Pacific-Basin Finance Journal xxx (xxxx) xxx

Contents lists available at ScienceDirect

Pacific-Basin Finance Journal

journal homepage: www.elsevier.com/locate/pacfin

Does size and book-to-market contain intangible information about managerial incentives? Learning from corporate D&O insurance purchase

Rachel J. Huang [a,d], Vivian Jeng [b,d,*], Cheng-Wei Wang [b,d], Jack C. Yue [c,d]

[a] Department of Finance, National Central University, Taiwan, ROC
[b] Department of Risk Management and Insurance, National Chengchi University, Taiwan, ROC
[c] Department of Statistics, National ChengChi University, Taiwan, ROC
[d] Risk and Insurance Research Center, National Chengchi University, Taiwan

ARTICLE INFO

JEL classification:
D80
G22
C30

Keywords:
Size
Book-to-market
Directors' and officers' liability insurance
Advantageous selection
Intangible information
Adverse selection

ABSTRACT

Using 2008–2018 data for all publicly-listed firms in Taiwan, this paper tests for asymmetric information in the Directors' and Officers' (D&O) liability insurance market. We argue that size and book-to-market ratio contain information such as managerial risk preferences and their intention to reduce litigation risk. Our results show that a negative relationship exists between litigation risk and insurance purchase among small and low book-to-market firms. Our findings pinpoint out the importance of using size and the book-to-market ratio when detecting asymmetric information in the corporate level.

1. Introduction

The numbers and settlements of shareholder litigations against firms, executives, and board members have increased rapidly in recent years all around the world. For example, in China the average number of lawsuits from 2010 to 2014 was about 7.4 times that from 2001 to 2009 (Feng and Fuerman, 2018). Moreover, in the U.S. the total amount of settlement increase from $1511 million in 2017 to $5064 million in 2018.[1] This trend has spurred strong demand for directors' and officers' liability insurance (hereafter, D&O insurance). A typical D&O policy can protect applicant managers from the risk of shareholder litigation by covering losses that include compensatory damages, settlement amounts, and legal fees incurred in defense of claims arising as a result of the insured acting as directors or officers.

Information asymmetry is a major problem challenging the insurance industry (Rothschild and Stiglitz, 1976), including the D&O insurance. The literature has tried to provide evidence regarding adverse selection in this market, showing firms with higher chance to be involved with a securities-related litigation would purchase high D&O insurance coverage (e.g., see Chalmers et al. (2002), Lin et al.

* Corresponding author at: Department of Risk Management and Insurance, National Chengchi University, 64 Zhinan Road, Section 2, Wenshan District, Taipei City 116, Taiwan, ROC.
E-mail addresses: vjeng@nccu.edu.tw (V. Jeng), jwwang@nccu.edu.tw (C.-W. Wang), csyue@nccu.edu.tw (J.C. Yue).

[1] See https://www.cornerstone.com/Publications/Reports/Securities-Class-Action-Settlements-2018-Review-and-Analysis.

https://doi.org/10.1016/j.pacfin.2021.101560
Received 4 April 2020; Received in revised form 15 April 2021; Accepted 22 April 2021
Available online 25 May 2021
0927-538X/© 2021 Elsevier B.V. All rights reserved.

Please cite this article as: Rachel J. Huang, *Pacific-Basin Finance Journal*, https://doi.org/10.1016/j.pacfin.2021.101560

(2011) and Gillan and Panasian (2015)). Yet, the focus of the literature is on the U.S. or Canada markets rather than the markets in the Pacific-Asia, while the characteristics regarding litigation and D&O insurance between these two areas are quite different. For example, almost all of the public firms in the U.S. and Canada are covered by the D&O insurance, whereas the market in the Pacific-Asia is at its developing period.[2] In addition, the legal systems in most countries in Pacific-Asia are based on civil law but the U.S. and Canada follow common law.[3] The chance for investors to successfully sue the firms can be altered by different legal systems. This paper aims at fulfilling the gap.

In this paper, we manually collect data on D&O insurance purchases and actual litigation events for all publicly-listed firms in Taiwan from 2008 to 2018. We examine the market in Taiwan due to the following reasons. First, as in most countries in the Pacific-Asian area, D&O market in Taiwan is less developed than in the U.S. and Canada. In Taiwan, the first D&O policy was not locally sold until 2002, yet the market share has grown from 49.1% in 2008 to 82.2% in 2018. Second, the regulation in Taiwan provides an ideal research environment to examine the D&O insurance market. In an attempt to increase the overall transparency and accountability of the market, starting from 2008, the Financial Supervisory Commission (FSC) in Taiwan required all publicly-traded firms to disclose their D&O insurance purchase mandatorily. This makes the Taiwanese market one of the only two in the world (with Canada) that need to do mandatory disclosure and the only one in Asia-Pacific countries.[4] The FSC also required such firms to report all available information on litigation events.[5]

Third, as the majority in Asia, the legal system in Taiwan is based on civil law. Whether the investors successfully pursue a lawsuit can be examined through our litigation event data. Using data from Taiwan thus could help us to understand the differences in behaviors of corporate managers who purchase insurance and who do not.

To detect adverse selection in the D&O insurance market, empirical researchers typically construct their tests based on Rothschild and Stiglitz (1976) in the sense that, in case customers are heterogeneous in risk type only and the risk type is hidden information to the insurance companies, then a high risk type purchases high coverage, and a positive risk-coverage relationship, i.e. adverse selection is observed under asymmetric information. After Rothschild and Stiglitz (1976), numerous researchers proposed that in addition to risk type, other characteristics may also be candidates of hidden private information for insurers, for instance, risk preferences (Smart, 2000; Liu and Browne, 2007) and the intention of making efforts to reduce risk (de Meza and Webb, 2001; Sonnenholzner and Wambach, 2009; Wang et al., 2009).[6]

Wang et al. (2009) focus on commercial fire insurance market, and they suggest that the role played by risk preferences and intention of making efforts is as follows: Firms which are more aware of risk aversion purchase insurance, and these firms have a greater tendency to make efforts to reduce risks by installing fire safety equipment. It is also found that these firms are less likely to suffer a fire accident. Therefore, these policyholders exhibit low risk, but demand higher level of coverage. In addition, buying more insurance may subject oneself to insurers' monitoring. As Holderness (1990) and Boyer and Stern (2014) provide evidences on the monitoring effect of D&O insurance, compared with the uninsured firms, the risk of the insured firms may be reduced. The arguments above suggest that a negative risk-coverage relationship exists, and advantageous selection is thus observed. Xiao and Tao (2021) examines the scope of consumer finance and reviews the empirical literatures on advantageous selection in the consumer level.

We argue that in the corporate level such hidden information could be associated with firm size and book-to-market (B/M) ratio of the insured firms. Documented by the abundant literatures in finance, size and B/M ratios are the two prominent firm attributes focused by researches in terms of stock performance. Here we show how past literatures suggest size and B/M are related to the intangible information of a firm, e.g., risk preferences and the intention to reduce litigation risk.

Regarding the relationship between firm size and risk preferences, the literature has proposed that firm size negatively correlates with managers' risk aversion (Walls and Dyer, 1996). Decreasing absolute risk aversion is commonly assumed in the literature. Large firms usually pay higher salaries to directors and officers and thus their managers would be less risk-averse and would demand less D&O insurance. Firm size is also related to the intention of making efforts to reduce risk. According to Prendergast (2002) and Mildonis and Stathopoulos (2014), in a principal-agent relationship, stockholders as principal may delegate responsibilities to agents (the managers), making the managers to have higher incentive to reduce risk. A firm with higher earnings volatility thus provides incentives for managers to reduce firm risk. As Gharghori et al. (2009) suggested that small firms have higher default risk, small firms could have higher incentives to reduce litigation risk.

The literature also provides evidence on B/M being related to managers' intention of reducing litigation risk. Here we first explain how B/M contains intangible information. Daniel and Titman (2006) suggest that B/M proxies for the intangible information inside the

[2] For example, the D&O market in countries like China is covered at less than 50%.

[3] In Canada, only Quebec follows civil law.

[4] The regulatory authority in Korea used to require mandatory disclosure for D&O information but has stopped that since 2008.

[5] Note that we collect litigation events rather than actual claim records. The claim records provided by insurance companies may underestimate the risk due to deductible design and the long-tailed nature of the risk. Specifically, for those firms whose managers do not purchase insurance, which happen to be the situation in Pacific-Asia area, we cannot tell their litigation risks by the presence of claim records. The litigation event records in this paper are relatively reliable for estimating the litigation risks.

[6] The intention of making efforts to reduce risk might be due to different reasons, such as risk aversion, wealth, overconfidence, or patience.

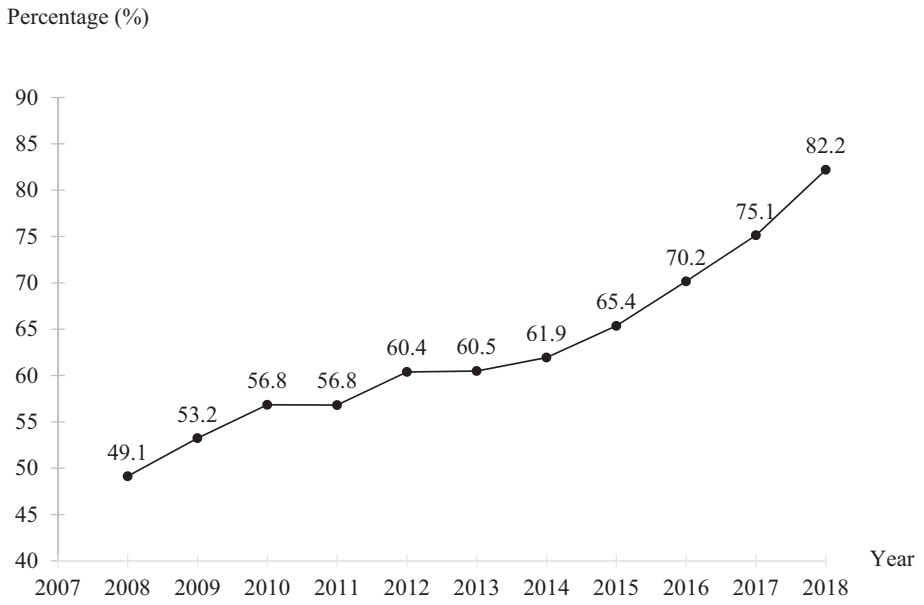


Fig. 1. The market share of D&O insurance in Taiwan in 2008–2018.

firm and results in high returns of the high BM firms. By decomposing future returns of a firm into the accounting-based component and future-signaling component, Daniel and Titman (2006) suggest that the future returns of high BM firms are unrelated to the former component, i.e. the tangible information, but related to the latter component, i.e. the intangible information. Specifically, the intangible returns are obtained from the portion that cannot be explained by fundamental accounting variables.[7] Consistent with Daniel and Titman (2006), our paper suggests that B/M contain intangible information about managerial incentives of reducing litigation risk.

Young firms, typically empowered with more growth opportunities while equipped with less developed internal legal protection, are lower in B/M and face more litigation troubles. Tsui et al. (2001) suggest that the internal monitoring mechanism is less effective in growth firms, which may increase audit effort and thus result in higher audit fees. As growth firms are by nature more difficult to value than the assets in place, these firms thus have higher earnings volatility than value firms. In addition, as cash flows are expected to follow earnings, high earnings volatility could lead to high cash flow volatility. Volatile cash flows can increase litigation risk by increasing the risk of business failure. In this way, earnings volatility may result in higher litigation risk (Bryan and Mason, 2020). As higher earnings volatility provides incentives for managers to reduce firm risk (He et al., 2014), growth firms could have higher incentives to reduce litigation risk.

To clarify the hidden information associated with market equilibrium, we specifically classify our sample firms according to their firm size and B/M. We follow the well-established methodology proposed by Chiappori and Salanié (2000) to examine asymmetric information.[8] Their approach is a reduced form approach rather than a structured form: loss probability and coverage are first separately estimated by public information from two probit regressions. Since risk type is unobservable, they suggest to use the residual of the estimated loss probability as the proxy of risk type. The residual of the estimated insurance coverage could be viewed as the coverage level affected by intangible information. They proposed that whether adverse selection or advantageous selection exist depends on the correlation between these two residuals. If the conditional correlation is positive (negative), then it suggests evidence of adverse (advantageous) selection. To see how these correlations vary with size and B/M, we examine the correlation between coverage and risk in each of the 5×5 portfolios categorized by size and B/M.

We find that the correlation between these two residuals is significantly negative within the group of small and low B/M firms. In other words, within this group, advantageous selection exists. We find our results to be robust when excluding the financial crisis effect, adjusting for industry and yearly levels, using alternative two-stage methods, and changing the definition of litigation events. In addition, we further find that the correlation is insignificantly different from in the overall market.

The remainder of this paper is organized as follows. Section 2 provides an overview of the D&O liability insurance market in

[7] BM can be decomposed into the part that is related to past accounting measures and the part orthogonal to them. Daniel and Titman (2006) define the first part as tangible information, and they define the intangible information as the residual of a model which regresses multi-year returns on the accounting growth measures mentioned above. By examining how the tangible and intangible information are related to the stock returns, they show that the returns are explained by intangible information but not the tangible one.

[8] Many empirical studies have adopted this methodology, such as Fang et al. (2008). We explain more about the development of the different methodologies in Section 4.

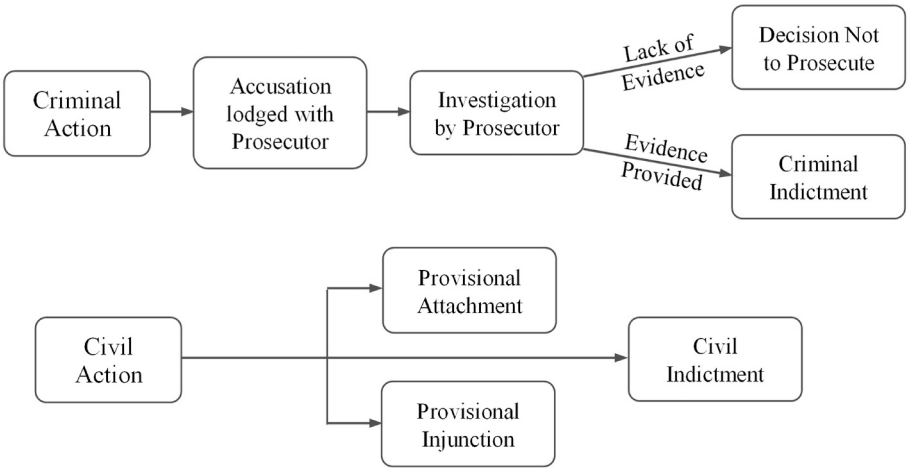


Fig. 2. Legal system in Taiwan.

Taiwan. Section 3 develops our hypotheses. Section 4 introduces the dataset and the methodologies. Section 5 presents the descriptive statistics and the main results. Section 6 checks the robustness of the results and Section 7 concludes.

2. Overview of the legal system and D&O insurance in Taiwan

This section first introduces the D&O insurance market in Taiwan in recent years as the market has gone through some changes in our sample period from 2008 to 2018. We then introduce the protection and compensation provided by D&O liability insurance along with the legal system adopted in Taiwan.

2.1. D&O insurance market in Taiwan

The D&O insurance market in Asia has seen some substantial changes in th.e past two decades. While the market shares of D&O insurance in regional financial centers such as Hong Kong and Singapore hit 60%–70% as early as 2010, the market shares in the rest of Asia exhibited wide diversity, as the share has ranged from 30% to 50%. In Taiwan, starting from 2008, the Financial Supervisory Commission (FSC) required all publicly-traded firms to report the annual amount of D&O insurance purchased before January 15 of the following year.[9] The market has grown steadily since then as the awareness of corporate governance has also increased over the years.

Starting in 2019, one year after our sample ends, all publicly-traded firms are mandatorily required to purchase D&O insurance according to FSC regulations. Fig. 1 presents the market shares of the D&O insurance market in our sample period 2008–2018. The D&O market share was 49.1% for all firms in 2008 and increased steadily to 61.9% in 2014. It then started to grow substantially after 2015 and reached 82.2% in 2018, the year in which the sample period ends.[10]

2.2. Legal system in Taiwan

The legal system in Taiwan is based on civil law, which is different from the legal systems in the U.S. or the U.K. As common-law countries like U.S. or U.K. generally have the stronger legal protection of investors (La Porta et al., 1997, 1998), it is worthwhile to examine whether such difference with civil law countries results in differences in litigation risk and in compensation on directors and officers. However, in a way that is similar to that in the case of the U.S. legal system, plaintiffs can pursue a lawsuit through either a criminal or civil action. Fig. 2 illustrates the processes involved in criminal or civil actions related to the directors or officers of a firm in Taiwan. It reveals that shareholders/stakeholders may submit a case to the prosecutor if they believe that the accused party has been involved in any fraudulent offense or action to do with a breach of trust. Any such submission by shareholders/stakeholders gives rise to an investigation, which is then carried out by the prosecutor. If the prosecutor is unable to find any evidence of an offense or breach of trust, then the company defendant will not be prosecuted. However, if the prosecutor does find clear evidence of such an offense or breach, then the defendant will face a criminal indictment, will subsequently stand trial, and may ultimately be found guilty of fraud.

[9] The example of a firm's complete D&O purchase information is provided as follows: January 14, 2018: firm ABC, insured party: all directors, supervisors and important officers, coverage amount: US$10 million (NT$296 million), period: 2017/6/27–2018/6/27, condition: renewal, insurer: AIG & Chubb.

[10] Similar to the global D&O insurance market, the D&O market in Taiwan is an oligopolistic one and is mainly underwritten by four international companies - AIG, Ace/Chubb, XLCatlin, and Tokio Marine U.S. - with a combined market share of 80%.

Shareholders/stakeholders may also pursue a civil action against the company defendant leading to a civil indictment. The defendant will then face trial as a result of this indictment, with the outcome being decided by a judge. If the judge decides that the company defendant is innocent, then the defendant will be free of all liability. Conversely, if found guilty, then the director or officer will be held personally liable for payment of compensation for the defined losses of the plaintiff shareholder.[11]

In most cases, plaintiffs will prefer to pursue their lawsuit through a criminal action since they are not required to present proof or evidence, as this is clearly the duty of the prosecutor when carrying out the investigation. Similar to the U.S. legal system, criminal sanctions are an effective means of indicating the amount of civil compensation to be awarded; that is to say, the settlement amount of the compensation for civil liability will be based upon the result of the criminal action.

Similar to most countries, D&O insurance in Taiwan covers different types of losses or litigation events. First, the insurers will pay all legal representation expenses and defense costs on behalf of the insured party in respect of any criminal investigation, with the exclusion of any dishonest or fraudulent act of an insured firm or an intentional breach of the law if this is identified in the criminal action. Second, following the result of the criminal/civil indictment, the insurer will pay the related losses, including any judgments entered, damages awarded, or civil compensation settlements reached. In other words, regardless of whether the action pursued is criminal or civil, the purchase of D&O insurance indemnifies directors and officers from various actions.

3. Hypotheses development

Our paper assumes that in a perfectly competitive insurance market, the risk type, risk aversion level and the intention to reduce risk are all hidden information. Past literatures such as Wang et al. (2009) show that by focusing on the commercial fire insurance market, there is a group of firms that is more aware of risk aversion. This group also purchases more fire insurance. As this group is more risk averse, it has a greater tendency to make efforts to reduce risks by installing fire safety equipment. As a result, this group of firms exhibit low risk, but demand higher level of coverage. Advantageous selection thereby could be observed.

We suggest that by categorizing the sample by size or B/M, advantageous selection could be observed in our subsample. We follow Wang et al. (2009) and state our hypotheses as follows. Let's discuss the effect of size first. If small size firms are more risk averse as suggested by Walls and Dyer (1996), they tend to buy more insurance. In addition, Prendergast (2002) and Gharghori et al. (2009) suggest that small firms are with higher earnings volatility and thus are more willing to reduce risk. Thus, our model would suggest a negative correlation between D&O insurance and risk type in the group of small size firms. This gives us the first hypothesis:

Hypothesis 1. Among small firms, the correlation between coverage and claim is negative.

Regarding B/M, as the growth firms are more risk averse as suggested by Brenner (2015) and are with higher earnings volatility and thus are more willing to reduce risk according to Bryan and Mason (2020) and He et al. (2014), we expect to find a negative correlation between coverage and risk in the group of firms with low B/M. This is our final hypothesis:

Hypothesis 2. Among low B/M firms, the correlation between coverage and claim is negative.

As the phenomenon of advantageous selection only exists in subsamples when we categorize the sample by size or B/M, it is difficult to observe advantageous selection if the sample include all types. This is our third hypothesis:

Hypothesis 3. In the overall D&O insurance market, the correlation between coverage and claim is insignificantly different from zero.

We also establish a model to support our hypothesis. We intend to show that by categorizing the sample into different subgroups, either advantageous selection or adverse selection or both may exist. In other words, separating contracts are in equilibrium. While the risk type and the risk aversion level are hidden information and could be either high or low, we specifically assume that agents with high degree of risk aversion would have a higher intention to reduce risk and thus become low risk type. In this sense, three types of agents exist in the market, and our model shows that by comparing the contracts offered to different types, the separating equilibrium exists and advantageous selection can be observed.[12] The details and the derivation of the model are shown in Appendix 1.

4. Data and methodology

4.1. Data selection

The data used in this study are obtained from two sources. The first is the Market Observation Post System (MOPS), which provides

[11] Shareholders may also protect their rights by appealing against a *provisional attachment* or *provisional injunction* to the court. We explain this in the section on the robustness check.

[12] Literatures such as Smart (2000) studied the market equilibrium when there are four types of policyholders according to their loss probability and the degree of risk aversion. Under actuarially fair premium assumption, Smart (2000) found that the high risk and high risk averse agents receive the highest coverage (adverse selection). We consider unfair premium in this paper, and by assuming that agents with high degree of risk aversion would have a higher intention to reduce risk, we find that the market could settle on both adverse and advantageous selection. More discussions on these differences are explained in Appendix 1.

information on both D&O insurance purchases and litigation events. All data on D&O insurance purchases[13] and litigation events related to the conduct of directors or officers in all of the publicly-traded firms over our sample period were manually collected from the MOPS website.[14]

Our second data source is the Taiwan Economic Journal (TEJ), which compiles the financial statements of all publicly-traded firms listed on the Taiwan Stock Exchange (TSE). The data collected include corporate governance variables, such as the size of the board of directors, the voting rights of the controlling shareholders, and the number of independent directors on the board. We also collected data on financial variables including the book-to-market (*B/M*) ratio, firm size (*Size*), and return on assets (*ROA*), as well as other variables, all of which are explained in the variable description section. Both TSE firms and 'over-the-counter' (OTC) firms are included in our sample.[15]

The data period for this study runs from 2008 to 2018, with the original sample comprising a total of 15.328 firms. Extreme values such as observations with negative equity (seven observations) or those with returns on assets of −200% or worse (eight observations) are excluded from our sample. Our resulting five-year sample comprises 15,313 firms.

4.2. Methodology

We adopt the methodology proposed by Chiappori and Salanié (1997, 2000) which follows a reduced form approach since it is one of the most widely-used tests for asymmetric information.[16,17] The risk probability and the demand for insurance are estimated separately based on public information. The degree of asymmetric information is estimated by the correlation between the residuals of these two equations.[18]

Specifically, let the two variables of interest be denoted by Y_j, j = 1, 2, as the respective demand for D&O insurance and litigation risk:

$$\begin{aligned} Y_{1i}^{*} &= X_i\beta_1 + \varepsilon_{1i} \\ Y_{2i}^{*} &= X_i\beta_2 + \varepsilon_{2i} \end{aligned} \tag{1}$$

where the X_i are the independent variables, and the Y_j*, whicare unobservable, are related to the binary dependent variable Y_j based on the following definition[19]:

$$\begin{aligned} Y_j = 1, Y_j^{*} > 0 \; for \; j = 1, 2 \\ 0, Y_j^{*} \leq 0 \end{aligned} \tag{2}$$

Under the null of symmetric information, the residuals, ε_1 and ε_2, should be uncorrelated; otherwise, a statistically significant correlation between the two equations effectively rejects the null hypothesis. In order to determine the existence of any correlation

[13] The MOPS provides insurance coverage only, and so premiums are not available.

[14] All of the related information on litigation events involving the directors or officers of a firm is required to be reported within the MOPS, as set up by TSE; one example, exactly as shown in the MOPS, is provided here. October 1, 2009: "After the prosecutor executed the investigation, the directors and officers of firm XYZ, accused of hollowing out the company's assets in 2008, have been criminally indicted on the charge of violating the Securities Exchange Act in Taiwan". December 5, 2011: "The court convicted the directors and officers of firm XYZ in the first instance and sentenced them to imprisonment for three years". In such cases, the litigation dummy for the firm would be assigned a value of 1 in 2008, whereas it would be assigned a value of 0 in the remaining sample years.

[15] As the required information transparency in the OTC market in Taiwan is less strict than for the TSE, we further separated our sample into these two groups to examine whether the issue of asymmetric information in the OTC market differs from that on the TSE. However, no significant differences are found between the two markets.

[16] Another popular way is proposed by Puelz and Snow (1994) whose method follows a structural form approach. They suggested using a two-stage model, i.e., estimating the risk type at the first stage and then estimating the demand for insurance at the second stage by controlling the risk type. Dionne et al. (2001) further revised Puelz and Snow (1994)'s method by adding a non-linear relationship between the risk type and the demand for insurance.

[17] There are several papers using the approach proposed by Chiappori and Salanié (1997, 2000) to test for asymmetric information and the evidence is mixed for different insurance markets. For example, the decision to purchase insurance coverage is found to be positively correlated with the probability of claims in both the annuity market (Finkelstein and Poterba, 2004) and the health insurance market (Cardon and Hendel, 2001), which is consistent with the predictions of either adverse selection or moral hazard. Conversely, however, negative correlations have been identified between insurance coverage and the probability of claims in the life insurance market (Cawley and Philipson, 1999; McCarthy and Mitchell, 2010), long-term care insurance market (Finkelstein and McGarry, 2006), medical insurance market (Hurd and McGarry, 1997; Fang et al., 2008), reverse mortgage market (Davidoff and Welke, 2004), and commercial fire insurance market (Wang et al., 2009). Cohen and Siegelman (2010) provided a comprehensive review of the prior empirical literature on adverse selection in the insurance markets, by specifically focusing on the basic correlation between coverage and risk.

[18] Taking into account that estimating two probit models independently is appropriate in the absence of conditional independence between the dependent variables, we also estimate a bivariate probit model. Our analysis reveals that the results of the bivariate probit model are not found to be materially different from the results estimated from the two probit models.

[19] It is likely that the time lag effect may exist in our model; for example, future lawsuit events may be due to current independent variables such as financial performance. Therefore, we also use the lagged value of the independent variables in our model as a robustness check, but our results remain similar.

Table 1
Description of variables.

Variable	Description
D&O	Takes a value of 1 if the firm purchases D&O insurance; otherwise, 0.
Litigation	Takes a value of 1 if a director or officer of a firm was involved in misconduct in the specific sample year and the firm was subsequently involved in a litigation event; otherwise, 0.
Coverage	The total coverage amount of D&O insurance purchased in NT$ million.
CRatio	Coverage ratio, which refers to the coverage amount of D&O insurance divided by the market equity of the firm.
CRatio_Z	Takes a value of 1 if the coverage ratio (CRatio) of a firm is higher than the X^{th} sample quartile; otherwise, 0.
B/M	Book-to-market ratio, which is equal to the book value of equity divided by the market value of equity.
Size	Firm size, which is the natural logarithm of the market value of equity.
Voting	The proportion of the total voting rights in the firm owned by its controlling shareholders (following La Porta et al., 2002). This is measured by combining the direct voting rights in the firm (through shares registered in the shareholders' names) and indirect voting rights in the firm (through shares held by entities that, in turn, the shareholders control).
Ind	The proportion of independent directors on the board.
Boardsize	Number of members on the board of directors.
TobinQ	Tobin's Q, which is equal to the sum of the market value of the firm's equity, plus the book value of its liabilities, divided by the book value of total assets.
Lev	Leverage ratio, which is total debt divided by the sum of (market value of equity, plus book value of preferred stock, plus book value of debt).
ROA	Return on assets, which is net income divided by total assets.
Age	The age of the firm.
Investment	Sum of new purchases of property, plant and equipment (PPE) and expenditure on research and development, less the disposal of property, plant and equipment (PPE) in the following year, scaled by average total assets.

between the residuals, we first estimate the probit models independently and then proceed to compute the generalized residuals $\widehat{\varepsilon_1}$ and $\widehat{\varepsilon_2}$:

$$\widehat{\varepsilon_{1i}} = E(\varepsilon_{1i}|Y_{1i}) = \frac{\varnothing(X_i\beta_1)}{\Phi(X_i\beta_1)}Y_{1i} - (1 - Y_{1i}) \cdot \frac{\varnothing(X_i\beta_1)}{\Phi(-X_i\beta_1)} \tag{3}$$

$$\widehat{\varepsilon_{2i}} = E(\varepsilon_{2i}|Y_{2i}) = \frac{\varnothing(X_i\beta_2)}{\Phi(X_i\beta_2)}Y_{2i} - (1 - Y_{2i}) \cdot \frac{\varnothing(X_i\beta_2)}{\Phi(-X_i\beta_2)} \tag{4}$$

where ϕ and Φ specify the density and the cumulative distribution function of N(0,1). The W-test statistics are defined as:

$$W = \frac{\left(\sum_{i=1}^{n} \widehat{\varepsilon_{1i}}\widehat{\varepsilon_{2i}}\right)^2}{\sum_{i=1}^{n} \widehat{\varepsilon_{1i}}^2\widehat{\varepsilon_{2i}}^2} \tag{5}$$

Under the null of conditional independence between the two selected variables, $\mathrm{cov}(\varepsilon_{1i}, \varepsilon_{2i}) = 0$, W is distributed asymptotically as $\chi^2_{(1)}$. A statistically significant coefficient implies that the decision to purchase D&O insurance is correlated with litigation events, thereby confirming the existence of asymmetric information in the D&O insurance market. In specific terms, a positive coefficient indicates that those firms purchasing D&O insurance are more likely to be involved in litigation events, thereby providing evidence of moral hazard or adverse selection, while a negative coefficient provides evidence of advantageous selection.

To examine the conditional correlation for all publicly-listed firms, the sample firms are further classified according to their size and B/M. Fama and French (1993) use 5 × 5 portfolios to examine the stock returns of each sample group. We follow their method and examine the correlation coefficient between litigation risk and the probability of purchasing D&O insurance in each sample. The 5 × 5 portfolio gives a simple picture of the two-dimensional variation in correlation coefficients that results when the five size samples are each subdivided into five portfolios based on ranked values of the B/M for individual firms. The correlation coefficient between risk and the insurance purchased is then calculated for each of the twenty-five portfolios.

Our main focus is to analyze the relationship between the probability of facing litigation events and the probability of having D&O insurance. For the sample including insured and non-insured firms, the two binary variables of interest, Y_1 and Y_2, are respectively defined as *D&O* and *Litigation*. *D&O* is a dummy variable that takes a value of 1 if the sample firm engages in D&O insurance purchases; otherwise, it takes a value of 0. *Litigation* is a proxy for the type of litigation risk. It is a dummy variable that takes a value of 1 if the firm has any occurrences of misconduct related to its directors or officers in the specific sample year and subsequently goes through a litigation event; otherwise, its value is 0. Since our data include multiple years, the yearly fixed-effects model is considered. The industries in which our sample is located may also affect the risk and D&O decision of the firm.[20] We thus consider industry effects in our

[20] For example, the electronics industry accounts for 70% of the market capitalization of all publicly-traded firms. Firms in highly-regulated industries may also perform differently from industrial firms.

Table 2
Descriptive statistics.

Variable	Mean	Std. Dev.	Q1	Median	Q3
D&O (1/0)	0.64	0.48	0	1	1
Litigation (1/0)	0.0177	0.13	0	0	0
Coverage ($M)	161.13	338.22	0	87.39	164.13
CRatio (%)	5.55	14.89	0	1.31	5.38
B/M	0.88	0.55	0.50	0.77	1.14
Size	15.05	1.47	14.02	14.88	15.88
Voting (%)	30.63	18.55	15.33	28.21	43.13
Ind (%)	23.95	16.72	0	28.57	40.00
Boardsize	9.35	2.34	8	9	10
TobinQ	1.47	1.17	0.94	1.16	1.61
Lev (%)	32.18	20.98	15.47	28.38	45.38
ROA (%)	2.85	12.10	0.27	3.86	8.19
Age	28.72	13.35	19	27	38
Investment	6.26	8.01	1.84	4.86	9.12
N	15,313				

analysis as well.[21] To save space, the independent variables used in the models are provided in the Appendix section and Table 1 summarizes the descriptions of all the variables.

The litigation events examined in our study are specifically defined as follows. A sample firm is denoted as being involved in a litigation event if any directors or officers of the firm are found to have been involved in occurrences of misconduct related to the specific sample year, which subsequently results in the firm being involved in a litigation event. The definition for firms being involved in litigation events in our main analysis is that the directors or officers of the firms are involved in an indictment disclosed in material information, with both civil and criminal indictments related to directors or officers being included.[22]

In addition, we also study the relationship between the probability of facing litigation events and the probability of purchasing a higher level of D&O insurance for the insured firms in each sample group. Following past D&O studies such as Lin et al. (2011), we calculate the coverage ratio (*CRatio*), which equals the coverage amount of D&O insurance divided by the market equity of the firm. A dummy variable (*CRatio_Z*) is used and equals 1 when the *CRatio* of a firm is higher than the sample's Z^{th} percentile; otherwise, it equals 0. We then use *CRatio_*Z as Y_1 in the first equation of our model to replace the previous dependent variable, *D&O*.[23]

5. Results

5.1. Descriptive statistics

Table 2 provides the descriptive statistics of the variables used in our study. The average *D&O* is 0.64, thereby implying that approximately 64% of all publicly-traded firms in Taiwan have purchased D&O liability insurance. The *Litigation* results show that 1.77% of the firms have been involved in litigation issues - that is, from the sample of 15,313 firms, there is a total of 271 events. The firms are found to have purchased an average of NT$161.13 million (US$5.4 million) in D&O insurance coverage, with the largest amount being that for TSMC, the leading high-tech electronics firm in Taiwan, at NT$6.57 billion (US$219 million).

The average *B/M* for the firms is 0.88 with a median value of 0.77, while the average value of *Size* (the natural logarithm of the market value of equity) is 15.05. Moreover, 23.95% of all board members are independent directors, and the average leverage of the firms is found to be 32.18%. The average profitability measure (*ROA*) is 2.85%, and the sample firms have an average firm age of 28.72 years.[24]

Table 3 compares the average values of the variables in the alternative groups. Panel A of Table 3 shows the results of the overall sample, and the left-hand columns compare the average values between firms purchasing D&O insurance and those firms that do not. The right-hand columns compare the values between those firms that are involved in litigation events and those that are not. As the

[21] The performance of highly-regulated firms (specifically those in the banking, insurance, and securities industries) may differ markedly from that of industrial firms in aspects such as their D&O insurance purchase amount; however, the results remain similar after excluding these highly-regulated firms from our sample.

[22] Both indictments are included since a firm's directors or officers may be liable for any losses incurred by shareholders/stakeholders, regardless of whether the litigation is pursued through a civil or criminal action. We further test different scopes of the litigation events in the section entitled 'Checks for Robustness'.

[23] If the correlation coefficient is found to be significantly positive, then this implies that firms for which insurance coverage is higher than *Z*% tend to be subsequently involved in more litigation events, thereby indicating asymmetric information, while those firms with coverage lower than *Z*% are inclined to be associated with lower risk.

[24] In order to avoid the potential problem of multicollinearity, we consider the correlations between all of the variables by presenting a correlation coefficient matrix in Appendix Table 1. Given that the correlations between variables are all lower than 0.7 with the highest equal to −0.51, the issue of collinearity should not be a major concern in the present study. We also run the multicollinearity test and calculate the VIF values of all explanatory variables. None of the values exceeds 10 for any of the explanatory variables, suggesting that collinearity may not be a problem.

Table 3
Average values of the variables in the alternative groups.

Variable	*D&O*				*Litigation*			
	=0	=1	Diff		=0	=1	Diff	
Panel A: Overall Sample								
D&O (1/0)					0.64	0.59	0.05	*
Litigation (1/0)	0.02	0.016	0.004	**				
N	5513	9800			15,042	271		
Panel B: Sample Categorized by B/M								
B/M < 50%								
D&O (1/0)					0.67	0.55	0.12	**
Litigation (1/0)	0.022	0.013	0.008	**				
N	2550	5107			7534	123		
B/M > 50%								
D&O (1/0)					0.61	0.62	−0.01	
Litigation (1/0)	0.019	0.0196	−0.06					
N	2963	4693			7508	148		
Panel C: Sample Categorized by Size								
Size < 50%								
D&O (1/0)					0.58	0.50	0.08	**
Litigation (1/0)	0.024	0.017	0.007	***				
N	3220	4437			7505	152		
Size > 50%								
D&O (1/0)					0.70	0.71	−0.01	
Litigation (1/0)	0.0153	0.0157	−0.0004					
N	2293	5363			7537	119		

This table reports the results of a comparison between the average values of the variables in the alternative groups, along with a test of their differences. The left-hand columns compare the variables, which are dependent upon whether or not firms purchase D&O insurance, while the right-hand side columns compare the variables that are dependent upon whether or not firms are involved in litigation events. Panel A reports the results of the overall sample, and Panels B and C report the results of samples categorized by the B/M and size, respectively. The sample period runs from 2008 to 2018, with the sample comprising a total of 15,313 firms. The data are obtained from the Taiwan Economic Journal (TEJ) and the Market Observation Post System (MOPS) of Taiwan. The statistical difference for the *Litigation* variable is not calculated in the left-hand columns, and the differences for the *D&O* and *Coverage* variables are not calculated in the right-hand columns. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

Table 4
Correlation coefficients of probit regression residuals categorized by B/M and size.

Size (ME)	*Book-to-market equity (BE/ME)*						
	Low		*2*		*3*	*4*	*High*
Small	−0.0454	**	−0.0418	**	0.0204	0.0132	0.0214
	(4.2353)		(4.6606)		(0.6144)	(0.1236)	(0.3214)
2	−0.0152		−0.0015		−0.0195	0.0233	0.0019
	(1.0558)		(0.0036)		(0.1353)	(0.9512)	(1.2584)
3	0.0142		−0.0185		−0.0019	0.0154	0.0178
	(0.3266)		(0.4548)		(0.025)	(1.3574)	(0.9851)
4	−0.0147		0.0006		0.0104	0.0021	0.0063
	(0.4398)		(1.0369)		(1.9638)	(1.0258)	(1.3214)
Big	0.0043		0.0032		0.0068	0.0109	0.0168
	(1.5236)		(2.3654)		(3.2014)	(0.3214)	(1.3254)
All	−0.0319	*	−0.014		0.0105	0.0116	0.0036
	(2.8717)		(0.2187)		(0.9877)	(0.9876)	(0.9631)

This table reports the correlation coefficients of the probit regression residuals categorized by the book-to-market ratio and firm size. The results between purchase/non-purchase decisions and whether or not the firm was subsequently involved in litigation are reported. The sample comprises a total of 15,313 firms, with the sample period running from 2008 to 2018. Following the procedure used by Fama and French (1993), we form the 5×5 size-B/M portfolios by the intersection of size and the B/M. W-test statistics are reported in the parentheses and are distributed asymptotically as $\chi^2_{(1)}$. The independent variables included in the probit models consist of governance variables, financial variables, and others. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

table shows, the proportions of firms involved in litigation events between firms not purchasing D&O insurance and those firms that do purchase it are found to be significantly different at the 5% level (2.01% vs. 1.63%). We also find the proportion of firms purchasing D&O insurance to be significantly higher for firms not involved in litigation events than for firms that are involved in such events (0.64 vs. 0.59). In other words, our summary statistics in Table 3 show that the risk-coverage relationship seems to be significantly negative for the overall market.

Table 5
Results of correlation coefficients: Relationship between D&O insurance coverage and litigation risk.

Size (ME)	*Book-to-market equity (BE/ME)*					
	Low	*2*	*3*	*4*	*High*	*All*
Panel A: Correlation of regression residuals between CRatio_25 and Litigation						
Small	−0.0219	0.0123	0.0011	0.0123	0.0046	0.0232
	(0.5712)	(0.5921)	(0.1593)	(0.3589)	(0.9631)	(1.7618)
2	0.0122	−0.0274	0.0313	0.0081	0.0096	−0.022
	(0.1618)	(2.8131)	(1.0614)	(0.6241)	(0.2594)	(1.5825)
3	0.0207	0.0452	0.0180	0.0063	0.0106	0.0277
	(0.4665)	(2.2158)	(0.3532)	(0.3697)	(0.9513)	(2.432)
4	0.0241	0.0155	0.0176	0.0215	0.0078	0.0147
	(0.5412)	(0.9875)	(0.5741)	(0.3258)	(0.6547)	(0.9874)
Big	0.0167	0.0231	0.0152	0.0174	0.0180	0.0027
	(0.3574)	(0.3548)	(9568)	(1.0258)	(0.3219)	(0.3578)
All	0.0127	0.0188	0.0204	0.0158	0.0047	0.0158
	(0.5234)	(1.1545)	(1.3562)	(0.9547)	(0.1235)	(0.9457)
Panel B: Correlation of regression residuals between CRatio_75 and Litigation						
Small	0.0243	0.0121	0.0019	0.0011	0.0178	0.0238
	(0.7534)	(0.0046)	(0.5194)	(0.8521)	(0.3257)	(2.0068)
2	−0.0055	0.0069	0.0525	0.0270	0.0104	0.0008
	(0.0323)	(0.0518)	(2.9993)	(1.3695)	(0.5284)	(0.0102)
3	0.0192	−0.0309	−0.0133	0.0039	0.0171	0.0012
	(0.4000)	(1.0345)	(0.1933)	(0.2589)	(0.3236)	(0.0149)
4	0.0101	0.0174	0.0132	0.0013	0.0005	0.0085
	(0.6547)	(0.9852)	(0.3258)	(0.3247)	(0.1256)	(0.3251)
Big	0.0129	0.0054	0.0194	0.0201	0.0076	0.0072
	(0.9638)	(0.1563)	(0.9521)	(0.1596)	(0.3578)	(0.6569)
All	0.0073	0.0011	0.0284	0.0125	0.0049	0.0111
	(0.1728)	(0.0037)	(1.1626)	(0.3568)	(0.3698)	(1.1976)

This table reports the correlation coefficients of the probit regression residuals regarding the amount of D&O insurance coverage and litigation risk, including the correlations between the *CRratio_25*, *CRatio_*75, and *Litigation* regressions. The results are further categorized by the book-to-market ratio and firm size. Following the procedure used by Fama and French (1993), we form the 5 × 5 size-B/M portfolios by the intersection of size and the B/M. The sample comprises a total of 9800 firms, with the sample period running from 2008 to 2018. W-test statistics are reported in the parentheses and are distributed asymptotically as $\chi^2_{(1)}$. The independent variables included in the probit models consist of governance variables, financial variables, and others. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

To understand more about the asymmetric information issue in our sub-samples, we categorize firms by the B/M and by size and respectively report our results in Panels B and C in Table 3. The mean values of the coverage and control variables are in Appendix Table 2. The results in Panel B of Table 3 show that, within low *B/M* firms, the proportion of firms purchasing D&O insurance that are subsequently involved in litigation events is significantly lower (1.33% vs. 2.16%), while the proportion of firms involved in litigation is significantly lower for those purchasing insurance (0.55 vs. 0.67). However, similar results are not found within high *B/M* firms. This seems to provide evidence that a negative risk-coverage relationship (an implication of advantageous selection) exists only within low *B/M* firms. Similar situations are also found in Panel C of Table 3, which shows that a negative risk-coverage relationship exists within smaller-sized firms, but not within larger-sized firms.

5.2. Main results

Table 4 shows the correlation between the purchase/non-purchase insurance decision and litigation risk. We first categorize firms into five groups either according to size or according to B/M level. We also construct twenty-five portfolios from the intersections of the five size groups and the five B/M groups. For the sake of brevity, we tabulate only the correlation coefficients (ρ) for different groups that denote the conditional correlation between the decision to purchase D&O insurance and involvement in litigation events. The results of the probit models for firms in the overall market are in Panel A of Appendix Table 3 for reference.

Our results in Table 4 first show that when firms are categorized into five groups according to size, no significant relationship exists between insurance purchase and risk. However, our results show a significantly negative relationship ($\rho = -0.0497$) at the 5% level between purchase/non-purchase decisions and the occurrence of risk for firms in the smallest size and lowest B/M quintile. Similar results are found in the smallest size and second-lowest B/M quintile (a significantly negative relationship $\rho = -0.0318$ at the 5% level). When firms are categorized into five groups according to their B/M level, a significantly negative relationship ($\rho = -0.0319$) at the 10% level also appears in the lowest B/M group.

Table 6
Industry- and yearly-adjusted results of correlation coefficients categorized by B/M and size.

Size (ME)	*Book-to-market equity (BE/ME)*						
	Low		*2*		*3*	*4*	*High*
Panel A: Industry-Adjusted Results							
Small	−0.0424	**	−0.0589	***	0.0216	0.0184	0.0195
	(4.7009)		(6.6408)		(1.7477)	(0.5555)	(0.9632)
2	−0.0088		−0.0021		−0.0180	0.0204	0.0135
	(0.1327)		(0.0076)		(0.5535)	(0.3215)	(0.2145)
3	−0.0239		−0.0179		−0.0086	0.0107	0.0010
	(0.9703)		(0.5476)		(0.1267)	(0.4586)	(0.5548)
4	0.0309		0.0132		0.0022	0.0133	0.0018
	(0.5885)		(0.3214)		(0.2142)	(0.6599)	(0.5458)
Big	0.0242		0.0134		0.0039	0.0119	0.0126
	(0.2521)		(0.9638)		(0.9874)	(0.5415)	(0.5446)
All	−0.0274		−0.019		0.0221	0.0169	0.0132
	(2.2770)		(1.8421)		(2.8741)	(0.3659)	(0.6565)
Panel B:Yearly-Adjusted Results							
Small	−0.0459	**	−0.0604	***	0.0115	0.0118	0.0131
	(4.2443)		(5.5743)		(0.2706)	(0.9512)	(0.3645)
2	−0.0121		0.0125		0.0105	0.0032	0.0077
	(0.0843)		(0.2637)		(0.1857)	(0.3251)	(0.1555)
3	0.0004		−0.0271		0.0048	0.0171	0.0094
	(0.0004)		(2.6724)		(0.0390)	(0.3214)	(0.9855)
4	0.0026		0.0008		0.0124	0.0088	0.0147
	(0.2321)		(0.3252)		(0.9848)	(0.9658)	(0.3698)
Big	0.0093		0.0127		0.0142	0.0274	0.0199
	(0.9858)		(0.9874)		(0.5659)	(0.5498)	(0.2147)
All	−0.0367	**	−0.0157		0.0261	0.0187	0.0165
	(3.9624)		(1.2634)		(3.4671)	(0.2147)	(0.3214)

This table reports the industry- and yearly-adjusted correlation coefficients of the probit regression residuals categorized by the book-to-market ratio and firm size. The results between purchase/non-purchase decisions and whether or not the firm was subsequently involved in litigation are reported. The sample comprises a total of 15,313 firms, with the sample period running from 2008 to 2018. Following the procedure used by Fama and French (1993), we form the 5 × 5 size-B/M portfolios by the intersection of size and the B/M. Panel A shows the results of adjusting both the B/M and size variables by the industry level, and Panel B shows the results of adjusting both the B/M and size variables by the yearly level. W-test statistics are reported in parentheses and are distributed asymptotically as $\chi^2_{(1)}$. The independent variables included in the probit models consist of governance variables, financial variables, and others. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

Our results indicate that there is advantageous selection among the small firms. This evidence is consistent with our hypothesis 1 and also consistent with the finding of Walls and Dyer (1996) and Gharghori et al. (2009) in that managers in small firms are more risk-averse and have higher default risks and thus have higher intention to reduce risk. In addition, the evidence is consistent with our hypothesis 2 and also supports He et al. (2014) in that growth firms have a higher earnings volatility, making them more likely to reduce risk. In other words, in the group with small size and growth firms, the percentage of LH types in Fig. 1 is higher, and thus advantageous selection is found.[25]

Finally, when we analyze the overall market, the correlation coefficient for all firms is found to be 0.0019, which is not significantly different from zero. Our results are consistent with hypothesis 3 in that some low-risk type firms demand a higher level of coverage and some low-risk types demand a lower level of coverage compared to high-risk firms. Therefore, we observe a correlation that is insignificantly different from zero. Our results with a separating equilibrium are different from those in the previous literature such as Gillan and Panasian (2015) in that a significantly positive correlation between coverage and ex post claim frequency exists in the market for Canadian firms. The sample discussed in Gillan and Panasian (2015) covers only large firms in Canadian market. In contrast, D&O market in Taiwan in our sample period is still growing, and all the publicly traded firms in Taiwan, including both small and large firms, are included in our sample. This might explain why our results, specifically those among small and growth firms, are different from those in previous studies like Gillan and Panasian (2015).

Two important issues are summarized here. First, our results show that firm characteristics such as size and the B/M are not only associated with the stock returns of firms, but are also associated with the correlation between risk and insurance coverage. Specifically, among small firms, advantageous selection can be found in those firms with low B/M. However, such phenomenon may not be found in those firms with high B/M, making no significant relationship appears when small firms are examined as a whole. Second,

[25] Endogenous issues might arise in a way that firms that cannot hire managers who are risk-averse and care about risk management are unable to not enlarge their size and/or have a small B/M ratio. To test this endogeneity problem, we further classify firms according to their size and B/M in the previous year and test the conditional correlation in the current year. The main conclusion remains the same. We find in the S/L group that the correlation coefficient is −0.0475 with a *p*-value of 0.0693.

while adverse selection is found in the D&O insurance market as shown in previous studies such as Gillan and Panasian (2015), our paper is the first to observe that advantageous selection does exist in the D&O insurance market.

In taking the analysis further, Table 5 reports the correlations between the amount of D&O insurance coverage and involvement in litigation events (the results between the *CRatio_Z* and *Litigation* regressions) for the insured firms. All the insured firms are formed into 5 × 5 subsamples according to size and B/M, and Panels A and B of Table 5 present the results using the *CRatio_25* and *CRatio_75* regressions, respectively.[26] The results are presented for all subgroups, but only the coefficients between *CRatio_25* and *Litigation* for second-smallest size and second-lowest B/M are found to be significant at the 10% level. No other significant relationships appear elsewhere. In other words, while the correlation between the purchase/non-purchase decision and litigation risk exists in our sample, the correlation between the insurance amount and risk is not obvious for the insured firms. As the potential compensatory damages or settlement amounts in a lawsuit are usually smaller for civil law countries, our results indicate that the buy-or-not decision matters more than the amount of coverage when we examine the coverage-risk relationship in civil law countries like Taiwan.

6. Checks for robustness

This section investigates the robustness of our results in different ways. We first examine the results adjusted by either the yearly or industry level of the B/M and size variables. Next, all of our above results are based on correlation coefficients of residuals between the probability of D&O purchase and the probability of litigation regressions. Following the methods of Dionne et al. (2001), we use an alternative two-stage method to examine whether the relationship between risk and the insurance purchased still holds. Third, we redefine our sample period by excluding the effect of the 2008 financial crisis from the sample, and redefine our key variables by expanding the definition of litigation events in three alternative ways. Finally, as other factors such as the investment level may perform in ways similar to the B/M, we examine whether using the investment variable to replace the B/M affects the correlations of the probit regression residuals.

6.1. Industry- and yearly-adjusted results

Since the competition environment differs according to the industry and year, we adjust both the *size* and *B/M* variables by industry and by yearly level. The results are presented in Panels A and B of Table 6. The industry-adjusted results in Panel A remain similar to those shown in Table 5 in that a significantly negative relationship is found for firms in the smallest size with the lowest and second lowest B/M group. The significance level for the smallest size with the second-lowest B/M sample is at 1%. The yearly-adjusted results in Panel B also remain similar. In other words, our robustness check shows that advantageous selection exists among small firms with low B/M when industry- and yearly-effects are considered.

6.2. Two-stage regression analysis

Differing from Chiappori and Salanié (2000), Puelz and Snow (1994) in their seminal work use a two-stage regression model to verify the issue of asymmetric information. Dionne et al. (2001) further consider the nonlinearity feature of the risk variable in Puelz and Snow's first equation and introduce the predicted value of the risk variable in Puelz and Snow's second equation. Following Dionne et al. (2001) and Gao et al. (2017), we consider all the factors affecting the D&O insurance purchase as our first equation. In our second equation, the probit model is examined when the dependent variable is *Litigation* and the key independent variable is *D&O*. Following Dionne et al. (2001), we introduce the variable Eˆ(D&O) in our second equation, which is acquired from the first equation and denotes the estimated probability that a firm will purchase insurance given all the information available.

Our first equation is similar to the D&O demand equation shown in Eq. (1). The results of the first equation are reported in Panels B and C of Appendix Table 3. To make comparisons with our results above, we present the results of the two subgroups that have significant results above only, that is, the subgroup with smallest size and lowest B/M (S/L group) and the subgroup with smallest size and second-lowest B/M (S/SL group). The second equation is stated as follows:

$$Litigation_i = \beta_0 + \beta_1 D\&O_i + \beta_2 E\hat{}(D\&O)_I + \sum_{k=3}^{8} \beta_k X_{ki} + \varepsilon_i \quad (6)$$

where the X_{ki} are the explanatory variables of *Litigation*. The purpose of the second equation is to examine whether conditional dependence between Litigation and D&O exists after considering the explanatory variables of litigation risk (ΣX_i) and the nonlinearity feature of Eˆ(D&O). If the coefficient of the *D&O* variable (β_1) in Eq. (6) is significant, then the conditional dependence of D&O purchase and litigation risk exists, i.e., asymmetric information is present in our analysis. Specifically, if the coefficient of the *D&O* variable is significantly negative, it implies that advantageous selection exists in our sample, and a significantly positive coefficient implies that adverse selection exists.

Table 7 reports the results of our second-stage analysis, with Panel A (Panel B) reporting the probit regression results for S/L (S/SL) firms. Our results show that the coefficient of the *D&O* variable is significantly negative at the 10% level in Panel A and significantly

[26] We present the analyses of *CRatio*_25 and *CRatio*_75 here, since it is potentially more valuable to examine the relationship in the case of insured firms purchasing the lowest and highest amounts of D&O insurance.

Table 7
Two-Stage Regression Analysis.

	Panel A: *S/L sample*		Panel B: *S/SL sample*	
	Litigation		*Litigation*	
Intercept	3.12		3.24	*
	(1.54)		(2.12)	
D&O	−0.21	*	−0.23	**
	(2.90)		(4.72)	
Eˆ(D&O)	−1.12		−1.22	*
	(1.02)		(2.74)	
Voting	−0.02	*	−0.01	
	(2.81)		(1.02)	
Ind	0.24		1.09	
	(0.08)		(0.06)	
Size	0.08		0.29	
	(0.99)		(0.71)	
TobinQ	−0.03		−0.42	
	(0.56)		(0.64)	
Lev	−0.02		−0.06	*
	(0.99)		(2.79)	
ROA	−1.42	***	−1.56	***
	(15.12)		(12.24)	
Industry Effect	Yes		Yes	
Yearly Effect	Yes		Yes	
Observations	613		613	
Log-Likelihood	−128.72		−151.24	

This table reports the relationship between purchase/non-purchase decisions and whether or not the firm was subsequently involved in litigation. Panel A reports the results of smallest size with lowest-B/M (S/L) firms and Panel B reports the results of smallest size with second lowest-B/M (S/SL) firms. Following Dionne et al. (2001) and Gao et al. (2017), we run the first-stage regression by considering all the factors affecting the D&O insurance purchase. The second-stage regression shown here uses *Litigation* as the dependent variable and *D&O* is the key independent variable in the analysis. The variable Eˆ(D&O) is introduced in our second equation, which is acquired from our first equation and denotes the estimated probability that a firm will purchase insurance given all the information available. The second equation is stated as follows: $Litigation_i = \beta_0 + \beta_1 D\&O_i + \beta_2 E\hat{}(D\&O)_I + \sum_{k=3}^{8}\beta_k X_{ki} + \varepsilon_i$ where the X_{ki} are the explanatory variables of *Litigation*. The values in parentheses refer to Wald Chi-square statistics. ***, ** and *denote statistical significance at the 1%, 5% and 10% levels, respectively, with t-statistics in parentheses.

Table 8
Results of Correlation Coefficients: Excluding the 2008 Effect.

Size (ME)	*Book-to-market equity (BE/ME)*						
	Low	*2*	*3*	*4*	*High*	*All*	
Small	−0.0480	* −0.0471	* 0.0032	0.0261	0.0135	−0.0032	
	(3.6278)	(4.1507)	(0.2676)	(0.3666)	(0.6445)	(0.0788)	
2	−0.0272	0.0203	−0.0038	0.0211	0.0250	0.0007	
	(1.1526)	(0.6420)	(0.0221)	(0.4215)	(1.6221)	(0.0246)	
3	0.0011	−0.0328	0.0152	0.0118	0.0101	0.0008	
	(0.0021)	(1.1187)	(0.3631)	(1.0562)	(1.2650)	(0.0548)	
4	0.0181	0.0026	0.0189	0.0185	0.0147	0.0018	
	(0.7224)	(1.6454)	(0.9958)	(1.3825)	(0.8524)	(0.6412)	
Big	0.0035	0.0229	0.0094	0.0172	0.0064	0.0042	
	(0.9658)	(0.9638)	(1.1164)	(0.6992)	(0.0633)	(1.4187)	
All	−0.0326	* −0.0126	0.0205	0.0026	0.0144	0.0013	
	(3.6215)	(0.7405)	(1.9733)	(1.2733)	(0.3122)	(0.0223)	

This table reports the correlation coefficients of the probit regression residuals categorized by the book-to-market ratio and firm size, and it shows the results after excluding the effect of the global financial crisis, i.e., the sample observations in 2008 are excluded. The results between purchase/non-purchase decisions and whether or not the firm was subsequently involved in litigation are reported. The sample comprises a total of 14,100 firms. Following the procedure used by Fama and French (1993), the 5 × 5 size-B/M portfolios are formed by the intersection of size and the B/M. W-test statistics are reported in the parentheses and are distributed asymptotically as $\chi^2_{(1)}$. The independent variables included in the probit models consist of governance variables, financial variables, and others. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

Table 9
Correlation coefficients of probit residuals categorized by investment level and size.

Size (ME)	*Investment level*				
	Low	*2*	*3*	*4*	*High*
Small	0.0314	−0.0095	−0.0210	0.0324	0.0093
	(1.1599)	(0.1310)	(0.6925)	(1.5402)	(0.5441)
2	−0.0051	−0.0264	0.0289	0.0115	0.0038
	(0.0493)	(2.0210)	(1.3166)	(0.9554)	(1.6559)
3	−0.0209	0.0106	0.0383	0.0160	0.0214
	(0.0292)	(0.1877)	(2.3178)	(0.3225)	(1.0335)
4	0.0092	0.0184	0.0040	0.0064	0.0050
	(0.6225)	(0.9857)	(1.5447)	(0.8774)	(1.0852)
Big	0.0086	0.0011	0.0195	0.0013	0.0127
	(0.4154)	(1.6982)	(0.9825)	(1.0231)	(0.5478)
All	−0.1086	−0.0116	0.0185	0.0211	0.0019
	(0.0555)	(0.2405)	(1.6423)	(1.4221)	(0.7931)

This table reports the correlation coefficients of the probit regression residuals categorized by the investment level and firm size. The investment level is defined as the sum of new purchases of property, plant and equipment (PPE) and expenditure on research and development, less the disposal of property, plant and equipment (PPE) in the following year, scaled by average total assets. The results between purchase/non-purchase decisions and whether or not the firm was subsequently involved in litigation are reported. The sample comprises a total of 15,313 firms, with the sample period running from 2008 to 2018. Following the procedure used by Fama and French (1993), the 5 × 5 size-investment portfolios are formed by the intersection of size and investment levels. W-test statistics are reported in parentheses and are distributed asymptotically as $\chi^2_{(1)}$. The independent variables included in the probit models consist of governance variables, financial variables, and others. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

positive at the 5% level in Panel B. Similar to what we find in Table 5, the advantageous selection is found in both of the S/L and S/SL group. In other words, our results remain consistent when we use an alternative econometric method.

6.3. Exclusion of the financial crisis effect

As the results for the descriptive statistics in 2008 are different from those for the rest of the sample, we examine the correlation coefficients of the probit regressions by excluding the sample observations in 2008 and present their results in Table 8. Our results in Table 8 remain similar to those in Table 4, implying that the findings of advantageous selection are not affected by the exclusion of the financial crisis.[27]

6.4. Alternative definitions of litigation

Our analysis has thus far defined litigation events as cases where directors or officers are involved in indictments only. We modify the definition of litigation events here by including those firms involved in a 'provisional attachment' or a 'provisional injunction' as high-risk firms.[28] In addition, we illustrated earlier in Fig. 2 that after a shareholder has submitted a case to the prosecutor and an investigation has ensued, the company defendant may still escape prosecution due to a lack of evidence. We therefore further include firms 'investigated but not prosecuted' as high-risk firms. Finally, we add 'dissenting or qualified opinions expressed by independent directors' to the previous sample. Given that any dissenting or qualified opinions expressed by independent directors will be explicitly noted in the minutes of the board meeting, we believe that examining the dissenting opinions of independent directors provides a method for predicting potential litigation events.

When compared to the 271 events in the original sample, the respective numbers of events included in these three alternative samples are 281, 284, and 292. Our results show that the correlation coefficients using the alternative definitions of litigation have even greater significance. For example, when using the broadest definition (all 292 events included), we find that the correlation coefficient for a buy-or-not decision in the smallest size and lowest-B/M group, originally shown in Table 4, is now −0.0432 (p-value = 0.0131), and the coefficient in the smallest size and second lowest-B/M group is −0.0415 with p-value of 0.0108. All other results remain similar.

[27] We do not find any significant results based on a sample that includes only the year 2008 except for the presence of advantageous selection among S/L firms. While it is likely that litigation events may easily occur under any firm size or life stage during the period, the small sample size for a single year may also be a concern.

[28] In a civil indictment, plaintiff shareholders may sometimes submit a 'provisional attachment' or a 'provisional injunction'. According to Article 522 of the Taiwan Code of Civil Procedure, a provisional attachment refers to an event in which a director or officer is not allowed to execute the firm's monetary claims in order to secure the firm's property rights, while a provisional injunction refers to an event in which a director or officer is not allowed to execute the firm's non-monetary claims in order to secure the firm's property rights.

6.5. Replacement of investment level for the B/M

We propose in our analysis that size and the B/M are important risk factors that may affect the correlation between litigation risk and the purchase of D&O insurance. It may be argued that other factors such as the investment level may also demonstrate the lack of financial tools for a firm to attract good managers, and thus perform similarly to the B/M in our analysis. Here we use the investment level to replace the B/M in order to see whether our current result remains. Following Li and Liao (2014), we define the investment level of a firm as the sum of new purchases of property, plant and equipment (PPE) and expenditure on research and development, less the disposal of property, plant and equipment (PPE) in the following year, scaled by average total assets. A 5×5 portfolio based on the interaction of size and the investment level is created to examine whether similar results hold.

We provide our results in Table 9. We find that in all of our portfolios, none of the correlation coefficients is significant. In other words, when we categorize our sample by investment level and size, the advantageous selection is not found. Although the level of investment may indicate that a firm lacks financial tools, it may not be significantly related to the level of firm risk. Specifically, talented managers may be attracted by the growth opportunities of the firm even when the investment level is not high for the firm. This might explain why significant results are not found when our sample is categorized by investment level and size.

7. Conclusions

Based upon a 2008–2018 data sample of all publicly-listed firms, this study provides evidences of asymmetric information in the D&O insurance market in Taiwan. Using data from Taiwan helps to examine whether the asymmetric information problem exists in the Pacific-Asian market, as different characteristics regarding litigation and D&O insurance exist between this market and the developed markets. Our results suggest that size and book-to-market are important factors for insurance companies to clarify the type of asymmetric information. After classifying the data according to firm size and the B/M, we find advantageous selection in firms that are small in size and with low B/M. In addition, our paper is the first to reveal the existence of advantageous selection in the D&O insurance market.

Acknowledgements

This work was financially supported by the Center for Research in Econometric Theory and Applications [Grant 109L9002] from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan. R. J. Huang gratefully acknowledge financial support from the Ministry of Science and Technology in Taiwan [MOST107-3017-F-002-004] and [MOST107-2410-H-008-012-MY3]. Vivian Jeng gratefully acckonwledge financial support from the Ministry of Science and Technology in Taiwan (107-2410- H-004-070-MY2).

Appendix A. A theoretical model

This appendix proposes a new model as a theoretical foundation of our hypotheses. We employ all of the assumptions in the seminal paper of Rothschild and Stiglitz (1976), with the risk type, risk aversion level and the intention to reduce risk are assumed as hidden information. While the risk type and risk aversion level could be either high or low, we propose that there exists a group of agents who are more risk-averse and care more about risk management than other agents. Since these agents adopt a number of risk management tools to reduce their litigation risk, they are classified as low-risk types. In other words, the low-risk types could have either a high degree of risk aversion or a low degree of risk aversion, but the high-risk types have a low degree of risk aversion.[29] In sum, three types of agents exist in the market.

Some papers have also adopted this two-dimensional heterogeneity while examining the equilibrium under asymmetric information in insurance markets. For example, Smart (2000) and Wambach (2000) assumed that customers are heterogeneous with respect to risk type and risk aversion. In these papers, there are four types of agents, whereas we only have three types. This three-type setting is similar to Sandroni and Squintani (2007) who assumed that individuals are heterogeneous in terms of their risk perception: some high-risk types are overconfident and believe that they belong to the low-risk type.[30]

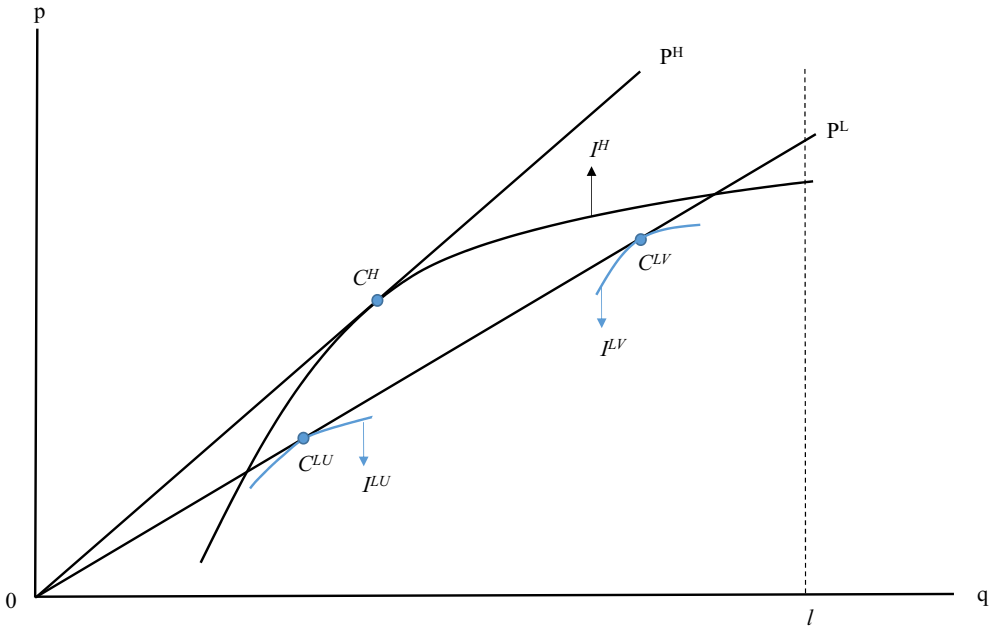
We explain the details as follows. Assume that each insurance applicant with initial wealth w faces a fixed loss l in a loss state. Some of the applicants have high litigation risk. Let π_H denote their probability of loss. Others have low risk with probability of loss π_L. Assume that the high-risk applicants have homogeneous risk preferences and that the utility function is denoted by u with $u' > 0$ and $u'' < 0$. Furthermore, assume that the low-risk applicants have heterogeneous risk preferences: some of them have utility function u, and

[29] The assumption that high-risk types are characterized by a low degree of risk aversion is consistent with the empirical evidence. For example, Roussanov and Savor (2014) use US public firm data and find that firms run by single CEOs exhibit higher stock return volatility than those run by married CEOs. They further find that single CEOs do not reduce investment in response to an increase in idiosyncratic risk, which suggests that single CEOs are less averse to risk.

[30] Another approach is to assume one-dimensional heterogeneity. For example, de Meza and Webb (2001), Jullien et al. (2007), Sonnenholzner and Wambach (2009), Huang et al. (2010) and Huang et al. (2016) assume that agents are heterogeneous in relation to some characteristics but the ex ante risk types are homogeneous. Those with heterogeneous characteristics engage in certain unobservable actions and this results in different risk types ex post.

the utility of the others is v, where the degree of absolute risk aversion of v is higher than that of u . In other words, there are three types of applicants: the H type is the one with loss probability π_H; the LU type refers to applicants with loss probability π_L and utility function u; and the LV type refers to applicants with loss probability π_L and utility function v. The type is hidden knowledge to each applicant. Insurance companies only know the fraction of each type, but cannot identify each applicant's type.[31]

Each insurance applicant can purchase an insurance contract $C = (p, q)$ from a perfectly competitive insurance market, where p



The optimal demand for insurance for each type of insured under full information.

denotes the insurance premium and q is the insurance coverage. Let λ denote the insurance loading. We assume that the insurance is not fair, i.e., $\lambda > 0$. We also assume that the insurance companies are risk-neutral, and thus the insurance premium becomes $p = (1 + \lambda)\pi q$ when the loss probability is π.

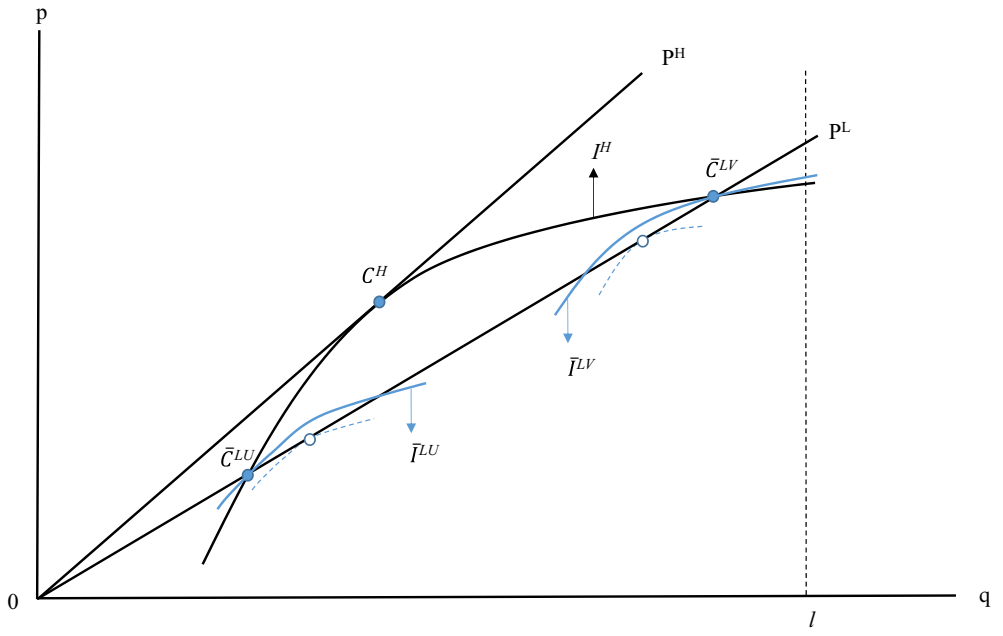
Fig. 3

illustrates the optimal contract purchased by each type under full information. In Fig. 3, P^i is the pricing line, C^i denotes the optimal contracts purchased, and I^i denotes the corresponding indifference curves, where $i = H, LU$ and LV. Note that all applicants purchase partial coverage in equilibrium due to the unfair premium. Given the same utility function, a higher-risk type will demand a higher level of insurance. However, since the LV type is more risk-averse than the H type, it is possible that the former demands a higher level of insurance coverage than the latter. This requires a double crossing of the indifference curves between the two types. The conditions are shown in the appendix.

Under asymmetric information, if the insurance firms offer the first-best contracts - i.e., C^H, C^{LU} and C^{LV}, then the H type pretends it is an LU or LV type and chooses C^{LU} or C^{LV}, because it can then enjoy a higher level of utility by choosing these two contracts. This behavior results in a reduction in the profits of the insurance companies, and thus none of them will offer these first-best contracts.

The market can settle on a separating equilibrium. The separating contracts appear in Fig. 4

[31] Another possible setting is that all of the high-risk types' utility function is v instead of u. In this type of setting, the market will only exhibit adverse selection. The intuition is as follows. Since the H type and LV types have the same degree of risk aversion, the only difference between these two types is the risk probability, which satisfies Rothschild and Stiglitz's setting. Thus, the H type will demand high coverage and the LV type will demand low coverage. Since the LU type exhibits a lower degree of risk aversion, they will demand even less insurance than the LV type, which means that the LU type will also demand less insurance than the H type. Thus, in equilibrium, all of the low-risk types will demand less insurance than the high-risk types. In other words, the equilibrium is characterized by adverse selection.



A separating equilibrium under asymmetric information.

. The second-best contracts for the LU and LV types are respectively denoted by $\overline{C}^{LU}$ and $\overline{C}^{LV}$, which are the two intersections of I^H and P^L. Compared with the first-best contracts C^{LU} and C^{LV}, the optimal coverage for the LU type becomes lower, while that for the LV type becomes higher under asymmetric information.[32] By comparing contracts C^H and $\overline{C}^{LU}$, a high-risk type purchases high coverage and a low-risk type purchases low coverage; i.e., there is adverse selection. However, if we compare contracts C^H and $\overline{C}^{LV}$, we then obtain that a high-risk type purchases low coverage and a low-risk type purchases high coverage; i.e., there is advantageous selection. In other words, in equilibrium, adverse selection and advantageous selection co-exist.[33] This finding is summarized as the following proposition:

Proposition 1. *Under the conditions that the indifference curves of the H type and LV type double cross each other, a separating pair contract* $(C^H, \overline{C}^{LU}, \overline{C}^{LV})$ is sustained as a competitive equilibrium.

Proof. We first show the condition such that LH types demand a higher level of coverage under full information. The objective function of the insurance applicants is:

The first-order condition is:

$$\pi(1-(1+\lambda)\pi)u'(w-l+q-p)-(1-\pi)(1+\lambda)\pi u'(w-p)=0$$

Let q_H, q_{LU}, and q_{LV} (p_H, p_{LU}, and p_{LV}) respectively denote the optimal demand for insurance (the corresponding insurance premium) for types H, LL, and LH. Since the applicants are risk-averse, the second-order condition holds, and the first-order condition is the necessary and sufficient condition for the optimality problem. Thus, we have $q_{LV} > q_H$ when the following conditions hold:

$$\pi_L(1-(1+\lambda)\pi_L)v'(w-l+q_H-((1+\lambda)\pi_L)q_H)-(1-\pi_L)(1+\lambda)\pi_L v'(w-((1+\lambda)\pi_L)q_H)$$

$$\geq \pi_L(1-(1+\lambda)\pi_L)v'(w-l+q_{LV}-((1+\lambda)\pi_L)q_{LV})-(1-\pi_L)(1+\lambda)\pi_L v'(w-((1+\lambda)\pi_L)q_{LV})=0,$$

and:

$$\pi_H(1-(1+\lambda)\pi_H)u'(w-l+q_{LV}-((1+\lambda)\pi_H)q_{LV})-(1-\pi_H)(1+\lambda)\pi_H u'(w-((1+\lambda)\pi_H)q_{LV})$$

[32] To show that under asymmetric information contracts C^H, $\overline{C}^{LU}$ and $\overline{C}^{LV}$re in equilibrium, one can follow the standard analyses. An additional condition is the incentive constraint for the LU type; i.e., the LU type prefers contract $\overline{C}^{LU}$ to $\overline{C}^{LV}$.

[33] Note that the equilibrium in Proposition 1 is not the only possible solution. If the insurance loading is high, then the first-best contract of the LU type could be located on the left-hand side of the lower intersection point of I^H and P^L If the LV types are very risk-averse, then their first-best contract could be located on the right-hand side of the upper intersection point of I^H and P^L. In this case, the first-best contracts are the separating equilibrium contracts.

$$\leq \pi_H(1-(1+\lambda)\pi_H)u'(w-l+q_H-((1+\lambda)\pi_H)q_H)-(1-\pi_H)(1+\lambda)\pi_H u'(w-((1+\lambda)\pi_H)q_H)=0.$$

QED.

Appendix B. Descriptions of independent variables

The method used to measure the independent variables is explained in this section, where the variables are categorized into three groups comprising 'governance variables', 'financial variables', and other variables. While we have D&O insurance coverage available for all publicly-listed firms, we do not have insurance premiums. To alleviate possible bias, we include most of the factors that insurers use for pricing in our regression models below.

B.1. Governance variables

Corporate governance can affect both the demand for D&O insurance and the risk of litigation in various ways. On the one hand, Baker and Griffith (2007) and Gillan and Panasian (2010) indicated that good governance could provide closer monitoring, thereby reducing the risk of litigation; on the other hand, D&O insurance is in itself a type of governance mechanism, and as such those firms that already have other governance mechanisms in place may have reduced incentives to purchase D&O insurance for monitoring purposes (Holderness, 1990).

The first governance variable adopted herein is voting rights (*Voting*). As pointed out by Gupta and Prakash (2012), voting rights can capture the degree of information asymmetry between the firm and outsiders. Following La Porta et al. (2002), *Voting* is defined in the present study as the proportion of the firm's voting rights owned by its controlling shareholders. This variable is calculated by combining the direct and indirect voting rights of the shareholders in the firm.[34]

The second and third governance variables adopted in the present study are the proportion of independent directors on the board (*Ind*) and the number of directors on the board (*Boardsize*). Firms with a larger proportion of independent directors are likely to be those with good governance features and among those demanding more D&O insurance (Core, 1997; Chalmers et al., 2002).[35] *Boardsize* clearly affects the demand for D&O insurance and potential litigation risk as firms with a larger board size may have a higher probability of purchasing D&O insurance.[36]

B.2. Financial variables

Although the B/M ratio and firm size are used to categorize our sample, firm size is also used as a control variable in our probit models.[37] The Tobin's Q (*TobinQ*) and leverage ratio (*Lev*) variables are both used as proxies for firm risk, since those firms engaging in higher risk-taking activities may have a greater likelihood of purchasing D&O insurance, along with a greater likelihood of subsequent involvement in litigation events. *TobinQ* is therefore used as a proxy for the growth opportunities within a firm. Debtholders will, however, have a greater incentive to monitor firms with higher leverage ratios, which thereby implies the existence of negative relationships between: (i) leverage and the demand for D&O insurance, and (ii) leverage and the level of litigation risk.[38]

The return on assets (*ROA*) assists in evaluating firm performance, since those firms with better performance are less likely to face litigation events. Therefore, they will have a reduced demand for D&O insurance. In addition to the above variables, a firm characteristic variable such as the age of the firm (*Age*) is also included in this study.

[34] Direct voting rights refer to a situation where the shares are registered in the shareholder's name, while indirect voting rights refer to a situation where the shares are held by entities controlled by the shareholders.

[35] Zou et al. (2008) examined data on China and identified a significantly positive relationship between two variables, namely, the proportion of independent directors and the demand for D&O insurance, whereas Boyer and Stern (2012) and Gupta and Prakash (2012) were unable to identify any significant relationship between these two variables.

[36] Boyer and Stern (2012) and Boyer and Tennyson (2015) showed that firms with a larger number of board members are more likely to buy D&O insurance.

[37] Given that prior related studies did not propose any relationship between the B/M and the demand for D&O insurance or litigation risk, we do not include the *B/M* variable in our probit models; it should, however, be noted that although *B/M* is regarded as one of the control variables in our 'Checks for Robustness' section, the results are found to remain very similar.

[38] There is mixed evidence in prior studies on the use of Tobin's Q and the leverage ratio. Core (1997) and Boyer and Stern (2012) identified a positive relationship between growth opportunities and the demand for D&O insurance, whereas Lin et al. (2013) only found an insignificant relationship. Boyer and Stern (2012) presented evidence of an insignificant negative relationship between the debt ratio and the demand for D&O insurance, whereas Zou et al. (2008) showed that when the leverage ratio is higher than average, this tends to increase the likelihood of the firm purchasing D&O insurance.

ARTICLE IN PRESS

Appendix Table 1
Correlation coefficients matrix.

Variable	*D&O*	*Litigation*		*Coverage*		*CRatio*		*B/M*		*Size*		*VotingVoting*		*IND*		*Boardsize*		*TobinQ*		*Lev*		*ROA*	
Litigation	−0.0139																						
Coverage	0.3574	0.0014																					
CRatio (%)	0.2867	0.0076		0.2466	***																		
B/M	−0.0614	0.1670	**	−0.0146	*	−0.0989	***																
Size	0.1658	−0.0239	***	0.3904	***	−0.2266	***	−0.2656	***														
Voting (%)	−0.1750	−0.0222	***	−0.0925	***	0.0235	***	−0.0377	***	−0.0646	***												
Ind (%)	0.3174	−0.0244	***	0.0911	***	0.1034	***	−0.1358	***	−0.0231	***	0.0010											
Boardsize	0.0145	0.0018		0.0921	***	−0.0756	***	−0.0009	***	0.2921	***	−0.0859	***	−0.1496	***								
TobinQ	0.0647	−0.0034		0.0108		0.1476	***	−0.5114	***	0.2177	***	0.0086		0.1163	***	−0.0036							
Lev (%)	−0.0376	0.0327	***	0.0784	***	−0.1286	***	0.4930	***	−0.0656	***	−0.0045		−0.1007	***	0.0820	***	−0.4189	***				
ROA (%)	0.0002	−0.0977	***	0.0260	***	−0.2435	***	−0.2068	***	0.3150	***	0.0702	***	0.0271	***	0.0414	***	0.0576	***	−0.2261	***		
Age	−0.2127	0.0114		−0.0750	***	−0.1697	***	0.1351	***	0.1298	***	0.0808	***	−0.3023	***	0.1237	***	−0.1761	***	0.1339	***	0.0356	***

This table reports the Pearson correlation coefficient results among all of the variables, with the sample period running from 2008 to 2018. The correlation coefficients between two variables are reported. The data are obtained from the Taiwan Economic Journal (TEJ) and the Market Observation Post System (MOPS) of Taiwan. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

Appendix Table 2
Differences in the coverage and control variables in the alternative groups.

Variable	*D&O*				*Litigation*			
	=0	=1	Diff		=0	=1	Diff	
Panel A: Firms in the Overall Sample								
Coverage	0	251.78			161.07	164.58	−3.51	
CRatio (%)	0	7.11			4.54	5.22	−0.68	
B/M	0.92	0.85	0.07	***	0.88	0.95	−0.07	*
Size	14.72	15.23	−0.51	***	15.05	14.78	0.27	***
Voting (%)	34.96	28.20	6.76	***	30.69	27.57	3.12	***
Ind (%)	16.87	27.93	−11.06	***	24	20.91	3.09	***
Boardsize	9.30	9.37	−0.07	*	9.34	9.38	−0.04	
TobinQ	1.36	1.52	−0.16	***	1.47	1.44	0.03	
Lev (%)	33.23	31.58	1.65	***	32.08	37.28	−5.20	***
ROA (%)	2.85	2.85	0		3.01	−5.95	8.96	***
Age	32.51	26.59	5.92	***	28.70	29.86	−1.16	
N	5513	9800			15,042	271		

This table compares the average values of the coverage and control variables in the alternative groups, along with a test of their differences. In each panel, we show that the average values of the variables and the differences in significance are dependent upon whether or not firms purchase D&O insurance and whether or not they are subsequently involved in litigation events. Panel A reports the results of the overall sample, and Panels B and C report the results of samples categorized by the B/M and size, respectively. The statistical differences for the Coverage and CRatio variables are not calculated in the left-hand columns. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

Variable	*D&O*				*Litigation*				Variable	D&O				Litigation			
	=0	=1	Diff		=0	=1	Diff			=0	=1	Diff		=0	=1	Diff	
Panel B: Firms categorized by B/M																	
B/M < 50%									*B/M* > 50%								
Coverage	0	245.86			164.56	128.80	35.76	*	*Coverage*	0	258.22			157.57	194.32	−36.75	
CRatio (%)	0	8.40			5.62	4.73	0.89		*CRatio (%)*	0	5.70			3.45	5.63	−2.18	*
B/M	0.50	0.48	0.02	***	0.49	0.48	0.01		*B/M*	1.28	1.26	0.02	**	1.27	1.33	−0.06	
Size	15.07	15.51	−0.44	***	15.37	15.07	0.30	**	*Size*	14.42	14.93	−0.51	***	14.73	14.54	0.19	
Voting (%)	35.93	28.89	7.04	***	31.30	27.46	3.84	***	*Voting (%)*	34.13	27.44	6.69	***	30.07	27.65	2.42	*
Ind (%)	19.37	29.45	−10.08	***	26.17	21.49	4.68	***	*Ind (%)*	14.73	26.27	−11.54	***	21.83	20.43	1.40	
Boardsize	9.34	9.29	0.05		9.31	9.09	0.22		*Boardsize*	9.27	9.46	−0.19	***	9.38	9.61	−0.23	
TobinQ	1.89	2.07	−0.18	***	2.01	2.07	−0.06		*TobinQ*	0.92	0.92	0	**	0.92	0.91	0.01	
Lev (%)	23.84	22.18	1.66	***	22.65	28.01	−5.36	***	*Lev (%)*	41.3	41.82	−0.52		41.55	44.98	−3.43	*
ROA (%)	4.93	5.09	−0.16		5.26	−8.68	13.94	***	*ROA (%)*	1.06	0.42	0.64	***	0.76	−3.69	4.45	***
Age	30.02	24.53	5.49	***	26.33	28.61	−2.28	*	*Age*	34.65	28.83	5.82	***	31.09	30.89	0.20	
No. of Obs.	2550	5107			7534	123			*No. of Obs.*	2963	4693			7508	148		
Panel C: Firms categorized by Size																	
Size < 50%									*Size* > 50%								
Coverage	0	143.51			83.30	76.18	7.12		*Coverage*	0	341.35			238.51	277.50	−38.99	
CRatio (%)	0	11.68			6.75	7.49	−0.74		*CRatio (%)*	0	3.33			2.33	2.34	−0.01	
B/M	1.04	0.98	0.06	***	1.00	1.04	−0.04		*B/M*	0.76	0.75	0.01		0.75	0.83	−0.08	
Size	13.84	13.95	−0.11	***	13.91	13.66	0.25	**	*Size*	15.96	16.28	−0.32	***	16.19	16.22	−0.03	
Voting (%)	33.84	29.89	3.95	***	31.59	29.92	1.67		*Voting (%)*	36.53	26.80	9.73	***	29.79	24.55	5.24	***
Ind (%)	18.29	29.42	−11.13		24.83	20.4	4.43	***	*Ind (%)*	14.88	26.70	−11.82	***	23.18	21.56	1.62	
Boardsize	8.86	8.90	−0.04	***	8.89	8.76	0.13		*Boardsize*	9.92	9.76	0.16	**	9.80	10.17	−0.37	
TobinQ	1.21	1.26	−0.05	***	1.24	1.32	−0.08		*TobinQ*	1.59	1.74	−0.15	***	1.69	1.59	0.10	
Lev (%)	35.29	32.64	2.65	***	33.69	37.15	−3.46	**	*Lev (%)*	30.33	30.71	−0.38		30.49	37.44	−6.95	***
ROA (%)	0.48	−0.78	1.26	***	−0.01	−12.51	12.50	***	*ROA (%)*	6.18	5.86	0.32		6.01	2.42	3.59	***
Age	30.22	24.59	5.63	*	26.96	27.14	−0.18		*Age*	35.72	28.25	7.47	***	30.44	33.32	−2.88	*
No. of Obs.	3220	4437			7505	152			*No. of Obs.*	2293	5363			7537	119		

Appendix Table 3
Probit model regression results for all firms and insured firms.

	Panel A: All Firms				Panel B: S/L Firms		Panel C: S/SL Firms	
	D&O		*Litigation*		*D&O*		*D&O*	
Intercept	−2.6407	***	−2.0116	***	−4.0024	***	−6.0214	**
	(283.52)		(35.29)		(20.03)		(5.87)	
Voting	−0.0095	***	−0.0048	***	−0.0078	**	−0.034	*
	(219.84)		(9.90)		(5.12)		(0.05)	
Ind	1.7788	***	−0.0003		3.1211	***	2.5432	***

(*continued on next page*)

Appendix Table 3 (*continued*)

	Panel A: All Firms				Panel B: S/L Firms		Panel C: S/SL Firms	
	D&O		*Litigation*		*D&O*		*D&O*	
	(487.26)		(0)		(69.31)		(38.59)	
Boardsize	0.0023		−0.0042		−0.0074		0.0125	
	(0.19)		(0.14)		(0.05)		(2.12)	
Size	0.2430	***	−0.0101		0.5571	***	0.6599	***
	(598.84)		(0.24)		(21.14)		(13.61)	
TobinQ	−0.0316	***	−0.0020		−0.0714		−0.0243	
	(7.59)		(0.01)		(0.56)		(1.09)	
Lev	0.1430	**	0.3408	**	0.1098		−0.0322	
	(4.38)		(5.83)		(0.12)		(0.09)	
ROA	−0.7482	***	−1.1855	***	−0.4201	**	−0.5140	***
	(54.39)		(52.42)		(5.98)		(9.19)	
Age	−0.0163	***	0.0019		−0.0412	***	−0.0354	***
	(258.20)		(0.75)		(31.12)		(30.28)	
Industry Effect	Yes		Yes		Yes		Yes	
Yearly Effect	Yes		Yes		Yes		Yes	
Observations	15,313		15,313		613		613	
Log-Likelihood	−8279.9		−1282.7		−989.4		−1003.1	

This table reports the results of three groups of probit regressions. Panel A reports the results for all insured and non-insured firms in our sample, and the results of the *D&O* regression and the *Litigation* regression model are reported. Panels B and C report the results of the first stage of our two-stage analysis by considering all the factors affecting the purchase of D&O insurance in the regression. Panel B reports the results of smallest size with lowest-B/M (S/L) firms and Panel C reports the results of smallest size with second lowest-B/M (S/SL) firms. Both industry and yearly effects are considered. The values in parentheses refer to Wald Chi-square statistics. ***denotes statistical significance at the 1% level; **denotes statistical significance at the 5% level; and *denotes statistical significance at the 10% level.

References

Baker, T., Griffith, S.J., 2007. Predicting corporate governance risk: evidence from the directors' & officers' liability insurance market. Univ. Chic. Law Rev. 74, 487–544.
Boyer, M.M., Stern, L.H., 2012. Is corporate governance risk valued? Evidence from directors' and officers' insurance. J. Corp. Finan. 18 (2), 349–372.
Boyer, M.M., Stern, L.H., 2014. D&O insurance and IPO performance: what can we learn from insurers? J. Financ. Intermed. 23 (4), 504–540.
Boyer, M.M., Tennyson, S., 2015. Directors' and officers' liability insurance, corporate risk and risk taking: new panel data evidence on the role of directors' and officers' liability insurance. J. Risk Insur. 82 (4), 753–791.
Brenner, S., 2015. The risk preferences of US executives. Manag. Sci. 61 (6), 1344–1361.
Bryan, D.B., Mason, T.W., 2020. Earnings volatility and auditor risk assessments: evidence from auditor resignation. Account. Horiz. 34 (4), 33–56.
Cardon, J.H., Hendel, I., 2001. Asymmetric information in health insurance: evidence from the national medical expenditure survey. RAND J. Econ. 32 (3), 408–427.
Cawley, J., Philipson, T., 1999. An empirical examination of information barriers to trade in insurance. Am. Econ. Rev. 89 (4), 827–846.
Chalmers, J.M., Dann, L.Y., Harford, J., 2002. Managerial opportunism? Evidence from directors' and officers' insurance purchases. J. Financ. 57 (2), 609–636.
Chiappori, P.A., Salanié, B., 1997. Empirical contract theory: the case of insurance data. Eur. Econ. Rev. 41 (3–5), 943–950.
Chiappori, P.A., Salanié, B., 2000. Testing for asymmetric information in insurance markets. J. Polit. Econ. 108 (1), 56–78.
Cohen, A., Siegelman, P., 2010. Testing for adverse selection in insurance markets. J. Risk Insur. 77 (1), 39–84.
Core, J.E., 1997. On the corporate demand for directors' and officers' insurance. J. Risk Insur. 64 (1), 63–88.
Daniel, K., Titman, S., 2006. Market reactions to tangible and intangible information. J. Financ. 61 (4), 1605–1643.
Davidoff, T., Welke, G., 2004. Selection and Moral Hazard in the Reverse Mortgage Market. Working Paper. Haas School of Business, University of California, Berkeley.
de Meza, D., Webb, D.C., 2001. Advantageous selection in insurance markets. RAND J. Econ. 32 (2), 249–262.
Dionne, G., Gouriéroux, C., Vanasse, C., 2001. Testing for evidence of adverse selection in the automobile insurance market: a comment. J. Polit. Econ. 109 (2), 444–453.
Fama, E.F., French, K.R., 1993. Common risk factors in the returns on stocks and bonds. J. Financ. Econ. 33, 3–56.
Fang, H., Keane, M.P., Silverman, D., 2008. Sources of advantageous selection: evidence from the Medigap insurance market. J. Polit. Econ. 116 (2), 303–350.
Feng, N., Fuerman, R.D., 2018. Securities class actions of Chinese companies. Corp. Ownersh. Control. 15 (4), 107–130.
Finkelstein, A., McGarry, K., 2006. Multiple dimensions of private information: evidence from the long-term care insurance market. Am. Econ. Rev. 96 (4), 938–958.
Finkelstein, A., Poterba, J., 2004. Adverse selection in insurance markets: policyholder evidence from the UK annuity market. J. Polit. Econ. 112 (1), 183–208.
Gao, F., Powers, M.R., Wang, J., 2017. Decomposing asymmetric information in China's automobile insurance market. J. Risk Insur. 84 (4), 1269–1293.
Gharghori, P., Chan, H., Faff, R., 2009. Default risk and equity returns: Australian evidence. Pac. Basin Financ. J. 17 (5), 580–593.
Gillan, S.L., Panasian, C.A., 2010. What Matters in Corporate Governance: Evidence From the Market for Directors' and Officers' Liability Insurance. Working Paper. Texas Tech University.
Gillan, S.L., Panasian, C.A., 2015. On lawsuits, corporate governance and directors' and officers' liability insurance. J. Risk Insur. 82 (4), 793–822.
Gupta, M., Prakash, P., 2012. Information embedded in directors and officers insurance purchases. Geneva Pap. Risk Insur. 37 (3), 429–451.
He, Z., Li, S., Wei, B., Yu, J., 2014. Uncertainty, risk, and incentives: theory and evidence. Manag. Sci. 60 (1), 206–226.
Holderness, C.G., 1990. Liability insurers as corporate monitors. Int. Rev. Law Econ. 10 (2), 115–129.
Huang, R.J., Liu, Y.J., Tzeng, L.Y., 2010. Hidden overconfidence and advantageous selection. Geneva Risk Insur. Rev. 35 (2), 93–107.
Huang, R.J., Muermann, A., Tzeng, L.Y., 2016. Hidden regret in insurance markets. J. Risk Insur. 83 (1), 181–216.
Hurd, M.D., McGarry, K., 1997. Medical insurance and the use of health care services by the elderly. J. Health Econ. 16 (2), 129–154.
Jullien, B., Salanie, B., Salanie, F., 2007. Screening risk-averse agents under moral hazard: single-crossing and the CARA case. Economic Theory 30 (1), 151–169.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R., 1997. Legal determinants of external finance. J. Financ. 52 (3), 1131–1150.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R., 1998. Law and finance. J. Polit. Econ. 106 (6), 1113–1155.
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R., 2002. Investor protection and corporate valuation. J. Financ. 57 (3), 1147–1170.
Li, K.F., Liao, Y.P., 2014. Directors' and officers' liability insurance and investment efficiency: evidence from Taiwan. Pac. Basin Financ. J. 29, 18–34.

Lin, C., Officer, M.S., Zou, H., 2011. Directors' and officers' liability insurance and acquisition outcomes. J. Financ. Econ. 112 (3), 507–525.
Lin, C., Officer, M.S., Wang, R., Zou, H., 2013. Directors' and officers' liability insurance and loan spreads. J. Financ. Econ. 110 (1), 37–60.
Liu, J.W., Browne, M.J., 2007. First-best equilibrium in insurance markets with transaction costs and heterogeneity. J. Risk Insur. 74 (2), 739–760.
McCarthy, D., Mitchell, O.S., 2010. International adverse selection in life insurance and annuities, ageing in advanced industrial states. Int. Stud. Popul. 8, 119–135.
Milidonis, A., Stathopoulos, K., 2014. Managerial incentives, risk aversion, and debt. J. Financ. Quant. Anal. 49 (2), 453–481.
Prendergast, C., 2002. The tenuous trade-off between risk and incentives. J. Polit. Econ. 110 (5), 1071–1102.
Puelz, R., Snow, A., 1994. Evidence on adverse selection: equilibrium signaling and cross-subsidization in the insurance market. J. Polit. Econ. 102 (2), 236–257.
Rothschild, M., Stiglitz, J., 1976. Equilibrium in competitive insurance markets: an essay on the economics of imperfect information. Q. J. Econ. 90, 629–649.
Roussanov, N., Savor, P., 2014. Marriage and managers' attitudes to risk. Manag. Sci. 60 (10), 2496–2508.
Sandroni, A., Squintani, F., 2007. Overconfidence, insurance, and paternalism. Am. Econ. Rev. 97 (5), 1994–2004.
Smart, M., 2000. Competitive insurance markets with two unobservables. Int. Econ. Rev. 41 (1), 153–170.
Sonnenholzner, M., Wambach, A., 2009. On the role of patience in an insurance market with asymmetric information. J. Risk Insur. 76 (2), 323–341.
Tsui, J.S., Jaggi, B., Gul, F., 2001. CEO domination, growth opportunities, and their impact on audit fees. J. Acc. Audit. Financ. 16 (3), 189–208.
Walls, M.R., Dyer, J.S., 1996. Risk propensity and firm performance: a study of the petroleum exploration industry. Manag. Sci. 42 (7), 1004–1021.
Wambach, A., 2000. Introducing heterogeneity in the Rothschild-Stiglitz model. J. Risk Insur. 67 (4), 579–591.
Wang, K.C., Huang, R.J., Tzeng, L.Y., 2009. Empirical evidence for advantageous selection in the commercial fire insurance market. Geneva Risk Insur. Rev. 34 (1), 1–19.
Xiao, Tao, 2021. Consumer finance/household finance: the definition and scope. China Fin. Rev. Int. 11 (1), 1–25.
Zou, H., Wong, S., Shum, C., Xiong, J., Yan, J., 2008. Controlling-minority shareholder incentive conflicts and directors' and officers' liability insurance: evidence from China. J. Bank. Financ. 32 (12), 2636–2645.