Strict or relaxed: remedy for duty of disclosure

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Abstract

One hundred years ago, when signing the marine insurance contract, the underwriter was not well-informed and in a disadvantageous position. As a result, Marine Insurance Law of UK 1906 regulates a strict ex post remedy with respect to the duty of disclosure. Today it has become the most significant regulation in the jurisdiction of the marine insurance disputes, widely referred by many countries during drafting the marine or non-marine insurance laws. But with the development of the shipping industry and the insurance market, the underwriter now has much better understanding of the IoM for the business. And Marine Insurance Law 1906 is believed outdated regarding the duty of disclosure. The amendment of the related clauses has been questioned by the academia, the legislators and the shipping industry.

In this paper, we classify the IoM into the three categories: (1) important for the underwriter only; (2) important for the policyholder only; (3) important for both parties. Based on the disclosed IoM, the underwriter uses a stochastic control model to price the premium rate. And the policyholder may provide the biased IoM information to obtain a low price. Through the analysis of the policyholder's utility before and after the ex post remedy, the weaknesses of the current marine insurance law are revealed. Some amendment suggestions are also provided in this study.

1. Introduction

Marine insurance is the oldest type of insurance born in UK. Marine insurance laws adopted in the world, currently, are mainly *Marine Insurance Law of UK 1906* or her derivative versions. With the development of shipping industry, the remedy of duty of disclosure regulated by the law seems so strict for policyholders. Assureds have mandatory obligation to disclose any information of materiality to marine insurers, otherwise, underwriters have rights to discharge insurance contract, refuse to cover the loss and refund the extra premium, if it is witnessed policyholders conceal some information. Since it is difficult for policyholders to identify whether the information is of materiality, the court will adopt the declaration done by underwriters. As a result, marine insurers have great motivation to reject their coverage obligations intentionally. Legal scholars advocate that the old version of marine insurance law is outdated, where the benefit of policyholders is not protected appropriately.

In marine insurance practice, the clauses about duty of disclose have become the pretext of underwriter to terminate contract maliciously, which makes people more dissatisfied with the present marine insurance law, especially the legal consequence of violation. In the case Mackay v. London

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General Insurance Co, Lord Swift appealed to people for more attention on assured's disadvantageous situation under the present clauses of duty of disclosure. Assured is suffering rude attitude of underwriter. After collecting premium, underwriter rejects to cover the claim, even though the loss event is definitely not influenced by the information concealed by assured. Accordingly, from 1950s, the common law system countries, including UK, try to relax the strict request about duty of disclosure. After 100-year development, steal hull, advanced engineer, electronic equipment, high-level cargo packing technology, especially containerization, advanced navigation and security system are widely used in shipping industry. The risk level of vessel and cargo on board is significantly reduced. Underwriter is facing the reducing insurance risk caused by violating duty of disclosure, where insurer can employ developed acceptance technology, communication technology and special human resource to investigate the actual situation of insurance bids and estimate risk more precisely. A famous scholar in UK questioned if it is still applicable to conclude the rights and obligations of the two parties in the insurance contract in the 21st century basing on the dated case 250 years before.

(1) Duty of disclosure is a concept of marine insurance law. Law and the quality of its enforcement are potentially important determinants of what rights policyholders have and how well these rights are protected (see in la Porta et al, 1998). The purpose of this research is to find a better revision of duty of disclosure in the present marine insurance law. The whole procedure of marine insurance business can be divided into three steps: (1) the formation of insurance contract; (2) the occurrence of marine insurance disputation; (3) the remedy of law.

Intuitively, an underwriter and a policyholder would not accept a certain insurance contract, unless they predict that sufficient benefit can be satisfactorily obtained through such agreement. We can say that the contract is *expectedly fair*. Usually, policyholder is the more informed party rather than underwriter. When the marine insurance disputation happens, it must imply there is the actual unfairness contained in the contract. Such bias deviating from the expected fairness should be redressed by law. At the mean time, the efficiency and the enforcement of the law depend on the objective of legislation.

2. Literature Review

The issue of duty of disclosure is essentially connected to the information asymmetry existing in insurance business. The common view is asymmetric information are plaguing insurance market and reducing the social wealth. However, Garidel-Thoron (2005) obtains the opposite conclusion. By a two-period model, Garidel-Thoron (2005) finds that when the initial contract choice of a policyholder cannot be shared among underwriter in the second period, a strict increase in welfare is obtained. More exactly, in the second period, the ex post welfare of the insurance contract is improved, which, however, decrease the efficiency of the ex ante competition. Finally, the overall welfare decreases in these two periods.

Generally, information disclosure is much discussed in corporate finance, but few appear in the literatures of insurance economics. Analogous to de Garidel-Thoron (2005), Li and Madarasz (2008) describe a scenario that expert provides advices to the uninformed decision maker. Since there are the conflicting interests between the two parties, an expert can provide a bias report, right-biased or left-biased. Li and Madarasz (2008) discussed the uncertainty of the conflicting direction and the uncertainty of the conflicting extent, separately. The main results suggest that the expert of lower conflicting interest will obtain higher expected payoff under disclosure, whereas the expert of high conflicting interest will achieve higher expected payoff under nondisclosure. The decision maker always obtain higher expected payoff under nondisclosure. When there is only the uncertainty of conflicting direction, nondisclosure will increase welfare. If the uncertainty of conflicting extent exists, the decision maker and the expert of low conflicting interests can improve their situations more under disclosure.

The conclusions of de Garidel-Thoron (2005) and Li and Madarasz (2008) imply that the absolute information symmetry is not improving the social welfare. De Garidel-Thoron (2005) constructs a dynamic model, while Li and Madarasz (2008) adopted a comparative static model. The former study offers a method to analyze the information asymmetry among multiple underwriters and the insurance strategies of distinct types of policyholders. The latter research takes into consideration of how the uncertainty of conflicting interest direction and severity makes impact on the distribution of social wealth, which reveals the fundamental occasion of information asymmetry. Such consequence supports our intuitive understanding of Marine Insurance Law 1906 that the information symmetry obtained by executing the extremely strict remedies fails to promote the further development of the contemporary marine insurance business. Gu (2007) suggests to revise Marine Insurance Law of China from three perspectives, where the main purpose is to relax the remedy regulation about duty of disclosure and, indirectly, allow the existence of information asymmetry to some extents. Simpler than Li and Madarasz (2008), the scenario we want to emphasize is one-side bias. Underwriter takes the role of the decision maker in Li and Madarasz (2008), and policyholder is an expert of more information than the uninformed underwriter. Obviously, the two parties are of conflicting interest. Any policyholders have great incentive to underestimate their risk level and perform overconfident.

Differing from de Garidel-Thoron (2005), a more subdivisible temporal model is constructed by Boot and Thakor (2001), where the three types of investors seek for information through costly transmission, or firm disclosure policy after some investor becoming informed. When the true value of the firm becomes known, the investors obtain payoff. Compared with the social welfare analysis done by de Garidel-Thoron (2005) and Li and Madarasz (2008), Boot and Thakor (2001) emphasize the benefit or the loss with respect to each type of firm and investor. Under disclosure, the firm of good quality is always better off and the bad-quality firm always worse off. Intuitively, in the insurance market, the low-risk individual is also better off under duty of disclosure than the high-risk one, who is thus intent to conceal his risk state to obtain the identical contract for a low-risk policyholder.

Our issue in this study is not only an economic problem, but also a legislation topic about how to revise marine insurance law to prevent the marine insurance contract from the despiteful violation done by some party of the contract. In the law academia, it is questioned that the targets of legislation are difficult to be affirmed among the conflicting goals, efficiency, fairness, good faith and the protection of individual autonomy. Marine insurance contract is typically a contract between two firms, either long-term or short-term. Contract law presumes, in principle, the two parties of a contract want to maximize joint gains, with which the observation is conflicting in the real world (see in Schwartz and Scott, 2003). Each party of a contract wants to maximize its profit as much as possible rather than maximize the joint gains of the both sides. It implies that the maximal joint gain of the contract is not necessarily the sum of the maximal profits of the two parties. Marine insurance is of its own unique characteristics. In this market, there are two types of underwriters, stock and mutual, with the absolutely opposite objective functions. The former type wants to maximize the profit and the latter type performs non-profitable.

The general principle of contract law is not always available to guarantee the insurance contracts. Insurance contracts are risk shifting contracts subject to a distinct and heavily regulated legal field. Due to the interpretation style, the court can possibly deviate from the correct answer. Schwartz and Scott (2003) suggest that the expectation of judicial errors is zero with variance. It implies that we can describe the court's interpretation through an adapted Brownian process without the loss of generality. In the modern insurance industry, the contract is written in a relatively standardized style, before which a policyholder has obligations to submit his private information to the underwriter through filling some standardized forms. There is possibly a huge gap between the knowledge mastered by policyholder and underwriter, which induces that contracts are often incomplete in relevant respects. Law, correspondingly, has to contribute to completing such contract by providing the plain interpretation.

3. Basic Assumption

Let Φ denote the set of information mastered by policyholders. In Φ, there consist of N aspects of information totally. Each policyholder can rank all of the information by the materiality. Let X_i denote the actual value of the i^{th} information. For instance, if we suppose the first information is the tonnage of a vessel, the actual size of this vessel is recorded by X_1 in scale of ton. Analogously, if the second information is the age of a vessel, X_2 can be 10 years or some other numbers. X_i denotes the i^{th} aspect of information.

Limited by the knowledge pool and the investigation capability, each underwriter is impossible to focus on all sorts of information in Φ. Basing on the private understanding, an underwriter believes that there are n aspects of information are of importance, $n \leq N$. Since the underwriter is the information disadvantage side in the formation of insurance contract, it is impossible for him to rank the n aspects of information before obtaining the information set through investigation. Let $\Phi_u = \{X_1, X_2, ..., X_n\}$ denote the IoM set that the underwriter focus on, where each aspect of information has the equal evaluation with respect to the materiality.

On the other hand, each policyholder knows all N aspects of information in Φ but does not consider that all of the information is of materiality. Suppose the policyholder ranks m aspects of information which are of materiality he believes. Let subscript (1) indicate the least important information and subscript (m) denote the most important one. The policyholder has the information set of materiality, $\Phi_p = \left\{X_{(1)}, X_{(2)}, ..., X_{(m)}\right\}$, where j is the queued index by the extent of importance, rather than the value of the information X, because each aspect of information has its own measure scale. Thus, all aspects of the information can be separated into four categories: (1) the information of no materiality, $\overline{\Phi_u \bigcup \Phi_p}$; (2) the information important for underwriter only, $\Phi_u - \Phi_u \bigcap \Phi_p$; (3) the information important for policyholder only, $\Phi_p - \Phi_u \bigcap \Phi_p$ (private information appearing in many studies); (4) the information important for both parties, $\Phi_u \bigcap \Phi_p$. An underwriter would like to investigate any information important for him, so the policyholder has to submit such information contained in Φ_u truly or falsely. As for the information belonging to the third category, policyholder can submit it voluntarily. If a policyholder prefers showing his good reputation and good faith, he discloses, truthfully, the information of materiality in his own understanding. Otherwise, he will conceal the information. There is no necessity for the policyholder to lie, when he decides to disclose. One extreme situation is $\Phi_u \bigcap \Phi_p = \phi$, that is, there is no overlap between the reorganizations of IoM between an underwriter and a policyholder. The policyholder does not consider that the information enquired by the underwriter is too important to conceal. The only decision done by the policyholder is whether to provide the IoM he believes. Another extreme situation is $\Phi_u \bigcap \Phi_p = \Phi_p$, which implies that any IoM known by a policyholder is also the information of materiality for the underwriter. The policyholder has to decide whether to offer the true story, while for the information contained in $\Phi_u \bigcap \overline{\Phi_p}$ the policyholder can directly give the precise value of the information. As for $\Phi_u \bigcap \Phi_p = \Phi_u$, it implies that all information in which an underwriter is interested is also the IoM capturing the attention of the policyholder.

Consider a policyholder has the IoM vector $\left(X_{(1)}, X_{(2)}, ..., X_{(m)}\right)$. The reason why the m^{th} aspect of information is ranked as the most important information is because the value of this piece of information indicates the highest possibility to induce a claim of insured loss, compared with other information. The policyholder also believes any information possible to induce an accident must be contained in the set of IoM Φ_p, while the information out of Φ_p is useless to estimate the actual loss probability and the actual loss size. Since the policyholder is the information advantageous side in an insurance contract, it is rationale to assume that the most precise loss estimation cannot be obtained unless the policyholder offers all information in Φ_p truthfully. However, the disadvantageously informed underwriter cannot affirmatively ask the whole correct questions. Suppose an underwriter involves luckily k questions contained in Φ_p. Then we have

Table 3.1 Information sets and disclosure bias

Section / Items	$\Phi_u - \Phi_p \bigcap \Phi_u$	$\Phi_p \bigcap \Phi_u$	$\Phi_p - \Phi_p \bigcap \Phi_u$
$\in \Phi_u$	√	√	
$\in \Phi_p$		√	√
No. of IoM**	$n-k$	k *	$m-k$
Disclose	Disclose Completely	Disclose with Bias	Disclose with Bias
Bias Ratio	= 0	$\neq 0$	$\neq 0$

* If $k = 0$, the underwriter ask all questions on the incorrect directions.

Define vector $\delta = (\delta_{[1]},.., \delta_{[n+m-k]})$ as the bias ratios related to the n aspects of information provided by the policyholder. Obviously, Table 3.1 shows that

$$\delta = \begin{cases} 0, & i = 1, 2, ..., n-k \\ \delta_{[i]} > 0, & i = n-k+1, n-k+2, ...n-k+m \end{cases}$$

The information sent by the policyholder and received by an underwriter is the message adjusted by the bias ratios. Each aspect of information value is multiplied by $1 + \delta_{[i]}$, correspondingly, where $\delta_{[i]}$ describes the distance between the disclosed value and the actual value of the same information. The bias ratios $\delta_{[i]}$ is not necessarily positive or negative, because the value of a certain information could be positively or negatively proportional to the loss size. For instance, generally either old or new-built vessel is not security enough to be sea-worthy. The most preferable age of a vessel should be falling into a certain middle range. Thus, if the policyholder wants to insure his old vessel, he intends to offer the age information with a negative bias to say that the age of his vessel is in the middle range, and it is safe and seaworthy. Hereby, the bias ratio is a negative rate. On the contrary, if the vessel is new-built, the bias ratio could be positive.

Accordingly, when a policyholder is asked to provide the IoM by the underwriter, he combines the bias into the disclosed information based on his own understanding. Recall that $j \in \{1, 2, ...m\}$ denotes the importance rank of the j^{th} information with respect to a policyholder. Hereafter, let the superscript (j) indicate that the i^{th} information $X_{[i]}^{(j)}$ is ranked as the j^{th} in the information set of the policyholder. The whole information submitted can be written as the vector

$$\left(\hat{X}_{[1]}, ..., \hat{X}_{[n+m-k]}\right) = \left(X_{[1]} \cdot \left(1 + \delta_{[1]}\right), ..., X_{[n+m-k]}^{(j)} \cdot \left(1 + \delta_{[n+m-k]}\right)\right)$$

where $\delta_{[i]} \propto \beta_{[j]} \cdot j$ for $i = n - k + 1, \ldots, n + m - k$, and the rest bias ratios are nil. The non-nil bias ratios imply that the bias ratio of a disclosed IoM depends on the rank of this piece of information in the evaluation of the policyholder. If the rank is high, the absolute value of the bias ratio is also large.

Let y denote the random loss of a normal distribution, which can be described by a stochastic diffusion process based on the Brownian motion. Let $\mu(\cdot)$ denote the arrival rate and $\sigma^2(\cdot)$ denote the variance rate. The loss y has the normal distribution with the mean $\mu \cdot \Delta t$ and the variance $\sigma^2 \cdot \Delta t$, where Δt denotes the time interval. An underwriter has to estimate the parameters basing on the statement of the policyholder and obtains $\mu_u\left(X_{[1]}\cdot\left(1+\delta_{[1]}\right),\ldots,X_{[n]}^{(\cdot)}\cdot\left(1+\delta_{[n]}\right)\right)$ and $\sigma_u^2\left(X_{[1]}\cdot\left(1+\delta_{[1]}\right),\ldots,X_{[n]}^{(\cdot)}\cdot\left(1+\delta_{[n]}\right)\right)$, while the actual loss is normally distributed with parameters $\mu_p\left(X_{[n-k+1]}^{(\cdot)}\cdot\left(1+\delta_{[n-k+1]}\right),\ldots,X_{[n+m-k]}^{(\cdot)}\cdot\left(1+\delta_{[n+m-k]}\right)\right)$ and $\sigma_p^2\left(X_{[n-k+1]}^{(\cdot)}\cdot\left(1+\delta_{[n-k+1]}\right),\ldots,X_{[n+m-k]}^{(\cdot)}\cdot\left(1+\delta_{[n+m-k]}\right)\right)$.

4. Formation of Insurance Contract

As known, there are two types of underwriter, stock and mutual, differing from each other on ownership. Each of them has his own particular objective. A stock underwriter seeks for the maximal profit to satisfy the requirement of stockholders, while a mutual underwriter is non-profitable so that the mutual maximizes the utilities of his members. Both of stock and mutual underwriters, however, have the common interest, that is, to minimize the ruin probability. At time t, every kind of underwriter collects premium q_t from the policyholders to construct the risk reserve R_t and cover the claims. When the risk reserve is less than nil, the underwriter is ruined. Let τ denote the ruin time, $\tau=\inf\left\{t:R_t\le 0\right\}$, and the ruin probability is $\Pr\left(\tau<\infty\right)$.

When pricing the insurance contract, an underwriter can only estimate the possible loss distribution depending on the statement done by the policyholder. The underwriter believes that the risk reserve R_t is described by a diffusion process that

$$dR_t^u=\left(q_t-\mu_u\right)dt+\sigma_u dw_t^u$$

where w_t^u is an adapted Brownian motion. Unfortunately, the policyholder provides the IoM with bias of some extent, to which the underwriter mostly underestimates the risk level more or less, while the risk reserve is reduced by rapidly the unexpected claims of normal distribution $N\left(\mu_p,\sigma_p^2\right)$. The actual risk reserve variation is expressed by the following process

$$dR_t^p=\left(q_t-\mu_p\right)dt+\sigma_p dw_t^p$$

where w_t^p is an adapted Brownian motion. Let U denote the concave utility function of the policyholder, denoted with $U'>0$, $U''<0$. Suppose the policyholder has the fixed initial wealth ω. Intuitively, any price strategy of the insurance contract, q_t, has the cumulative value Q_τ satisfying the incentive condition

$$U\left(\omega-Q_\tau\right)\ge EU\left(\omega-y\right)$$

where $Q_\tau=\int_0^\tau q_t e^{-r_f t}dt$, r_f is risk free rate. The risk free rate is the interest rate that it is assured can be obtained by investing in financial instruments without default risk. When default risk is not taken into consideration as the main issue of a study, the assumption of risk free should be adopted without the loss of generality. The right side of inequality is the expected utility of a policyholder suffering the loss y without insurance protection. The cumulative premium collection must be less than a baseline, that is, $Q_\tau\le\omega-U^{-1}\left[EU\left(\omega-y\right)\right]$. Define *the disclosed baseline* as $\omega-U^{-1}\left[E_uU\left(\omega-y\right)\right]$, estimated basing on the IoM with bias, and analogously define *the actual baseline* as $\omega-U^{-1}\left[E_pU\left(\omega-y\right)\right]$. Thus, the objective function of an underwriter is

$$
\begin{aligned}
&\min_{q_t} \Pr(\tau < \infty) \\
s.t.\quad & dR_t^u = (q_t - \mu_u)dt + \sigma_u dw_t^u \\
& R_0^u = x_u \\
& \tau = \inf\{t : R_t^u \le 0\}
\end{aligned} \tag{1}
$$

where x_u denotes the initial risk reserve. Let $V_1(x_u)$ be the value function of the minimal ruin probability, and we have $V_1(x_u) = \exp\left\{-\frac{2(q_t - \mu_u)}{\sigma_u^2} x_u\right\}$. When the initial risk reserve $x_u = 0$, the ruin probability equals to one. On the contrary, if the initial risk reserve $x_u \to \infty$, this underwriter will be never bankrupt. Given a certain level of the initial risk reserve, the ruin probability decreases with an increasing q_t, which implies an underwriter intends to collect premium at a high rate to prevent himself safely from the bankruptcy. The underwriter also knows that there is an upper limit of premium, beyond which the price of the insurance contract is unacceptable for a policyholder with the utility function U. Since the underwriter makes decision depending on the policyholder's statement, the cumulative amount of the collected premium Q_τ must be no more than the disclosed baseline. Suppose the underwriter prefers to dominate the minimal ruin probability at a certain extent v, $0 < v \le 1$. It is easily obtained $q_t = \mu_u - \sigma_u^2 \cdot \frac{\ln v}{2x_u}$. There are two scenarios: (1) $Q_\tau \le \omega - U^{-1}\left[E_u U(\omega - y)\right]$, where an acceptable premium rate q_t must fall in the range satisfying this inequality; (2) $Q_\tau > \omega - U^{-1}\left[E_u U(\omega - y)\right]$, where the contract is unacceptable. In the second scenario, if the policyholder still performs his interests in this insurance contract, the policyholder sends a signal to indicate his concealing in the information disclosure.

Let us further consider the situation without concealing, where all of IoM is disclosed by the policyholder truthfully. Let $\bar{\tau}$ denote the ruin time of the risk reserve with the complete information disclosure. The dynamic programming of the minimized ruin probability of an underwriter is rewritten as

$$
\begin{aligned}
&\min_{q_t} \Pr(\bar{\tau} < \infty) \\
s.t.\quad & dR_t^p = (q_t - \mu_p)dt + \sigma_p dw_t^p \\
& R_0^p = x_p \\
& \bar{\tau} = \inf\{t : R_t^p \le 0\}
\end{aligned} \tag{2}
$$

The solution of the stochastic control (2) is denoted by the value function $V_2(x_p)$. $V_2(x_p)$ has the structure similar with V_1 so that let us denote the premium rate as $\bar{q}_t = \mu_p - \sigma_p^2 \cdot \frac{\ln v}{2x_p}$. Correspondingly, the cumulative premium collection can be denoted by $\bar{Q}_{\bar{\tau}} = \int_0^{\bar{\tau}} \bar{q}_t e^{-r_f t} dt$. Actually, a policyholder with the full of IoM would like to accept any premium program $\bar{Q}_{\bar{\tau}} \le \omega - U^{-1}\left[E_p U(\omega - y)\right]$, and the policyholder can always be better off unless the underwriter collects the total amount of the premium exceeding $\omega - U^{-1}\left[E_p U(\omega - y)\right]$.

Hereby, the following two subsections indicate four scenarios contained in $\Phi_p \cup \Phi_u$. The formation of an insurance contract depends on the voluntary behavior of the two parties, demand and supply, both of which have their own target prices of contract respectively. It is subdivided into the following categories to discuss in detail.

(1) No insurance contract is available with truthfully disclosed IoM. In this scenario, the underwriter prefers to collect premium at the rate no less than $\overline{q}_t$, which exceeds the acceptable price of the policyholder. In order to get protection from the underwriter, the policyholder provides the IoM with bias to some extent or conceals the private knowledge of risk components directly.

Figure 4.1a

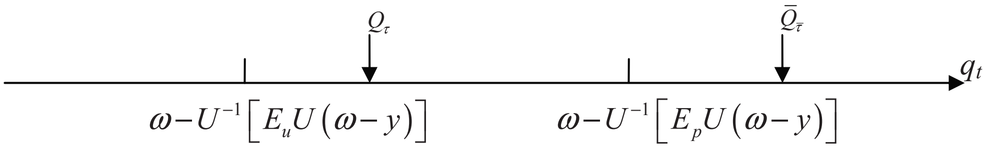

Figure 4.1b

An underwriter estimates the loss probability distribution through analyzing the IoM disclosed by the policyholder. By solving the minimization of the ruin probability, it is found that there is the lowest premium rate for the underwriter to keep the risk reserve at the safe level. If the situation in Figure 4.1a is hold, that is, the cumulative premium collection is lower than $\omega - U^{-1}\left[E_u U(\omega - y)\right]$, it must be the most favor price for the policyholder, because he obtains *the utility surplus* $U(\omega - Q_\tau) - E_p U(\omega - y)$. Especially, the stock underwriter intends to seek for a higher premium rate q_t as close as possible to the disclosed baseline $\omega - U^{-1}\left[E_u U(\omega - y)\right]$ and furthermore reduce the ruin probability, while the mutual underwriter prefers to adopt the lower limit of q_t and prevent his members from the extra burden of insurance cost.

On the contrary, if the situation in Figure 4.1b is hold, the cumulative premium collection is higher than $\omega - U^{-1}\left[E_u U(\omega - y)\right]$. Albeit the contract price is still attractive for the policyholder at this moment, it is also dangerous and irrational to accept this contract at the very premium rate. It is easily understood that there is the risk to expose the policyholder's fraud that the policyholder provides the false IoM unless he does not perform any interests in this premium rate. Thus, in the scenario of Figure 3.2b, there is no insurance contract formed.

(2) Insurance contract can be formed with the truthfully disclosed IoM. Albeit a policyholder provides the IoM with bias, the underwriter is still able to find a contract of the premium rate larger than or equal to $\overline{q}_t$, and, simultaneously, the premium rate is less than the actual baseline of the policyholder.

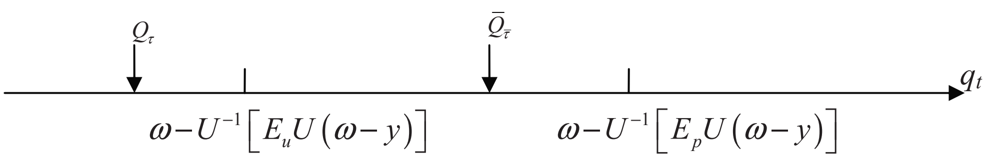

Figure 4.2a

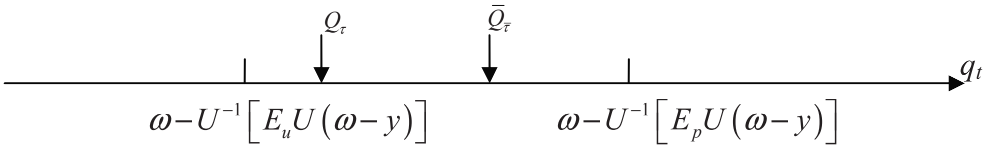

Figure 4.2b

The essential characteristic of these two situations (Figure 4.2a and Figure 4.2b) is that there exists a premium rate priced on the truthfully disclosed IoM. If the situation in Figure 4.2a holds, the insurance contract is constructed at the lower premium, and the policyholder benefits from concealing the true IoM. *The utility surplus of the policyholder is the distance of the utilities under two alternative prices*. In Figure 4.2b, when the policyholder fails to purchase insurance contract priced on the biased IoM, another alternative is available, which is also attractive below the actual baseline of the policyholder. In this situation, the policyholder is unable to obtain any benefit from disclosing the biased IoM, while the premium rate priced on the actual IoM is also acceptable. Thus, the preferred option of this policyholder is to disclose all IoM truthfully.

Briefly, among the four situations, the case in Figure 4.1b is no insurance contract formed, no matter how severe the bias of the information disclosure is. Thus, there is no legal dispute of such a non-existing insurance contract. The case in Figure 4.2b is the insurance contract formed and priced on the actual risk state. This is the most ideal situation for an underwriter, also most security for a policyholder. The policyholder provides the accurate IoM, on which the underwriter bases to price the contract. The policyholder completely performs the duty of disclosure, and the underwriter has unshakable obligations to cover the loss happened to his client.

The case in Figure 4.1a represents the situation that if a policyholder disclosed the unbiased IoM, there would be no underwriter willing to supply the insurance contract. The policyholder, accordingly, has motivation to disclose the biased IoM to make sure the insurance contract is formed at a worthy price. By contrast, the case in Figure 4.2a, essentially, reflects the tradeoff between two premium alternatives. The target of the policyholder, hereby, is not only to find an underwriter offering the loss coverage, but also to reduce the insurance cost through distorting the actual loss distribution intentionally.

5. Social Welfare and Amendment of Marine Insurance Law

Accordingly, there are only two scenarios, which should be regulated precisely by the insurance law, especially, with respect to the duty of disclosure. They are the cases in Figure 4.1a and Figure 4.2a. Under the biased disclosure of IoM, a policyholder can be benefited from the lower premium rate and the indemnity. Since the underwriter is the information disadvantage side, the insurance law regulates a strict remedy to protect the right of the underwriter. If one arbitrarily concluded that the target of the insurance law was to compensate the loss of the less informed underwriter, it ought to be misunderstood the fundamental mission of legislation, that is, to maximize the social welfare, or say, to minimize the loss of the social welfare.

In the pricing model in Section IV, the underwriter presumes the policyholder is trustable and prices a long-run insurance contract with this policyholder at the equilibrium premium rate q_t. The stochastic process of the risk reserve implies connotatively that the premium is paid continuously, where from $t = 0$ to $t = \tau$, it is a long-run picture. This premium rate ensures the risk reserve is worn out with the proposed low probability v. The legal issues faced to the insurance law, however, are usually the disputes in the short run. Since the continuous premium collection only exists in the theoretical circumstance, the premium actually is levied periodically, yearly, monthly, or daily, for instance. Without the loss of the generality, consider the unit time interval randomly, $[T, T+1]$, where

$0 \le T < T+1 \le \tau$. At time T, the premium $Q_T = \int_T^{T+1} q_t e^{-r_f(t-T)} dt$ is collected to cover the claims during T to $T+1$. Suppose at time $T^* \in [T, T+1]$, the loss y_{T^*} comes out which is of the normal distribution $N\left(\mu_p \cdot \left(T^* - T\right), \sigma_p^2 \cdot \left(T^* - T\right)\right)$.

Table 5.1 shows the expected and actual utility surplus of the policyholder before and after the ex post remedy. Vertically, if all of the IoM is disclosed truthfully, we have two categories: (1) no insurance contract can be formed; (2) an insurance contract can be formed at a highly priced premium rate. Horizontally, the ex post utilities are discussed, respectively, with respect to the possible inducements belonging to the two information sets.

Table 5.1 Utility of the policyholder under the current duty of disclosure

		No Insurance Contract with the Fully Disclosed IoM	Highly Priced Insurance Contract with the Fully Disclosed IoM
Ex ante expected utility surplus of the policyholder		$U(\omega - Q_\tau) - E_p U(\omega - y)$	$U(\omega - Q_\tau) - U(\omega - \bar{Q}_{\bar{\tau}})$
Ex post utility	$X_{[n-k+1]}^{(\cdot)}, \ldots, X_{[n]}^{(\cdot)}$	$U\left(\omega - Q_T - y_{T^*}\right)$	$U\left(\omega - Q_T - y_{T^*}\right)$
	$X_{[n+1]}^{(\cdot)}, \ldots, X_{[n+m-k]}^{(\cdot)}$	$U\left(\omega - Q_T - y_{T^*}\right)$	$U\left(\omega - Q_T - y_{T^*}\right)$

Under the strict remedy, an underwriter has the right to reject to cover the claims and refuse to refund the collected premium, if it is witnessed that the policyholder concealed the IoM or disclosed the biased IoM in the formation of the insurance contract, where the IoM is mostly identified by the statement of the underwriter submitted to the court. Table 5.1 shows that if the policyholder provides the biased information, the strict remedy results in the unique consequence, that is, the policyholder pays the premium (albeit it is cheaper) to the underwriter for a *self-insurance* contract. The weaknesses of the strict remedy with respect to the duty of disclosure are obvious:

(1) The remedy fails to distinguish the situation of highly priced contract from the scenario of no insurance contract formed. From Table 5.1, it is easy to find that the surplus of the former situation is less than the latter one, $U(\omega - Q_\tau) - U(\omega - \bar{Q}_{\bar{\tau}}) < U(\omega - Q_\tau) - E_p U(\omega - y)$. It implies that the policyholder obtains the different levels of the illegal benefit from the violation of the duty of disclosure. But from the ex post remedy, such difference cannot be reflected. Obviously, the motivations of the policyholders in these two scenarios are quite discriminative. If there is no insurance contract available in the normal market, the incentive of the policyholder to conceal or lie is the formation of the insurance contract. On the other hand, if there is a highly priced contract formed, the purpose of providing the biased information is to obtain a relatively low premium rate.

(2) The remedy takes sides with the underwriter through the identification of IoM in the court. The IoM in $X_{[n+1]}^{(\cdot)}, \ldots, X_{[n+m-k]}^{(\cdot)}$ is mastered by the policyholder, and the underwriter does not request it during the formation of the contract. Under the current regulation, if the inducement of the loss event does not belong to $X_{[n+1]}^{(\cdot)}, \ldots, X_{[n+m-k]}^{(\cdot)}$, but the IoM in this set is concealed by the policyholder and proved to be of materiality for the policyholder, the underwriter still has right to uncover the loss and refuse to refund the premium in the excuse of the duty of disclosure. In another words, it is questioned whether the policyholder should be responsible for the information asymmetry caused by the ignorance of the underwriter. This weakness offers the underwriter an opportunity to deny his liabilities intentionally and maliciously.

(3) The remedy regulates an indifferent penalty rule for policyholders of every variety, albeit a policyholder could be classified in the four types. The loss of the policyholder cannot be covered, and, simultaneously, the extra premium is impossible to be refunded. As a result, a policyholder discloses all of IoM in $\Phi_u \cup \Phi_p$ so that either the insurance contract is priced highly, which induces more insurance costs for the policyholder, or the underwriter cannot provide the coverage, where the policyholder cannot share his risk in the financial market.

Amendment must be done to regulate a more relax remedy about the duty of disclosure. The remedies should be discriminative with respect to the variety of policyholders. Consider the following four scenarios: (1) no insurance contract formed in the normal market and the inducement belonging to $X_{[n-k+1]}^{(\cdot)},...,X_{[n]}^{(\cdot)}$; (2) no insurance contract formed in the normal market and the inducement belonging to $X_{[n+1]}^{(\cdot)},...,X_{[n+m-k]}^{(\cdot)}$; (3) highly priced insurance contract formed in the normal market and the inducement belonging to $X_{[n-k+1]}^{(\cdot)},...,X_{[n]}^{(\cdot)}$; (4) highly priced insurance contract formed in the normal market and the inducement belonging to $X_{[n+1]}^{(\cdot)},...,X_{[n+m-k]}^{(\cdot)}$.

Table 5.2 Utility of the policyholder under the amended duty of disclosure

		Insurance Contract without the Fully Disclosed IoM	Highly Priced Insurance Contract with the Fully Disclosed IoM
Ex ante expected utility surplus of policyholder		$U(\omega-Q_\tau)-E_pU(\omega-y)$	$U(\omega-Q_\tau)-U(\omega-\bar{Q}_{\bar{\tau}})$
Ex post utility	$X_{[n-k+1]}^{(\cdot)},...,X_{[n]}^{(\cdot)}$	$U(\omega-Q_T-y_{T^*})$	$U(\omega-\bar{Q}_{T^*})$ *
	$X_{[n+1]}^{(\cdot)},...,X_{[n+m-k]}^{(\cdot)}$	$U(\omega-\min\{Q_T,\bar{Q}_{T^*}\})$	$U(\omega-Q_{T^*})$ **

* $\bar{Q}_{T^*}=\int_T^{T^*}\bar{q}_t e^{-r_f(t-T)}dt$

** $Q_{T^*}=\int_T^{T^*}q_t e^{-r_f(t-T)}dt$

The general principle, differing from the current duty of disclosure in Marine Insurance Law 1906, is that the utilities of the policyholder after the ex post remedy in these four scenarios are rank in the order (4) > max{(2), (3)} > min{(2), (3)}> (1), and (3) > (1), (4) > (2) as well. A possible amendment suggestion is expressed in Table 5.2.

Scenario (1) The most strict remedy is adopted in this situation. The policyholder provides the biased IoM important for the underwriter intentionally, and purposely through concealment he obtains the formation of the insurance contract, which impossibly exists in the normal market. The underwriter has right to discharge the insurance contract, uncover the loss y_{T^*} and refuse to refund the premium covering time interval $[T^*,T+1]$.

Scenario (2) Albeit the policyholder fails to provide the related IoM about the loss inducement to the underwriter, the underwriter also has the liability for the underestimation of the loss probability due to the ignorance about the insured bids. The underwriter can discharge the insurance contract but has the obligation to cover the loss. On the other hand, the policyholder should pay the extra premium to fill the gap between Q_{T^*} and the theoretical premium amount $\bar{Q}_{T^*}$. Since the insurance contract cannot be formed in the normal market, the premium rate must be extremely high so that $\bar{Q}_{T^*}$ also might exceed the actual baseline of the policyholder. Thus, the premium compensation is constrained by an upper limit, the collected premium for the whole interval Q_T.

Scenario (3)   Albeit the policyholder provides the biased IoM, which is important for the underwriter, the motivation of the policyholder is not as severe and unforgivable as the situation (1). The underwriter has right to discharge the contract. However, if the policyholder would like to pay the extra premium to fill the premium gap, the underwriter has obligation to cover the loss.

In the scenarios (2) and (3), the actual payment for the premium depends on the severity of each scenario and the theoretical premium. If there is still the extra premium collection left after compensation, the extra part should be refunded to the policyholder.

Scenario (4)   The underwriter should take charge of the most of the liability in this dispute. The underwriter has right to discharge the insurance contract, but he has obligation to cover the loss and refund the extra premium.

The advised amendment gives a policyholder the more convenient opportunity to pool risk in the insurance market, especially for the policyholder of some particular IoM privately. New penalty rules are regulated with respect to the different scenarios. The underwriter will not suffer the premium loss in the new penalty rules, while he is also unable to earn a lot from rejecting coverage intentionally.

The severity of the information asymmetry is not same as the situation hundred years before. Through the variety of the investigation tools, an underwriter can observe and understand more and more IoM used to be the private one. However, the application of new technology in the shipping industry generates the new private IoM, which is more valuable for the underwriter to estimate the loss distribution. This is a learning process, in which the underwriter discovers the new IoM through covering the loss induced correspondingly. If the remedy is over strict, the insurance contract is difficult to be formed, which objectively blocks the learning process. On the other hand, the policyholder operates in the world full of risk, where any effort on the application of new technology requests the protection from the insurance market. The strict remedy enforces the policyholder to adopt a more traditional technology and delays the development of the shipping industry.

The suggested amendment indicates the whole learning process: (1) collect IoM from the policyholder to form the initial information set; (2) price the insurance contract to obtain the equilibrium premium rate; (3) identify the liabilities of each party, the policyholder and the underwriter, and remedy; (4) collect new IoM and update the initial information set to form a fresh set; (5) re-price the insurance contract to obtain the premium rate for the next period; (6) repeat (3) – (5). If it is found that the policyholder is uninsurable during the re-pricing of the insurance contract, the loop is broken down. The underwriter has to seek for the protection from the reinsurance market.

6. Empirical Evidence

Empirically, the information of materiality with respect to the marine insurance can be classified into two categories, the internal (natural) properties of a vessel and the external influence from the maritime adventure. In this research, the data of the marine loss and the detailed vessel information during 1999-2007 are collected to test the materiality of each piece of information. World Casualty Statistics by Lloyd's Register provides the marine loss data about the detailed information of the total-loss[4] vessels during 1999-2007, including vessel name, vessel type, registry, vessel size (in dwt),

[4] Total loss, defined by the Act 1906, composed of two situations, actual total loss and constructive total loss. Where the subject-matter insured is destroyed, or so damaged as to cease to be a thing of the kind insured, or where the assured is irretrievably deprived thereof, there is an actual total loss. Subject to any express provision in the policy, there is a constructive total loss where the subject-matter insured is reasonably abandoned on

vessel age, incident type, incident zone and incident time (season). Shipping Intelligence Network by Clarkson's Research Service offers the time series data of the sizes and the numbers of non-total-loss vessels.

Table 6.1 Summary of variables in regression

Variable type		Variable name	Variable structure
Independent Variables		Incidence possibility index (IPI)	$\log\left[\frac{\text{Number of the certain type of total-loss vessels in this year}}{\text{Total number of the certain type of vessels in this year}} \cdot \frac{\text{Size of the certain type of total-loss vessels in this year}}{\text{Total size of the certain type of vessels in this year}}\right]$
Dependent Variables	Internal property	Vessel type	Dummy (eight types of vessel)
		Registry	Dummy (FOC or closed registry) Ratio: $\frac{\text{the annual incident number with respect to certain registry}}{\text{the total incident number in this year}}$
		Vessel size	In dwt
		Vessel age	Dummy (four age intervals, 0-16, 17-25, 26-42, larger than 42)
	External influence	Incident type	Ratio: $\frac{\text{the annual incident number with respect to certain incident type}}{\text{the total incident number in this year}}$
		Incident zone	Ratio: $\frac{\text{the annual incident number with respect to certain zone}}{\text{the total incident number in this year}}$
		Incident time	Ratio: $\frac{\text{the annual incident number with respect to certain season}}{\text{the total incident number in this year}}$

In this research, we have totally collected the information of 882 total-loss vessels, distributed to eight types of vessels taken into the considerations, that is, bulk carrier, chemical, container, liquefied gas, MPP, reefer, Ro-Ro and tanker. These eight types of vessels have already occupied the main shares of the global tonnage and dominated the major part of shipping business, especially the international seaborne transportation.

The regression process and the results are reported in Table 6.2 attached in the appendix. After the eight steps of regressions, the insignificant variables are deleted from the regression models one by one based on the *p*-values of the *t* test. Finally, under the confidence level of 90%, the variables, incident zone, vessel size, vessel age interval 26-42, vessel types (bulk carrier, chemical, liquefied gas, MPP, reefer and Ro-Ro) and registry dummy (FOC) are left in the regression, while under the confidence level of 95%, the impact of registry dummy is no longer significant.

The regression steps and significance levels of dependent variables reflect the general sequence of the materiality with respect to each piece of information. Accordingly, the information of materiality can

account of its actual total loss appearing to be unavoidable, or because it could not be preserved from actual total loss without an expenditure which would exceed its value when the expenditure had been incurred.

be found, confirmed and ranked from the most important as follow. (1) Vessel type makes significant impact on the incident possibility, albeit it is not hold for every vessel type, for instance, container and tanker. The rest vessels, belonging to MPP, Ro-Ro, bulk carrier, chemical, reefer and liquefied gas, determine significantly the incident possibility correspondingly due to their particular functions on their own business lines. (2) Vessel size has positive impact on the incident possibility index, which implies that the huge-size vessel has great insurance value as well as the destroy capability. (3) Incident zone is the only external factor left in the last regression step. According to World Casualty Statistics 199-2007, about 74% of the total-loss incidents happened on the busiest ship routing connecting Europe and Eastern Asia, which starts from UK, passing through the Mediterranean, Red Sea, Indian Ocean, comes into Southern China Sea by Malacca, and finally ends at Eastern Asian countries, China, Japan and Korea. (4) The vessels in ages 26 – 42 is more dangerous than the ones of the same type in the other age intervals. (5) Open registry has positive impact on the incident possibility index. The vessel registered in a flag-of-convenience (FOC) country has probably greater motivation to loose his security management, which results in an increasing incident possibility.

Among the varieties of information of materiality examined, an underwriter can investigate the information purposely. Obviously, most of the information is difficult to conceal, for instance, vessel type, vessel size and registry. With the development of the specialized-function vessels, the internal properties of an insured vessel are no longer the private information of the policyholder. The strict remedy with respect to duty of disclosure in the Act 1906 fails to coincide with the current development of the shipping industry. The more flexible and loosen remedy rules should be legislated.

On the contrary, the information of materiality, which is most possibly provided with bias, should be closely connected to the business activities, for example, the routing lines (possible incident zones) and cargo states (cargo varieties).

7. Conclusion

In this study, we focus on the duty of disclosure in Marine Insurance Law 1906, which performs outdated and over strict in the remedy rules. Through analyzing the information structures of the underwriter and the policyholder, we separate the whole picture of the IoM into three categories. The policyholder provides the IoM with bias to make the insurance contract formed and obtain the low premium. By the stochastic control model, the optimal premium rates are calculated with respect to the truthfully disclosed IoM and the biased IoM, respectively. The insurance contract is accepted by the both parties.

When a dispute happens, there are four possible scenarios. The current remedy rule is so strict that it fails to distinguish the four scenarios from each other. Our amendment suggestion about the duty of disclosure provides a slightly relaxed remedy, which improves the learning process of the underwriter and encourages the policyholder to develop and apply new technology.

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Appendices

The solution of optimization (1) can be obtained by solving the following HJB equation about the value function $V_1\left(x_u\right)$.

$$\frac{1}{2}\sigma_u^2 V_1''\left(x_u\right)+\left(q_t-\mu_u\right)V_1'\left(x_u\right)=0 \tag{A1}$$

It is easy to solve (A1) and obtain $V_1\left(x_u\right)=\exp\left\{-\frac{2\left(q_t-\mu_u\right)}{\sigma_u^2}x_u\right\}$, since $V_1\left(0\right)=1$ and $V_1\left(\infty\right)=0$.

Similarly, optimization (2) can be solved by the HJB equation (A2)

$$\frac{1}{2}\sigma_p^2 V_2''\left(x_p\right)+\left(\overline{q}_t-\mu_p\right)V_2'\left(x_p\right)=0 \tag{A2}$$

And we can obtain $V_2\left(x_p\right)=\exp\left\{-\frac{2\left(\overline{q}_t-\mu_p\right)}{\sigma_p^2}x_p\right\}$.

Table 6.2 Regression Result

Regression Steps	IPI							
	1	2	3	4	5	6	7	***8***
Incident Season	0.0615353 0.38 0.706	0.061535 0.38 0.706	0.061535 0.38 0.706	0.064396 0.4 0.691	0.065031 0.4 0.688			
Incident Type	-0.1375355 -1.63 0.104	-0.13754 -1.63 0.104	-0.13754 -1.63 0.104	-0.1386 -1.65 0.1	-0.13859 -1.65 0.1	-0.13846 -1.65 0.1	-0.14017 -1.67 0.096	
Incident Zone	-0.4534743 -2.39 0.017	-0.45347 -2.39 0.017	-0.45347 -2.39 0.017	-0.45187 -2.39 0.017	-0.45241 -2.39 0.017	-0.43441 -2.37 0.018	-0.4497 -2.48 0.013	***-0.47168*** ***-2.6*** ***0.009***
Registry (Ratio)	-0.1250929 -0.5 0.615	-0.12509 -0.5 0.615	-0.12509 -0.5 0.615	-0.12485 -0.5 0.616	-0.12436 -0.5 0.617	-0.13333 -0.54 0.59		
Vessel Size	2.52E-06 3.85 0	2.52E-06 3.85 0	2.52E-06 3.85 0	2.53E-06 3.88 0	2.53E-06 3.9 0	2.53E-06 3.89 0	2.52E-06 3.88 0	***2.57E-06*** ***3.96*** ***0***
Age (0 – 16)	-0.0556855 -0.89 0.375	-0.06623 -1.66 0.097	-0.06623 -1.66 0.097	-0.06484 -1.66 0.098	-0.06524 -1.67 0.095	-0.06417 -1.65 0.1	-0.06479 -1.66 0.096	
Age (17 – 25)	0.0105414 0.19 0.852							
Age (26 – 42)	-0.0600213 -1.09 0.278	-0.07056 -2.43 0.015	-0.07056 -2.43 0.015	-0.06894 -2.49 0.013	-0.06906 -2.5 0.013	-0.06872 -2.49 0.013	-0.06963 -2.53 0.012	***-0.05582*** ***-2.16*** ***0.031***
Age (≥ 43)	(dropped)	-0.01054 -0.19 0.852	-0.01054 -0.19 0.852					
Bulk Carrier	1.155068 9.22 0	1.155068 9.22 0	1.129602 17.88 0	1.130165 17.92 0	1.133677 18.76 0	1.133402 18.76 0	1.130625 18.79 0	***1.125641*** ***18.71*** ***0***
Chemical	1.454247 10.54 0	1.454247 10.54 0	1.428781 16.29 0	1.429418 16.31 0	1.433196 16.78 0	1.433463 16.79 0	1.433391 16.79 0	***1.415162*** ***16.62*** ***0***
Container	(dropped)	(dropped)	-0.02547 -0.2 0.842	-0.02507 -0.2 0.844				
Liquefied Gas	0.8164032 4.6 0	0.816403 4.6 0	0.790937 5.58 0	0.791531 5.59 0	0.795237 5.67 0	0.793351 5.66 0	0.795369 5.68 0	***0.800528*** ***5.71*** ***0***
MPP	3.321799 27.82 0	3.321799 27.82 0	3.296333 62.17 0	3.296487 62.21 0	3.3002 66.69 0	3.29914 66.8 0	3.298857 66.83 0	***3.290416*** ***67.41*** ***0***
Reefer	1.488227 10.49 0	1.488227 10.49 0	1.46276 15.72 0	1.462769 15.72 0	1.466472 16.11 0	1.466027 16.11 0	1.464542 16.11 0	***1.458702*** ***16.02*** ***0***
Ro-Ro	2.31124 18.45 0	2.31124 18.45 0	2.285773 35.02 0	2.285979 35.05 0	2.28971 36.71 0	2.290003 36.74 0	2.287548 36.81 0	***2.275607*** ***36.78*** ***0***
Tanker	0.0254662 0.2 0.842	0.025466 0.2 0.842						
Registry (FOC or not)	0.0524086 1.82 0.069	0.052409 1.82 0.069	0.052409 1.82 0.069	0.05269 1.83 0.067	0.052707 1.83 0.067	0.053741 1.88 0.061	0.04753 1.82 0.07	***0.049676*** ***1.9*** ***0.58***
Constant	-6.707169 -49.62 0	-6.69663 -52.34 0	-6.67116 -94.12 0	-6.67368 -95.97 0	-6.67744 -99.91 0	-6.66427 -114.47 0	-6.66559 -114.64 0	***-6.71222*** ***-123.3*** ***0***
Adjust- R^2	0.8915	0.8915	0.8915	0.8916	0.8917	0.8919	0.8919	***0.8915***