

# 有利選擇、逆選擇或道德危險？ 探討再保險市場的資訊不對稱

## Propitious/Adverse Selection or Moral Hazard? Information Asymmetry in the Reinsurance Markets

許永明\* *Yung-Ming Shiu*

國立政治大學風險管理與保險學系

Department of Risk Management and Insurance,  
National Chengchi University

陳瑞祥 *Juei-Hsiang Chen*

實踐大學會計學系

Department of Accounting,  
Shih Chien University

本文引用格式建議：許永明、陳瑞祥，2024，「有利選擇、逆選擇或道德危險？探討再保險市場的資訊不對稱」，中山管理評論，32 卷 4 期：633~665。DOI：10.6160/SYSMR.202412\_32(4).0004。

Suggested Citation：Shiu, Y. M. and Chen, J. H., 2024, “Propitious/Adverse Selection or Moral Hazard? Information Asymmetry in the Reinsurance Markets,” **Sun Yat-sen Management Review**, Vol. 32, No. 4, 633-665. DOI: 10.6160/SYSMR.202412\_32(4).0004.

---

\* Corresponding author: Yung-Ming Shiu. Address: NO. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City, 11605, Taiwan (R.O.C). Phone: +886-2-29393091 ext.81014. Email: yungming@nccu.edu.tw. The authors thank editor and anonymous reviewers for their helpful comments.

## 摘要

雖然在保險市場的資訊不對稱已經被廣泛討論，但在再保險市場卻不是如此。在本文中，我們探討是否以及哪一種形式的資訊不對稱存在於英國產險的再保險市場。利用 1985 至 2012 年的資料，我們發現有利選擇普遍存在於再保險市場，特別是在第三方責任險與其他及金錢損失再保險市場。此外，資訊不對稱現象也被發現存在於汽車與海上、航空及運輸再保險市場。我們進一步發現有利選擇存在於高損失率分出分量，但卻沒有證據顯示其存在於低損失率分出分量裡。

**關鍵詞：**資訊不對稱、再保險、有利選擇、分量迴歸

## Abstract

Although information asymmetry is extensively discussed in insurance markets, this is not the case in reinsurance markets. In this paper, we determine whether and which kind of information asymmetry exists within the United Kingdom non-life reinsurance markets. Using data from 1985 and 2012, we find that propitious selection is generally found to exist throughout the reinsurance markets, particularly in the third-party liability and miscellaneous and pecuniary loss reinsurance markets. Additionally, information asymmetry phenomena are also found in the motor and marine, aviation and transport reinsurance markets. Our results further reveal that propitious selection is found to exist in high loss ratio ceded quantiles, whereas there is no evidence of its existence in low loss ratio ceded quantiles.

**Keywords:** Asymmetric information; Reinsurance coverage; Propitious selection; Quantile regressions.

# 1. INTRODUCTION

Information asymmetry has been extensively examined in the insurance markets with the extant literature including a wealth of related studies.<sup>1</sup> Such emphasis on information asymmetry is clearly important within the insurance markets since it can lead to a phenomenon of propitious, adverse selection or moral hazard; the main focus in the majority of the prior related studies has been placed on adverse selection, with a few studies also concentrating on moral hazard.<sup>2</sup> However, relatively little research has been undertaken examining the issue of propitious selection (Hemenway, 1990, 1992; Karagyozyova & Siegelman, 2012).

Furthermore, the majority of the prior studies on asymmetric information relate to the insurance markets, with the subject remaining relatively under-researched within the reinsurance markets.<sup>3</sup> Thus, we aim in this study to fill a void in the literature by examining informational asymmetry within the reinsurance markets. We will specifically attempt to examine whether the reinsurance markets exhibit evidence of the phenomena of propitious/adverse selection and the problem of moral hazard, with the motivation for our research being threefold.

First, the issue of information asymmetry has been examined far less in the reinsurance markets than in the insurance sectors; indeed, to our best knowledge, no prior studies have yet been undertaken to simultaneously examine the issues of adverse selection, propitious selection and moral hazard, despite the fact that these phenomena may coexist and even interact with each other. In our study, we aim to contribute to the related literature by increasing the understanding of the nature and degree of adverse selection, propitious selection and moral hazard among insurers.

Second, research into information asymmetry within the reinsurance markets is important, insofar as it would be of interest to reinsurers and policymakers to know whether insurers take advantage of those who are relatively uninformed about the

---

<sup>1</sup> Examples include Chiappori & Salanié (2000), Cohen (2005), Saito (2006), Kim et al. (2009), Spindler et al. (2014) and Finkelstein & Poterba (2014).

<sup>2</sup> Studies on adverse selection include Puelz & Snow (1994), Cohen & Siegelman (2010) and Shi et al. (2012), whilst those on moral hazard include Holmström (1979), Parsons (2003) and Lee (2013).

<sup>3</sup> The very limited existing research in the reinsurance markets includes Bohn & Hall (1999), Jean-Baptiste & Santomero (2000), Adams & Diacon (2006), Doherty & Smetters (2005), Yan (2013), Garven et al. (2014) and Yan & Hong (2015).

financial condition of the insurer. We expect to gain some insights into this issue in the present study and provide some implications for reinsurers. Third, none of the prior studies has yet tested asymmetric information within the reinsurance markets across different levels of loss ratio ceded. Since various percentiles of loss ratio ceded represent different levels of risk-aversion, it may be of considerable interest for reinsurers to know whether the phenomenon of information asymmetry varies across different segments of the reinsurance market.

Our study uses the 1985-2012 statutory returns of United Kingdom (UK) non-life insurers from the SynThesys Non-life dataset. According to the Swiss Reinsurance Company, the UK non-life insurance industry generated annual premiums of £66.55 (US\$105.50) billion in 2012, accounting for 5.30 per cent of all worldwide non-life insurance premium income (Swiss Reinsurance Company, 2013: 38-39). In 2012, the UK non-life market was ranked second in Europe in terms of premium volume and fourth in the world.

Furthermore, as compared to their US counterparts, the UK insurance industry is far less regulated (Kilin & Kilin, 2001; Wang, 2002) and more oriented towards principle-based supervision. In summary, the legislative/market characteristics of the UK insurance industry make this an appropriate setting in which to test the issues identified above with little cause for concern over any confounding effects on the results.

Our empirical results reveal that propitious selection is generally found to exist in the UK reinsurance market, and also in the third-party liability and miscellaneous and pecuniary loss reinsurance markets. In addition, information asymmetry is found within the motor and marine, aviation and transport reinsurance markets. The quantile regression results further show that propitious selection is found to exist in high loss ratio ceded quantiles, but not in low loss ratio quantiles. These results are consistent with those of Cohen & Siegelman (2010) who found that the phenomenon of information asymmetry varied across markets and even across different segments of the same market.

The contributions made by the present study are as follows. First, there is a distinct absence of tests of information asymmetry in the reinsurance markets within the extant asymmetric information literature. Our approach aims to test whether information asymmetry exists throughout the UK reinsurance market; that is, in

various lines of business and in various risk dispersions. Second, ours is the first study to employ a quantile regression model to test various risk dispersions of information asymmetry in the reinsurance market since the prior studies on the existence of asymmetric information in this market investigated only the average effects of such asymmetry. Third, our results indicate that propitious selection does indeed exist in the reinsurance market, with information asymmetry varying based upon the loss ratio ceded dispersion, which is contrary to the notion of the general positive correlation property of asymmetric information (Yan, 2013; Yan & Hong, 2015).

## **2. RELATED THEORIES AND HYPOTHESIS DEVELOPMENT**

### ***2.1 Related Theories***

Within the insurance markets, information asymmetry indicates that the insured party has some knowledge relating to their risk exposure which is important for insurance price setting, but this is unknown to the insurer. Similarly, information asymmetry may also exist in the reinsurance markets. For instance, the efficiency of reinsurance transactions depends on long-term relationship between primary insurers and reinsurers since the information of underwriting risk will gradually reveal over time and the reinsurer could further use such information into reinsurance pricing (Jean-Baptiste & Santomero, 2000). Additionally, information asymmetry of internal reinsurance, internal capital market, is lower than that of external reinsurance, capital from external sources (Gertner et al., 1994). Specifically, in the context of reinsurance, the insurers, who are also risk professionals, obviously know themselves better than the reinsurers and will potentially take advantage of important risk-related attributes of which the reinsurers have no knowledge.

The consequences of information asymmetry include adverse/propitious selection and moral hazard, all of which have been extensively investigated within the insurance markets. One of the most common approaches to directly examining these issues is to look at the risk-coverage relation. A positive relation indicates adverse selection or moral hazard, whereas a negative relation may suggest propitious

selection. However, the negative relation may result from other dimensions (Wang et al., 2009). Thus, we need to provide additional evidence to provide evidences to support the existence of propitious selection.

In the context of the reinsurance markets, this positive relation suggests that an insurer who purchases more reinsurance tends to file more claims. Under adverse selection, it is the riskiness of the insurer that determines the choice of reinsurance contracts, and indeed, riskier insurers do tend to buy more reinsurance coverage and file more claims. Rothschild & Stiglitz (1976) proposed an adverse selection model which showed the influence of inherent information asymmetry on the pricing of insurance policies. They argued that equilibrium pricing may not exist, essentially because the insurer may not be fully aware of the riskiness of the policyholder, and thus, cannot accurately estimate the probability and the magnitude of the policyholder being involved in accidents in the future. From a reinsurance perspective, even though the reinsurer is a professional and very good at underwriting, it is still difficult for the reinsurer to fully comprehend the risk characteristics of the insurer, since the insurer is also a professional. Such a situation can give rise to adverse selection.

Although Doherty & Smetters (2005) documented evidence of moral hazard within the reinsurance markets, under moral hazard it is the choice of reinsurance that determines the frequency and severity of claims. After purchasing reinsurance, insurers may relax their underwriting rules/standards or reduce their loss prevention/reduction activities, and thus, will tend to file more claims to their reinsurers. Doherty & Smetters (2005) found that affiliated reinsurers tended to use monitoring whilst non-affiliated reinsurers used price incentives. Nevertheless, even when such measures are put in place, this problem may not be completely avoided.

Cohen & Siegelman (2010) proposed three approaches to disentangling adverse selection from moral hazard, with the first of these approaches being to observe the relation between prior risk and future claims. This relation is reflected in the sign of the bonus-malus coefficient, which reflects the insurer's claims history; the higher the coefficient, the worse the insurer's prior claims record.

Under adverse selection, we expect to find a positive sign on the prior claims record variable which would indicate that an insurer with inferior claims history would continue to have high claims. However, under moral hazard, we would expect

to find a negative sign, which would indicate that insurers with a better claim history (smaller bonus-malus coefficient or claims record variable) would become higher-claim insurers if they decided to buy more reinsurance.

Dionne et al. (2013) extended the model of Abbring et al. (2003) by proposing and demonstrating a way of disentangling moral hazard and asymmetric learning relating to risk. Bajari et al. (2014) went on to disentangle both moral hazard and adverse selection through the estimation of a latent health status distribution.

Hemenway (1990, 1992) proposed a contradictory theory, known as propitious/advantageous/cherry-picking selection. Under the propitious selection argument, a risk-averse insurance firm would tend to obtain more reinsurance and take more precautionary measures, and thus, would tend to have fewer claims. In such a case, we would expect to find a negative risk-coverage relation and a negative risk-aversion relation. It is worth noting that propitious selection is also a consequence of information asymmetry; that is, similar to adverse selection, the theory of propitious selection assumes that the insured party has more information than the insurer (Karagyzova & Siegelman, 2012).

The insured party also makes a choice; however, in contrast to the case of adverse selection, this choice is propitious for the insurer, although the insured party knows more about him/herself than the insurer does. In the context of reinsurance markets, both the reinsurer and insurer are risk professionals, and thus, it would seem to be quite difficult to determine which party has an informational advantage over the other. Nevertheless, arguing that the insurer is more capable of evaluating risk than the insured party, Villeneuve (2000) proposed a model to analyze such a situation.

## ***2.2 Hypothesis Testing***

In this study, we argue that propitious selection/advantageous selection/cherry picking exists within the reinsurance market and therefore investigate propitious selection in the reinsurance market from two aspects, preventive risk-mitigation and reinsurance purchasing behavior. First, reinsurers set their reinsurance pricing based primarily on observable information; however, the risk preference type of the insurance company managers and the preventive risk-mitigation behavior exhibited by the primary insurance company managers are generally unobservable to reinsurers. Naturally, the insurers have an information advantage on, and more control of, the

risk being ceded than the reinsurers. Reinsurers are therefore less informed regarding the quality of the risks they are assuming and the preventive risk-mitigation behavior exhibited by the primary insurers during the reinsurance contract run-off period. However, reinsurers cannot make fair reinsurance pricing based purely on the information that is observable to them since other private information distorts such reinsurance pricing.

In the context of reinsurance, insurers are risk-averse to ceded business due to the contingent pricing scheme, contingent reinsurance commissions, reinsurance price, and reinsurers' expertise and specialized knowledge, and, thus, these risk-averse insurers have a greater likelihood of exerting greater effort into risk-mitigation activities and purchasing higher reinsurance coverage.<sup>4</sup> Since those insurers that buy more reinsurance coverage tend to be more safety conscious, they are therefore more inclined to take physical loss-mitigation measures (Hemenway, 1990). The following derivations show that primary insurers will purchase more reinsurance coverage and place greater precautionary effort into loss-mitigation.

The claims costs of an insurer will have been revealed for a considerable period of time because the business is underwritten and the corresponding premiums are already paid in. In addition, the eventual losses are heavily dependent upon the abilities and risk-mitigation efforts of the primary insurers during the run-off period. However, such risk-mitigation effort is difficult to be verified by non-expert outsiders.

Jean-Baptiste & Santomero (2000) suggested that reinsurers are better informed than the capital markets because they can monitor insurers and accumulate related past underwriting information by maintaining long-term reinsurance transaction relationship. However, the effort placed into loss-mitigation measures by the primary insurers during the run-off period are also unobservable to the reinsurers (Bond & Crocker, 1997); therefore, within the non-life reinsurance industry it is very important to be able to identify the mechanisms that incentivize primary insurers to place greater effort into loss-mitigation. Three mechanisms incentivizing primary insurers to exert loss-mitigation effort and increase their reinsurance coverage purchases are described below.

---

<sup>4</sup> Borch (1962) indicated that risk-averse managers in insurance firms tended to maximize their utility through the use of reinsurance.



First, primary insurers can be encouraged to try to mitigate their ceded loss by the use of ‘contingent pricing’ schemes. In a typical relation, primary insurers and reinsurers share the premiums that have been collected, and at the time of reinsurance contracting, the reinsurers cannot observe the preventive loss-mitigation efforts taken by the insurers, or indeed, what the real ceded loss experience will be; however, in the later time period, reinsurers can use the real loss experience to retroactively modify the premium on past reinsurance coverage or determine the price for future coverage (Jean-Baptiste & Santomero, 2000). Specifically, information asymmetry between reinsurance transaction parties lowers as the relationship between primary insurers and reinsurers lengthens. In addition, financial performance, reinsurance usage, and credit quality of primary insurers improve as such relationship lengthens (Garven et al., 2014). Thus, primary insurers have incentives to take measures to maintain long-term reinsurance transaction relationship. At this time, the primary insurers will face both downward and upward ceding commission adjustments and future reinsurance price fluctuations. In order to obtain higher ceding commission, reduce their future reinsurance price and maintain a long-term relation with the incumbent reinsurers, the primary insurers will adopt various risk-mitigation measures during the run-off period.<sup>5</sup>

Second, reinsurers will use ‘monitoring’ to reduce the ceded loss to enhance the underwriting performance of ceded business. The reinsurance premium of internal reinsurance accounts for a majority of the total reinsurance premium (Powell & Sommer, 2007). On the condition that both insurers and reinsurers are affiliated within the same insurance group, those affiliated primary insurers will take measures to lower their ceded loss since they are monitored by their parent group (Doherty & Smetters, 2005). Specifically, based on the transaction-cost based model of Williamson (1988), it is efficient for an insurance group to monitor its subsidiaries to mitigate the conflicts between an insurance group and its subsidiaries.

---

<sup>5</sup> Reinsurers are generally involved in a long-run relationship with ceding insurers who then behave in ways that will help to build their reputation (Plantin, 2006).

Third, reinsurance allows primary insurers to tap the expertise of reinsurers whilst maintaining control of the valuable relation between the two parties. Reinsurers can provide real services to primary insurers by providing more information and expertise about underwriting, claims handling and risk management expertise on the sort of lines in which the primary insurers do not excel (Anand et al., 2021). Therefore, to obtain such real services from the reinsurers, in order to improve their loss experience and expand their underwriting capacity, the primary insurers will purchase more reinsurance coverage and adopt more loss-mitigation measures, resulting in lower ceded risk.

According to the above discussion, we would expect to find highly risk-averse primary insurers purchasing more reinsurance coverage and exerting greater loss-mitigation effort to improve their loss experience, including the ceded loss experience, thereby resulting in lower ceded loss.<sup>6</sup> As such, we expect to find a negative correlation between the loss ratio ceded and reinsurance coverage and a positive correlation between the loss ratio ceded and standard deviation of loss ratio.<sup>7</sup> Therefore, we derive the following hypothesis.

**Hypothesis:** *Propitious selection exists in the reinsurance markets.*

### 3. DATA, METHODOLOGY AND EMPIRICAL FRAMEWORK

#### 3.1 Data

Our analyses are based upon the regulatory returns filed by UK non-life insurers between the years 1985 and 2012; these returns are obtained from the Synthesys Non-life dataset collated by Standard & Poor's. We employ a number of data exclusion criteria commonly seen in the prior related studies, as follows.

---

<sup>6</sup> Ehrlich & Becker (1972) found that market insurance and self-protection may be complements under the assumptions that insurers have full information regarding the risk type of individuals, but they cannot observe their self-protection behavior.

<sup>7</sup> In this study, we use standard deviation of loss ratio as a proxy for risk aversion for primary insurers.

Observations with non-positive admissible assets, premiums written, earned premiums ceded and claims incurred ceded are excluded from our sample, as are observations on insurers reporting a value outside the range of 0 and 1 on the amount of reinsurance variable (*Reins*), because these observations indicate extraordinary operating characteristics (Mayers & Smith, 1990; Shiu, 2011). We also exclude any observations on insurers reporting a value of less than 0 for the loss ratio ceded (*LRCede*) variable. It is worth noting here that the use of lagged control variables results in a loss of data.

It has been argued in several prior studies that since insurers with reinsurance assumed which accounts for more than 75 per cent of the premiums written are acting very much like reinsurers, they should also be excluded;<sup>8</sup> however, these reinsurers and quasi-reinsurers are not excluded from the sample in the present study because there is no reason why adverse selection, propitious selection and moral hazard should only work for insurers. In addition, the Synthesys Non-life dataset does not provide specific reinsurance contract data; therefore, we employ aggregate reinsurance coverage data in this study.

### 3.2 Methodology and Empirical Framework

We begin by regressing risk on reinsurance coverage in conjunction with several control variables that are generally considered, both theoretically and empirically, to have impacts on risk.<sup>9</sup> The model is constructed as follows:

$$Risk_{i,t} = \alpha + \beta_1 \cdot Reins_{i,t-1} + \beta_2 \cdot SDLoss_{i,t-1} + \sum \gamma \cdot CV_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

where  $Risk_{i,t}$  represents the ex-post realization of the ceded risk of insurer  $i$  in year  $t$ ; loss ratio ceded (*LRCede*), which is proxied by claims incurred ceded in the current year divided by earned premiums ceded in the current year, is used as the proxy for this variable.  $Reins_{i,t-1}$  represents the choice of reinsurance coverage of firm  $i$  in year  $t-1$ ; this variable is defined as the ratio of reinsurance premiums ceded to direct business written plus reinsurance assumed (Shiu, 2011). Since risk averse

<sup>8</sup> Examples include Cole & McCullough (2006) and Shiu (2011).

<sup>9</sup> Unless otherwise stated, all of the explanatory variables used in this study are lagged by one year relative to the dependent variable.

primary insurer managers tend to avoid the uncertainty of cash flows, they underwrite more prudently and exert more effort in risk classification, underwriting, and claim handling activities to alleviate the uncertainty of underwriting results. Thus, we use standard deviation of loss ratio of primary insurers,  $SDLoss_{i,t-1}$ , to capture the extent of primary insurer managers' risk aversion; such variable is measured by using 5-year rolling periods data.<sup>10</sup> Specifically, the higher the value of  $SDLoss$ , the more volatile of primary insurers' cash flows, the lower level of the primary insurer managers' risk averse.<sup>11</sup>  $CV$  represents the control variables that are considered in the extant literature to have influences on the dependent variable.<sup>12</sup>

The use of explanatory variables is instrumental in alleviating the problem of endogeneity. Following Upreti & Adams (2015), we winsorize all of the variables used in this study at the 5% level at each tail. Table 1 presents the definitions of the variables used in our analysis.

---

<sup>10</sup> Specifically, standard deviation of loss ratio at time  $t$  is measured by using loss ratio at time  $t$ ,  $t+1$ ,  $t+2$ ,  $t+3$ , and  $t+4$  of primary insurers (Ho et al., 2013). Since 1-year lagged independent variable is specified, we calculate standard deviation of loss ratio at time  $t-1$  by using loss ratio at time  $t-1$ ,  $t$ ,  $t+1$ ,  $t+2$ , and  $t+3$ .

<sup>11</sup> Risk-averse managers would rather prefer lower cash flow variance than wish higher cash flow variance (Fama, 1980).

<sup>12</sup> See, for example, Berry-Stölzle & Born (2012), Doherty & Smetters (2005), Yan (2013) and Ho et al. (2013).

**Table 1. Variable definitions**

Variables	Definitions
<i>LRCede<sub>t</sub></i>	Claims incurred ceded at time $t$ divided by premiums written ceded at time $t$ .
<i>LRCede<sub>t-1</sub></i>	Claims incurred ceded at time $t-1$ divided by premiums written ceded at time $t-1$ .
<i>LRCede<sub>t-2</sub></i>	Claims incurred ceded at time $t-2$ divided by premiums written ceded at time $t-2$ .
<i>Reins</i>	Ratio of reinsurance premiums ceded to direct business written plus reinsurance assumed.
<i>SDLoss</i>	Standard deviation of loss ratio at time $t-1$ , $t$ , $t+1$ , $t+2$ , and $t+3$ .
<i>DPCon</i>	Ratio of direct premiums earned at time $t-1$ divided by direct claims incurred at time $t-1$ multiplied by the ratio of reinsured claims incurred at time $t-1$ divided by direct claims incurred at time $t-1$ .
<i>ExpRat</i>	Experience rating: Direct premiums earned in the previous year divided by direct claims incurred in the previous year.
<i>Monitoring</i>	Claims incurred ceded in the previous year divided by direct claims incurred in the previous year.
<i>LRRatio</i>	Loss retention ratio: Claims incurred retained divided by total claims incurred.
<i>Size</i>	Firm size: Natural logarithm of total admitted assets.
<i>FinLev</i>	Financial leverage: Ratio of direct premiums written to policyholder surplus.
<i>ROA</i>	Ratio of pre-tax profits to total admissible assets.
<i>LBCon</i>	Herfindahl index of line-of-business concentration using premiums written in line of business by the insurer.
<i>Growth</i>	Ratio of premiums written in year $t$ divided by premiums written in year $t-1$ minus 1.

Data source: This study

We use parametric models to test whether asymmetric information exists in the UK reinsurance markets, employing a generalized least squares model and a random effects Tobit model to estimate the correlation between reinsurance coverage and loss ratio ceded. The generalized least squares model accounts for heteroscedasticity in the error term (Wooldridge, 2016), whilst Tobit regression is a standard approach

for dealing with censored dependent variables (Cummins, Phillips & Smith, 2001). The random effects model is used based upon the assumption that the unobserved effect is not correlated with all of the explanatory variables (Wooldridge, 2016).

### 3.3 Control Variables

#### 3.3.1 One- and two-year loss ratio ceded

An underwriting cycle is a phenomenon wherein periods of low claim (high profitability) are followed by periods of high claims (low profitability) (Boyer et al., 2012). The insurance markets typically exhibit cyclical underwriting behavior quantified by autoregression of order 2 (Berry-Stölzle & Born, 2012). A dynamic model is employed by including a lagged dependent variable to account for historical factors that affect the dependent variable but are difficult to account for (Wooldridge, 2016).<sup>13</sup> We therefore include one- and two-year lagged loss ratio ceded variables, and expect to find the  $LRCede_{t-1}$  ratio being positively correlated with the loss ratio and the  $LRCede_{t-2}$  ratio being negatively related to the loss ratio if the phenomenon of an underwriting cycle is found to exist; otherwise we expect to find both variables being positively correlated if there is consistent growth in the loss ratio ceded.

#### 3.3.2 Direct price control

Doherty & Smetters (2005) derived the model arguing that as more reinsurance is purchased, there will be a corresponding increase in the responsiveness of reinsurance price to prior loss of direct business, with such direct price controls effectively reducing the loss ratio ceded.  $DPCon$  is measured as the ratio of direct premiums earned at time  $t-1$  divided by direct claims incurred at time  $t-1$  multiplied by the ratio of reinsured claims incurred at time  $t-1$  divided by direct claims incurred at time  $t-1$ , in the form of interactive variable. Specifically, the former ratio, positive associated with loss ratio ceded, indicates the inverse of 1-year lagged direct losses, normalized by 1-year lagged insurance premium.<sup>14,15</sup> The latter ratio captures

---

<sup>13</sup> In this study, we include a lagged dependent variable to proxy for the contract level information that is not included due to data unavailability.

<sup>14</sup> The reason why we normalize the loss of ceded business is that the loss of ceded business is shown in the dependent variable to prevent the spurious correlation (Doherty & Smetters, 2005).

deductible level or reinsurance level since reinsurance deductible is unattainable. Specifically, the higher the ratio, the lower the deductible level, the higher extent of reinsurance purchasing. To reflect the prediction of Doherty and Smetters' model, we expect to document a positive correlation between direct price control (*DPCon*) and *LRCede* in this study.<sup>16</sup>

### 3.3.3 Experience rating

As predicted by the model of Doherty & Smetters (2005), reinsurers will give an 'experience rating' based upon a primary insurer's prior direct losses. Specifically, their model predicts that a negative relationship between reinsurance premium price and the inverse of lagged direct losses since reinsurers charge primary insurers with poor prior underwriting experience for higher reinsurance premiums. However, insurers with poor prior underwriting experience tend to put more efforts in loss control to improve underwriting performance to lower the cost of risk management. Thus, a positive relation between *LRCede* and the inverse of lagged direct losses is also expected. *ExpRat* is proxied in this study by direct premiums earned in the prior year divided by direct claims incurred in the prior year. Therefore, we do not have prior expectation on the effects of *ExpRat* on *LRCede*.

### 3.3.4 Monitoring

The more the reinsurers monitor the underwriting activities of the primary insurers, the less the loss ratio ceded; we thus expect to find a negative relation between monitoring and loss ratio ceded. However, as pointed out by Doherty &

---

<sup>15</sup> Specifically, the relationship between prior period loss and reinsurance price is positive, indicating that reinsurers charge high reinsurance price for primary insurers with poor past loss experience by employing experience rating method. Therefore, the inverse of prior period loss is also positive correlated with loss ratio ceded, the inverse of reinsurance price.

<sup>16</sup> Since it is expected that a poor underwriting experience results in higher reinsurance price in the next period, the value of inverse of prior loss is negatively associated with the ratio of reinsurance premium divided by reinsurance loss ceded. Thus, it is expected that the value of the inverse of prior loss is positively associated with loss ratio ceded. Since the direct price control variable captures the effects of responsiveness of the effects of prior loss on reinsurance price, the DPC variable is positive associated with loss ratio ceded to capture the phenomenon of Doherty & Smetters (2005)' model. In other words, this variable captures the enhancement of the effect of experience rating on loss ratio ceded.

Smetters (2005), it is difficult to directly measure monitoring; thus, we follow their approach in this study to measure *Monitoring* as the ratio of claims incurred ceded to direct claims incurred. Specifically, the higher the ratio, the more share of reinsured business, the more investments in monitoring by reinsurers, the higher level of monitoring devoted by reinsurers since the benefits of monitoring increases with the increase of the share of reinsured losses (Doherty & Smetters, 2005). For primary insurer managers, they tend to conduct underwriting and claim handling activities more prudently to obtain better reinsurance contract terms in the future.

### **3.3.5 Loss retention ratio**

The loss retention ratio represents a ceding insurer's share of loss under reinsurance contracts, with a higher loss retention implying that the ceding insurer shares a higher proportion of the insured losses with the reinsurer, thereby providing the ceding insurer with the incentive to place greater effort into underwriting loss mitigation, including retained or ceded business. We therefore expect to find the loss retention ratio (*LRRatio*) being negatively correlated with *LRCede*. We follow Yan (2013) in this study to define *LRRatio* as the ratio of retained claims incurred to gross claims incurred.

### **3.3.6 Firm size**

Larger firms have better risk management techniques in areas such as screening policyholders, underwriting policies, monitoring during the policy run-off period and reducing insurance fraud to improve their loss experience, including retained and ceded business. *Size*, which is defined as the natural logarithm of total admitted assets, is expected to have a negative correlation with *LRCede*.

### **3.3.7 Financial leverage**

Financial leverage is an indicator of a firm's likelihood of bankruptcy; thus, insurers with higher financial leverage tend to be under closer solvency regulation monitoring (Yan & Hong, 2015). Highly-leveraged firms are therefore more likely to adopt sound underwriting strategies and place greater effort into loss mitigation, including retained and ceded business, in their attempts to reduce their financial leverage. *FinLev* is defined as direct premiums written to policyholders' surplus, and we expect to find this variable having a negative correlation with *LRCede*.



### 3.3.8 Return on assets

Return on assets, which indicates the profitability of an insurer, is defined as the ratio of pretax profits to total admissible assets. Profitable primary insurers follow appropriate operational policies, implementing good risk management techniques, including risk classification and transfer. By implementing good risk classification techniques, profitable primary insurers retain their good business and cede their bad risk business by purchasing reinsurance contracts. However, profitability insurers tend to devote more resources into loss prevention and mitigation activities to improve underwriting experience to purchase reinsurance at a lower price in the future. Therefore, *LRCede* will be lower for those insurers with higher profitability, and we expect to find *ROA* being negatively correlated with *LRCede*.

### 3.3.9 Line-of-business Concentration

With the increasing focus on product line concentration, primary insurers will increase their own focus on the line-of-business in which they excel; therefore, the loss experience of retained and ceded business will improve. *LoBCon* is measured in this study by the Herfindahl index of line-of-business concentration using gross premiums written,<sup>17</sup> and we expect to find a negative relation between *LoBCon* and *LRCede*.

### 3.3.10 Firm growth rate

Fast written premiums growth is probably the result of an insurer's loose underwriting strategies, which may lead to inferior underwriting performance; we thus anticipate to find a positive correlation between *Growth* and *LRCede*.

### 3.3.11 Year dummies

Year dummies are included in this study to control for any time trend in the loss ratio ceded. We have no prior expectations of the year effect on the loss ratio.

---

<sup>17</sup> These lines include accident and health, marine aviation and transport, property, motor, third-party liability and miscellaneous and pecuniary losses (Shiu, 2011).

## 4. EMPIRICAL RESULTS

### 4.1 Univariate Analysis

The summary statistics of the variables are presented in Table 2, where the mean value of *LRCede* is 0.823, with a standard deviation of 1.841. The average value of *Reins* and *SDLoss* are 0.320 and 2.115, respectively. A total of 127 firms are included in our analysis, providing us with 430 firm-year observations.

**Table 2. Descriptive statistics of UK non-life insurers, 1986-2012.**

Variables	Mean	S.D.	Min	Median	Max	No. of Obs.
<i>LRCede<sub>t</sub></i>	0.823	1.841	0.000	0.500	16.348	430
<i>LRCede<sub>t-1</sub></i>	0.831	2.751	0.000	0.457	25.754	430
<i>LRCede<sub>t-2</sub></i>	0.535	0.259	0.078	0.518	1.701	430
<i>Reins</i>	0.320	0.267	0.005	0.229	0.953	430
<i>SDLoss</i>	2.115	12.925	0.017	0.116	118.717	430
<i>DPCon</i>	2.222	4.483	0.000	0.545	25.878	430
<i>ExpRat</i>	2.566	2.408	0.124	1.854	19.171	430
<i>Monitoring</i>	1.124	0.329	0.000	0.329	12.594	430
<i>LRetRat</i>	0.686	0.272	0.073	0.752	1.000	430
<i>Size</i>	12.423	1.779	9.248	12.507	15.800	430
<i>FinLev</i>	1.223	0.919	0.020	1.011	3.719	430
<i>ROA</i>	0.038	0.046	-0.076	0.033	0.159	430
<i>LBCon</i>	0.582	0.327	0.003	0.537	1.000	430
<i>Growth</i>	0.098	0.265	-0.321	0.030	1.103	430

This table reports the descriptive statistics of the estimation sample for the full sample period (winsorized at the 5% level at each tail). All of the variables are as defined in Table 1.

Data source: This study

We also report the Pearson correlation coefficient matrix, with the results reported in Table 3 showing that all of the correlations between *Reins* and *LRCede* are negative, although insignificant. *LRCede*<sub>*t*-1</sub> and *LRCede*<sub>*t*-2</sub> have significantly positive correlations with *LRCede* at the 1% level; thus, our results suggest that all of the loss ratio ceded variables have consistent correlations with each other.

*SDLoss* is positively linked with *LRCede* at the 1% level, indicating that less risk-averse managers of primary insurers tend to adopt riskier underwriting strategy. *ExpRat* is found to be significantly negatively related to *LRCede* at the 1% level, which is consistent with our earlier point that reinsurers will tend to use experience rating to reduce the risk of their ceded business. *LRRatio* is negatively and significantly correlated with *LRCede*, which suggests that the higher the loss retention, the greater the incentive for primary insurers to place greater effort into loss mitigation.

The ‘variance inflation factor’ (VIF) values for all of the explanatory variables are less than 10, ranging from 1.08 to 8.15, which suggests that the multi-collinearity problem is probably not to be severe in the present study (Gujarati, 1995).

Table 3. Correlation coefficient matrix of UK non-life insurers, 1986-2012

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)
(a)	-												
(b)	0.275***	-											
(c)	0.275***	0.613***	-										
(d)	-0.056	-0.018	-0.081*	-									
(e)	0.792***	0.137***	0.154***	0.026	-								
(f)	-0.002	0.144***	0.005	0.508***	-0.025	-							
(g)	-0.158***	-0.088*	-0.311***	-0.028	-0.082*	0.404***	-						
(h)	0.074	0.242***	0.125***	0.640***	0.020	0.782***	0.232***	-					
(i)	-0.089*	-0.230***	-0.068	-0.862***	-0.005	-0.686***	-0.104*	-0.780***	-				
(j)	0.005	-0.041	0.104**	-0.022	-0.062	-0.011	-0.114**	-0.016	0.016	-			
(k)	-0.155***	-0.137***	-0.054	-0.459***	-0.134***	-0.261***	0.020	-0.359***	0.392***	0.187***	-		
(l)	-0.137***	-0.082*	-0.135***	-0.274***	-0.068	-0.102**	0.143***	-0.178***	0.252***	-0.113**	0.061	-	
(m)	-0.187***	-0.139***	-0.155***	-0.177*	-0.120*	-0.088*	0.106**	-0.118**	0.196***	-0.393***	0.253***	0.219***	-
(n)	0.060	0.131***	0.039	0.055	0.062	0.225***	0.262***	0.113**	-0.116**	-0.111**	0.050	-0.070	-0.010

This table presents the correlation coefficient matrix for the main variables examined in this study. The correlation coefficients are computed using Pearson Product Moment Correlation Analysis (winsorized at the 5% level at each tail). The proxies are as follows: (a) *LRCode<sub>t</sub>*; (b) *LRCode<sub>t-1</sub>*; (c) *LRCode<sub>t-2</sub>*; (d) *Reins*; (e) *SDLoss*; (f) *DPCor*; (g) *ExpRat*; (h) *Monitoring*; (i) *Size*; (j) *FinLev*; (k) *ROA*; (l) *LBCon*; (m) *Growth*. All of the variables are as defined in Table 1. \* indicates two-tailed statistical significance at the 10% level; \*\* indicates significance at the 5% level; and \*\*\* indicates significance at the 1% level.

Data source: This study

## 4.2 Multivariate Analyses

The generalized least squares and random effects Tobit regression results for the entire market are reported in Table 4. The chi-squares statistics for the goodness of fit of the models are all significant at the 1% level, thereby indicating that the fitted models are better than a null model with no independent variables.

Table 4. Total business of UK non-life insurers, 1986-2012

Variables	Dependent variable: <i>LRCede<sub>t</sub></i>			
	Generalized Least Squares		Random Effects Tobit Model	
	Coefficient	S.D.	Coefficient	S.D.
Constant	0.771	0.973	1.310*	0.729
<i>LRCede<sub>t-1</sub></i>	0.079***	0.025	0.059**	0.026
<i>LRCede<sub>t-2</sub></i>	-0.109	0.274	0.339	0.264
<i>Reins</i>	-0.819*	0.481	-0.795*	0.481
<i>SDLoss</i>	0.107***	0.004	0.107***	0.004
<i>DPCon</i>	-0.015	0.021	-0.017	0.020
<i>ExpRat</i>	-0.051*	0.028	-0.051*	0.027
<i>Monitoring</i>	0.026	0.050	0.006	0.046
<i>LRetRat</i>	-0.487	0.529	-1.074**	0.534
<i>Size</i>	0.063	0.059	0.031	0.033
<i>FinLev</i>	-0.167*	0.093	-0.069	0.070
<i>ROA</i>	-1.681	1.238	-2.121*	1.194
<i>LBCon</i>	-0.252	0.283	-0.154	0.188
<i>Growth</i>	0.209	0.199	0.143	0.209
Year effects	Yes		Yes	
No. of Firms	127		127	
No. of Obs.	430		430	
$\chi^2$	599.022*** (0.000)		507.14*** (0.000)	

This table presents the results of the effect of the reinsurance ratio on loss ratio ceded in total business examined in this study based upon generalized least squares regressions and a random effects Tobit model. All of the variables are as defined in Table 1. \* indicates two-tailed statistical significance at the 10% level; \*\* indicates significance at the 5% level; and \*\*\* indicates significance at the 1% level.

Data source: This study

The Reins variable is negative and significant at the 10% level, which indicates that those insurers purchasing more reinsurance are more likely to have a lower loss ratio ceded. In addition, the SDLoss variable is found to be positive associated with loss ratio ceded at the 1% significant level, providing supports for the notion that risk-averse managers tend to exert more effort into loss mitigation activities, resulting in lower loss ratio ceded. Thus, the above results suggest that propitious selection does indeed exist in the UK reinsurance market. When purchasing high reinsurance coverage, risk-averse insurers may be simultaneously engaging in risk-mitigation activities, thereby resulting in a low ceded loss ratio.

The lagged loss ratio ceded variable, LRCede<sub>t-1</sub>, is found to have significantly positive correlation with the current LRCede<sub>t</sub>, thereby indicating a consistent increase in the loss ratio ceded from the prior period to the current period. ExpRat is found to have a significantly negative correlation with LRCede at the 10% level, indicating that insurers with better claims records have a lower loss ratio ceded. LRetRat is also found to have a negative and significant association with LRCede at 5% significant level by using random effect Tobit model, denoting that insurers retaining high level of loss tend to have incentives to place greater effort into underwriting loss mitigation.

FinLev is significantly negatively correlated with LRCede at 10% level when utilizing generalized least squared model, which suggests that high levered primary insurers adopt sound underwriting strategies and place greater effort into risk classification, underwriting, and loss mitigation activities. The ROA variable is negative and significant linked with LRCede at 10% significant level by using random effects Tobit model, thereby indicating that more profitable insurers have a lower LRCede, possibly because they devote more resources in risk classification and loss control activities.

## 5. ADDITIONAL ANALYSES

Information asymmetry may well be found to vary across different segments within the same reinsurance market or in different lines of business (Cohen and Siegelman, 2010); therefore, in this section, we begin by employing a quantile regression model to examine whether the phenomenon of information asymmetry

varies across different loss ratio ceded quantiles and then go on to examine such information asymmetry across various line-of-business reinsurance markets.

We also use a non-parametric model in conjunction with the quantile regression model to analyze whether the phenomenon of information asymmetry is sensitive to various quantiles of loss ratio ceded dispersions. The quantile regression model allows us to estimate the relation between loss ratio ceded and its explanatory variables at any specific quantile. As compared to the OLS regression model, the quantile regression model has been found to be more robust (Koenker, 2005).

The quantile regression model shows the link between reinsurance and loss ratio ceded under various quantiles; however, the prior significantly negative risk-coverage and risk-risk aversion correlation are both the average effects. We will therefore investigate whether a negative correlation still exists for the risk-coverage correlation and a positive relationship exists between the ceded risk-risk aversion relationship in various loss ratio ceded quantiles. We argue that the negative correlation will still be found to exist in high loss ratio ceded quantiles, but not in low loss ratio ceded quantiles. We also argue that these phenomena may exist by considering risk aversion aspects.

Based on Koenker (2005), the quantile regression designed to examine the effect of reinsurance on the loss ratio ceded for  $\tau$  quantiles is given by:

$$Q_y(\tau|x) = x'\beta \quad (2)$$

where  $y$  is a dependent variable;  $x$  is a vector of explanatory variables; and  $\beta$  is a vector of coefficients.<sup>18</sup> The quantile regression coefficient  $\widehat{\beta}_\tau$  determines the relation between reinsurance and the  $\tau^{\text{th}}$  conditional quantile of the loss ratio ceded.

The main unobservable factor for reinsurers regarding propitious selection is risk aversion of primary insurer managers. However, the primary insurer managers become more risk-averse as loss experience of ceded businesses worsens since they concern that their ceded business will not be renewed by the incumbent reinsurer or will be charged with a higher reinsurance premium in the next run-off period.<sup>19</sup> Therefore, we argue that propitious selection exists in high level of loss ratio ceded but does not exist in low level of loss ratio ceded. We will discuss such phenomenon

---

<sup>18</sup> The estimates of  $\beta$  for a given quantile in Equation (2) can be obtained by minimizing the weighted deviations from the condition quantile.

<sup>19</sup> Specifically, reinsurance costs much (Cummins et al., 2021).

from the aspects of reinsurance price and reinsurance commission.

Since those primary insurers with poor loss experience of ceded business will purchase reinsurance at a higher cost and obtain less reinsurance commissions, they will become more risk-averse.<sup>20</sup> Specifically, they will take conservative underwriting strategies, enhance underwriting standard, and exert more effort in loss control, including loss prevention and mitigation activities, to improve their underwriting performance by reducing adverse selection and moral hazard phenomena since the reinsurers experience rate direct business (Yan, 2013) and primary insurer managers have incentives to avoid their reputation from being harmed and maintain the safety of their position (Cheng & Weiss, 2013).<sup>21</sup> In addition, such risk-aversion effect rises if the manager's human capital is closely tied with the firm (Chava & Purnanandam, 2010). Furthermore, they could not increase investment return since the duration of both insurance products and investment is short-term in non-life insurance market due to the asset-liability matching principle (Chen et al., 2021).

However, managers of primary insurers with better underwriting performance of ceded business will become less conservative and more aggressive in underwriting activities since they will have more underwriting capacity by purchasing reinsurance at a lower cost in the next run-off period but also receiving more reinsurance commission from reinsurers due to better loss experience of ceded business. Therefore, primary insurers could charge lower insurance price in insurance market since they could transfer risk at a lower cost than other rivals could in the same insurance market. Since primary insurers' managers have incentives to take measures to raise salaries and compensations, they adopt aggressive underwriting strategies by relaxing their underwriting standard and underwriting risky businesses to increase insurance income. Therefore, they are likely to transfer riskier business to reinsurers, resulting in high level of adverse selection. In addition, they also tend to exert less effort in loss control related activities since their benefits of effort decreases, also

---

<sup>20</sup> Primary insurers are prone to maintain risk-taking at an appropriate level to fulfill the commitment made to policyholders and protect the value of those policyholders' insurance policies from being reduced (Cummins & Sommer, 1996).

<sup>21</sup> Specifically, the primary insurers reduce claim expenses by putting more efforts in detecting insurance fraud. In addition, based upon playing it safe hypothesis, the primary insurer's managers tend to forgo risky but value-enhancing business (Agha et al., 2021). Since managers having human capital, specific to firm and industry, may lose a lot personally when they are laid off or their firms are taken over (Jokipii & Milne, 2011).



resulting in higher moral hazard. Therefore, the negative risk-coverage correlation is mitigated as the loss ratio ceded decreases since it causes a higher loss ratio ceded and more reinsurance purchased. We, therefore, argue that propitious selection will be found to exist in the higher loss ratio ceded quantiles, but not in the lower quantiles.

Table 5 reports the quantile regression results of reinsurance coverage and standard deviation of loss ratio on loss ratio ceded at various loss ratio ceded levels. The results reveal that the coefficients of reinsurance on LRCede have significantly negative correlations at the higher quantiles (from 0.5 to 0.9) but insignificant correlations at the lower quantiles (from 0.1 to 0.4). Additionally, the coefficients of standard deviation of loss ratio on LRCede also present significant positive relationships at the higher quantiles (from 0.5 to 0.9). Thus, the two main results suggest that the phenomenon of propitious selection/advantageous selection/cherry picking does indeed exist in high loss ratio ceded quantiles, although no information asymmetry is found to exist in low loss ceded quantiles.

**Table 5. Total business of UK non-life insurers, 1986-2012**

Percentiles	Reinsurance	Std. Dev.	<i>SDLoss</i>	Std. Dev.	Pseudo $R^2$
Dependent Variable: <i>LRCede<sub>t</sub></i>					
0.1	-0.255	0.281	0.022***	0.004	0.162
0.2	0.034	0.284	0.022	0.063	0.193
0.3	-0.147	0.234	0.123	0.089	0.222
0.4	-0.152	0.143	0.133***	0.027	0.288
0.5	-0.364**	0.165	0.131***	0.002	0.342
0.6	-0.558**	0.237	0.132***	0.002	0.390
0.7	-0.498**	0.277	0.130***	0.003	0.446
0.8	-0.637***	0.238	0.132***	0.004	0.513
0.9	-1.274***	0.474	0.131***	0.007	0.601
Control Variable	Yes				
No. of Firms	127				
No. of Obs.	430				

This table reports the results of the various effects of reinsurance on the loss ratio ceded in total business as percentiles 0.1 to 0.9. All of the variables are as defined in Table 1, and are winsorized at the 5% level on both sides. The standard deviations are robust standard errors. \*\* indicates two-tailed statistical significance at the 5% level; and \*\*\* indicates significance at the 1% level.

Data source: This study

The results suggest that by purchasing a higher amount of reinsurance coverage and exerting greater precautionary effort to mitigate their ceded losses, high ceded risk primary insurers exhibit characteristics of risk aversion. The result is consistent with transaction cost economies (Williamson, 1988), indicating that primary insurers will take measures to reduce their business risk to guard against purchasing expensive reinsurance. Additionally, the result is also consistent with the notion that managers concern about the safety of their position and their reputation when their underwriting performance of ceded business is poor. However, the results show that adverse selection, moral hazard, and propitious selection may interact with each other at low loss ratio ceded quantiles, with no effect dominating any of the others; it is, therefore, very difficult for ceding insurers or reinsurers to take advantage of each other.

Using a generalized least squares model and a random effects Tobit model, we obtain estimation results on various individual markets. These results, reported in Table 6, show that reinsurance has a significantly negative correlation with loss ratio ceded and standard deviation of loss ratio has a positive association with loss ratio ceded in the third-party liability, and miscellaneous and pecuniary loss reinsurance markets, indicating propitious selection exists. However, information asymmetry exists in motor and marine, aviation and transport reinsurance markets since significant and positive correlations between reinsurance and loss ratio ceded are found. Therefore, consistent with the Cohen and Siegelman argument, our results suggest that the phenomenon of information asymmetry may vary across the different segments of a market.

**Table 6. UK non-life insurers, 1986-2012**

Variables	Dependent Variable: <i>LRCede<sub>t</sub></i>			
	Generalized Least Squares		Random Effects Tobit Model	
	Coefficient	S.D.	Coefficient	S.D.
Accident and health reinsurance market				
Reinsurance	-0.351	0.622	-0.351	0.622
<i>SDLoss</i>	-0.008**	0.003	-0.008**	0.003
Control variable	Yes		Yes	
No. of Obs.	98		98	
Motor reinsurance market				
Reinsurance	5.706*	2.917	5.706*	2.917
<i>SDLoss</i>	-0.019	0.015	-0.019	0.015
Control variable	Yes		Yes	
No. of Obs.	89		89	
Marine, aviation and transport reinsurance market				
Reinsurance	89.00*	47.880	89.00*	47.880
<i>SDLoss</i>	-0.705	2.029	-0.705	2.029
Control variable	Yes		Yes	
No. of Obs.	27		27	
Third-party liability reinsurance market				
Reinsurance	-0.540**	0.266	-0.554**	0.258
<i>SDLoss</i>	0.574***	0.122	0.571***	0.120
Control variable	Yes		Yes	
No. of Obs.	178		178	
Miscellaneous and pecuniary loss reinsurance market				
Reinsurance	-0.714*	0.360	-0.704*	0.400
<i>SDLoss</i>	0.341***	0.087	0.293***	0.078
Control variable	Yes		Yes	
No. of Obs.	203		203	

This table reports the results of the effects of reinsurance on the loss ratio ceded in the accident and health, motor, marine, aviation and transport, third-party liability, and miscellaneous and pecuniary loss reinsurance markets using generalized least squares and a random effects Tobit model. All of the variables are as defined in Table 1. \* indicates two-tailed statistical significance at the 10% level; and \*\* indicates significance at the 5% level.

Data source: This study

## 6. CONCLUSIONS

Determining the existence of information asymmetry is a very important issue in the reinsurance industry; however, as compared to the focus on such asymmetry within the extant insurance literature, little relevant research has been carried out in the context of the reinsurance markets. In an attempt to fill this gap, we examine information asymmetry in this study using data on UK non-life insurance firms covering the years 1985 to 2012.

Our results show that propitious selection is indeed generally found to exist within the UK reinsurance market as a whole, thereby providing evidence in support of the argument that primary insurers are risk averse, place greater effort into loss mitigation, and thus, tend to purchase higher amounts of reinsurance coverage. However, whilst the results confirm the existence of propitious selection in high loss ratio ceded quantiles, this is not the case for low loss ratio ceded quantiles. Finally, the results show that propitious selection exists within the third-party liability and miscellaneous and pecuniary loss reinsurance markets but information asymmetry exists within the motor and marine, aviation and transport reinsurance markets.

Due to the lack of availability of related data, it is not possible to extend this research through an examination of residual moral hazard using internal reinsurance data on the UK non-life reinsurance market, or indeed, to test dynamic adverse selection using data on the tenure of the insurer-reinsurer relation. Therefore, future studies should look into various reinsurance markets in various countries, such as Japan, Korea or China, in an attempt to identify detailed data on the reinsurance markets of such countries. Future research may also explore how information asymmetry in insurance markets would transmit to and/or affect information asymmetry in reinsurance markets.

## REFERENCES

- Abbring, J. H., Chiappori, P. A., and Pinquet J., 2003, "Moral Hazard and Dynamic Insurance Data," **Journal of the European Economic Association**, Vol. 1, No. 4, 767-820.
- Adams, M. B. and Diacon, S. R., 2006, "Testing for Information Asymmetries in the United Kingdom Market for Property-Liability Reinsurance." Working Paper, European Business Management School, University of Wales, Swansea.
- Agha, M., Pham, M. D. (M.), and Yu J., 2021, "Management Connectedness and Corporate Investment," **Journal of Banking & Finance**, Vol. 124, 106042.
- Anand, V., Tyler Leverty, J., and Wunder, K., 2021, "Paying for Expertise: The Effect of Experience on Insurance Demand," **Journal of Risk and Insurance**, Vol. 88, No. 3, 727-756.
- Bajari, P., Dalton, C., Hong, H., and Khwaja, A., 2014, "Moral Hazard, Adverse Selection, and Health Expenditure: A Semi-parametric Analysis," **The RAND Journal of Economics**, Vol. 45, No. 4, 747-763.
- Berry-Stölzle, T. R., and Born, P., 2012, "The Effect of Regulation on Insurance Pricing: The Case of Germany," **Journal of Risk and Insurance**, Vol. 79, No. 1, 129-164.
- Bohn, J. G. and Hall, B., 1999, "The Moral Hazard of Insuring the Insurers" in Froot, K. A. (ed.), **The Financing of Catastrophe Risk**, 1<sup>st</sup> Edition, Chicago, IL: University of Chicago Press, 363-390.
- Bond, E. W. and Crocker, K. J., 1997, "Hardball and the Soft Touch: the Economics of Optimal Insurance Contracts with Costly State Verification and Endogenous Monitoring Costs," **Journal of Public Economics**, Vol. 63, No. 2, 239-264.
- Borch, K., 1962, "Equilibrium in a Reinsurance Market," **Econometrica**, Vol. 30, No. 3, 424-444.
- Boyer, M. M., Jacquier, E., and Van Norden, S., 2012, "Are Underwriting Cycles Real and Forecastable?" **Journal of Risk and Insurance**, Vol. 79, No. 4, 995-1015.
- Chava, S. and Purnanandam, A., 2010, "CEOs versus CFOs: Incentives and Corporate Policies," **Journal of Financial Economics**, Vol. 97, No. 2, 263-278.
- Chen J. H., Chang, S. C., and Shiu, Y. M., 2021, "Risk-based Capital Regime Adoption and Underwriting Performance: Evidence from the Property-Casualty Insurance Industry in Taiwan," **Review of Securities and Futures Markets**, Vol. 33, No. 3, 83-119.
- Cheng, J. and Weiss, M. A., 2013, "Risk-based Capital and Firm Risk Taking in Property-liability Insurance," **The Geneva Papers on Risk and Insurance-Issues**

- and Practice**, Vol. 38, No. 2, 274-307.
- Chiappori, P. A. and Salanié B., 2000, "Testing for Asymmetric Information in Insurance Markets," **Journal of Political Economy**, Vol. 108, No. 1, 56-78.
- Cohen, A., 2005, "Asymmetric Information and Learning: Evidence from the Vehicle Insurance Market," **Review of Economics and Statistics**, Vol. 87, No. 2, 197-207.
- Cohen, A. and Siegelman, P., 2010, "Testing for Adverse Selection in Insurance Markets," **Journal of Risk and Insurance**, Vol. 77, No. 1, 39-84.
- Cole, C. R. and McCullough, K. A., 2006, "A Reexamination of the Corporate Demand for Reinsurance," **Journal of Risk and Insurance**, Vol. 73, No.1, 169-192.
- Cummins, J. D., Dionne, G., Gagné, R., and Noura, A., 2021, "The Costs and Benefits of Reinsurance," **The Geneva Papers on Risk and Insurance-Issues and Practice**, Vol. 46, No. 2, 177-199.
- Cummins, J. D., Phillips, R. D., and Smith, S. D., 2001, "Derivatives and Corporate Risk Management: Participation and Volume Decisions in the Insurance Industry," **Journal of Risk and Insurance**, Vol. 68, No.1, 51-91.
- Cummins, J. D. and Sommer, D. W., 1996, "Capital and Risk in Property-Liability Insurance Markets," **Journal of Banking & Finance**, Vol. 20, No. 6, 1069-1092.
- Dionne, G., Michaud, P. C., and Dahchour, M., 2013, "Separating Moral Hazard from Adverse Selection and Learning in Automobile Insurance: Longitudinal Evidence from France," **Journal of the European Economic Association**, Vol. 11, No. 4, 897-917.
- Doherty, N. and Smetters, K., 2005, "Moral Hazard in Reinsurance Markets," **Journal of Risk and Insurance**, Vol. 72, No. 3, 375-391.
- Ehrlich, I. and Becker, G. S., 1972, "Market Insurance, Self-insurance, and Self-protection," **Journal of Political Economy**, Vol. 80, No. 4, 623-648.
- Fama, E. F., 1980, "Agency Problems and the Theory of Firm," **Journal of Political Economy**, Vol. 88, No. 2, 288-307.
- Finkelstein, A. and Poterba, J., 2014, "Testing for Asymmetric Information Using 'Unused Observables' in Insurance Markets: Evidence from the UK Annuity Market," **Journal of Risk and Insurance**, Vol. 81, No. 4, 709-734.
- Garven, J. R., Hilliard, J. I., and Grace, M. F., 2014, "Adverse Selection in Reinsurance markets," **The Geneva Risk and Insurance Review**, Vol. 39, No. 2, 222-253.
- Gertner, R. H., Scharfstein, D. S., and Stein, J. C., 1994, "Internal versus External Capital Markets," **The Quarterly Journal of Economics**, Vol. 109, No. 4, 1211-1230.
- Gujarati, D. N., 1995, **Basic Econometrics**, 3<sup>rd</sup>, New York: McGraw-Hill Inc.

- Hemenway, D., 1990, "Propitious Selection," **The Quarterly Journal of Economics**, Vol. 105, No. 4, 1063-1069.
- Hemenway, D., 1992, "Propitious Selection in Insurance," **Journal of Risk and Uncertainty**, Vol. 5, No.3, 247-251.
- Ho, C. L., Lai, G. C., and Lee, J.P., 2013, "Organizational Structure, Board Composition and Risk Taking in the US Property Casualty Insurance Industry," **Journal of Risk and Insurance**, Vol. 80, No. 1, 169-203.
- Holmström, B., 1979, "Moral Hazard and Observability," **Bell Journal of Economics**, Vol. 10, No. 1, 74-91.
- Jean-Baptiste, E. L. and Santomero, A. M., 2000, "The Design of Private Reinsurance Contracts," **Journal of Financial Intermediation**, Vol. 9, No. 3, 274-297.
- Jokipii, T. and Milne, A., 2011, "Bank Capital Buffer and Risk Adjustment Decisions," **Journal of Financial Stability**, Vol. 7, No. 3, 165-178.
- Karagyozyova, T. and Siegelman, P., 2012, "Can Propitious Selection Stabilize Insurance Markets?" **Journal of Insurance Issues**, Vol. 35, No. 2, 121-158.
- Kilin, R. J. and Kilin, S., 2001, **Reinsurance in Practice**, 4<sup>th</sup>, London: Witherby Seaman International.
- Kim, H., Kim, D., Im, S., and Hardin, J. W., 2009, "Evidence of Asymmetric Information in the Vehicle Insurance Market: Dichotomous versus Multinomial Measurement of Insurance Coverage," **Journal of Risk and Insurance**, Vol. 76, No. 2, 343-366.
- Koenker, R. W., 2005, **Quantile Regression**, 1<sup>st</sup>, Cambridge: Cambridge University Press.
- Lee, Y. W., 2013, "Testing for the Presence of Moral Hazard Using the Regulatory Reform in the Car Insurance Market: Case of Korea," **Japanese Economic Review**, Vol. 64, No. 3, 414-429.
- Mayers, D. and Smith, C. W., 1990, "On the Corporate Demand for Insurance: Evidence from the Reinsurance Market," **The Journal of Business**, Vol. 63, No. 1, 19-40.
- Parsons, C., 2003, "Moral Hazard in Liability Insurance," **The Geneva Papers on Risk and Insurance - Issues and Practice**, Vol. 28, No. 3, 448-471.
- Plantin, G., 2006, "Does Reinsurance Need Reinsurers?" **Journal of Risk and Insurance**, Vol. 73, No. 1, 153-168.
- Powell, L. S. and Sommer, D. W., 2007, "Internal Versus External Capital Markets in the Insurance Industry: The Role of Reinsurance," **Journal of Financial Services Research**, Vol. 31, No.2-3, 173 - 188.
- Puelz, R. and Snow, A., 1994, "Evidence on Adverse Selection: Equilibrium Signaling and Cross-Subsidization in the Insurance Market," **Journal of Political Economy**, Vol.

102, No. 2, 236-257.

Rothschild, M. and Stiglitz, J., 1976, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," **The Quarterly Journal of Economics**, Vol. 90, No. 4, 629-649.

Saito, K., 2006, "Testing for Asymmetric Information in the Vehicle Insurance Market under Rate Regulation," **Journal of Risk and Insurance**, Vol. 73, No. 2, 335-356.

Shi, P., Zhang, W., and Valdez, E. A., 2012, "Testing Adverse Selection with Two-dimensional Information: Evidence from the Singapore Auto Insurance Industry," **Journal of Risk and Insurance**, Vol. 79, No. 4, 1077-1114.

Shiu, Y. M., 2011, "Reinsurance and Capital Structure: Evidence from the United Kingdom Non-life Insurance Industry," **Journal of Risk and Insurance**, Vol. 78, No. 2, 475-494.

Spindler, M., Winter, J., and Hagmayer, S., 2014, "Asymmetric Information in the Market for Automobile Insurance: Evidence from Germany," **Journal of Risk and Insurance**, Vol. 81, No. 4, 781-801.

Swiss Reinsurance Company, 2013, "World Insurance in 2012," **Sigma**, Vol. 3, 1-46.

Upreti, V. and Adams, M., 2015, "The Strategic Role of Reinsurance in the UK Non-life Insurance Market," **Journal of Banking and Finance**, Vol. 61, 206-219.

Villeneuve, B., 2000, "The Consequences for a Monopolistic Insurance Firm of Evaluating Risk Better than Customers: The Adverse Selection Hypothesis Reversed," **The Geneva Papers on Risk and Insurance Theory**, Vol. 25, No. 1, 65-79.

Wang, W. H., 2002, **Reinsurance Regulation: A Contemporary and Comparative Study**, 1<sup>st</sup>, London: Kluwer Law International.

Wang, K. C., Huang, R. J., and Tzeng, L. Y., 2009, "Empirical Evidence for Advantageous Selection in the Commercial Fire Insurance Market," **The Geneva Risk and Insurance Review**, Vol. 34, No.1, 1-19.

Williamson, O. E., 1988, "Corporate Finance and Corporate Governance," **The Journal of Finance**, Vol. 43, No. 3, 567-591.

Wooldridge, J. M., 2016, **Introductory Econometrics: A Modern Approach**, 4<sup>th</sup>, Canada: South-Western Cengage Learning.

Yan, Z., 2013, "Testing for Moral Hazard in Reinsurance Markets," **Managerial Finance**, Vol. 39, No. 8, 696-713.

Yan, Z. and Hong, L., 2015, "Testing for Asymmetric Information in Reinsurance Markets," **The Geneva Papers on Risk and Insurance-Issues and Practice**, Vol. 40, No. 1, 29-46.



## About the Authors

### **Yung-Ming Shiu**

Yung-Ming Shiu is Distinguished Professor in the Department of Risk Management and Insurance at National Chengchi University, Taiwan. He teaches risk management, insurance and CSR. Professor Shiu's research focuses on the areas of reinsurance, corporate hedging and CSR. His research has appeared in a number of scholarly and trade journals such as Strategic Management Journal, Journal of Risk and Insurance, Journal of Futures Markets, Journal of Derivatives, Annals of Actuarial Science and British Actuarial Journal.

Email: [yungming@nccu.edu.tw](mailto:yungming@nccu.edu.tw)

### **Juei-Hsiang Chen**

Juei-Hsiang Chen received his PhD degree from National Chengchi University. He is an assistant professor in Department of Accounting at Shih Chien University. His research interests include risk management and insurance economics. Some of his published papers are in Review of Securities and Futures Markets, Management Review and Taiwan Insurance Review.

Email: [raychen@g2.usc.edu.tw](mailto:raychen@g2.usc.edu.tw)