



The Impact of Diversification and COVID-19 Pandemic on Financial Stability for Property-Liability Insurers: Quantile Regression Approach

Chen-Ying Lee ¹

1. *Shih Chien University, Taiwan*

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A B S T R A C T

This study examines the impact of the COVID-19 pandemic on the relationship between diversification and insurer financial stability in Taiwan. We use ordinary least squares (OLS) and quantile regression (QR) methods to explore the impact of diversification and the COVID-19 pandemic on insurer financial stability during 2010-2022, especially for the insurers at the different quantiles. The results show that product diversification presents a significantly negative impact on insurers' Z-scores using OLS and QR (all quantiles), and that higher quantiles insurer diversification is significantly and positively associated with the RBC ratio. In addition, The COVID-19 pandemic is negatively and significantly associated with insurer Z-score for the OLS regressions, whereas the COVID-19 pandemic is also negatively and significant associated with Z-scores for lower and median quantiles insurers. The findings suggest that managers must carefully evaluate and establish systems to control the degree of diversification to reduce solvency risk. The results also provide the regulatory authorities with a basis for supervision of diversification and financial stability.

Keywords: Diversification, Financial stability, Covid-19 pandemic, Quantile Regression

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¹ Email : jack1014@g2.usc.edu.tw

1. Introduction

Cross-border operation of the financial industry has become an important trend. Therefore, at the end of 2000, under the trend of financial liberalization and internationalization, Taiwan's government passed the Financial Institution Merger Law to improve the economic efficiency of the financial industry, and passed the Financial Holding Company law in 2001, allowing banks, insurance, and securities to merge with each other, catalyzing the development of the financial industry. As a result, some insurers were acquired or merged, and financial holding companies began to develop. Many financial holding groups established insurance subsidiaries respectively or increased the scale of insurance operations through mergers and acquisitions, while some non-financial holding insurers cooperate with financial institutions to cross-market insurance products through various channels.

In view of the experience of advanced insurance countries and consumer awareness, there is still room for adjustment in the future business structure of the Taiwanese insurance industry. However, from the information disclosed by various insurers, we can also see the rapid growth and development of the insurers' scale and insurance product lines. As the market competition becomes more fiercer, business integration and cost structure reduction are very important for the sustainable operation of insurers. Therefore, insurers through business diversification may increase product categories or expand various business, produce and operate various products in different areas to promote operational scope and increase market share to improve firm performance to achieve economics of scope. However, diversified operations are like an asset pool, and companies can reduce the volatility of overall cash flow and, thus, minimize their financial risks (Amit & Livant, 1988). Hann et al. (2013) indicate that diversified companies can generate internally the effect of coinsurance, compared to enterprises operating in a single industry, and can obtain lower equity capital costs and reduce the risk of earnings fluctuations. In contrast, when an enterprise crosses over to different market or industries through diversified operations, the greater the difference in the fields it crosses, the more it can reduce the correlation of cash flow of each operating department of the firms, but it will also increase the difficulty for the enterprise to master information and integrate resources, and increase the risk of business operation (Bettis & Hall, 1982). Therefore, diversified enterprises may have increased their corporate operational risks due to the need for an increased management capacity and coordination requirement, as well as having large amounts of information that need to be mastered and processed when facing multiple products, (Hitt et al., 2006; Reeb et al., 1998). Previous studies point out that diversification strategy is an important factor affecting corporate value and risk (Bausch & Plis, 2009; Wan et al., 2011). However, previous empirical literature has not obtained consistent evidence and conclusions on whether diversification can reduce corporate risk. Due to the small size of Taiwan's insurance market, the property-liability (P-L) insurers hope to expand the scale of insurance and obtain sufficient investment funds through a diversification strategy, but they must also pay attention to their business risk.

The COVID-19 pandemic had a major impact on the global economy, triggering an unexpected economic crisis. The insurance sector is one of the industries that suffered the most serious losses from the epidemic. Insurers must use their own funds to handle a larger number of claims, but at the same time they need to maintain sufficient solvency. Due to the product diversification strategy, the P-L insurers operate in both accident and health insurance. In 2022, Taiwan's local epidemic broke out again. Omicron, which is highly contagious and has a high infection rate, caused a peak in confirmed cases and led to a new high in epidemic prevention policy sales. At the same time, insurers' underwriting risk also increased, resulting in huge subsequent compensation payments, which in turn affects insurers' financial status. In Taiwan, the COVID-19 epidemic has also had an impact on the economy and industry, with the insurance sector bearing the brunt. According to statistics from the P-L Insurance Association, from 2022 to the end of March 2023, the total amount of epidemic prevention insurance claims was NT\$264.983 billion, which is equivalent to the entire profit of P-L insurers for 20 years. In response to a new wave of epidemic prevention insurance claims, the top six insurers underwriting epidemic prevention insurance have completed a capital increase of nearly NT\$1125 billion. Based on the above background, the purpose of this study is to explore the impact

of diversification in the insurance sector on financial stability and further explore whether COVID-19 caused financial instability for P-L insurers. Consequently, understanding the relationship between diversification and insurance risks during times of economic uncertainty, such as the COVID-19 pandemic, is essential.

This paper has the following contributions: First, previous studies on diversification in the insurance sector mostly focus on performance (Liebenberg & Sommer, 2008; Shim, 2011; Lee, 2017; Duijm & Van Beveren 2022) and risk-taking (Che & Liebenberg, 2017; Lee, 2020), and bank diversification and financial stability (Al-Habashneh et al., 2023; Chowdhury et al., 2024); but less on insurers' financial stability. This study offers an in-dept analysis of P-L insurers' diversification strategies and the COVID-19 pandemic on financial stability, and attempts to bridge the gap in the literature on the insurance sectors. Second, different from previous literature, where most of the data analyzed was for developed countries such as Che and Liebenberg (2017); Shim (2017 b); Sheehan et al. (2023), this research focuses on developing economies, that is for the Taiwanese insurance sector, and can provide references for developing countries. Thirdly, the results of this study provide another perspective, analyzing whether the diversification of P-L insurers may have an adverse impact on financial stability. Managers must carefully evaluate these considerations when making diversification decisions. Finally, the findings will provide valuable insights for policymakers and insurers, aiding in the formulation of strategies to mitigate risks and ensure insurance and financial sector stability in times of economic uncertainty.

2. Literature Review

2.1 Theoretical Issues

The theories related to diversification and risk can be roughly divided into portfolio theory, coinsurance effect theory, and principal-agent theory. Portfolio diversification involves allocating wealth across various assets. Additionally, a balanced portfolio of various kinds of assets can successfully decrease investment risk while maintaining a minimal return (Li, 2022). The benefit is risk reduction through multilateral insurance, minimizing the likelihood and severity of portfolio loss (Koumou, 2020). The empirical research on diversification (whether industrial diversification or global diversification) and corporate risk in the literature has not found a consistent finding. For example, diversification strategies can reduce a firm's risk by reducing the cash flow dependencies among its various operation divisions (Berger & Ofek, 1995). Coinsurance effect theory is a theoretical hypothesis based on portfolio theory to explain the potential benefits of diversification. Hann et al. (2013) proposed that if a firm's cash flows from different business activities are not perfectly correlated, there will be a coinsurance effect that can stabilize the financial position of diversified institutions. On the other hand, the principal-agent theory denies the internal capital market of diversified enterprises market efficiency. The theory believes that the market is imperfect and has some insurmountable defects, such as low resource allocation efficiency under information asymmetry. Since diversification often has longer organizational levels and management chains, information may be blocked or distorted. Moreover, diversified operations bring principal-agent problems to enterprises, increasing opportunities for managers to obtain personal benefits, which may affect corporate strategy formulation and investment decisions and increase its business risks (Jensen, 1986). And when a company crosses over to different markets or industries through diversified operations, the greater the difference in the cross-border fields, the more it can reduce the correlation of cash flow of each operating department of the company, but it will also increase the difficulty for the company to master information and integrate resources. It increases the risk of operating the company (Bettis & Hall, 1982). Liang et al. (2020) finds that the increase of diversification will lead to more contributions to the risk of the banking system, which may be due to the higher similarity of activities. With the development of diversification, this may result in financial institutions facing common risks by holding similar investment portfolios (Wagner, 2010), resulting in financial instability. Adem (2022) states that diversification reduces risks and improve bank stability in emerging and developing economies during crisis and non-crisis periods, supporting portfolio theory.

2.2 Diversification on financial stability

Hoyt and Trieschmann (1991) studied insurers in the United States from 1973 to 1987 and found that insurers with diversified operations have higher risks than those with non-diversified operations. Cummins et al. (2010) considered that while diversification brings positive effects, it also amplifies the risks of insurance business operations, which is a new challenge for insurance supervision, and for the benefits derived from risk reduction. Ho et al. (2013) provided a different geographic view, finding that U.S. P-L insurance companies with lower geographic diversification had higher investment risks and financial stability. Che and Liebenberg (2017) find that diversified insurers take more asset risks than non-diversified insurers, and that the asset risk-taking is positively related to the degree of diversification. Shuang and Chan (2018) also dictated that the regulatory difficulties caused by diversification may lead to the rent-seeking behaviors of insurers and may increase the risks of insurers. The diversification of insurers may also lead to the different risk types and risk bearers, thereby increasing the operating difficulties of insurer. On the contrary, Che and Liebenberg (2017) argue that geographic diversification can reduce underwriting risk through cross-subsidies, allowing geographically diversified insurance companies to take on additional risks in the portfolios. Nguyen and Vo (2020) explore the relationship between corporate risk and solvency in listed insurers within the European Union, and highlight business diversification as a commonly regarded risk mitigation tool. Wu and Deng (2021) indicated that product diversification will improve the solvency of Chinese P-L insurers, but will reduce the solvency of foreign insurers. One possible reason for Chinese P-L insurers having improved solvency risk is the reduced volatility of its premium income and claims expenditure through a diversified portfolio of unrelated businesses and achieving a coinsurance effect. However, the information asymmetry caused by the principal-agent problem in foreign insurers makes external supervision and internal management become more difficult and expensive (Wei & Niu, 2006). Looking at the above literature, diversification is one the main growth factors for the insurers. This operation method brings benefits and lower costs to companies. For the question of whether diversified operations affect insurers' financial stability, there are positive and negative opinions, each with theoretical support. Nonetheless, there is still a divergence of opinion in the research and ideas regarding whether insurers diversification is beneficial. Therefore, the diversified strategy for insurers still needs to be verified by more empirical research. This study considers that P-L insurers can reduce the possibility of portfolio losses and achieve financial stability through diversification strategies. Therefore, this study formulates the following hypothesis:

H1: Diversification strategies have a positive impact on the P-L insurers' financial stability.

2.3 COVID-19 pandemic and insurance stability

The COVID-19 pandemic was a major challenge for the global financial system following the 2008 to 2010 financial crisis and great recession. The pandemic caused a huge shock to the global economy, affecting various industries. However, this crisis is different from other previous types of crises—especially financial or banking crisis. COVID-19, as a major virus that spreads fast, had the widest impact, which is difficult to prevent and control, and caused the most serious damage to global economic development. Puławska (2021) confirmed that Covid-19 had a negative impact on the operation of the insurance sectors. In particular, any failure for an insurer could cause turmoil in the other business sectors. Wu et al. (2022) explores the impact of COVID-19 on China's insurers, showing that the return rate of listed insurers shows an “inverted N” curve of “declining, rising and falling again”. The negative effects of the epidemic on insurers were mainly reflected in premium income and indemnity expenditure. Berry-Stölzle and Esson (2024) examine capital issuance and premium growth of U.S. P-L insurance during COVID-19 recessions, and their results showed that the business model of the P-L insurance is surprisingly resilient, even under the most different circumstances, and that P-L insurers can also provide financial stability services. The 2008-2009 crisis negatively impacted insurers, consumers, and business in Asia, compared with other regions. Taiwan's insurers underwrote a large number of epidemic prevention insurance policies, and its insurers were the most pessimistic about the impact of the COVID-19 pandemic on corporate finances (Teresiene et al., 2021). Based on the above, the following hypothesis is formulated:

H2: The COVID-19 pandemic has negatively impacted P-L insurers' financial stability.

3. Data, Methodology, and variables

3.1 Data Sources

The sample used in this research includes Taiwan's P-L insurance companies from 2010 to 2022, data collected from the Taiwan Insurance Institute (TII) website database, the Insurance Public Information Observatory website database, and *Taiwan Economic Journal* (TEJ). There are approximately 19 P-L insurers in Taiwan. Some foreign insurers are excluded from this study because they operate a special line of insurance and have a small market share. Therefore, this study chooses 15 insurers with relatively complete information. These 15 companies were selected as the research sample because their combined share in Taiwan's P-L insurance market is as high as up to 98.8 per cent, and the overall sample is representative.

3.2 Variables measuring in the research

3.2.1 Measuring financial stability

The key dependent variables in this study are the Z-score and the RBC ratio. The Z-score is a measure of risk that considers factors other than capitalization and events like bankruptcy. It is often used in financial stability literature as a proxy for the probability of corporate bankruptcy (Rauch & Wende, 2015; Turk-Ariss, 2010). Although the Z-score measure has traditionally been used as a proxy for individual risk in the banking sector (Baselga-Pascual et al., 2015; Khan et al., 2017), it may also be a useful tool when applied to the insurance sector (Cummins et al., 2017; Shim, 2017 a; Pavic et al., 2019; Moreno et al., 2022). This study uses the Z-score proposed by Rubio-Misas (2020), which indicates the probability of failure of a given insurer. Higher values of Z-scores imply lower probabilities of failure. Another indicator in this study is RBC ratio. RBC is a solvency ratio that indicates the assets and capital of insurers to be able to fulfill their obligations. However, Taiwan's insurers currently also use RBC ratio as a solvency indicator. The RBC regime requires insurers to maintain sufficient capital (own funds) determined by the risk that they assumed as a safety net for any unexpected investment and underwriting losses (Chen et al., 2021). The greater the RBC level of an insurers, the healthier the financial condition of that company (Hery et al., 2023). Therefore, we use RBC ratio proxy for insurers' capital adequacy is measured by their RBC ratio, that is, the ratio of owned capital divided by risk capital multiplied by 100%.

3.2.2 Measuring diversification and Covid-19 pandemic

Product diversification is one of dependent variables in this study. This study uses Herfindahl-Hirschman index (HHI) to measure the degree of diversification for each insurer. The product diversification (PD) is calculated as the sum of the squares of the percentages of direct premiums written across all product lines for each insurer in each year. In addition, the study measures the degree of geographical diversification using the number of branches of the company (Number of Branch Office; NBO), as a proxy variable for regional diversification, geographical diversification (GD) is the sum of the number of branches and the number of communications offices. Additionally, regarding measuring the COVID-19 pandemic's impact on P-L insurers, to analyze this effect, we follow Aqabna et al. (2023) by using a dummy variable, equal to 1 if firm is during COVID-19 period and 0 otherwise.

3.2.3 Factors affecting financial stability

1. Firm Size (FS)

Firm size is one of important factors affecting the solvency risk of insurers. Larger insurers bring low costs, richer cash flows and stronger solvency through economies of scale (Wu & Li, 2021). Likewise, larger insurers are better able to spread portfolio risk through diversification than smaller insurers. However, Lopez-Valeiras et al. (2016) indicated firm size and financial performance had a negative impact on financial soundness. Al-Habashneh et al. (2023) also show that bank size adversely affects bank stability. Therefore, firm size factor presents the potential for a mixed result.

2.Firm age (FA)

Calantone et al. (2002) indicates that the older firms are able to respond to the market information more effectively and have higher good business performance than younger firms. In addition, Pottier (2007) pointed out that older firms have accumulated more experience through the learning effect and thus can better control the solvency risk.

3.Growth of premium (GP)

High premium growth is associated with an increase in a firm's corporate risk, as aggressive growth strategies may increase the risk of insolvency. (Lee & Urrutia,1996). When economies are bad, if an insurer increases its market share by increasing premiums coming through cash flow underwriting, it may not be able to bear the financial consequences of adverse circumstances.

4.Reinsurance (RE)

The use of reinsurance expands the insurer's underwriting capacity and allow insurers to hold less capital, reduce liabilities, and increase solvency without increasing its likelihood of its bankruptcy (Shim, 2017a). In addition, insurers transfer the risks through reinsurance to achieve risk diversification, reducing the potential for severe financial losses resulting from catastrophes.

5.Profitability (PRO)

Shim (2010) found that profitability plays an important role in determining an insurer's ability to increase capital. Moreno et al. (2020) also conclude that insurer solvency is positively related to profitability in Spain insurance sector.

6.Financial leverage (FL)

Colquitt and Hoyt (1997) indicated that leverage brings lower operational costs but also increases the likelihood of financial risks. Capital structure literature confirms that leverage increases, the value of the firm increases to optimum situation. Therefore, leverage about this optimum level may result in high risk of firm bankruptcy (Chen & Wong, 2004).

7.GDP growth (GDP)

The high growth of GDP during the rise of business capital creates good business opportunities for insurers (Tan,2016), and insurer may have good profits. Therefore, macroeconomic factors can affect the financial status of insurers; if insurers continue to be optimistic about the overall economic situation may be stimulated to engage in risky behavior, and vice versa. This study uses GDP growth rate as the macroeconomic environment variable (Hsieh et al., 2015).

8.COVID-19 pandemic (COVID)

The COVID-19 pandemic could lead to the beginning of another economic crisis (Oravský et al., 2020), since the P-L insurers face unique claims challenges due to the widespread disruption and uncertainty caused by the pandemic. As a result, the COVID-19 pandemic could have a serious impact on the insurers' capital.

9.Financial holdings (FH)

As far as the financial market is concerned, if an insurer belongs to one of the large groups, it can integrate and share the resources to improve efficiency and achieve good performance. Therefore, the chances of bankruptcy are lower. The definition of the variables is presented in table 1.

Table 1 Variables and Definitions

Variable	Definition
Dependent variables	
Z-score	$(100 + \text{Average ROE}) / (\text{Standard deviation of ROE})$
Risk-Based Capital (RBC)	$(\text{Owned capital} / \text{Risk-based capital}) \times 100\%$
Explanatory	
Product diversification (PD)	Measured by 1-Herfindahl index (HHI) of product line
Geographic diversification (GD)	The number of branches of the company
Control variables	
Firm size (FS)	Natural logarithm of total assets
Firm age (FA)	Number of years since an insurer was established

Growth premium (GP)	Percentage growth in premiums from year t-1 to year
Reinsurance (RE)	It is calculated by dividing the reinsurance premium by the retained earned premium income.
Profitability (PRO)	Pre-tax income (losses) /average assets
Financial leverage (FL)	Total liabilities / total assets
GDP growth (GDP)	$(GDP_t - GDP_{t-1}) / (GDP_{t-1})$, where GDP respects real gross domestic product
COVID-19 pandemic (Covid)	Dummy variable, during COVID-19 pandemic period then equal to 1, for the period before the COVID-19 pandemic to 0.
Financial holdings group (FH)	Dummy variable equals 1 if financial holding company; 0 otherwise.

3.3 Methodology

Traditional diversification determinants analysis adopts the ordinary least squares (OLS) approach (Liebenberg & Sommer, 2008; Che et al., 2017). The goal of the OLS approach is the minimum sum of the sum of squares of the error terms and emphasizes the average relationship between variables typically depends on an a priori distributional assumption of the dependent variable and the independent variable. Other parameters of conditional assignment of dependent variable are omitted, and different from the OLS, the quantile regression (QR) approach uses the minimum sum of the absolute values of the error terms in the target. Therefore, when the gap between samples is large or there are extreme values, the Quantile regression is more robust (Koenker & Hallock, 2001). This approach details how the conditional distribution of the dependent variable depends on the covariates of independent variables at each quantile (Chang and Tsai, 2014). In recent years, more of scholars have adopted QR models to analyze insurance data; for example, Shim (2017 b) used QR to examines diversification-performance relationship and Hung and Chang (2018) analysis of capital structure for P-L insurance.

Therefore, this study uses traditional OLS method and adds the QR approach for more detailed analysis. Through literature review, the regression model of insurers' financial stability can be predicted by the different following different factors:

$$Z \text{ score}_{it} = \alpha + \beta_1 PD_{it} + \beta_2 GD_{it} + \beta_3 PRO_{it} + \beta_4 GP_{it} + \beta_5 RE_{it} + \beta_6 FS_{it} + \beta_7 FA_{it} + \beta_8 GDP_{it} + \beta_9 FL_{it} + \beta_{10} FH_{it} + \beta_{11} COVID - 19_{it} + \varepsilon_{it} \dots \quad (1)$$

$$RBC_{it} = \alpha + \beta_1 PD_{it} + \beta_2 GD_{it} + \beta_3 PRO_{it} + \beta_4 GP_{it} + \beta_5 RE_{it} + \beta_6 FS_{it} + \beta_7 FA_{it} + \beta_8 GDP_{it} + \beta_9 FL_{it} + \beta_{10} FH_{it} + \beta_{11} COVID - 19_{it} + \varepsilon_{it} \dots \quad (2)$$

where i represents firms, t is years, and ε_{it} is the error term, α is the intercept; β is the estimated regression coefficient of independent variable; $j = 1, 2, 3 \dots 11$; assuming that is obeys the normal distribution.

4. Empirical results

4.1 Descriptive Statistics

Observing from the mean value of Z-score and RBC, P-L insurers are 8.4917 and 4.6445 respectively, among which RBC' maximum 10.8189 and minimum value of -16.8092, and the difference is extremely large, indicating that the solvency of this P-L insurers shows a wide range of extreme values. Further, the means of product and geographic diversification of P-L insurers are 0.6264 and 38.0972 respectively, show that P-L insurer has a high degree of product and geographic diversification strategy. In addition, P-L insurers' overall profitability (ROA) average -1.52% due to Covid-19 pandemic. Subsequently, this study uses the variance inflation factors (VIF) to test for multicollinearity among independent variables in the regression program. The VIF of all independent variables in the study were less than 5, which was lower than 10 of Cohen et al. (2003). Therefore,

the regression results are not affected by multicollinearity. The descriptive statistics and the VIF values used in the regression analysis will be presented in Table 2.

Table 2 Descriptive Statistics of Variables

Variable	Mean	Std. dev.	Median	Min	Max	VIF
Z-score	8.4917	1.4892	8.7637	1.5995	10.8874	
Risk-Based Capital (RBC)	4.6645	3.0135	4.0186	-16.8092	10.8189	
Product diversification (PD)	0.6264	0.0683	0.6354	0.3618	0.7620	1.67
Geographic diversification (GD)	38.0972	17.8148	37.0000	1.0000	90.0000	2.60
COVID-19 pandemic (Covid)	0.1538	0.3617	0.0000	0.0000	1.0000	1.34
Profitability (PRO)	-0.0152	0.3489	0.0344	-4.0535	0.1684	3.62
Growth premium (GP)	0.0584	0.0773	0.0555	-0.1611	0.5392	1.10
Reinsurance (RE)	0.3195	0.1177	0.290	0.159	0.780	2.46
Firm size (FS)	16.6723	0.7323	16.6469	14.7983	18.6951	4.58
Firm age (FG)	48.2667	19.2796	53.0000	4.0000	91.0000	1.73
GDP growth (GDP)	0.0368	0.0226	0.0296	0.0147	0.1025	1.07
Financial leverage (FL)	0.7024	0.1401	0.6794	0.5068	1.8619	3.66
Financial holdings group (FH)	0.2769	0.4486	0.0000	0.0000	1.0000	1.51

4.2 Analysis of differences in variables before and during the COVID-19 Pandemic

Table 3 shows the differences in the mean values of each variable before and during the COVID-19 crisis. The table contains before and during the COVID-19 pandemic, as well as the differences, between the average value. Focusing on the statistically significant differences, this study can see that the mean values of Z-score and RBC before and during the COVID-19 pandemic periods were 8.7309, 7.1923, and 4.8782, 3.4894 respectively. It shows that during the COVID-19 pandemic period, the solvency of P-L insurers has shown a downward trend. The average of the profitability for the before and during of COVID-19 pandemic periods were 0.0320 and -0.2719, respectively, indicating that the profitability of P-L insurers has been greatly affected by the COVID-19 pandemic and has turned negative. Averages of premium growth, firm size, firm age and GDP growth during the COVID-19 pandemic have increased compared to before the COVID-19 crisis. Finally, before the COVID-19, financial leverage averaged 68.96%, and during the COVID-19 pandemic, financial leverage averaged 77.32%, indicating an increase on financial leverage during COVID-19 period. These figures show that the average Z-score and RBC have declined during the COVID-19 pandemic, compared to previous non COVID-19 pandemic period, demonstrating the impact of COVID-19 pandemic on P-L insurers' financial stability. Univariate analysis showed that most variables differed significantly during Covid-19 and before the COVID-19 pandemic. The results are detailed in Table 3.

Table 3 Analysis of Differences in Variables before and During the COVID-19 Pandemic

	Before-the COVID-19 pandemic average (2010– 2020)	During the COVID- 19 pandemic average (2021– 2022)	Difference between before pandemic and pandemic average
Key variables			
Z-score	8.7309	7.1923	2.3488 ***
RBC	4.8782	3.4894	5.5955 ***
Product Diversification (PD)	0.6287	0.6141	1.0754
Geographic Diversification (GD)	37.8546	39.8667	-0.4267
Profitability (PRO)	0.0320	-0.2719	4.6126***
Growth premium (GP)	0.0535	0.0869	-2.2123**
Reinsurance (RE)	0.3319	0.2516	3.5369
Firm size (FS)	16.6203	16.9582	-2.3513***
Firm age (FA)	47.2667	53.7667	-1.7070**
GDP growth (GDP)	0.0355	0.0445	-2.0278**
Financial leverage (FL)	0.6896	0.7732	-3.0709***
Financial holdings (FH)	0.2667	0.3333	-0.7478

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively.

4.3 Diversification and COVID-19 pandemic on financial stability

This study used both OLS and QR approaches, and the corresponding results are shown in Table 4. The product diversification coefficients in the OLS model have a significant negative correlation with Z-score ($\beta=-6.961$, $p<0.01$). In addition, the product diversification coefficients in the QR model are also significantly negatively related to the Z-score at the all quantiles, which is consistent with the principal-agent theory. Product diversification leads to information asymmetry among insurers, causing agency problems, increasing management costs and the risk of bankruptcy. The Geographic diversification coefficient has a positive impact on the Z-score but insignificant in OLS and QR model, indicating that if Taiwan's P-L insurers are diversified in regions, this may positively contribute to finances, but this may be due to the small size of the geographic area, so that there is no significant correlation. In addition, the coefficient of the COVID-19 pandemic dummy is negative significant with Z-score in OLS ($\beta=-1.356$, $p<0.01$), whereas the COVID-19 pandemic dummy coefficients in the QR are negative significant at the lower and median quantiles ($\tau=0.1, 0.25, 0.5, 0.75$), which is consistent with Puławska (2021) that shows that the pandemic has had a negative impact on stability of the insurance sector, reducing insurers' average ROA and Solvency II ratio. Furthermore, for higher quantiles insurers, the Covid-19 pandemic dummy coefficients in are negative, but not significant. This shows that Covid-19 is not having a significant negative financial impact on all P-L insurers. In table 4, an insurer's financial leverage is negatively related to the Z-score for both OLS and the QR models. The result is consistent with the view proposed by Chen and Wong (2004) that insurers having greater financial leverage level could lead to high bankruptcy risk.

For other control variables, the coefficients of the RE variable are significantly positive for OLS model ($\beta=1.899$, $p<0.1$), which is consistent with Shim (2017 a), reinsurance is a substitute for capital that reduces the capital held by insurers without increasing insurers' probability of insolvency. The RE coefficients in the QR model are positive at median quantiles. The insurers at the median quantiles($\tau=0.5, 0.75$), show that insurers can reduce their capital burden and have higher financial stability by using reinsurance. The coefficients FS are positive and significant for the OLS model($\beta=0.564$, $p<0.05$), consistent with the predictions of Wu and Li (2021). Larger insurers through economies of scale lead to low costs, with richer cash flows, whereas coefficients in the QR model are positive at lower and low and median quantiles($\tau=0.1, 0.5$), suggesting that insurers in the low and median quantiles may have more rigorous management and therefore have higher financial stability. The coefficients FH are positive and significant in the OLS and QR model, which is

consistent with the views of Phillips et al. (1998), that an insurer that is a member of a group may be bailed out by the group to protect the group's reputation.

Table 4 Empirical Results of the OLS and QR Approach (Independent Variable: Z-score)

	OLS	Quantiles (τ =0.1, 0.25, 0.5, 0.75, and 0.90)				
		0.1	0.25	0.5	0.75	0.9
Intercept	7.1185*	5.2229	5.4740	1.2727	10.9503*	20.2250**
	(3.8889)	(5.5234)	(5.1841)	(6.3415)	(6.5098)	(10.1052)
PD	-6.9608***	-9.9570***	-5.7372***	-5.6530***	-6.1100***	-9.5462***
	(1.5560)	(2.8005)	(2.8201)	(2.2023)	(2.1587)	(2.7278)
GD	0.0030	-0.0075	0.0072	0.0102	0.0236	0.0303
	(0.0084)	(0.0113)	(0.0111)	(0.0101)	(0.1496)	(0.0240)
COVID-19	-1.3557***	-1.4574**	-1.0536***	-0.9887***	-0.7587**	-0.6691
	(0.2789)	(0.6589)	(2.0080)	(0.2702)	(0.3676)	(0.5439)
PRO	-0.5321	0.6724	1.1295	-0.9144	-0.4988	-0.5293
	(0.5515)	(2.9406)	(3.1188)	(3.0573)	(2.5920)	(2.8165)
GP	0.1525	0.8061	0.4135	-0.8381	-0.8602	-1.6623
	(0.7646)	(1.2448)	(0.9019)	(0.8986)	(1.8348)	(2.4795)
RE	1.8990*	2.5267	1.9825	2.8175**	3.6475**	3.2568
	(1.0932)	(1.9184)	(1.6336)	(1.2959)	(1.6414)	(2.4283)
FS	0.5636**	0.7341*	0.5883	0.8388**	0.2332	-0.1468
	(0.2388)	(0.3843)	(0.3698)	(0.3556)	(0.3886)	(0.6062)
FA	0.0071	0.0035	0.0046	0.0038	0.0057	0.0054
	(0.0053)	(0.0078)	(0.0062)	(0.0055)	(0.0094)	(0.0132)
GDP	-2.6468	0.7601	-1.8218	-2.8417	-7.6727*	-2.8383
	(3.4151)	(5.4584)	(5.1008)	(3.8507)	(4.3081)	(4.7195)
FL	-6.6349***	-6.8550***	-7.1396***	-6.2745***	-5.6658***	-6.4333**
	(1.3292)	(2.6380)	(2.0080)	(1.4402)	(1.6709)	(2.8443)
FH	0.7728***	1.2725***	0.8275***	0.3400	0.6204*	0.6421**
	(0.2088)	(0.3916)	(0.2542)	(0.2898)	(0.3439)	(0.4068)
N	195	195	195	195	195	195

This table presents the results of the OLS approach (column 2) and of the QR approach with quantiles $\tau=0.1, 0.25, 0.5, 0.75$ and 0.9 (column 3-7). The dependent variable is the insurers' Z-score. Standard errors are in parentheses. Note: ***, ** and * represent statistical significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively.

Using the OLS and QR approaches as analysis tools, and the relevant results are listed in Table 5. The product diversification coefficients in the OLS model have a significant negative correlation with RBC ($\beta=-6.413$, $p<0.01$). It shows that the diversification of insurers may lead to differences in risk types and risk bearers, thereby increasing the operating difficulties of an insurer, whereas the product diversification coefficients in the QR model are significant at the lower and median quantiles ($\tau=0.25, 0.5$). In addition, the finding is that QR result provides insurers product diversification is significant and positive with the RBC ratio at the higher quantiles ($\tau=0.90$) indicating higher quantiles insurers support coinsurance effect theory, insurers' cash flows from different business activities are not perfectly correlated, thus stabilizing the financial position of the diversified insurers (Hann et al., 2013). The P-L insurers product diversification reports a negative relationship with insurers' RBC ratio, which is same as the previous Z-score. The Geographic diversification coefficient shows a positive impact on Z-score, but is insignificant in OLS and QR model, indicating for Taiwan's P-L insurers that are diversified in regions, this may positively contribute to finances, but it may be that the small size of the geographic area results in no significant correlation. Furthermore, the coefficient of the COVID-19 pandemic dummy is insignificant with the RBC ratio in OLS, whereas the COVID-19 crisis pandemic coefficients in the QR are also insignificant at the all quantiles. The possible reason is that according to the Taiwan's financial supervision regulations, if the RBC ratio is between 150% and 200%, an insurer must increase capital

with a time limit. Therefore, some insurers likely continuously increased capital during the period to raise or restore the RBC to the normal level, resulting in an insignificant relationship between the Covid-19 dummy and the RBC ratio.

For other control variables, we find that the coefficients of FS variable are insignificantly positive for the OLS model, whereas the FS coefficients in the QR model are negative at median and higher quantiles ($\tau=0.5, 0.75$), which is consistent with the argument of Lopez-Valeiras et al.(2016), that indicates that firm size has a negative impact on financial soundness. The coefficients FA are positive and significant in OLS model, whereas coefficients in the QR model are positive at median and higher quantiles ($\tau=0.5, 0.75$), consistent with the predictions of Pottier (2007). Older firms have accumulated more experience thus can better control the solvency risk. The coefficients GDP are negative and significant in the OLS and QR model, indicating that insurers have optimistic expectations about economic growth and are prone to engage in high-risk investment behaviors that affect their solvency.

Table 5 Empirical Results of the OLS and QR Approach (Independent Variable: RBC)

	OLS	Quantiles ($\tau=0.1, 0.25, 0.5, 0.75$, and 0.90)				
		0.1	0.25	0.5	0.75	0.9
Intercept	26.7705*** (5.5120)	15.1305** (6.8140)	22.5308*** (8.3061)	30.7838*** (5.4512)	29.4154*** (5.6462)	19.4446** (8.8167)
PD	-6.4132*** (2.1611)	-4.0345 (3.4199)	-7.3853** (3.4739)	-8.5485*** (2.7026)	-1.7398 (3.4704)	7.0887* (3.6337)
GD	0.0109 (0.0107)	0.0105 (0.0099)	0.0164 (0.0113)	0.0159 (0.0116)	0.0175 (0.0142)	-0.1625 (0.0273)
COVID-19	0.3117 (0.3782)	0.4663 (0.3391)	0.5269 (0.3751)	-0.0475 (0.4232)	-0.3109 (0.3882)	-0.2009 (0.4478)
PRO	1.3488** (0.6363)	3.6541** (1.7448)	3.1733* (1.9099)	0.1555 (2.6326)	-0.4756 (2.9891)	-1.7378 (3.8140)
GP	-1.5470 (1.6027)	2.7497 (1.9562)	-1.0344 (2.8233)	-0.5937 (2.6367)	0.1295 (2.5980)	-2.9652 (2.3497)
RE	-0.5532 (1.5382)	0.1946 (1.3939)	-0.9582 (2.0214)	-0.0365 (1.9476)	-1.6068 (2.4133)	1.2603 (4.0008)
FS	-0.5306 (0.3411)	-0.3906 (0.3403)	-0.5766 (0.4327)	-0.6178* (0.3468)	-0.7854** (0.3839)	-0.2650 (0.5322)
FA	0.0268*** (0.0082)	0.0055 (0.0094)	0.0111 (0.0121)	0.0251*** (0.0071)	0.0298*** (0.0092)	0.0171 (0.0143)
GDP	-23.3945*** (5.4284)	-3.2204 (5.1800)	-12.9512** (6.3920)	-24.9123*** (6.4900)	-12.3463** (6.7030)	-22.3512*** (7.8029)
FL	-13.9680*** (1.6082)	-6.0407* (3.1183)	-7.6613* (4.4059)	-16.4304*** (3.1329)	-14.6798*** (3.5107)	-17.1216*** (4.3628)
FH	-0.1355 (0.3247)	0.3862 (0.2611)	0.2245 (0.4560)	0.5433 (0.4465)	-0.4688 (0.3652)	-1.1061* (0.6025)
N	195	195	195	195	195	195

This table presents the results of the OLS approach (column 2) and of the QR approach with quantiles $t=0.1, 0.25, 0.5, 0.75$ and 0.9 (column 3-7). The dependent variable is the insurers' Z-score. Standard errors are in parentheses. Note: ***, ** and * represent statistical significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively.

5. Conclusions and Policy Implications

The evidence shows that product diversification presents a significantly negative impact on insurers' Z-score at the OLS and QR (all quantiles). For insurers at all quantiles, the principal-agent argument is supported, indicating that product diversification makes information asymmetry in insurers, which increases management costs and the risk of bankruptcy. Some scholars (Berger & Ofek, 1995; Borghesi et al., 2007; Volkov & Smith, 2015) have proposed that diversification discount due to such

as opportunistic behavior, internal coordination and management costs and the failure of manager in product diversification decision-making. In this study, health insurance operations during COVID-19 brings high liquidation risks to Taiwan's P-L insurers due to high volatility of new activities resulting in higher loss than expected profits (Castro & Mejía, 2019), show high product diversification leads to financial instability of insurers. However, product diversification has a significantly negative impact on insurers' RBC ratio at the lower and median quantiles which is same as previous Z-score, but higher quantiles insurer's diversification is significant and positive with RBC ratio, indicating insurers' cash flows from different business activities are not perfectly correlated, stabilizing the financial position of the diversified insurers. In addition, Geographic diversification coefficient is positive impact on Z-score and RBC but insignificant in OLS and QR model, indicates Taiwanese P-L insurers cannot effectively perform its diversification function due to small size geographic. There is a negative significant relationship between the COVID-19 pandemic with the Z-score in OLS, whereas there is also a negative significant relationship between the COVID-19 crisis with the Z-score for insurers in the lower and median quantiles in the QR model ($\tau=0.1, 0.25, 0.5, 0.75$), indicating the COVID-19 pandemic on financial impact of Taiwan's P-L insurers. The COVID-19 crisis is insignificant with RBC ratio in OLS and QR models, possible reasons may be affected by the capital increase of the supervisory authority in the current year. These results contrast with those of the OLS approach.

Other major findings are summarized below. First, there is evidence that insurers with greater financial leverage have lower solvency and higher solvency risk. Second, reinsurance is generally considered as a risk transfer tool and higher and median quantile's insurers use reinsurance will help improve insurers' solvency risk. Third, insurers that belong to financial holding groups will be able to improve their solvency due to the financial support of the group. Finally, economic growth may lead to optimistic expectations among insurers and increase risk behavior that affect their finances.

Many literatures (Hann et al., 2013; Koumou, 2020; Adem, 2023) believes that diversification is beneficial to financial stability. Different from previous studies. The findings highlight some policy implications for insurance regulation, policymakers and insurers. First, the results of this study provides another perspective, the product diversification of P-L insurers may have an adverse impact on financial stability, insurers pay attention to diversification strategies, policymakers and/or regulators should understand the relationship between the product diversification and solvency of insurers, and managers must carefully evaluate and establish systems to control the degree of diversification to reduce potential risk. Second, The COVID-19 pandemic has indeed created financial instability for P-L insurers, which reflects the irresponsible risk-taking behaviors by insurers in order to profit. As a result, insurers face unbearable claims losses and financial risks, resulting in huge negative external impacts (Yeh & Lian, 2024). Finally, this study proposes a QR method instead of using traditional OLS method to examine the impact of diversification and COVID-19 pandemic on financial stability for P-L insurers. Therefore, in terms of practice applications, we suggest not only considering the results of the OLS method, but also carefully studying the results of the QR approach, so that more complete information can be obtained. This study has some limitations, including the problem of insufficient sample size. In the future, it is suggested that life insurance or banks can be added for further comparative analysis. Additional, subsequent research suggests that different evaluation indicators such as net worth ratio can be added in terms of financial stability to obtain more complete results for reference. As a caveat, since Taiwan P-L insurers diversified into health insurance, entailing large payouts during the Covid pandemic, this type of diversification may have had a significant effect on the results for the negative relationship between diversification and an insurer's solvency risk.

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