North American Journal of Economics and Finance 29 (2014) 185–199

Contents lists available at ScienceDirect

North American Journal of Economics and Finance

Risk management in life insurance companies: Evidence from Taiwan

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ARTICLE INFO

Article history:
Received 11 January 2014
Received in revised form 20 June 2014
Accepted 23 June 2014

JEL classification:
G22
G32

Keywords:
Investing risk
Underwriting risk
Two-stage quantile regression
Risked-based capital

ABSTRACT

The solvency issue of life insurance companies has become more important in recent years as business risks turn increasingly greater. This study examines the relationship among investing risk, underwriting risk, and the capital ratio during the post risk-based capital regulation period of 2004–2009 in Taiwan. In addition to the two-stage least square regression (2SLS), we also adopt the two-stage quantile regression (2SQR) to capture the effects of low capital (or risk) levels and high capital (or risk) levels. 2SLS do not fully explain the capital-risk relation. Contrary to previous evidence reported in the U.S., our findings in 2SQR model indicate that the relationship between capital and underwriting risk is positive, while the relationship between investing risk and capital shows a reverse pattern. Overall, the 2SQR provides stronger evidence than the 2SLS.

1. Introduction

This is the first study to examine the interrelationships among capital, investing risk, and underwriting risk in the life insurance industry by using the two-stage quantile regression (2SQR) method. For the insurance sector, theoretical literature and academic studies in this area have focused mostly on

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http://dx.doi.org/10.1016/j.najef.2014.06.012
1062-9408/

the influence of the risk-based capital (RBC) regulatory instrument. The theoretical literature widely examines a variety of hypotheses predicting insurers' capital and risk-taking behavior, such as risk subsidies, transaction costs and regulatory costs. The first is the risk subsidy hypothesis that assumes a negative relation between risk and capital. This hypothesis implies that financial firms are prone to have more incentives to increase risks through exploiting the benefits of guaranty funds (Lee, Mayers, & Smith, 1997) since the guaranty charges are flat on premiums rather than being risk-based. The second is called the regulatory cost hypothesis and suggests a positive relation between risk and capital (Shrieves & Dahl, 1992). This hypothesis predicts that if the regulatory capital cost is high, then the financial firms may tend to take on more risk to balance the explicit and implicit costs of regulation. The third is represented as the transaction cost hypothesis and first introduced by Coase (1937) and further expanded by Williamson (1988), who contends that the level of transaction costs mostly determines the degree of vertical integration and capital structure.

Baranoff and Sager (2002) use the view of transaction costs to predict the relation between product risk and capital in the life insurance industry. They recognize that health insurance is the kernel of transaction costs, because it involves more contractual uncertainty than other product lines. When life insurers sell riskier products such as health insurance, they may increase their equity, rather than debt. Hence, the transaction cost hypothesis implies that risk and capital are positively related.

Similar to the theoretical literature, the empirical literature also produces contradictory conclusions, since each study may outline capital and risk decisions in its small set of financial firms, risk measures, and methods, depending on the study's characteristics. Table 1 shows several representative studies regarding risk-capital relationships. Among insurance studies, Cummins and Sommer (1996) address that the insurers increase their risk positions as capital levels increase in the property/casualty insurance market. Baranoff and Sager (2002, 2003) and Baranoff, Papadopoulos, and Sager (2007) show a positive relationship between capital and regulatory asset risk (or opportunity asset risk), supporting the regulatory cost hypothesis and the bankruptcy avoidance hypothesis. They also find a negative relationship between product risk and the capital ratio. In banking studies, Shrieves and Dahl (1992) find a positive relationship between capital and asset risk, revealing that banks that have increased their capital level have also raised their risk level. Their results support several hypotheses, including the unintended effect of minimum capital regulation, regulatory costs, as well as bankruptcy cost avoidance.

The opposite findings are encountered by Jacques and Nigro (1997), who post a negative relation between portfolio risk and capital among a large number of U.S. commercial banks. Several bank studies report that banks may take on more or less risk depending on their different capital positions. Calem and Rob (1999) argue that severely undercapitalized banks may bear greater risks than medium-sized capital banks as well as well-capitalized banks. Heid, Porath, and Stolz (2003), Jeitschko and Jeung (2007) and Jokipii and Milne (2011) note that, for well-capitalized banks, risk and capital level are positively related, while for undercapitalized banks, there is a negative relation between the two.

Both theoretical and empirical arguments raise some questions in terms of RBC requirements. For instance, how do life insurers react to capital requirements? Do they raise or reduce their risk-taking behavior? How do they react to different types of risk? As we know, the life insurance sector is a highly regulated industry, because insurers' insolvency brings about a negative impact upon the soundness and stability of the financial system. As Lee, Huang, and Yin (2013) note, the life insurance market, particularly the life insurance premium, plays a significant role in financial markets. When the regulators implement financial or economic policies, they must take account of the impacts of these policies on the insurance market. da Silva and Divino (2013) also warn that financial institutions' credit risks are pro-cyclical and default risks depend on structural features, and thus the regulator should set up a policy to promote financial stability and efficiently reduce fluctuations.

Life insurers in Taiwan have recently been increasingly exposed to greater risks, because of more competitors, expanding insurance interest losses, and the recent global financial crisis. To mitigate life insurers' excessive risk seeking, Taiwan has implemented the RBC requirements in its domestic insurance system since 2003. This mechanism may bring a substantially important impact on life insurers' capital decision and risk-taking behaviors. Since risk management in the insurance industry has become an important issue, investigating the relationships among investing risk, underwriting risk, and capital is crucial for regulators and life insurers in Taiwan.

Table 1
Summary of representative studies examining risk-capital relationships.

Country	Authors	Risk measure	Sample	Method	Findings
U.S.	Shrieves and Dahl (1992)	1. Asset risk 2. Non-performing loans risk	1800 FDIC-insured and holding company commercial banks (1983–1984)	Simultaneous equations approach (2SLS)	A positive relation between asset risk and capital supports the regulatory bankruptcy cost avoidance and managerial risk-averse theory
U.S.	Cummins and Sommer (1996)	Standard deviation of ROA and loss ratio	Property–liability insurers (1979–1990)	Simultaneous equations approach (2SLS)	Positive relation (agency-cost theory)
U.S.	Aggarwal and Jacques (1998, 2001)	1. Risk weighted asset (RWA) 2. Non-performing loans risk	Banks (1991, 1992, 1993–1996)	Three-stage simultaneous equations (3SL)	*Mixed*: Negative relations in 1991–1992, but positive relation in 1993 (RWA)
U.S.	Jacques and Nigro (1997)	Risk-weighted asset	2570 U.S. FDIC-insured commercial banks (1990–1991)	Simultaneous equations approach (2SLS)	Negative relation
U.S.	Beatty and Gron (2001)	1. Risk adjusted assets 2. Asset growth	438 holding company banks (1990–1995)	OLS and 2SLS	Risk is positively related to equity capital financing, particularly for banks with low capital
U.S.	Baranoff and Sager (2002)	1. Regulatory asset risk 2. Product risk	1022 life insurers (1993–1997)	Simultaneous equations approach (2SLS)	There exists a positive relation between asset risk and capital, but a negative relation between product risk and capital (transaction cost theory).
U.S.	Baranoff and Sager (2003)	1. Regulatory asset risk 2. Product asset risk	789 life insurers (1993–1999)	Simultaneous equations approach (2SLS)	There is a positive relation between asset risk and capital
U.S.	Baranoff et al. (2007)	1. Regulatory asset risk 2. Opportunity asset risk	719 life insurers (1994–2000)	Structural equation model (SEM)	Both RAR and OAR have positive effects on capital for larger insurers
U.S.	Jokipii and Milne (2011)	1. Risk weighted assets 2. NPL risk	U.S. holding companies and commercial bank (1986–2008)	1. Single equation 2. GMM equations	For well-capitalized banks, RWA and buffer capital are positively related, but for undercapitalized banks, RWA and buffer capital are negatively related
Swiss	Bichsel and Blum (2004)	1. S.D. of rate of return on assets 2. S.D. of stock index	19 Publicly traded banks (1990–2002)	Two-step FGLS procedure	Positive relation (regulatory cost theory)
Germany	Heid et al. (2003)	Risk weighted assets	550 saving banks (1994–2002)	2SLS and 3SLS	There exists a positive relation for banks with high capital buffers and a negative relation for low capital banks
Japan	Deelchand and Padgett (2009)	Market risk (S.D. of stock return)	263 cooperative banks (2003–2006)	2SLS	1. Negative relations (buffer effect) 2. Larger banks hold less capital and take on more risk

Our research is of interest for several reasons. First, life insurers may show different managerial discretion when considering two types of risk under increased capital requirements. Due to a gradual relaxation of portfolio restrictions in recent years in Taiwan, insurers may have more incentives to pursue greater investing risk for the maximization of profits while the incentive for underwriting is not obvious, because insurers suffer from a great deal of insurance interest losses, prompting them to adopt relatively conservative strategies. Second, the capital requirements of Taiwan may differ from those of the U.S. and other countries due to different regulatory cultures, economic development, and managers' risk preferences. For instance, Taiwan's portfolio restrictions may be more stringent such as on regulating overseas investment, while the authority capital requirement seems looser, when compared to the U.S. This may cause different policy effects between Taiwan and the U.S. Third, the ability of Taiwan's life insurers to adjust their capital and risk may differ from that of the U.S. Such adjustment abilities may be marginal in Taiwan for lower liquidity among the stock shares of small firms and a fledgling market for asset-backed securities. Most of Taiwan's small companies find it difficult to raise capital in a less developed capital market due to their limited resources and asymmetric information. Moreover, Taiwan has not had much experience in asset securitization like in the U.S. Such a difficulty in adjusting capital and risk may impact Taiwan insurers' risk-taking behaviors.

One contribution of our study is to provide empirical findings of risk management in a developing economy outside the U.S. and European financial institutions. A second contribution is to push forward the literature not only by using the two-stage least squares (2SLS) method, but also by adopting a new method of the two-stage quantile regression (2SQR). While many empirical economists prefer the traditional two-stages least squares (2SLS) due to its advantage in lowering estimation biases caused by endogeneity, the two-stage quantile regression (2SQR) approach provides more information, other than the mean, when researchers are interested in a specific part of the distribution of the variables (Kim & Muller, 2004; Fattouh, Scaramozzino, & Harris, 2005). Third, this paper simultaneously takes into account two types of risks: investing risk[2] and underwriting risk.[3] We believe this paper offers some insights for the empirical literature on the life insurance industry.

2. Analysis of Taiwan's life insurance sector and the hypothesis

Taiwan's life insurance industry has experienced tremendous growth since it was deregulated in 1992 by allowing new entrants into the market under the global liberalization trend. Life insurance in the country is an integral financial service industry with NT$2006 (US$60.70) billion in premium income and NT$10,782 (US$326.24) billion in assets in 2009.

Most profits in the life insurance industry come from financial investment. As the importance of financial investment for insurers' profitability is increasing, Taiwan's regulator has expanded the scope of investment targets, like relaxing corporate bond restrictions and allowing investments to acquire up to 25% of the shares of an insurance company in China. The regulator is currently considering to further lift the overseas investment ceiling from 40% to 50%. Under the relaxation of portfolio restrictions, life insurers may have more incentives to engage in investing rather than underwriting. They may hold the lowest capital level as possible in order to pursue more overseas investments, which may lead to a moral hazard problem. Moreover, Taiwan's guaranty fund system for insolvency protection is not executed on the basis of risk. Life insurers are not penalized for their risk-taking behaviors, because any shortfall of capital is expected to be covered by the guaranty fund mechanism. Under such a flat guaranty fund mechanism, life insurers may choose to take on more investing risk, because they want to obtain more profits from investing, which is their main source of profitability. According to the

[2] *Investing risks*: Life insurers may have different levels of risks when they invest in many types of assets such as loans, bonds, stock securities, real estate, or foreign investment. For example, overseas financial investments are viewed as high risk assets when compared to loans and bonds, in which the risk from the latter faced by insurers is relatively low.

[3] *Underwriting risks*: For insurers, different types of insurance products may face different levels of risks. When life insurers write more health insurance products, which usually involve more contractual uncertainty, they may take on more risks. In contrast, life insurers take on less risk to handle life insurance and annuities.

moral hazard hypothesis, we predict that life insurers may increase their investing risk when capital declines as stated below.

H1. There is a negative relation between capital and investing risk after controlling underwriting risk.

In the insurers' product markets, intense competition has erupted into a price war, leaving almost no margin for underwriting profitability. In order to uphold market share to survive, life insurers try to adopt a risky product strategy, but they still have to be careful as excessive exposure may deepen the existing insurance interest losses. Health insurance is considered as a riskier product strategy than life insurance or annuities (Baranoff & Sager, 2002, 2003). If life insurers write riskier products like health insurance, then they may try to hold more buffer capital to respond to the higher risks, because they may be burdened with high transaction costs and eroding capital may result in greater underwriting inefficiency. On the other hand, highly capitalized insurers may have more financial capital or social capital to provide differentiated services to attract policy holders and also carry superior bargaining power to write riskier products. This is because they may have a greater risk tolerance to deal with increasing disputes among the stake-holders or to cope with any dramatic change in the competitive environment. In addition, the regulatory cost of heath insurance is high, since the regulator imposes higher penalty weights on health insurance compared to life insurance and annuities according to Taiwan's capital requirements. Insurers may be forced to write more health insurance to compensate for regulatory capital costs. According to the transaction cost hypothesis and regulatory cost hypothesis, we predict that the capital level may be positively related to underwriting risk.

H2. There is a positive relation between capital and underwriting risk after controlling investing risk.

3. Investing risk, underwriting risk, capital, and relevant variables

3.1. Investing risk (INR)

In additional to selling insurance products, life insurers invest the funds that are entrusted to them, thus making them a part of the financial institution industry. Regulators assess insurers' credit or default risk mostly by means of the asset risk component in the RBC formula. Our paper uses regulatory assets as a proxy for investing risk based on two reasons. First, this measure essentially echoes the regulators' objective of minimizing business risk and reflects insurers' solvency. Second, it can reflect firms' risk-taking decision in a timely manner (Rime, 2001) as a result of being an ex ante indicator. Similar to prior studies (Jacques & Nigro, 1997; Baranoff & Sager, 2003), we define investing risk by the ratio of risk-weighted assets to total assets.

3.2. Underwriting risk (UNR)

The life insurance industry is in the business of selling insurance coverage and annuities (Baranoff & Sager, 2002). For life insurers, each product sold to policy-holder is a contract basically. Thus, underwriting risk derives from incompleteness, uncertainty, and complexities of insurance contracts within the process of trading risky products such as health insurance. Baranoff and Sager (2002) note that health insurance is riskier than life insurance and annuities. Pottier and Sommer (1997) also hold the same view. In life insurance and annuities, life insurers largely count on mortality tables to predict longevity and to reduce their risks, but a sudden increase in the cost of health insurance is unpredictable, because relevant information is not available. Moreover, fraud events of accident insurance have raised litigation costs and risks due to more conflicts of interest among insurers and policyholders. Following Baranoff and Sager (2002),[4] we measure the ratio of health writings plus accident writings to total writings by a life insurer as a proxy for underwriting risk.

[4] They use the health writings ratio to total writings as a proxy for underwriting product risk. In our case, we differ by adding accident writings. There is a slight difference between the two.

3.3. Capital ratio (CAR)

Some studies adopt the ratio of total equity to total risk-weighted assets after the introduction of risk-based capital regulation, while others (Baranoff & Sager, 2002; Deelchand & Padgett, 2009) prefer using the ratio of total equity to total assets. Following Baranoff and Sager (2002) and Deelchand and Padgett (2009), we define the capital ratio used in our study as a ratio of equity capital to total assets. Market data are preferable to book value data, but not readily available, because most life insurers are not publicly traded companies in Taiwan.

3.4. Relevant variables

In addition to size, ROA, and the recent global financial crisis, we also incorporate ownership structure variables that may affect the capital-risk relationship based on agency issues. The size feature is a critical determinant of a firm's capitalization according to the economies of scale hypothesis. Firm size (SIZE) is measured by the natural log of total assets. Return on assets (ROA), representing the profitability of insurers, may play an important role in determining capital (or risk) level. The recent global financial crisis (GFC) is considered in this paper, because market condition may relate to insurers' capital decision and risk taking. As McAleer, Jimenez-Martin, and Perez-Amaral (2013) note, firms may have executed different risk management strategies (conservative or aggressive) during the 2008–2009 global financial crises. As Liao, Chou, and Chiu (2013) state that foreign ownership investors are momentum traders in financial market and have enjoyed remarkable returns on their investments, foreign insurers (FOR) may be different from local insurers in capital decisions and risk management styles. A publicly held company (PUB) can test the relationships between the separation of ownership from management and risk-taking behavior (Cole, He, McCullough, & Sommer, 2011; Cummins & Sommer, 1996). We also add an indicator for whether the insurer is a member of a financial holding group (FHG). If insurers are part of a larger financial holding group, then they will have superior access to capital and investment opportunities, because of their different mechanisms for controlling performance (Shrieves & Dahl, 1992). A family-controlled company (FAM) may perform differently (Huang, Hsiao, & Lai, 2007), or have a different risk and capital level, because of its undiversified ownership structure based on the agency cost theory. FOR, PUB, FHG, FAM, and GFC are represented as dummy variables. If an insurer is a FOR (or PUB, or FHG, or FAM, or GFC), then the value is one, while it is zero otherwise.

4. Data and methodology

Although quantile regression has not been as widely used as the least squares, the former may be more desired if conditional quantile functions are of interest. Relative to the ordinary least squares regression, one advantage of quantile regression is that the quantile regression estimates are more robust, particular for misspecification errors related to non-normality and to the presence of outliers (Kim & Muller, 2004). However, the major attraction of quantile regressions may go beyond that. In practice, economic researchers often prefer using different measures of central tendency and statistical dispersion to obtain a more comprehensive analysis of the relationship between variables. Therefore, we use two-stage least squares and two-stage quantile regressions to investigate the relation between risk and capital.

4.1. Data collection

The sample used in this research includes life insurance companies in Taiwan during the period of 2004–2009, collected from the Taiwan Insurance Institute website database,[5] Taiwan Economic Journal,[6] and the Annual Statistics Report of Taiwan Life Insurance Companies published by the Life

[5] Taiwan Insurance Institute website: http://pivot.tii.org.tw.
[6] Taiwan Economic Journal website: http://www.finasia.biz.

Insurance Association. There are about 30 life insurance companies in Taiwan. Due to missing data in some years, this dataset is unbalanced. Except for new entrants whose data are not complete in the first year of their business, we choose 28 (or 27) insurance companies available each year,[7] presenting the whole population.

4.2. Two-stage least squares

According to the prior literature, capital and risk are determined simultaneously. If we use ordinal least squares, the estimators of the parameters will be inconsistent. The traditional 2SLS may be a good choice to reduce the endogeneity bias and obtain consistent estimations. As Cummins and Sommer (1996) note, the two-stage procedure is designed to deal with the estimation of simultaneous equations with lagged endogenous variables. Baranoff and Sager (2002) also address that the autoregressive 2SLS procedure provides a correction for autocorrelation in simultaneous equations by means of instrumental variables. For our six years of data, autocorrelation may be predictable. As in Baranoff and Sager (2002) and Cummins and Sommer (1996), we model the disturbance through a first-order autoregressive process, which generates a diagonal structure for the covariance matrix of the disturbance. By using autoregressive 2SLS, we specify a simultaneous equation system that allows us to test for the relationship between capital and risk levels as follows.

$$\begin{aligned} CAR_{it} = {} & \alpha_0 + \alpha_1 INR_{it} + \alpha_2 UNR_{it} + \alpha_3 CAR(-1)_{it} + \alpha_4 SIZE_{it} + \alpha_5 ROA_{it} + \alpha_6 GFC_{it} + \alpha_7 FOR_{it} \\ & + \alpha_8 PUB_{it} + \alpha_9 FHG_{it} + \alpha_{10} FAM_{it} + e_1 \end{aligned} \quad (1)$$

$$\begin{aligned} INR_{it} = {} & \beta_0 + \beta_1 CAR_{it} + \beta_2 UNR_{it} + \beta_3 INR(-1)_{it} + \beta_4 SIZE_{it} + \beta_5 ROA_{it} + \beta_6 GFC_{it} + \beta_7 FOR_{it} \\ & + \beta_8 PUB_{it} + \beta_9 FHG_{it} + \beta_{10} FAM_{it} + e_2 \end{aligned} \quad (2)$$

$$\begin{aligned} UNR_{it} = {} & \gamma_0 + \gamma_1 CAR_{it} + \gamma_2 INR_{it} + \gamma_3 UNR(-1)_{it} + \gamma_4 SIZE_{it} + \gamma_5 ROA_{it} + \gamma_6 GFC_{it} + \gamma_7 FOR_{it} \\ & + \gamma_8 PUB_{it} + \gamma_9 FHG_{it} + \gamma_{10} FAM_{it} + e_3 \end{aligned} \quad (3)$$

where INR – risk-weighted assets to total assets of insurer i in year t; UNR – health writings plus accident writings to total writings of insurer i in year t; CAR – ratio of total equity to total assets of insurer i in year t; ROA – return on the total assets of insurer i in year t; SIZE – total assets of insurer i in year t; FOR – one for foreign company – and zero otherwise – for insurer i in the t year; GFC – one for the period of the 2008 global financial crisis, and zero otherwise, for insurer i in the t year; PUB – one for a publicly held company, and zero otherwise, for insurer i in the t year; FHG – one for a financial holding company, and zero otherwise, for insurer i in the t year; FAM – one for a Taiwan-foreign joint company, and zero otherwise, for insurer i in the t year; and α, β, γ – coefficients to be estimated, where ε represents error terms.

Investing risk (INR), underwriting risk (UNR), and capital ratio (CAR) are dependent variables, while firm size (SIZE), return on assets (ROA), global financial crisis (GFC), foreign company (FOR), financial holding group (FHG), and family company (FAM) are independent variables. Eq. (1) represents the insurers' capital ratio (CAR), which is determined by endogenous variables like investing risk (INR), underwriting risk (UNR), and other exogenous factors. Eq. (2) has underwriting risk (UNR) as the dependent variable. Eq. (3) explains the determinants of the investing risk (INR).

4.3. Two-stage quantile regression

Compared to the traditional 2SLS method, the 2SQR method takes into account the heterogeneity of the capital (or risk) structure of insurers or the large variation across the insurers. Kim and Muller

[7] There are 165 observations in our dataset.

(2004) propose two-stage quantile regression, where the first stage is based on quantile regressions with the same quantile as in the second stage. They present the asymptotic properties of 2SQR with random regressors, ensuring robustness of the estimation. Since the change in the mean of capital for Taiwan insurers is determined by a few observations in the upper parts of the distribution, classical methods based on the estimation of the conditional mean may not fully explain the capital (or risk) structure of Taiwan. Therefore, we also adopt the 2SQR approach to capture the effect of different levels of capital (risk). Following the symbols used by Amemiya (1982), Powell (1983), and Kim and Muller (2004), we rewrite the equations as below.

$$y = Y\gamma_o + X_1\rho_o + \varepsilon, \tag{4}$$

where y shows the dependent variables like the capital level (or risk level); Y represents other endogenous variables like the risk level (or capital level); X_1 represents exogenous variables that relate to y; and ε represents the residual. Moreover, $[y, Y]$ is a $I \times (G+1)$ matrix of endogenous variables, X_1 is a $I \times K_1$ matrix of exogenous variables, and ε is a $I \times 1$ vector. The endogeneity of Y in Eq. (4) might cause $Q_\theta(\varepsilon|Y) \neq Q_\theta(\varepsilon)$, where $Q_\theta(\cdot)$ is the quantile function of order θ, and $Q_\theta(\cdot|Y)$ is the quantile function of order θ conditional on Y.

In this context above, the estimation of the traditional one-stage quantile regression may result in endogeneity bias. Hence, using two-stage quantile regression is necessary for reducing endogeneity problem. Here, we assume that Y has the reduced form as below:

$$Y = X\Pi + \nu, \tag{5}$$

where $X = [X1, X2]$ represents a $I \times K$ matrix, $\bar{\Pi}$ represents a $K \times G$ matrix of unknown parameters, and ν is a $I \times G$ matrix of error terms. The first-stage quantile regression is represented as follows.

$$\underset{\prod_j}{Min}\sum_{i=1}^{n}\beta_\theta(Y_{ij} - X_i\prod\nolimits_j), \tag{6}$$

where Y_{ij} is the (i, j)th element of Y. Via Eq. (6), we estimate the fitted value of the jth endogenous variable $(\hat{Y}_j = X\hat{\Pi}_j)$ and substitute it into Y in Eq. (4): $y = Y\gamma_o + X_1\rho_o + \varepsilon$. In the second stage, we again conduct the quantile regressions as the following.

$$\underset{\gamma_o\rho_o}{Min}\sum\beta_\theta(y - \hat{Y}\gamma_o - X_1\rho_o). \tag{7}$$

The parameters (γ_0 and ρ_0) are consequently estimated by two-stage quantile regressions. Kim and Muller (2004) prove that the estimate of the parameter in 2SQR has asymptotic normality (see Appendix A and Assumption 3 in Kim and Muller (2004)). Although Kim and Muller (2004) present that the parameters estimated by the 2SQR carry asymptotic normality, we also use a bootstrapping set, and the results show no significant differences as compared with the original results.

The relative size of an insurance company does not suddenly change over time. However, panel data quantile regression mainly deals with the cross-section heterogeneity problem. Because the sample size of each quantile in each year is too small, panel data quantile regression is better than cross-section quantile regression by incorporating intertemporal observations of the same quantile in one regression.[8]

5. Empirical results and discussion

5.1. Data features of Taiwan and the U.S.

Table 2 lists the mean values of all variables. As we can see, the mean value of firms' total assets increases annually with the passage of time. The mean value of ROA is generally poor, but fluctuates heavily during 2008–2009. Low profitability implies that life insurers in Taiwan operate in a saturated

[8] The authors thank an anonymous referee for providing the justification to use two-stage quantile panel data regression.

Table 2
Mean of variables.

Variable	Year						
	2004|2009	2004	2005	2006	2007	2008	2009
Capital ratio	0.050	0.059	0.055	0.084	0.058	0.013	0.032
Investing risk	0.056	0.051	0.054	0.0554	0.0583	0.054	0.062
Underwriting risk	0.181	0.182	0.181	0.175	0.180	0.179	0.191
Return on assets	−2.388	−1.908	−2.248	−3.700	−0.995	−4.246	−1.158
Total assets (NT$ billion)	277.402	189.719	225.095	257.703	300.468	302.780	384.469
Total assets (US$ billion)	8.512	5.676	6.997	7.921	9.149	9.606	11.633
Global crisis	0.169	0	0	0	0	1	0
Foreign comp.	0.236	0.222	0.222	0.25	0.222	0.25	0.25
Publicly held	0.400	0.407	0.407	0.392	0.407	0.392	0.392
Holding comp.	0.145	0.148	0.148	0.143	0.148	0.143	0.143
Family comp.	0.299	0.296	0.296	0.286	0.296	0.286	0.286
Sample	165	27	27	28	27	28	28

Notes:
For a few sample insurers, some annual observations are lost, because proxy data are incomplete and/or insurers within the group have merged.
US$1 is approximately equal to NT$33.422 in 2004; NT$32.617 in 2005; NT$32.531 in 2006; NT$32.842 in 2007; NT$31.517 in 2008; NT$33.049 in 2009.

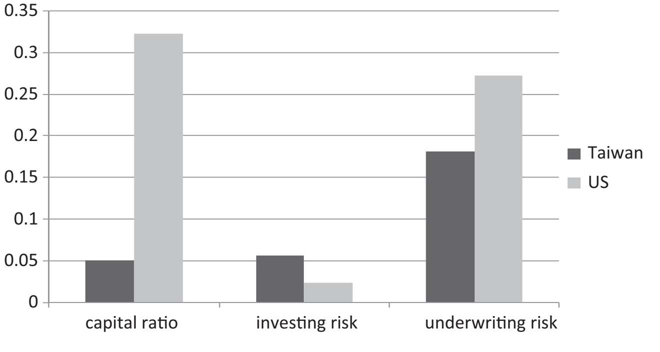

Fig. 1. Capital ratio, investing risk, and underwriting risk in Taiwan and the U.S.

and highly competitive market. Overall, the mean capital ratio increases from 5.901% in 2004 to a peak of 8.849% in 2006. However, influenced by the global financial crisis, it sharply drops to the lowest point of 1.256% in 2008, and then rapidly rises to 3.242% in 2009. Investing risk gradually increases from 5.119% to 6.253% except for 2008. Underwriting risk approaches the highest point of 19.15% in 2009, implying that there is a slight recovery from the global recession.

It is interesting to compare the differences between the data of Taiwan and the U.S. as noted by Baranoff and Sager (2002), because their study and ours examine life insurers' capital-risk relationship over the respective time periods of 2004–2009 and 1993–1997. Although Taiwan's capital requirements principally refer to those of the U.S., both economies still present some divergences, which may arise from different strict degrees of capital regulations based on different cultural backgrounds and operating experiences (i.e., Taiwan implemented RBC in 2003, later than the U.S. by about 10 years).

Fig. 1 demonstrates investing risk, underwriting risk, and capital ratio for Taiwan and the U.S.[9] The capital ratio (5.02%) in Taiwan is prominently smaller than in the U.S. (32.21%). On the other hand, the average investing risk (5.60%) in Taiwan is relatively higher than in the U.S. (2.40%). The data show that life insurers in Taiwan tend to hold a far lower capital ratio and invest in a riskier asset portfolio

[9] In Fig. 1 the U.S. data refer to the study of Baranoff and Sager (2002, p. 1192) who report the relation among asset risk, product risk, and capital in the U.S life insurance sector. Except for the research time, investing risk, underwriting risk, and capital ratio in our study are similar to their measures.

compared to life insurers in the U.S. A possible explanation is that, being in the largest financial market in the world, U.S. insurers may be willing to hold a higher capital level for more diversified investment opportunities. In contrast, looking for appropriate investment channels is not easy for insurers in a small financial market such as Taiwan. Underwriting risk is 27.27% in the U.S., which is greater than 18.20% in Taiwan. It seems predictable under great demand for long-term medical care in developed countries like the U.S. that there will be an increase in writing riskier products (e.g., health insurance) with claims disputes.

5.2. Interrelationship among investing risk, underwriting risk, and capital

Table 3 shows the estimations of the 2SLS and 2SQR in regression equations. Panels A, B, and C correspond to the equations for the capital ratio, investing risk, and underwriting risk, respectively. In the 2SQR model, our paper analyzes the relationship among investing risk, underwriting risk, and capital level at the 10th, 50th, and 90th conditional quantile distributions, representing the low, median, and high capital (or risk) levels of insurers, respectively, according to the suggestions by Kim and Muller (2004).[10] In the investing risk equation, the *R*-square in the 2SLS model is 0.55, and the Pseudo *R*-squares[11] in the 2SQR models are about 0.57. In the capital equation, the *R*-square in the 2SLS model is 0.45, and the Pseudo *R*-squares in the 2SQR model are about 0.71. In the underwriting risk equation, the *R*-square in the 2SLS model is 0.24, and the Pseudo R-squares in the 2SQR model are about 0.64. Overall, the Pseudo R-squares in the 2SQR models appear to be higher than *R*-squares in the 2SLS models, indicating that the explanatory power in the 2SQR models is better to that in the 2SLS models.

In Panel A the estimation results of the 2SLS model show that the level of investing risk has no impact on the capital level, while the level of underwriting risk posts a significant and positive effect on the capital level. The estimations results of the 2SQR models show that the investing risk → capital relation is significantly negative at the low and median quantiles, indicating that insurers holding lower levels of capital tend to reduce their capital levels as investing risk increases. This supports the moral hazard hypothesis. Nevertheless, the underwriting risk → capital relation is significantly positive at the median quantile and high quantile, implying that, compared to poorly capitalized insurers, median-capitalized and well-capitalized insurers are significantly willing to raise their capital position when they face greater underwriting risk. This lends support to the transaction-cost hypothesis.

In Panel B the estimation result of the 2SLS model reports that the capital level is not related to the level of investing risk, and the relation between investing risk and underwriting risk is positive, but insignificant. In the 2SQR model there is a negative relation between capital and investing risk at a lower conditional quantile distribution, implying that insurers' investing risk may increase as their capital declines. Moreover, underwriting risk and investing risk are positively related at higher conditional quantiles, but are negatively related at lower conditional quantiles.

In Panel C the estimation of the 2SLS model illustrates that the relation between the capital level and underwriting risk level is positive, but insignificant. We also find that investing risk is positively related to the underwriting risk. In the 2SQR model the capital → underwriting risk relation is significantly positively related at median and high quantile distributions. A possible explanation is that insurers with higher underwriting risk may tend to hold higher levels of capital in response to higher risks than insurers with lower underwriting risk.

Generally speaking, when compared to the 2SLS model, the 2SQR model seems to fully capture the effect of different types of risk. In 2SLS, most results are insignificant in the capital-risk relation. We find stronger evidence in 2SQR that investing risk and capital are negatively related, while underwriting risk

[10] They conduct Monte Carlo simulation experiments to investigate the finite-sample properties of the 2SQR. For all types of error terms, the 2SQR has good finite sample properties, although a size that is too small or when there are too extreme quantiles (θ = 0.05, 0.95) may degrade its performance. Therefore, under the 2SQR approach, the 10th, 50th, and 90th quantiles are adequate for our model.

[11] In linear regression models (i.e., ordinary least squares), R^2 is a statistic, which is often used as a goodness-of-fit measure. Since quantile regression is not a linear regression model, Pseudo R^2 is used to calculate the explanatory power of quantile regression. Pseudo R^2 = 1 − (Estimated likelihood of unrestricted model/Estimated likelihood of restricted model). The reader may refer to Gujarati (2003, pp. 605–606, chap. 3).

Table 3
Estimated results of the 2SLS and 2SQR.

	INR	UNR	CAR(−1)	SIZE	ROA	GFC	FOR	PUB	FHG	FAM
Panel A. Capital equations										
2SLS	−0.102	0.135***	−0.356	−2.382*	−0.210*	−5.933**	−0.122	−6.149*	12.490***	−0.753
	(−0.324)	(3.682)	(−1.872)	(−2.642)	(−2.476)	(−3.365)	(−0.044)	(−2.271)	(3.610)	(−0.712)
Q = 0.1	−18.44***	0.772	0.095	−0.407	−0.392***	−0.399	−25.25**	4.180***	18.932***	19.383***
low	(−31.45)	(0.776)	(0.985)	(−0.594)	(−6.902)	(−0.269)	(−13.130)	(10.730)	(6.781)	(21.246)
Q = 0.5	−2.369**	0.793***	−0.003	−0.195	0.648***	−2.844***	−12.38***	−3.655**	5.552***	4.476***
med	(−3.241)	(16.555)	(−0.176)	(−0.572)	(8.893)	(−4.395)	(−4.898)	(−2.815)	(7.241)	(3.634)
Q = 0.9	−1.004	1.265*	0.063	1.817*	0.484	−2.970*	−41.421	2.591	32.351*	−3.108
high	(−1.612)	(2.408)	(0.054)	(2.581)	(0.315)	(−2.180)	(−1.598)	(0.607)	(2.326)	(−0.810)
Panel B. Investing risk equations										
	CAR	UNR	INR(−1)	SIZE	ROA	GFC	FOR	PUB	FHG	FAM
2SLS	−0.216	0.054	−0.401	0.606	−0.124	−14.523	−1.906	1.636	0.465	1.148
	(−1.865)	(1.709)	(−1.901)	(1.06)	(−1.02)	(−1.706)	(−0.925)	(1.239)	(0.265)	(0.818)
Q = 0.1	−0.827***	−0.714*	−0.005	−1.98***	0.915***	−2.186**	−3.468**	3.250**	6.558***	−0.589
low	(−4.169)	(−2.041)	(−0.076)	(−3.658)	(4.064)	(−2.801)	(−4.159)	(2.887)	(3.877)	(−0.610)
Q = 0.5	−0.084	0.005	−0.093	0.180	−0.031	−0.255	−3.906***	0.828	0.412	1.557*
med	(−1.301)	(0.218)	(−1.121)	(0.739)	(−0.650)	(−0.511)	(−3.498)	(1.167)	(0.641)	(2.346)
Q = 0.9	0.125	0.427***	−0.334**	1.382**	0.280	0.162	−18.45**	0.078	−8.382***	−5.16***
high	(1.651)	(3.692)	(−2.757)	(3.121)	(1.407)	(0.127)	(−4.946)	(0.069)	(−4.480)	(−4.480)
Panel C. Underwriting risk equations										
	CAR	INR	UNR(−1)	SIZE	ROA	GFC	FOR	PUB	FHG	FAM
2SL	0.321	1.975**	−0.601*	−5.15**	−0.022	2.238	7.579	−6.902	17.318	−0.176
	(1.355)	(2.645)	(−2.532)	(−3.167)	(−0.094)	(0.546)	(1.213)	(−1.493)	(1.652)	(−0.034)
Q = 0.1	1.292	0.291	0.012	3.125*	−1.422*	0.665	3.526	6.868	−15.688*	5.932
low	(1.901)	(0.056)	(1.824)	(2.122)	(−1.985)	(0.265)	(0.429)	(0.379)	(−2.095)	(0.493)
Q = 0.5	5.864***	1.271	0.045**	1.274**	2.411***	9.885***	−3.454	13.639***	−18.28***	−11.51**
med	(73.974)	(1.732)	(2.924)	(2.833)	(62.980)	(15.976)	(−1.054)	(12.581)	(−17.828)	(−11.05)
Q = 0.9	3.287***	−0.167	−0.015	4.689**	2.027***	7.875***	6.784***	16.409***	−9.789**	−11.94**
high	(83.497)	(−0.704)	(−0.918)	(19.744)	(27.151)	(17.685)	(13.142)	(20.003)	(−14.356)	(−14.132)

Notes:
1. The numbers in parentheses are *t* values.
2. *, **, and *** indicate significance at the 5%, 1%, and 0.1% levels, respectively.
3. CAR = capital ratio; INR = investing risk; UNR = underwriting risk; CAR (−1) = lag of capital; INR (−1) = lag of investing risk; UNR (−1) = lag of underwriting risk; SIZE = total assets; ROA = return on assets; the others are dummy variables in which GFC = global financial crisis, FOR = foreign branch, PUB = publicly held, FAM = family-controlled, and FHG = financial holding group.
4. Most Pseudo R^2 in the 2SQR are between 0.57 and 0.71, and R^2 in 2SLS are between 0.24 and 0.55.
5. The "low", "med", and "high" represent low levels, median levels, and high levels of risk (or capital), respectively.

and capital are positively related at most quantile distributions. A negative relation between investing risk and capital supports the moral hazard hypothesis. A positive relation between underwriting risk and capital supports the transaction-cost hypothesis or regulatory cost hypothesis.

This paper also examines the relation between underwriting risk and capital in the period 2000–2002 before the adoption of RBC regulation in Taiwan. Contrary to the positive relation in the period of post-RBC, we find that the capital ratio has a negative impact on underwriting risk at the medium quantile and is significant at 10% level, although the relation between the two does not exist at the low quantile or high quantile distribution.[12] In other words, life insurers tend to take greater underwriting risk in the period of post-RBC, when compared to the period of pre-RBC. This may be attributed to insurers' increased regulatory cost. Such contrasting results between the two periods suggest the importance of capital regulation, and this mechanism partially changes life insurers' capital positions and risk-taking behaviors.

5.3. Impact of explanatory variables in capital-risk relations

Compared to the 2SLS method, the 2SQR can analyze the effects of explanatory variables in detail. In the 2SQR model, firm size has mixed effects on capital and risk. ROA has a positive effect on capital at the medium quantile, while there is a reverse relation at the low quantile. The insurers' profitability has a positive effect on investing risk at the low quantile and shows conflicting effects on underwriting risk across three quantiles. The global financial crisis is found to be negatively associated with the insurers' capital level at the low and the medium quantiles, suggesting that the insurers tended to hold a low capital level of capital when the global crisis hit. The global financial crisis is also found to have a positive impact on underwriting risk at the medium quantile and high quantile, while a reverse relation between the global financial crisis and investing risk is found at the low level of quantile. This result may be explained by when facing the crisis, life insurers preferred to adopt conservative financial investment strategies to avoid losses. On the other hand, they tend to pursue more underwriting risks to survive in the insurance industry.

Foreign companies overall tend to hold lower capital and have less investing risk than domestic local insurers at different quantile distributions. Not surprisingly, this may be due to better experiences in risk management derived from their parent companies, even though most of them are much smaller companies. As expected, financial holding companies are found to hold much more capital than independent companies, which may be attributed to their better financial strength. Interestingly, they also tend to pursue greater investing risk at a low quantile and are risk adverse at a high quantile, while significantly taking on less underwriting risk than non-holding insurers. Publicly held insurers tend to hold a high level of capital at a low quantile and have a low level of capital at a medium quantile. They are also found to take higher underwriting risk and investing risk than closely held insurers. Family-controlled insurers seem to maintain a larger amount of capital than non-family insurers and also have a lower level of investing risk and underwriting risk at high quantile distributions.

5.4. A comparison of Taiwan and the U.S.

It might be more useful to explain the observed results between Taiwan and the U.S., because of the differences in specifications of the RBC regulations and managerial discretion owing to different economic development stages or regulatory culture. Such a comparison also helps us understand the policy effects between the two and provides evidence to learn about risk management practices.

Among most U.S. studies, the findings of Baranoff and Sager (2002) are regarded as the most representative work, because this is the first empirical study to observe the relation between risk and capital in the life insurance industry. We compare Taiwan and the U.S. through the following two

[12] We only use the underwriting risk measure, because investing risk is measured by life insurers' risk-weighted assets, which are not available before the implementation of RBC requirements. The detailed results of the other independent variables are not reported here due to limited space.

steps: First, we use similar variables as used by Baranoff and Sager (2002)[13] to run data using the same 2SLS method. Second, new variables are subsequently added to our models and the results are quickly obtained. Through the two-step process, we do not find a negative relation between investing risk and capital although there is a positive relation between underwriting risk and capital. In 2SQR, our results show a negative relation between investing risk and capital and a positive relation between underwriting risk and capital. It is worth noting that the results are contrary to the evidence of the U.S. in Baranoff and Sager (2002), who report a positive relation between asset risk and capital and a negative relation between product risk and capital.

It is not surprising that Taiwan's insurers hold a relatively lower level of capital and a higher level of regulatory assets than insurers in the U.S. as Fig. 1 shows. In practice, Taiwan's insurers are increasing their risky financial investments with the relaxation of portfolio restrictions and profit incentives. It seems that Taiwan's insurers may have the moral hazard of pursuing investing risk compared to U.S. insurers. On the other hand, a positive relation between underwriting risk and capital implies that the rapid growth of Taiwan's long-term medical care in recent years has resulted in an increase in holding capital in response to more underwriting risks when compared to evidence in the U.S. Such contrasting results between Taiwan and the U.S. may be attributed to different managerial discretion for two types of risk or different regulatory cultures.

6. Conclusions and suggestion

Via the use of the 2SLS and 2SQR methods, this paper examines the relationships among investing risk, underwriting risk, and capital under the framework of simultaneous equations during the post-RBC time period in Taiwan. In 2SLS, we do not find a relation between investing risk and capital, but find underwriting risk has a positive impact on the capital level. The 2SQR method analyzes the capital-risk relation in greater detail and provides stronger evidence than 2SLS. In the 10th, 50th and 90th conditional quantiles, our empirical results indicate that the capital level is negatively related to investing risk level as the moral hazard hypothesis predicts, while the capital level is positively related to the underwriting risk level, lending support to the transaction cost hypothesis and regulatory cost hypothesis. Such contrasting findings emphasize the importance of simultaneously taking into account two kinds of risks given the assumption that insurers may react differently when encountering different faceted risks.

In the 2SQR model we also examine the effects of the 30th and 70th conditional quantile distributions, and most of the estimations are similar to the results mentioned above.[14] Our findings are contrary to previous evidence in the U.S. This may be due to different regulatory policy effects, depending on a stringent or a flat capital requirement, market-based incentive, and managers' risk preference based on different culture factors.

Our overall results have important implications for life insurer examination and surveillance. It is quite interesting to discuss a negative trade-off effect between capital and investing risk due to the existence of moral hazard in investing activities. If insurers hold too much capital over the regulatory minimum, then the investing risk may be reduced, but they have to give up some potential opportunities that have high expected returns. As Dickinson (1997) notes, too little capital is unable to fully absorb the business risks in financing future growth. Lee and Chih (2013) also warn that, for financial institutions, stricter regulation may be good for their stability, but not for efficiency. Life insurers should control investing risk according to their tolerance for risk or their sensitivities to the cost of capital so as to prevent their failure. Regulators also recognize that, even though increased capital requirements may diminish life insurers' risk and enhance safety, regulatory constraints also hold them back from investing in potential opportunities or push them to shift toward inefficient activities.

[13] They use the capital ratio, asset risk, product risk, total assets, return on capital, the RBC rate, a group member, a stock company (or a mutual company), etc. We employ most variables except for a stock company variable, because all the insurers are stock companies in Taiwan.

[14] Due to limited space, we do not report the results here.

In Taiwan the presence of a regulatory capital policy may either accentuate or mitigate life insurers' risk-taking behaviors, hinging on distinguishing between two types of risk: investing risk and underwriting risk. Therefore, both regulators and insurers should strengthen their awareness of the relation between capital and risk, particularly in the management of different kinds of risk. In addition, insurers' ownership structures play a crucial role in capital-risk relations, and thus a firm's type of ownership structure could be used as a flag for determining examination frequency. Lastly, the recent global financial crisis has negatively impacted insurers' capital ratio, limiting their financial investment behavior. For the health and stability of the insurance industry, the regulator should temporarily relax the RBC regulation, while at the same time insurers learn to be in a position to skirt market volatility when facing adverse market conditions.

Acknowledgments

We would like to thank valuable comments provided by an editor and two anonymous reviewers of this journal and seminar participants at Soochow University. The financial grant from Taiwan's Ministry of Science and Technology (NSC101-2410-H-009-044) is gratefully acknowledged.

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