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Asymmetric Dependence between Efficiency and Market Power in the Taiwanese Life Insurance Industry

Summary: Both market power and efficiency contribute to the viability of the insurer, making them essential for the management of life insurance companies. This study measured efficiency using the stochastic frontier approach based on the translog cost function. We then investigated the relationship between efficiency and market power using generalized extreme value analysis. The results show a strong nonlinear, asymmetric dependence between efficiency and market power of leading Taiwanese insurers. In other words, companies with greater market power do not necessarily exhibit greater efficiency. This study provides a reference to aid life insurance companies in the formulation of operational strategies.

Key words: Market power, Efficiency, Stochastic frontier approach, Asymmetric dependence.

JEL: D40, G22, L11.

The life insurance industry in Taiwan plays a vital role in the domestic financial system. Between 2002 and 2010, premium income of Taiwan increased from 8.54% to 16.99% of gross domestic product (GDP), representing a staggering growth rate of 99%. In the same period, the life insurance industry increased from 12.87% to 25.74% of the entire financial market in Taiwan, an increase of 100.21%. In terms of insurance penetration (the ratio of insurance premiums to GDP), Taiwan ranked first in the world in 2006, 2008, 2009 and 2012. This demonstrates the significant role of the insurance industry in the Taiwanese financial market.

Taiwan was ranked among the top 10 in the global ranking of income from total life premiums in 2010, and competition in the life insurance industry is intense. In 2010, 23 domestic and 8 foreign life insurance companies in Taiwan collectively earned an income of NT\$1,570 million from premiums. The life insurance company with the greatest assets in Taiwan approximately has a 26.01% share of the market, whereas the smallest life insurance company has a mere 0.08%. Each company endeavors to increase its market power and expand its economies of scale. The means by which these companies seek to attain greater market power to expand their economies of scale and increase operational efficiency are attracting considerable attention.

The main contributions of this paper include the use of the stochastic frontier approach (SFA) to measure the efficiency of the life insurance industry in Taiwan, the incorporation of relevant environmental variables to reduce estimation error, and the application of the generalized extreme value (GEV) approach to determine the relationship between maximum efficiency and maximum market power in the life insurance industry. The paper also uses the doubly censored regression between efficiency and market power for the robust test. The empirical results indicate a pattern of asymmetric dependence between maximum efficiency and maximum market power in the Taiwanese life insurance industry.

This paper provides a new perspective from which to view this topic. Life insurance companies in Taiwan should consider the importance of efficiency in their pursuit of greater market power, and *vice versa*. The novel merging of the SFA and the GEV in this study to examine the relationship between efficiency and market power in the life insurance industry in Taiwan provides a reference for managers in the formulation of operational strategies.

The remainder of this paper is organized as follows. Section 2 describes the data and methodology. The main empirical results are presented in Section 3. Finally, Section 4 presents the conclusion and suggestions.

1. Related Literature

Many previous studies have found evidence of a relationship between efficiency and market power, with several studies demonstrating that market power influences the efficiency (see Allen N. Berger 1995; Byeongyong Paul Choi and Mary A. Weiss 2005; Olivier de Jonghe and Rudi Vander Vennet 2008; Xiaoqing Fu and Shelagh Heffernan 2009). Moreover, management in the life insurance company should consider this in public interest. The efficient structure (ES) hypothesis proposed by Harold Demsetz (1973) suggests that the market rivalry and structure in which a company operates is also determined by efficiency. Furthermore, this paper followed Choi and Weiss (2005), and believes that increases in market share are not necessarily anti-competitive and do not always lead to detrimental external effects¹ for consumers. The hypothesis of relative market power (RMP) suggests that market share should provide an accurate reflection of market power (Michael Smirlock, Gilligan Thomas, and William Marshall 1984; Choi and Weiss 2005; Santiago Carbó Valverde, David B. Humphrey, and Rafael López del Paso 2007). Choi and Weiss (2005) claimed that a company that is more efficient in turn increases its market power. Accordingly, this paper uses market share as a proxy for market power.

As the insurance industry remains an imperfectly competitive market, an uneven allocation of resources may exist. Efficiency refers to both technical efficiency and allocative efficiency (see Xiaoying Xie 2010). For this reason, allocative efficiency is also considered in the evaluation of efficiency. Among the approaches employed to evaluate efficiency, the SFA presents a rigorous theoretical structure that

¹ External effects are also referred to as externalities, meaning the positive or negative effects exerted on others during the process of production and consumption of products. These externalities are generally divided into external costs and external benefits.

integrates mathematics, statistics and economics (see Subal C. Kumbhakar 1997; Berger, Iftekhar Hasan, and Mingming Zhou 2009; J. David Cummins and Xie 2013). As it is not easily affected by extreme values, the SFA takes residual terms into consideration in the measure of absolute efficiency. The SFA is a form of parameter analysis (see Kumbhakar 1997; Berger, Hasan, and Zhou 2009; Bannour Boutheina and Labidi Moez 2013), in which the setting of a translog function takes into account the cross-terms among the variables to reduce the number of errors resulting from model hypotheses. Hence, we derive efficiency using the SFA.

Previous studies have explored extreme relationships using the GEV method (refer to Ser-Huang Poon, Michael Rockinger, and Jonathan A. Tawn 2003; Alec Stephenson 2003; Hui Guo and Robert Savickas 2010). This paper assumes that life insurance companies tend to pursue maximum efficiency and market power without exception. Thus, the paper employs the GEV method to determine the relationship between maximum efficiency and maximum market power value. The maximum likelihood estimation method can be applied to the extreme sample to estimate parameters in the GEV distribution, proving an unbiased estimate with minimum variance (refer to Stuart G. Coles and Tawn 1991; Coles, Janet Heffernan, and Tawn 1999; Francois M. Longin 2000; Coles 2001; Wei Huang et al. 2009). Although the asymptotic GEV distribution is derived under the independent and identically distributed assumption of random variables, Richard L. Smith (1985) suggests that the dependence of the data does not constitute a major obstacle to attaining the limiting distribution of large samples.

2. Data and Methodology

2.1 Data

The data for the Taiwanese insurance industry cover the period 1976-2010 with a total of 663 observations. We employed unbalanced panel data from 36 insurance companies over a period of 35 years. Data with incomplete information were eliminated from the database. The data were generated from the Taiwan Insurance Institute Annual Report of Life Insurance (2010). A total of 35 sample observations were normalized by selecting the maximum efficiency and the maximum market power for each year. This study conducted extreme value processing on the data, coordinated with the GEV approach.

2.2 Variables of Efficiency and Market Power

We used output and input factors to calculate the efficiency and market power of insurance companies. We define all variables as given here.

To evaluate efficiency, we first selected input factors and output factors. Many studies suggest that insurers provide three principal services: the pooling and bearing of risk, financial intermediation and financial services related to insured losses (for more information on the three principal services, see Cummins and Weiss 2000; William H. Greene and Dan Segal 2004; Martin Eling and Michael Luhn 2010; Cummins and Xie 2013). Most previous studies have suggested a value-added approach employing the functional services of the insurer. In contrast, other studies related to

banking efficiency have employed the intermediation approach, such as Andrew M. Yuengert (1993), Berger, Cummins, and Weiss (1997), Cummins, Sharon Tennyson, and Weiss (1999), Cummins and Weiss (2000), Cummins, Maria Rubio-Misas, and Hongmin Zi (2004) and Greene and Segal (2004). This study employed a value-added approach suitable for the insurance industry as the basis for the selection of input and output factors as well as the SFA approach to measure outputs.

According to Yuengert (1993), in the selection of output factors, incurred benefits (Y1) (representing payments received by policyholders in the current year) are useful proxies for the functions of risk-pooling and risk-bearing. Incurred benefits include interest and income from dividends. We followed Berger, Cummins, and Weiss (1997) to measure life insurance output using incurred claims (Y2) on services related to insured losses. Finally, we adopted individual life insurance premiums (Y3) as a proxy for the function of intermediation. We referenced Lisa A. Gardner and Martin F. Grace (1993), Cummins and Zi (1998) and Greene and Segal (2004) to define insurance premiums as including life insurance, accident insurance, health insurance, and annuity insurance, and the dollar value of investment income as the dollar amounts of ordinary life insurance premiums, group life insurance premiums, ordinary annuity considerations, and group annuity considerations. In the selection of input factors and prices, outputs were produced using three inputs and input prices: (1) labor (refer to Gardner and Grace 1993; Cummins and Zi 1998); (2) financial capital (see Gardner and Grace 1993; Cummins and Zi 1998; Greene and Segal 2004); (3) business services (refer to Greene and Segal 2004). We combined both home office labor and agent labor as a single labor input. We measured the labor price (P1) in New Taiwan dollars (NTD) using data on average annual wages from the labor department. We treated financial capital that produces a net profit on investment as an input and defined invested assets as capital. The cost of financial capital (P2) was used as the ratio of total investment income to total invested assets. Business services comprise all operational expenses other than labor and capital expenses (e.g., Greene and Segal 2004), because most of the expenses are directly related to selling and servicing policies. In accordance with Greene and Segal (2004), the price of business service (P3) was defined as the related expenses divided by the total number of policies sold.

According to the above three input factors, we defined the total cost as an operational cost that should vary with input prices and the factors of production. The operational costs of the insurer include all costs associated with the operation of the insurance companies. Thus, total operational cost is the sum of labor, financial capital, and business service expenses. Table 1 presents descriptive statistics of all variables for evaluated efficiency.

As mentioned above, the RMP hypothesis suggests that the market power of a company determines its capacity in the market (see Smirlock, Thomas, and Marshall 1984; Vickie L. Bajtelsmit and Raja Bouzouita 1998; Valverde, Humphrey, and del Paso 2007). Choi and Weiss (2005) suggest that insurance companies with a large market share enjoy a unique form of market power. Therefore, this paper uses market share as a proxy for market power. To calculate market power, we defined market power as the premium of the individual insurance company divided by the total market premium per year.

Table 1 Descriptive Statistics of Sample Observations

Variable	Mean	SE	Min	Max
Cost (NTD million)	15.1080	36.8800	35.0000	362.6770
Incurred benefits (Y1, NTD million)	5.0460	13.1220	0.1051	98.2150
Incurred claims (Y2, NTD million)	10.1740	28.7370	0.0030	317.6830
Life insurance premiums (Y3, NTD million)	25.6830	56.3740	0.0200	484.5240
Average annual wages (P1, NTD million)	0.3378	0.1425	0.0345	0.5178
Ratio of total investment income to total invested assets (P2, %)	6.0389	9.2363	0.0291	26.1391
Related expenses divided by the total number of policies sold (P3, NTD million)	0.0287	0.1892	0.0155	4.3205

Notes: SE denotes standard error.

Source: Authors.

2.3 Methodology

This paper focuses on the relationship between efficiency and market power. Therefore, we introduce the following model to evaluate efficiency.

This study employed the SFA originally proposed by Dennis Aigner, C. A. Knox Lovell, and Peter Schmidt (1977). The SFA also considers relative price as an input (refer to Bajtelsmit and Bouzouita 1998; Huang, Ying-Ting Liao, and Li-Chih Chiang 2010; Nicholas Apergis and Effrosyni Alevizopoulou 2011) in determining the efficiency of each company. To control random error, the cost function in this study was set as follows: $\ln TC_{it} = x_{it}\beta + \varepsilon_{it}$, $\varepsilon_{it} = v_{it} + u_{it}$ (for cost function, see Huang, Liao, and Chiang 2010). First-order homogeneous functions of factor prices are Hessian matrix conditions, where x_{it} is a vector of input price and output quantity, TC represents the costs of insurer i , and β is a vector of unknown parameters to be estimated. The ε_{it} is disentangled into two main components: the first term is the random error term (v_{it}), which accounts for measurement error and other factors unspecified in the cost function. This is generally assumed to be an independent and identically distributed normal random variable with mean zero and constant variance σ_v^2 . The second term is a non-negative inefficiency term, u_{it} , which is generally assumed to have a half-normal or a truncated normal distribution, with variance equal to σ_u^2 , which expresses the likelihood function in terms of the two parameters of variance, $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma_s^2$. The γ takes a value between 0 and 1: 0 implies that all deviations from the frontier are random error. To evaluate efficiency, the function is calculated as Equation (1):

$$Efficiency_i = E(TC_i^* | u_{it} = 0, \beta_i) / E(TC_i^* | u_{it}, \beta_i). \quad (1)$$

For the deterministic kernel of the frontier and a flexible functional form, the translog function in this paper is specified in Equation (2) (for a description of the expansion of the translog function, see Kumbhakar 1997):

$$\begin{aligned}
 \ln TC_{it} = & \alpha_0 + \sum_{k=1}^{K-1} \beta_k \times \ln P_{kit} + \sum_{m=1}^M \gamma_m \times \ln Y_{mit} + 0.5 \sum_{k=1}^{K-1} \sum_{l=1}^{L-1} \beta_{kl} \times \ln P_{kit} \times \ln P_{lit} \\
 & + 0.5 \sum_{m=1}^M \sum_{n=1}^N \gamma_{mn} \times \ln Y_{mit} \times \ln Y_{nit} + \sum_{k=1}^{K-1} \sum_{m=1}^M \rho_{km} \times \ln P_{kit} \times \ln Y_{mit} + \varphi_{ll} \times t \\
 & + 0.5 \rho_{ll} \times t^2 + \sum_{k=1}^{K-1} \alpha_{lk} \times t \times \ln P_{kit} + \sum_{m=1}^M k_{lm} \times t \times \ln Y_{mit} + \varepsilon_{it},
 \end{aligned} \tag{2}$$

$$k, l = 1, 2, 3, \quad m, n = 1, 2, 3,$$

where TC_{it} is the total cost of the i th firm in period t , Y_{mit} is the output of m for the i th firm in period t , P_{kit} is the price of input k for the i th firm in period t , and β_{kl} , γ_{mn} , φ_l , and ρ_l are unknown parameters. Similar to the cost function mentioned above, ε_{it} is disentangled into two main components, which include non-negative inefficiency terms and random error terms. As usual, symmetry $\beta_{kl} = \beta_{lk}$, $\gamma_{mn} = \gamma_{nm}$ and linear homogeneity restrictions $\sum_{m=1}^M \gamma_m = 1$, $\sum_{m=1}^M \sum_{n=1}^N \gamma_{mn} = 0$, $\sum_{k=1}^K \sum_{m=1}^M \rho_{km} = 0$ are imposed to standardize the total cost TC and input prices P_k according to the last input prices. Based on a common frontier, the efficiency estimated includes technical efficiency and allocation efficiency obtained by comparing all the firms in the sample under the same technological and environmental conditions.

This study employed the GEV approach to prove the asymmetric relationship between maximum efficiency and maximum market power. Let x and y be maximum efficiency and maximum market power, respectively. Bivariate extreme value distributions of (x, y) are generated by measure H , which is not differentiable. In particular, we require a parametric family for H on $[0, 1]$ with a mean equal to 0.5 for every value of the parameter. Coles (2001) proposed the logistic family of a nondegenerate distribution function G as:

$$G(x, y) = \exp\{-V(x, y)\}, \quad x > 0, y > 0, \tag{3}$$

where V is said to be homogeneous on the order of -1 and is defined as:

$$V(x, y) = 2 \int_0^1 \max\left(\frac{w}{x}, \frac{1-w}{y}\right) dH(w), \quad 0 < w < 1, \tag{4}$$

and H is a distribution function on $[0, 1]$, satisfying the mean constraint.

$$\int_0^1 w dH(w) = \frac{1}{2}. \tag{5}$$

Equation (6) is obtained by setting the density function of H as:

$$h(w) = \frac{1}{2} (\alpha^{-1} - 1) \{w(1-w)\}^{-1/\alpha} \left\{w^{-1/\alpha} + (1-w)^{-1/\alpha}\right\}^{\alpha-2}, \quad 0 < w < 1, \quad (6)$$

where the parameter $\alpha \in (0, 1)$.

Harry Joe, Richard L. Smith, and Ishay Weissman (1992) proposed Equation (7) to allow for asymmetry in the dependence structure through a biologicistic model. It is obtained by setting the density function of H as:

$$h(w) = \frac{1}{2} (1-\alpha)(1-w)^{-1} w^{-2} (1-u) u^{1-\alpha} \{\alpha(1-u) + \beta u\}^{-1}, \quad 0 < w < 1, \quad (7)$$

where α and β are parameters, such that $0 < \alpha < 1$ and $0 < \beta < 1$, and $u = u(w, \alpha, \beta)$ is the solution of $(1-\alpha)(1-w)(1-u)^\beta - (1-\beta)wu^\alpha = 0$. In the case of $\alpha = \beta$, the biologicistic model is reduced to the logistic model. More generally, the value of $\alpha - \beta$ determines the extent of asymmetry in the dependence structure.

Coles and Tawn (1994) proposed an alternative asymmetric model, the negative biologicistic distribution function. Similar to the biologicistic model, the following negative biologicistic model can be obtained by setting the density function of H as:

$$h(w) = -\frac{1}{2} (1-\alpha)(1-w)^{-1} w^{-2} (1-u) u^{1-\alpha} \{\alpha(1-u) + \beta u\}^{-1}, \quad 0 < w < 1, \quad (8)$$

where α and β are parameters such that $\alpha > 0$, $\beta > 0$, and the root of the equation is similar to that of the biologicistic model. When $\alpha = \beta$, the negative biologicistic model is equivalent to the negative logistic model with the dependence parameter $dep = 1/\alpha = 1/\beta$. Complete dependence is obtained in the limit as $\alpha = \beta$ approaches zero. Independence is obtained as $\alpha = \beta$ tends to infinity, and when one of α , β is fixed and the other tends to infinity. Different limits occur when one of α , β is fixed and the other approaches zero.

Finally, because the values of maximum efficiency and maximum market power belong to $(0, 1)$, this paper uses the doubly censored Tobit model (see James Tobin 1958) to make the strong conclusion consistent with the GEV method. The Tobit model as:

$$\begin{aligned} y^* &= x' \beta + \varepsilon, \\ y &= 0, \text{ if } y^* \leq 0, \\ y &= y^*, \text{ if } 0 < y^* < 1, \\ y &= 1, \text{ if } y^* \geq 1. \end{aligned} \quad (9)$$

The log-likelihood is built up from three sets of terms:

$$\ln L = \sum_{y=0} \ln \Phi \left[\frac{0 - x'_i \beta}{\sigma} \right] + \sum_{0 < y < 1} \ln \frac{1}{\sigma} \phi \left[\frac{y - x'_i \beta}{\sigma} \right] + \sum_{y=1} \ln \left[1 - \phi \left(\frac{1 - x'_i \beta}{\sigma} \right) \right], \quad (10)$$

where β is an unknown parameter vector, y is the dependent variable, and x is the independent variable vector. The data range is censored at both 0 and 1.

3. Empirical Results

This section first reports the overall efficiency based on the econometric model, followed by the relationship between efficiency and market power of Taiwanese life insurance companies.

3.1 Efficiency versus Market Power

Efficiency is first evaluated using an SFA of translog function, the estimation results of which are shown in Table 2. Most of the output factors show a positive correlation with cost, which is broadly in line with the limitations of the cost function.

Table 2 Estimation Results of the Translog Cost Function Estimate of Life Insurance, 1976-2010 (n=35)

Variable	Coefficient	t-ratio	Variable	Coefficient	t-ratio
Constant	-1.2200**	-4.3711	Y3 × P2	-0.0033	-0.1128
Y1	-0.1061**	-3.6872	Y3 × P3	-0.0348	-1.5981
Y2	0.0023*	2.4001	Y2 × P2	1.0723**	5.3586
Y3	0.0581	1.5637	Y2 × P3	0.0909*	2.2703
P2	1.3618**	4.6158	P2 × P3	0.8986**	5.1999
P3	1.4083**	5.0629	P2 × P1	0.1677*	2.0298
Y1 × Y1	0.0042*	2.8410	P3 × P1	0.0458	0.6546
Y2 × Y2	0.0104*	2.8223	T × T	-0.0017	-0.5514
Y3 × Y3	-0.0040**	-3.3993	T	0.0045	0.0183
Y1 × Y2	-0.0121*	-2.9073	T × P2	0.0032	0.2238
Y1 × Y3	0.0071**	5.7499	T × P3	-0.0297**	-3.3889
Y3 × Y2	-0.0004*	-2.9328	T × Y1	-0.0098**	-11.8861
Y1 × P2	-0.0067	-0.2647	T × Y2	0.0042**	3.6516
Y1 × P3	0.0504*	2.3462	T × Y3	0.0195**	11.7487

Notes: (1) Y1 denotes incurred benefits; Y2 denotes incurred claims; Y3 denotes life insurance premium; P1 denotes the average annual wages; P2 denotes the ratio of total investment income to total invested assets; P3 denotes the related expenses divided by the total number of policies sold; T denotes time factor. (2) ** (*) indicates significance at a level of 1% (5%). (3) Log-likelihood = 1552.941.

Source: Authors.

Having evaluated the efficiency using the SFA, we present the descriptive statistics of efficiency and market power in the Taiwanese life insurance industry in Table 3. From this, we determine the mean and maximum efficiency of local life insur-

ance companies as 64.27% and 85.67%, respectively, with a mean market power of 8.06%. Foreign life insurance companies show mean and maximum efficiency values of 50.63% and 74.94%, respectively, with a mean market power of 1.03%.

Table 3 Descriptive Statistics of Efficiency and Market Power in the Taiwanese Life Insurance Industry

Variable	Mean	SE	Min	Max
Local (observation=409)				
Efficiency	0.6427	0.1250	0.5972	0.8567
Market power	0.0806	0.1335	2.7E-07	0.5899
Foreign (observation=254)				
Efficiency	0.5063	0.1243	0.5853	0.7494
Market power	0.0103	0.0203	7.5E-08	0.1030
Whole samples (observation=663)				
Efficiency	0.5844	0.1415	0.5853	0.8567
Market power	0.0527	0.1101	7.5E-08	0.5899

Notes: SE denotes standard error.

Source: Authors.

3.2 Dependence of Efficiency on Market Power

Figure 1 is a scatter plot for a 35-year time series of maximum efficiency versus maximum market power. The scatter plot shows an asymmetric trend. There appears to be a slight tendency for large values of one variable to correspond to large values of the other. However, this relationship is nonlinear.

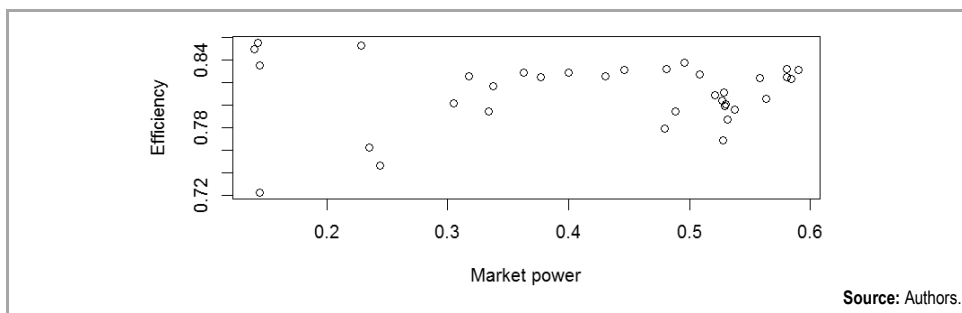


Figure 1 Scatter Plot of Maximum Market Power and Maximum Efficiency

We applied the maximum likelihood method to estimate the parameters of the logistic model, biologicistic model and negative biologicistic model. Table 4 lists the maximum likelihood estimates of the logistic model, biologicistic model, and negative biologicistic model for the series of maximum efficiency and maximum market power.

Table 5 shows that in the logistic model, the maximum likelihood estimate of the dependence parameter ($\alpha = 0.1007$) reached the 0.05 significance level and approached 0. This indicates a strong correlation between efficiency and market power. From the biologicistic model, we determined that $\alpha - \beta = -0.1044$. Through further hypothesis testing, it was established that the null hypothesis $H_1: \alpha - \beta \neq 0$ is an asymmetric relationship, and that, at a significance level of 0.05, market power and

efficiency exhibit a strong asymmetric relationship. Furthermore, in the negative bi-logistic model, the parameter $\alpha - \beta = -1.5$ did not equal 0 and reached the 0.01 level of significance. This also indicates a strong asymmetric relationship between the two variables.

Table 4 Maximum Likelihood Estimates for the Empirical Models to the Efficiency and Market Power

		Market power			Efficiency		
		μ_x	σ_x	ξ_x	μ_y	σ_y	ξ_y
Logistic	Estimate	2.5632*	1.9619*	-0.0008*	4.3729*	2.1251*	0.1724*
	SE	0.3721	0.2080	0.1070	0.4506	0.2856	0.1426
Bi-logistic	Estimate	1.6620*	1.3404*	0.6564*	3.2326*	1.1957*	1.0676*
	SE	0.3379	0.2781	0.2741	0.2392	0.2847	0.3161
Negative bi-logistic	Estimate	0.0245**	0.0192**	0.4672*	0.0320**	0.0101**	1.0252**
	SE	0.0072	0.0027	0.4802	0.0002	0.0015	0.1142

Notes: (1) ** (*) indicates significance at the 1% (5%) level. (2) SE denotes standard error.

Source: Authors.

Table 5 Dependence Estimates for the Empirical Models to the Efficiency and Market Power

Model		α	β	$\alpha - \beta$	Log-likelihood
Logistic	Estimate	0.1007**	-	-	-101.240
	SE	0.0002	-	-	
Bi-logistic	Estimate	0.1008**	0.2052**	-0.1044**	-113.750
	SE	2E-06	0.0499	0.0499	
Negative bi-logistic	Estimate	0.1004**	1.6065*	-1.5012*	188.235
	SE	0.0015	0.2522	0.2519	

Notes: (1) ** (*) indicates significance at the 1% (5%) level. (2) Log-likelihood denotes log-likelihood value. (3) SE denotes standard error.

Source: Authors.

This paper subsequently refers to some studies (see Bajtelsmit and Bouzouita 1998; Choi and Weiss 2005; Weiss and Choi 2008) in standardizing the variables. This is done in consideration of the restrictions of linear regression in adopting standardized efficiency and market power as dependent and explanatory variables, respectively. Because the values of both maximum market power and efficiency are censored at both 0 and 1, this paper uses the doubly censored Tobit model (see Tobin 1958; William H. Greene 2007). Table 6 lists the results of Tobit regression analysis, with market power as the dependent variable. The estimated regression coefficient of efficiency on market power is 0.7947, reaching the 0.01 level of significance. This indicates that the results of efficiency have a positive and significant influence on market power. Table 7 shows that in the event that efficiency is a dependent variable, the estimated regression coefficient of market power on efficiency is 1.2428, reaching the 0.01 level of significance. This demonstrates that the results of market power have a positive and significant influence on efficiency. Therefore, the link from market power back to efficiency seems to be less pronounced than *vice versa*. The doubly censored regression analysis is a robust test for variable relationships, consistent with the GEV method.

Table 6 Doubly Censored Regression of Market Power on Efficiency

Variable	Estimate	SE	p-value
Constant	-0.0115**	0.0011	0.0001
Efficiency	0.7947**	0.0165	0.0001
Log-likelihood	150.3337		

Notes: (1) ** (*) indicates significance at the 1% (5%) level. (2) Log-likelihood denotes log-likelihood value. (3) SE denotes standard error.

Source: Authors.

Table 7 Doubly Censored Regression of Efficiency on Market Power

Variable	Estimate	SE	p-value
Constant	0.0157**	0.0012	0.0001
Market power	1.2428**	0.0259	0.0001
Log-likelihood	142.5258		

Notes: (1) ** (*) indicates significance at the 1% (5%) level. (2) Log-likelihood denotes log-likelihood value. (3) SE denotes standard error.

Source: Authors.

4. Conclusion and Suggestion

This study aimed to identify the relationship between the efficiency and the market power of life insurance companies operating in Taiwan. We employed the SFA to measure the efficiency of the insurance companies. We then employed the GEV method to examine the relationship between efficiency and market power. Our results identified a strong relationship between efficiency and market power, which was further characterized as asymmetric. Moreover, this relationship was nonlinear, further confirming that the relationship is not symmetric. The dependence parameter of the logistic model approaches zero, indicating a strong relationship between efficiency and market power. In addition, the coefficients of the bi-logistic model and the negative bi-logistic model were unequal, revealing a strong asymmetric correlation between the two variables. This indicates that life insurance companies with high operating efficiency do not necessarily have a strong market power. In other words, strong market power does not guarantee a high degree of efficiency.

The mutual influence of the robust test was evaluated using doubly censored Tobit regression. With market power as the dependent variable, both technical efficiency and allocative efficiency had a positive influence on market power. Conversely, market power also had a positive and significant impact on efficiency. Therefore, in the pursuit of greater market power, life insurance companies should take into account the efficiency of input and output resources, and allocate controlled resources appropriately. Singular focus should not be placed on either technical efficiency or allocative efficiency. Many laws and regulations restrict the operations of life insurance companies in Taiwan, which may lead to an uneven distribution of resources. As a result, companies should pay attention to allocative efficiency as well as technical efficiency to ensure the optimal allocation of resources.

The empirical results of this study conform to the current status of the life insurance industry in Taiwan, in which companies with greater market power do not necessarily exhibit higher efficiency. This conclusion is consistent with the actual status of the Taiwanese insurance industry. For this reason, we suggest that the man-

agement of life insurance companies clarify their objectives and take advantage of company resources when dealing with market power and efficiency. In addition, operational strategies with the greatest advantages to the company should be adopted. It is our hope that the results of this study provide managers in life insurance companies more information with a reference to aid in the formulation of such strategies.

The empirical results also demonstrate that asymmetric correlations from a variety of regulatory environments require further study. It would also be advantageous to determine whether controlled variables, such as those associated with the management of companies and market power, could enhance the efficiency or alter the results of the SFA in the calculation of efficiency. Whether these variables lead to differences in the results is also worthy of further investigation. Finally, many companies in the industry have still been ineffectual in their efforts to use market power and efficiency to create value for shareholders and policyholders. This provides further motivation for consolidation.

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