The Non-linear Impact of the Diversification of Life Insurance Companies on Solvency Risk-An Empirical Research Based on Panel Threshold Model

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Abstract—**Risk dispersion and risk hedging are important goals for the diversification of life insurance companies. Based on the panel data of Chinese life insurers from 2010 to 2015, we try to explore the non-linear impacts of the diversification of life insurance companies on solvency risk under different thresholds by using the Hansen threshold model with company size as a threshold variable. The study finds out that there is a threshold effect between the diversification of life insurance companies and the solvency risk. When the company's size is in different intervals, the diversification will have different impacts on the solvency risk, showing an inverted "U" trend. When the company is small, the new product line will increase the company's solvency risk. With the expansion of the company size, the impact of diversification on reducing solvency risk will be significant.**

Keywords—Life insurance companies; Diversification; Solvency risk; Panel threshold model

I. INTRODUCTION

Diversification and specialization both are important strategic decisions for business management. Enterprises can optimize their internal resource allocation, improve operational efficiency, enhance market power through diversified operations. Besides, they can apply asset portfolio theory by implementing effective product diversification portfolio strategies so as to reduce corporate risk exposure. The diversification of insurance companies usually refers to the diversification of products, that is, the diversification of insurance types. Compared with the specialized business model of focusing on single insurance, the diversified business model of developing multiple types of insurance can meet the diversified protection needs of consumers and help the insurance industry truly return to the source of protection. However, due to the particularity of insurance companies' operations, the effect of diversification on insurers' risk is two-way. On one hand, the insurers can obtain coinsurance effect by running several kinds of insurance products at the same time, because the loss probability of different risk is not completely related. Besides, the insurance company can realize risk hedge by underwriting two kinds of insurance products with opposite loss directions. For example, pension products and life insurance products can hedge each other's mortality risk. On the other hand, diversification does not necessarily reduce risks. It may also carries additional risks such as associated transaction risks, system transfer risks and so on. At

the same time, the difficulties of supervision caused by diversification may lead to the insurer's rent-seeking activities and thus may increase the insurers' risks. The diversification of insurance companies may also result in diversification of their risk types and risk carriers, which will increase the difficulty of the operation of insurance companies. In the post financial crisis era, the government has paid more and more attention to risk prevention in the financial industry. Solvency is crucial to the soundness of the insurance company's operations. Once a solvency crisis occurs, not only can the insurance company fail to maintain normal operations, but the interests of the insured will be threatened or harmed. Solvency supervision is the core of the supervision of insurance industry. Therefore, it has certain theoretical and practical significance to think about how diversification will affect the solvency risk of life insurance companies in China.

II. THEORETICAL BASIS AND LITERATURE REVIEW

Since the diversification strategy has been proposed, many scholars have researched the impact of diversification on enterprise risk. However, there is no accordant conclusion. Some foreign Studies have found that the positive effect is existed. The theory of coinsurance effect was first proposed by Lewellen (1971). Different business units of diversified companies can generate incompletely related cash flow, which will reduce the bankruptcy risk and the financial constraints of the company. Chiorazzo, et al (2008) has found that non-interest income of a bank is negatively correlated with interest income, so the risk of a bank can be reduced by adopting a combination of diversified business. Berry-Stollzle et al. (2012) classified US property insurers' diversification into two groups: risk-related business diversification and irrelevant business diversification. By group study, they found that diversification does reduce risks for businesses where risk is not related. However, the dissenters are not in the minority. Lubatkin, et al (1994) believes that a company with a positive management strategy can change the cash flow of the business and thus affect its asset income and risk by adjusting the direction of asset fluctuations according to its own business objectives. Amihud and Lev (1981) analyzed from the perspective of reducing the risk of managers themselves and found that diversification will motivate managers to engage in business activities with low added value, resulting in principal-agent issues. Jensen (1986) believed that managers can obtain private benefits from controlling more cash

resources due to diversification, which may cause serious agency conflicts. The existence of agency problems may further affect the investment decisions of companies and the designation and selection of relevant diversification strategies. Che, X and Liebenberg, AP (2017) believe that the geographical diversification of property insurance companies enable insurers to reduce the insurance company's underwriting risk through cross-regional risk distribution.

The conclusions of domestic scholars on the relationship between diversification and enterprise risk are also inconsistent. Huang Wei (2003) believes that small companies will diversify their resources by diversification, thereby reducing market control and increasing risks. Ding Zhong and Deng Kebing has found that the coinsurance effect of diversification is weak by using the data of Chinese listed companies from 2000 to 2006 to conduct empirical research. Wu Guoding and Zhang Huili (2015) has adopted the modified Altman Z value as a measure of corporate financial risk and found that business diversification has increased its financial volatility instead of reducing the company's financial risk. The traditional theory of modern asset portfolio theory did not apply to the listed companies in China. The researches of Lu Zhengfei and Zhang Huili (2010) found that the rent-seeking behavior of the subsidiaries of listed companies in China is rather common, which seriously undermines the efficiency of the allocation of corporate resources. Sun Qixiang et al. (2015) has studied the relationship between business concentration and risk of life insurance companies and found that geographic expansion will increase information asymmetry in headquarters and branches, therefore increase the agency costs of the company, which cannot significantly reduce the life insurance company's operations risk. Liu Aoqiong (2017) takes the listed companies as a sample and found that entering a new industry will bring higher financial risk and eventually lead to a large increase in the volatility of the company's performance and the increase of the company's risk for the small listed companies. With the continuous expansion of the company, the diversification of companies will reduce the comprehensive risks faced by the company.

III. SAMPLE AND METHODOLOGY

For the sake of availability and integrity, this paper selects the data of China's life insurance company from 2010 to 2015. The data comes from the following aspects: First, the micro-data of the insurance industry are obtained from the CSMAR; Second, we get the missing and unclear micro-data of individual insurance companies, from the annual "China Insurance Statistical Yearbook" and the annual reports of insurance companies. This article eliminates the companies with imperfect information and those companies with negative owners' equity in the current year. Finally, they collected 270 valid samples, including 45 Chinese life insurance companies. In this paper, some variables (such as solvency adequacy ratio) are winsorized by 5% because their extreme values will significant influence the result.

A. Variable Construction

Solvency Risk (SOL). In this paper, the solvency adequacy ratio is used to measure the solvency risk of life insurance companies. As to the solvency, it is the ratio of the "actual capital" to the "minimum capital" of the insurance company, which reflects the ability of the insurance company to fulfill its policy responsibilities. The larger the solvency ratio is, the lower the solvency risk is.

Product Diversification. The index commonly used in measuring diversification include the Herfindahl Index, the Entropy Index, and Rumelt's method. This article uses the Herfindahl index to measure the degree of products diversification of the property-liability insurance company. At the same time, we using the entropy index as an alternative variable to the Herfindahl index as robustness test. The measurement of the property-insurance company's product diversity by the Herfindahl Index in year t is:

$$H - LINES_{i,t} = 1 - \sum_{j=1}^{n} S_{i,j,t}^{2}, \qquad (1)$$

where $S_{i,j,t}$ denotes the proportion of the income of the insurer i in the insurance product i in the year t to the total premium income of the insurer i in the year t.

Threshold Variable

Size. The effect of product diversification on risk is different due to the size of the life insurance company. This paper selects the company size (SIZE) of life insurance company as a threshold variable, in which the size of the company is expressed by the natural logarithm of the total assets of the life insurance company.

Control Variables

Size. Larger companies have more specialized investment skills and knowledge to better control their risk (Pottier, S W, 2007). However, studies in recent years have found that due to the emergence of service outsourcing, many smaller insurance companies can also obtain professional asset management services from the outside to reduce risks. Therefore, the impact of company size on the risk of insurance companies is uncertain. In this paper, the company's total assets are taken as logarithms to represent the company's size.

Rein. Reinsurance is an important way for insurance companies to transfer risks. There is a negative correlation between the solvency risk of insurers and their risk assets (Lee, SJ, Mayers, D and Jr, CW S, 1997). Insurers transfer part of their risk to reinsurer to strengthen their soundness. Therefore, we expect that there is a negative correlation between reinsurance and the risks of insurance companies. The value of reinsurance equals the ratio of the ceded-out premium to total premiums.

Level. The higher the company's debt level is, the greater the possibility of its financial crisis is, that is to say, the company's debt level is positively related to the risk of the insurance company. The level of debt equals the ratio of debt to total assets.

Growth. Companies with better growth tend to have higher profitability, and the possibility of financial difficulties is

relatively low. Therefore, growth is negatively related to the risk of insurance companies. We use premium growth rates to measure the growth of insurance companies.

GDP. On the macro level, with the continuous development of the national economy, different macroeconomic fluctuations will bring different risks to company. Therefore, the impact of macroeconomic fluctuations on the risk of insurance companies should be put into the model. Therefore, the GDP is considered as a control variable in the model. And we take the logarithm of the GDP.

B. The Model

This paper selects the size of life insurance companies as threshold variables. This paper applies the panel threshold model to study the relationship between the degree of product diversification and the solvency risk of China's life insurance companies. Taking a single threshold regression as an example, the model is as follows:

$$SOL_{it} = \mu_i + \alpha_1 HHI_{it}.I(Size_{it} \leq \gamma) + \alpha_2 HHI_{it}.I(Size_{it} > \gamma) + \beta Control_{it} + \varepsilon_{it} \quad (2)$$

Among them, μ_i denotes the individual fixed utility, SOL_{it} denotes the solvency risk, HHI_{it} indicates the degree of product diversification of the life insurers, γ denotes the threshold value, ε_{it} denotes the residual term; I (.) denotes the indicator function, when the expression in parentheses is true, I (.) =1, otherwise I (.) =0. According to the threshold variable Size, the observed values can be divided into two intervals. The corresponding slopes are α_1 and α_2, respectively. $Control_{it}$ denotes a series of control variables, including company size (Size), reinsurance (Rein), debt level (Level), growth (Growth), and gross national product (GDP). If there are multiple thresholds, the model setting can be analogized. For example, the double threshold model is extended to:

$$SOL_{it} = \mu_i + \alpha_1 HHI_{it}.I(Size_{it} \leq \gamma_1) + \alpha_2 HHI_{it}.I(\gamma_1 < Size_{it} \leq \gamma_2) + \alpha_3 HHI_{it}.I(Size_{it} > \gamma_2) + +\beta Control_{it} + \varepsilon_{it} \quad (3)$$

First of all, the parameter estimation of the measurement equation is carried out, and the slope coefficient is estimated by obtaining the threshold value γ by transforming the model into the fixed effect model. The estimated values of α_1 and α_2 can be obtained by using the least square method, and the square sum of the residual difference is minimized to determine the value of gamma. Secondly, we try to check whether the threshold effect is significant, test threshold value, and construct confidence interval of threshold value γ. The existence of threshold effect needs to be tested. The original hypothesis $H_0: \alpha_1 = \alpha_2$. When the original hypothesis is ture, the threshold effect does not exist, the original model is transformed into a standard panel data model, and the least square method is used to estimate the coefficient. If the original hypothesis is not true, there is a threshold effect, and the threshold value is required to be tested for authenticity. The original hypothesis of authenticity test is:$H_0: \gamma = \gamma_0$. The test method is to calculate the confidence interval of γ by likelihood ratio LR (γ), that is, $LR(\gamma) = [SSR(\gamma) - SSR(\hat{\gamma})]/\hat{\sigma}^2$. Because the distribution of likelihood ratio test is not standard normal distribution, Hansen (1999) puts forward the first order asymptotic distribution. It is pointed out that the model based bootstrap method (Bootstrap) is the appropriate method to solve the small sample inference. Therefore, we use the bootstrap method (Bootstrap) to repeat 500 times to get the exact p value. If F1 refuses the original assumption that there is no threshold, we will continue to test the distinction between one or two threshold, and the method is similar to that, only on the basis of a threshold effect.

C. Description Statistics

Table 1 shows the descriptive statistics of the relevant variables. The average value of solvency for the life insurance company is 312%, and the standard deviation of it is 3.162. The average value of product diversification for the life insurance company is 0.407, and the standard deviation of it is 0.209.

TABLE I   SAMPLE DESCRIPTIVE STATISTICS

Variables	Mean	Std.dev	Min	Max
SOL	3.120	3.162	0.350	26.39
HHI	0.407	0.209	0.033	0.789
Size	24.01	1.880	19.63	28.53
Rein (%)	7.043	17.13	-0.63	123.0
Level	0.860	0.099	0.398	0.985
Growth	0.456	1.087	-1	9.843
lnGDP	13.22	0.173	12.93	13.44

IV. EMPIRICAL RESULTS

A. *Threshold Effect Test*

In this paper, the above inspection and estimation ideas are carried out by stata14, and the grid search method is used to find the threshold value. At the same time, the data itself is used to determine the number of threshold values. The single threshold, double threshold and higher order threshold are estimated in turn, and 500 times are taken from the sampling times. The result is showed in table 2 and table 3. From table 2, we can find that the estimated values of the double threshold are 24.312 and 21.906, respectively, and the three threshold values are 24.312, 21.906 and 21.598, respectively. The differences between 21.906 and 21.598 is very small, thus there is no need to continue to consider the three-threshold value. Therefore, double threshold model is suitable for this model, as shown in formula 3, where threshold values are $\gamma_1 = 21.906$ and $\gamma_2 = 24.312$. Since the total asset is processed logarithmically in the preceding equation, the company size corresponding to the threshold value are $e^{\gamma_1} = 3{,}261{,}971{,}769.542$ and $e^{\gamma_2} = 36{,}191{,}078{,}529.826$ respectively.

TABLE II   TEST RESULT OF THRESHOLD EFFECT

	F Value	P Value	1% critical value	5% critical value	10% critical value
Single threshold	40.113	0.000	20.817	12.188	8.224
Double thresholds	21.755	0.000	13.698	8.383	5.990
Three thresholds	11.352	0.008	11.081	6.161	3.898

TABLE III   THRESHOLD VALUE AND CONFIDENCE INTERVAL

	Threshold value	confidence interval
Single threshold	21.906	[21.906，21.906]
Double thresholds	24.312	[23.633，24.670]
	21.906	[21.528，21.906]
Three thresholds	21.598	[21.528，21.598]

The existence of threshold value shows that there is a nonlinear relationship between the degree of product diversification and the solvency risk of life insurance companies. Therefore, according to the threshold value, the life insurance company can be divided into three intervals by the size of the company. The first interval is the life insurance company with the company size (Size) less than 21.906, and the second interval is the life insurance company with the company size (Size) larger than 21.906 less than 24.312, and the third interval are life insurance company with the company size (Size) larger than 24.312.

B. *Regression Analysis*

The table 4 shows the estimation parameters of the model. When the company size is less than 21.906, the coefficient of the diversification of life insurance companies is -6.993957, which indicates that the degree of diversification of the life insurance company is significantly negatively related to the solvency, that is, the diversification of the product will increase the solvency risk. When the size of the company is larger than 21.906 and less than 24.312, the diversification degree of the life insurance company is -3.380005, which indicates that the degree of product diversification of the life insurance company is negatively related to the solvency, that is, the diversification of the product will increase the solvency risk. When the size of the company is larger than 24.312, which indicates that the degree of diversification of the life insurance company is positively related to the solvency, that is, the increase in product diversification will reduce the risk of solvency. Specifically, according to the absolute value of the product diversification coefficient in each interval, the absolute value of the life insurance company's scale in the second interval is less than the absolute value of the first interval. The result shows that the degree of the negative impact of the product diversification on the solvency will be reduced as the scale of the life insurance companies increases gradually.

The estimation results of the parameters in the threshold model

	Estimated value	Std.dev	T value	P value
β_1	-6.993957	1.177535	-5.94	0.000
β_2	-3.380005	0.7628548	-4.43	0.000
β_3	3.189892	0.7680397	4.15	0.000

Note: the R^2 of the model is 0.6419, the F statistic is 85.21, and the corresponding p value is 0, which is highly significant.

The nonlinear relationship between diversification degree and solvency of life insurance companies is reported in table 4. To be specific, there is a "acquisition process" for the reducing effect of the diversification of life insurance companies on solvency risk, which is consistent with the qualitative analysis of Huang Wei (2003) and Liu Aoqiong (2017). When the size of the life company is small and the life insurance company is in the primary stage of development, blindly diversification of

the product expansion will make the internal resources excessive dispersion. In addition, the introduction of a new product to life insurance companies means operating a new type of risk. As for the small life insurance companies which is lack of management skills, product diversification will increase their solvency risk instead of enhancing their soundness. However, with the continuous expansion of the life insurance companies, its position of the main types of insurance in the market is gradually stabilized and the market power of the company is gradually increasing. Besides, the experience of its product research and development, actuarial pricing, exhibition, claim and customer service is accumulated, and the risk control system and operation ability of the life insurance companies are enhanced. Thus, with the adoption of the new product line, the adverse impact of the product line on its solvency will gradually decrease. Even when the scale of the company exceeds a threshold value, the increased diversification of the product will bring a favorable impact on the life insurance company. The life insurance company can apply the portfolio theory to the diversification strategy of its products and realize the risk dispersion and risk hedging by the diversification of unrelated insurance at the same time. At this stage, the diversification of life insurance companies will reduce their solvency risk, and the coinsurance effect of diversification will begin to appear.

V. CONCLUSIONS AND ENLIGHTENMENT

Using the panel data of 45 life insurance companies in China from the year 2010 to 2015, this paper studies the relationship between the product diversification of China's life insurance companies and the risk of solvency and explores the impact of different size of companies on the relationship. We apply panel threshold regression model to study this problem and take the natural logarithm of total asset of the life insurance company as a threshold variable to find out the boundary of interval change. The conclusions are as follows: first, there is a nonlinear relationship between product diversification and solvency risk of life insurance companies. The relationship between product diversification and solvency risk has interval effect, which can be divided into three intervals. When the size of the company is in different intervals, the diversification of the life insurance company has a different degree of effect on the solvency risk, and the difference of the effect is statistically significant. Secondly, the product diversification of life insurance companies has a "U" relationship which first decreases and then increases. When the company is small in size, the diversification of life insurance companies takes negative effect on its solvency adequacy ratio. When the company is larger, the diversification of life insurance companies takes positive significant on its solvency

adequacy ratio. With the development of the life insurance company, it can begin to benefit from the diversified operation of their products.

In view of the above conclusions, we can get the following enlightenment: faced with the increasingly fierce competition environment, most insurance companies choose strategy of diversification. After decades of development, China's insurance industry has many problems in its extensive pursuit of business scale and market expansion. It is not applicable to all insurance companies by gaining market power through product diversification strategy so as to occupy the market position. For the small and medium size of life insurance companies which are in the primary stage of development, it is not suitable to blindly follow the strategy of diversification. Their urgent task should be focused on their core business, so as to improve its product actuarial pricing skills, underwriting, claim, customer service and asset management ability, and strengthen the risk control ability of their new types of insurance. When the life insurance companies develop into a certain stage, it is advisable to introduce new insurance gradually and reduce the impact of the new insurance on the operation of the company. At the same time, for larger size of life insurance companies, they can moderately carry out product diversification and reduce the company's solvency risk by implementing effective portfolio diversification strategy.

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