the latter has a much looser registration system. However, Hong Kong can be a close competitor of Singapore, the Bahamas, or Cambodia, as they are similar in nature.

Table 6: Elasticity of likelihood to be chosen with respect to registration fee

Effect on	Panama	Liberia	Malta	Antigua	Marshall Islands	Cyprus	St Vincent
Panama	-0.554	0.130	0.082	0.077	0.062	0.044	0.023
Liberia	0.319	-0.743	0.082	0.077	0.062	0.044	0.023
Malta	0.319	0.130	-0.791	0.077	0.062	0.044	0.023
Antigua	0.319	0.130	0.082	-0.796	0.062	0.044	0.023
Marshall Islands	0.319	0.130	0.082	0.077	-0.811	0.044	0.023
Cyprus	0.319	0.130	0.082	0.077	0.062	-0.830	0.023
St Vincent	0.319	0.130	0.082	0.077	0.062	0.044	-0.850
Isle of Man	0.319	0.130	0.082	0.077	0.062	0.044	0.023
Gibraltar	0.319	0.130	0.082	0.077	0.062	0.044	0.023
Bahamas	0.142	0.058	0.037	0.034	0.028	0.019	0.010
Hong Kong	0.142	0.058	0.037	0.034	0.028	0.019	0.010
Singapore	0.142	0.058	0.037	0.034	0.028	0.019	0.010
Cambodia	0.142	0.058	0.037	0.034	0.028	0.019	0.010

Effect on	Isle of Man	Gibraltar	Bahamas	Hong Kong	Singapore	Cambodia
Panama	0.017	0.016	0.032	0.028	0.024	0.017
Liberia	0.017	0.016	0.032	0.028	0.024	0.017
Malta	0.017	0.016	0.032	0.028	0.024	0.017
Antigua	0.017	0.016	0.032	0.028	0.024	0.017
Marshall Islands	0.017	0.016	0.032	0.028	0.024	0.017
Cyprus	0.017	0.016	0.032	0.028	0.024	0.017
St Vincent	0.017	0.016	0.032	0.028	0.024	0.017
Isle of Man	-0.856	0.016	0.032	0.028	0.024	0.017
Gibraltar	0.017	-0.857	0.032	0.028	0.024	0.017
Bahamas	0.008	0.007	-0.705	0.153	0.123	0.084
Hong Kong	0.008	0.007	0.169	-0.720	0.123	0.084
Singapore	0.008	0.007	0.169	0.153	-0.750	0.084
Cambodia	0.008	0.007	0.169	0.153	0.123	-0.790

Note: Countries under the dotted line are quasi-open flags.

In summary, the results from the nested logit model reveal the structural differences among major open registers. In general, the preference for an open register is more sensitive to the registration fee than the annual due. Facing an increase in registration fee, own-elasticity is higher for flags in the full-open group than for those in the quasi-open group, whilst the cross-elasticity is higher than the cross-nest elasticity. This means that competition in the full-open group is higher than that in the quasi-open one. Ships from closed registry countries with a lower PSC inspection rate, stricter FSC and worse safety record prefer flags in the full-open group, whereas ships from open registry countries prefer the opposite.

6. Summary, conclusion and implication

This study analyzes the behaviour of decision-makers with regard to ship registration; whether or not to fly a foreign flag and, if the decision is to fly a foreign flag, which flag to fly. It does this by applying binary choice models and nested logit models to the observed vessel registration data for ships in the world merchant fleet, together with ship characteristics, economic and policy conditions of flag states, and geographical relationships. The model assumes that the utility of the decision makers for flag choice can be revealed through the actual flags flown on each ship, and that the utilities consist of an observable part derived from the actual data, and an unobserved random part with extreme-value distribution.

The binary-choice logit model reveals that flagging out decisions are different for vessels from closed registration countries compared with those from open registry countries. The major difference is that vessels flagged-out from closed registration countries tend to be high quality ships, whereas those from open registration countries tend to be lower quality. With regard to the significance and relevance of other important factors, such as vessel characteristics, vessel national country characteristics, and cost related factors, our results are consistent with a previous study (Hoffmann et al., 2005). In addition, we find that the policy on crew nationality requirements is a very significant factor in the flag-out decision. If the differences in this policy measure are higher between the vessel's national flag and the open registers, it will be more inclined to flag out. This indicates the importance of marine policy in ship registration; the principal reason for a vessel to flag out is for trade flexibilities and lower operating costs. If a country's policy objective is to develop a national shipping industry for the induced economic benefits, it may wish to relax its requirement on crew nationality, or set up its own second register. However, it is necessary to maintain a good safety record for its national fleet, as this can attract more ships to fly the national flag.

In analyzing the flag choice issue, we applied a nested logit model to capture the differences between full-open flags and quasi-open flags. The result shows that the high loss-rate of the country of origin has a positive impact on the choice of a full open register for the decision makers from closed-registration countries, whereas it has a negative impact on the choice of a full open register for open-registration countries. Quasi-open flags are less sensitive to the registration fee than full-open registers. Meanwhile cross-elasticity is greater than cross-nest elasticity, indicating closer competition among flags in the same nest as opposed to those in different nests. A country aiming to attract more ships, will find it more practical to compete with registers with a similar registration system.

The results show that the probability of choosing a particular flag will decrease with an increase in its registration fee and annual tonnage due, and that the flag choice is more sensitive to the registration fee than the annual tonnage due. For the ship operators from closed registry countries, if the country of origin has a lower PSC inspection rate, stricter FSC and worse safety record, they will prefer a full-open group. In contrast, those from open registry countries prefer a full-open group if the country of origin has a higher PSC inspection rate, loose FSC and better safety record.

While most of the opposition to an open registry stems from poor safety and manning practices (Thuong, 1987), it is necessary to differentiate between different open registers. The quasi-open countries are able to maintain efficient safety control without sacrificing the benefits provided by an open register. For example, Singapore passed the Merchant Shipping Regulations in 1981 to tighten up the registry requirements for foreign ships, converting its shipping registry to quasi-FOC (Toh & Phang, 1993). Hong Kong has also introduced strict entry criteria, refusing older ships and insisting on vessel inspections globally. Therefore, more resources should be put into PSC inspections for the higher priority flags, in order to change the inclination of decision makers to select a flag with a bad safety record.

This study also provides an opportunity to calculate the marginal utility of each individual attribute (policy regulation with fees and charges), so that the traditional maritime nations can estimate the monetary value of their national maritime policy, and then use it to prevent the loss of their national fleet to foreign flags. Open registers can make use of this trade-off between policy measures and monetary measures, so as to justify the cost of enforcing the international maritime safety regulations.

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References

Alderton, T. & Winchester, N., 2002. Flag states and safety: 1997-1999. *Maritime Policy & Management*, 29(2), pp.151-62.

Bertaintino, A. & Marlow, P., 1998. Factors influencing the choice of flag: empirical evidence. *Maritime Policy & Management*, 25(2), pp.157-74.

BIMCO, 2009. *Shipping Industry Flag State Performance Table*. [Online] Available at: HYPERLINK "https://www.bimco.org/en/Members/News/2009/2009/10/~/media/BIMCO_News_2009/General/Flag_Table_o9_web.ashx" [Accessed 17 January 2011].

Cariou, P., Mejia, M.Q.J. & Francois-Charles, W., 2008. On the effectiveness of port state control inspections. *Transportation Research Part E*, 44, pp.491-503.

Carson, R.T., Hanemann, W.M. & Wegge, T.C., 2009. A nested logit model of recreational fishing demand in Alaska. *Marine Resource Economics*, 24, pp.101-29.

Coles, R. & Watt, E., eds., 2009. *Ship registration: law and practice*. 2nd ed. London: informa.

Economic Freedom Network, 2000-2006. *Economic freedom of the world*. Canada: Fraser Institute.

Gianni, M., 2008. *Real and Present Danger: Flag State Failure and Maritime Security and Safety*. International NGO report. Oslo/London: World Wide Fund for Nature & International Tansport Workers' Federation.

Greene, W.H., 2008. *Econometric Analysis*. 6th ed. New Brunswick, New Jersey, USA: Prentice Hall.

Haralambides, H.E. & Yang, J.Q., 2003. A fuzzy set theory approach to flagging out: towards a new Chinese shipping policy. *Marine Policy*, 27, pp.13-22.

Hausman, J. & McFadden, D., 1984. Specification tests for the multinomial Logit model. *Econometrica*, 52(5), pp.1219-40.

Hill Dickinson LLP, 2008. *International ship registration requirements*. Liverpool.

Hoffmann, J., Sanchez, R.J. & Talley, W.K., 2005. Determinants of vessel flag. *Research in Transportation Economics*, 12, pp.173-219.

Kannan, P.K. & Wright, G.P., 1991. Modeling and testing structured markets: A nested logit approach. *Marketing Science*, 10(1), pp.58-82.

Li, K.X., Wang, Y. & Min, J., 2009. Quantitative analysis of materiality in marine insurance. *Maritime Policy and Management*, 36(5), p.437–455.

Li, K.X. & Wonham, J., 1999a. Registration of Vessels. *The International Journal of Marine and Coastal Law*, 14(1), pp.137-54.

Li, K.X. & Wonham, J., 1999b. Who is safe and who is at risk: a study of 20-year-record on accident total loss in different flags. Maritime Policy & Management, 26(2), pp.137-44.

Lloyd’s Fairplay, 1998-2007. *World casualty statistics*.

Lloyd's Fairplay, 2009. *Lloyd’s PC Register*.

Lo, H.K., Yip, C.-W. & Wan, Q.K., 2004. Modeling competitive multi-modal transit services: a nested logit approach. *Transportation Research Part C*, 12, pp.251-72.

McFadden, D., 1980. Models for probabilistic Choice Among Products. *The Journal of Business*, 53(3), pp.s13-29.

Metaxas, B.N., 1981. Flags of Convenince. *Marine Policy*, 5, pp.52-66.

Thuong, L.T., 1987. From flags of convenience to captive ship registries. *Transportation Journal*, 27(2) pp.22-34.

Toh, R.S. & Phang, S.Y., 1993. Quasi-flag of convenience shipping: the wave of the future. *Transportation Journal*, 33(2), pp.31-39.

Train, K.E., 2003. *Discrete choice methods with simulation*. Cambridge:UK.

UNCTAD, 1997-2008. *Review of maritime transport*. Geneva.

Veenstra, A.W. & Bergaintino, A.S., 2000. Changing ownership structures in the Dutch fleet. *Maritime Policy & Management*, 27(2), pp.175-89.

Yannopoulos, G.N., 1988. The economics of ‘flagging out’. *Journal of Transport Economics and Policy*, 22(2), pp.197-207.