African Journal of Business Management Vol. 5(14), pp. 5746-5752, 18 July, 2011
Available online at http://www.academicjournals.org/AJBM
DOI: 10.5897/AJBM11.048
ISSN 1993-8233 ©2011 Academic Journals

Full Length Research Paper

A cross-strait comparative study of efficiency of life insurance companies: An application of the input slack adjustment approach

Yan Zhi[1] and Jin-Li Hu[2]*

[1]College of Economic and Social Development, Nankai University, China.
[2]Institute of Business and Management, National Chiao Tung University, Taiwan.

Accepted 8 April, 2011

This paper applies the three-stage approach proposed by Fried et al. (2002) to analyze the efficiency of life insurance companies in the Mainland and Taiwan areas. This approach adjusts the input slacks obtained by data envelopment analysis (DEA) via the stochastic frontier analysis (SFA). Our major empirical findings are: (1) Efficiency scores of life insurance companies in both areas are significantly affected by both environmental factors and statistical noises. After input slack adjustments, the average efficiency score drops for 72.17%; (2) Compared to those companies in the Taiwan area, the life companies in the Mainland area have a large diversion in efficiency scores which range from less than 10 to 78.3%; (3) Debt equity has a significant effect to increase efficiency, indicating that increases in the market share and financial leverage ratio help promote efficiency; (4) Ownership types have different advantageous effects on different inputs. (5) The years since establishment have no significant effects on efficiency, indicating that the younger mainland Chinese life insurance companies do not have disadvantages because it is in an open and competitive market environment; (6) Under a similar environment, Taiwan-based life insurance companies are more efficient than mainland-based ones. The input slacks and managerial efficiency of life insurance companies in Taiwan and mainland China are significantly affected by environmental factors, showing that institutional reform does matter for improving the efficiency of financial institutions.

Key words: Life insurance industry, data envelopment analysis (DEA), stochastic frontier analysis (SFA), three-stage approach.

INTRODUCTION

Life insurance is a necessary complement for the social insurance and securities system (Chen and Chen, 2010), especially for the Chinese economies with higher and higher proportion with elder population. After mainland China joined WTO in 2001, overseas insurance companies enter these markets and compete with local insurance firms. Efficiency is hence an important issue for mainland Chinese firms to stay competitive. Taiwan has opened its life insurance market to overseas companies since 1986. However, a closer economic partnership is under development for both sides across the Taiwan Strait. The life insurance companies will have stronger competition as well as cooperation once after the two sides open their markets to each other. As a result, a comparative study of life insurance companies in mainland China and Taiwan will be important for predicting the future competition and cooperation among life companies across the Taiwan Strait.

Taiwan's insurance market has been open to the world since 1986, which is much earlier than mainland China's market being open since 2001. As a result, Taiwan gained more experiences in running the insurance market. Although the people in the two economies across the Taiwan Strait share quite similar language, cultural, and risk preference backgrounds, the development stages in

*Corresponding author. E-mail: jinlihu@gmail.com. Tel: +886 2 23812386/57641. Fax: +886 2 23494924.

these two economies are significantly different. Compared to insurance companies in other countries or areas, the experiences and patterns of insurance companies in Taiwan are worth referring to and should be easier to follow and learn from.

The insurance market in Taiwan is relatively more mature to that in mainland China. Taiwan has a population of only 23 million. In 2006, the life insurance premium revenue in Taiwan has been up to 15.88 billion US dollars, ranking top 14 in the global economy. The life insurance density in Taiwan has been up to 2070.9 US dollars, ranking top 20 in the world. The insurance penetration rate in Taiwan has been up to 13.51%, ranking top 3 in the world. However, the life insurance market size in mainland China in 2007 is only 72.56 billion US dollars, for its population of 1.3 billion.

The life insurance industry has attracted much attention by the researchers in efficiency analysis. The existing literature focuses on two aspects: One is the comparison of efficiency measurement approach. For example, Fecher et al. (1993) studied 84 life insurance companies by data envelopment analysis (DEA) as well as stochastic frontier analysis (SFA). They find that the efficiency scores obtained by these two approaches are highly correlated. Cummins and Zi (1998) compare results obtained by the translog stochastic cost frontier and DEA and find consistent efficiency rankings. Tsay et al. (2009) takes issues with applying the three-stage data envelopment analysis (DEA). The simulations show that the finite sample performance of the proposed MLE of the censored SFA model is very promising. An empirical example of farmers' credit unions in Taiwan illustrates the comparison between the censored and standard SFA in accounting for environmental effects and statistical noise.

The other is the factors of managerial efficiency for life insurance companies. For example, Fukuyama (1997) studied the effects of ownership types on managerial effiiency of Japanese life insurance companies from 1988 to 1993. Cummins and Zi (1998) discuss the relationship between scale and returns to scale for life insurance companies. Cummins et al. (1999) study the effect of merger on life insurance companies' efficiency. Toivanen (1997) uses the translog cost frontier to study the scale and scope economies of non-life insurance industry in Finland. He finds that the retained premiums-curve of portfolio management is U-shaped and is a positive function of the number of branches. Using the CCR-DEA model, Noulas et al. (2001) study the efficiency of 126 domestic and foreign non-life insurance companies in Greece during 1991 to 1996.

The above literature only resorts to traditional DEA models which cannot eliminate inefficiency caused by statistical noises and environmental effects. As a result, efficiency scores can be over or under-computed for these life insurance companies since they are not evaluated at a relatively fair basis. Fried et al. (2002) propose a three-stage DEA approach, adjusting the inputs in order to eliminate the effects of statistical noises and environmental factors (Yang and Chen, 2010). Therefore, this paper will apply the three-stage approach proposed by Fried et al. (2002) to comparatively compute the managerial efficiency of life insurance companies in mainland China and Taiwan.

METHODOLOGY

The three-stage approach proposed by Fried et al. (2002) is presented further, containing the following models in each stage.

Stage one: The DEA model with original inputs

In order to pursue the overall technical efficiency (OTE) in the first stage, the CCR model constructed by Charnes et al. (1978) is used. The input slacks in this paper are obtained by the CCR model. By the BCC model proposed by Banker et al. (1984), the overall technical efficiency can be further decomposed into the product of pure technical efficiency (PTE), times scale efficiency (SE) (Coelli et al., 2005).

Note that the input slacks data left censored at zero. The BCC model there will have zero input slacks than the CCR model, easily causing the second stage SFA estimation not to converge (Tsay et al., 2009). In order to overcome the censored regression problem, the CCR model with fewer zero slacks can help us obtain unbiased second stage estimation. In the DEA model, there are I decision making units, N inputs, M outputs, and K environmental factors. DEA models are often applied to compute the efficiency of DMUs with multiple outputs and inputs in various kinds of industries (Chen et al., 2010a, b, c; Lu et al., 2010; Yang and Chen, 2010).

Stage two: SFA regression

The efficiency scores obtained in stage one DEA computation are affected by managerial inefficiency, environmental variables, and statistical noises. Therefore, in the second stage, the SFA regression will analyze the factors of input slacks and decompose the effects of managerial inefficiency, environmental factors, and statistical noises. The input slack for input n of DMU i can be expressed as:

$$s_{ni} = x_{ni} - X_n\lambda \geq 0, n = 1,...,N, i = 1,...,I \quad (1)$$

Where s_{ni} is the input slack for input n of DMU i in the first stage; $X_n\lambda$ is the minimum (projected) input x_{ni} for input *n* of DMU i.

A stochastic cost frontier regression is then applied to analyze the factors of input slacks:

$$s_{ni} = f^n(z_i;\beta^n) + v_{ni} + u_{ni}, \quad n = 1,...,N, \quad i = 1,...,I \quad (2)$$

Where $z_i = [z_{1i},...,z_{Ki}], i = 1,...,I$ are K observable environmental variables; $f^n(z_i;\beta^n)$ is the deterministic input slack frontier; the vector β^n contains the unknown parameters to estimate; v_{ni} and u_{ni} ($u_{ni} \geq 0$) represent the statistical noise and managerial inefficiency of input n for DMU i. The conditional

Table 1. Summary of statistic of input and output variables.

Variable		Number of DMUs	Minimum	Maximum	Average	Standard error
Output	Premium revenue	360	0.00	23776.40	1297.85	3012.68
	Investment revenue	360	10.00	11059.49	245.77	826.21
Input	Debt	360	18.00	381587.14	5805.29	22857.46
	Equity	360	165.36	21188.42	953.11	1898.38
	Employees	360	17.00	96698.00	7310.62	16315.91

The monetary unit is million USD in 2002 prices.

Table 2. Correlation coefficients among input and output variables.

Variable	Premium revenue	Investment revenue	Debt	Equity	Employee
Premium revenue	1.0000				
Investment revenue	0.7976	1.0000			
Debt	0.5659	0.5368	1.0000		
Equity	0.7556	0.8098	0.3881	1.0000	
Employees	0.9211	0.7487	0.5784	0.6746	1.0000

expected estimate of v_{ni} can be expressed as:

$$\hat{E}[v_{ni}|v_{ni}+u_{ni}] = s_{ni} - z_i\hat{\beta}^n - \hat{E}[u_{ni}|v_{ni}+u_{ni}], \quad n=1,...,N,\ i=1,...,I. \tag{3}$$

Finally, the inputs of these DMUs are adjusted with the following formula:

$$x_{ni}^A = x_{ni} + [\max_i\{z_i\hat{\beta}^n\} - z_i\hat{\beta}^n] + [\max_i\{\hat{v}_{ni}\} - \hat{v}_{ni}], \quad n=1,...,N,\ i=1,...,I, \tag{4}$$

Where x_{ni}^A and x_{ni} are the inputs after and before adjustments of input n for DMU i; $\max_i\{z_i\hat{\beta}^n\}$ represents the maximum projected input slack caused by environmental factors for input n in the same year; and $\max_i\{\hat{v}_{ni}\}$ represents the maximum projected input slack caused by statistical noise for input n in the same year.

Stage three: The DEA model with adjusted inputs

We then run the CCR model again with the adjusted inputs x_{ni}^A, $n=1,...,N,\ i=1,...,I$. The efficiency scores without distortions from environmental and statistical noise can hence be obtained.

Data sources and variable descriptions

In our dataset, there are 41 and 28 life insurance companies in the mainland China and Taiwan respectively, making a total of 69. The sample period is from 2002 to 2007. The data sources are China Insurance Year book (2003 to 2008) and Insurance Year Book of Taiwan (2003 to 2008), respectively. Note that all of the life companies with complete data are included in this dataset and hence, our research objects are quite close to the whole population of life insurance companies in these two economies.

There are three input variables in the DEA model: The first input is the total number of employees since the life insurance industry is labor intensive. The second input is the debt equity which reflects the scale of business. The third input is equity capital which reflects the warranty to give benefit payments to the insured. There are two output variables in the DEA model: The first output is the insurance premium revenue which is the result of a life insurance company's operations. The second output is investment revenue which comes from the financial intermediacy function of a life insurance company. All nominal variables are transformed into real variables in 2002 by GDP deflators in each economy and then transformed into US dollars by annual exchange rates.

Table 2 shows that the inputs and outputs used in this paper all satisfy the isotonicity property such that an output does not decrease with any input. Moreover, although each correlation coefficient between an output and an input is high, each correlation coefficient between any two inputs or any two outputs is relatively lower. This implies that all inputs and outputs are necessary and cannot be replaced by another input or output.

There are 10 environmental variables in the SFA regression. These environmental variables catch up the macroeconomic and institutional differences in these two economies across the Taiwan Strait. The first one is degree of economic freedom to reflect the difference in macroeconomic environments, as summarized in Table 3. The second one is the per capita income is used to measure the potential market size. The third one is the per capita savings rate to depict the people's income disposal preference. The fourth one is the number of establishment years, reflecting the business experience of a life insurance company. The fifth one is the asset scale to represent the degree of scale economy or dis-economy. The sixth one is the market share to measure the market power of a life insurance company. The seventh is the financial leverage ratio to measure a DMU's borrowing ability and financial flexibility. The eighth one is the overseas ownership (with overseas

Table 3. The scores and rankings of degrees of freedom for Mainland China and Taiwan.

Year	Mainland China		Taiwan	
	Score	Ranking	Score	Ranking
2002	52.8	116	71.3	22
2003	52.6	120	71.7	21
2004	52.5	124	69.6	26
2005	53.7	113	71.3	20
2006	53.6	117	69.7	30
2007	52.0	133	69.4	29

Data source: http://www.heritage.org/index/.

Table 4. The average OTE scores without adjustments for life insurance companies in Mainland China and Taiwan.

Year	Average OTE score in both economies	Average OTE score in Mainland China	Average OTE score in Taiwan
2002	0.914	0.913	0.915
2003	0.842	0.826	0.859
2004	0.916	0.914	0.918
2005	0.566	0.507	0.642
2006	0.840	0.852	0.823
2007	0.809	0.869	0.726
Five-year average	0.815	0.813	0.814

mono-ownership as 1 and otherwise as 0). The ninth one is the joint ownership (with joint ownership as 1 and otherwise as 0). The tenth one is the mainland China base (with mainland China-based companies as 1 and otherwise as 0).

EMPIRICAL FINDINGS

Stage one results

The stage one analysis computes the OTE scores of 69 life insurance companies before adjustments, to get rid of environmental effects and statistical noises. Only the observations in the same year are included in each DEA model, that is, efficiency scores are obtained by comparing to the annual efficiency frontier constructed by DMUs in the same year. Table 4 shows that the average OTE score of life insurance companies in mainland China and Taiwan is 0.815 from 2002 to 2007. The average OTE scores generally go down in these six years, showing a wider dispersion among the managerial efficiency of these life insurance companies. The six-year average OTE score of mainland Chinese life insurance companies is 0.813, which is slightly lower than that of the Taiwanese ones. The trends OTE scores across the Taiwan Strait are consistent, where both generally show a decline.

Stage two results

In stage two, the three kinds of input slacks are used as the explained variables in the stochastic cost frontier regressions in which those ten environmental variables are explanatory variables. A higher value of an input slack implies a more inefficient use in this specific input. The regression results are listed in Table 5, which can come up with the findings listed thus:

i. Enhancing the degree of economic freedom significantly helps reduce the input slacks in debt capital and employees. Therefore, a higher degree of economic freedom significantly helps increase the managerial efficiency in both economies. An increase in per capita income significantly helps promote managerial efficiency by decreasing employee slacks, that is, as per capita income increases, on average, each life insurance employee can have generate more outputs. An increase in the savings rate significantly increases the debt capital and employee slacks, implying that personal savings is an effective substitute for life insurance. The number of establishment years has no significant effect on all input slacks, implying that newly established life insurance may not have disadvantages because of lack of business experiences in these two Chinese economies.

ii. An increase in the assets significantly increases all of the three input slacks, implying scale diseconomies. Therefore, expanding the asset scale may not be an efficient way to improve competitiveness. An increase in market share significantly reduces debt capital and equity capital slacks, but increases employee slacks. This is because an increase in the market share generates a

Table 5. The SFA regression results on input slacks for life insurance companies in Mainland China and Taiwan.

Variable	Slack of debt capital	Slack of equity capital	Slack of employees
Constant	15654.558 - (35.2582)	-8049.4635- (1.8935)	-12309.602- (1.1841)
Degree of economic freedom	-240.9491 - (47.6313)	94.3766- (4.6707)	129.2024-(56.5518)
Annual per capita income	-0.3733- (0.1444)	0.1148- (0.0151)	0.0302 (0.1773)
Annual per capita savings rate	83.8546- (48.8098)	-1.1078 (4.8045)	100.494- (56.0039)
Establishment years	0.5803 (10.7685)	-0.0725 (0.7413)	2.5137 (6.9073)
Assets scale	0.6668- (0.0192)	0.0133- (0.0021)	0.0734- (0.0198)
Market share	-1603.0991- (71.4950)	-0.2231 (3.4169)	227.1646- (34.2220)
Financial leverage ratio	393.1948- (28.4766)	-24.5237- (3.3944)	-59.2104- (30.2564)
Overseas mono-ownership	1111.4232-(151.2176)	-65.4038- (16.6283)	-125.0286-(27.4403)
Joint ownership	969.9972- (511.2912)	-72.0142-(38.1821)	849.1462- (106.8907)
Mainland China-based	-9255.8753-(28.5809)	3035.8027- (1.3973)	-571.1809- (1.0496)
σ^2	2.102E+07- (1.0021)	169634.37- (1.2860)	15008778- (1.0002)
γ	0.5862- (0.0359)	0.3256-(0.0505)	0.1220- (0.0709)
Log-likelihood function	-3456.7654	-2641.5059	-3472.4883

*, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively. The numbers in parenthesis are standard errors.

Table 6. The average adjusted OTE scores of life insurance companies in Mainland China and Taiwan.

Year	Average OTE score of both economies	Average OTE score in Mainland China	Average OTE score in Taiwan
2002	0.152	0.128	0.172
2003	0.144	0.101	0.190
2004	0.151	0.102	0.206
2005	0.141	0.095	0.199
2006	0.131	0.089	0.190
2007	0.155	0.117	0.206
Mean	0.146	0.105	0.194

pressure toward hiring more employees. An increase in the financial leverage ratio significantly decreases all three input slacks, implying that financial flexibility is beneficial to managerial efficiency improvement.

iii. Overseas mono-ownership, joint ownership, mainland-based ownership, and Taiwan-based ownership have different kinds of advantages. Overseas mono-ownership significantly helps reduce equity capital and employee slacks, but not for reducing debt capital slacks. Joint ownership is good for reducing debt capital and equity capital slacks, but was increasing the employee slacks.

The mainland-based ownership is good for reducing debt capital and employee slacks, but is increasing the debt capital slacks. As a result, different types of ownership have their own advantages to compete in these two economies. This may explain why this is a variety of ownership types in insurance markets across the Taiwan Strait.

Stage 3 results

The inputs are adjusted according to Equation (4), in order to get rid of the distortions caused by environmental effects and statistical noises. The OTE scores after adjustments are shown in Table 6. Comparing Tables 4 and 6, we find that after adjustments, the six-year average OTE scores decrease from 0.814 to 0.146, showing that the life insurance industry is heavily affected by environmental effects and statistical noises. After adjustments, the mainland Chinese life insurance companies have much lower OTE scores (0.105) than Taiwanese ones (0.194), showing that mainland Chinese companies are much more affected by both environmental factors and statistical noises.

Table 7 lists the top 10 efficient life insurance companies before and after adjustments. Before adjustments, the top 3 efficient life insurance companies in both economies are New China Life Insurance (CN), Samsung Air China Life Insurance (CN), and Chung Hwa Life Insurance (TW). However, after adjustments, the top 3 efficient life insurance companies in both economies become Cathay Life Insurance (TW), China Life Insurance (CN), and Nan Shan Life Insurance (TW). Therefore, if in the future both economies further open their life insurance markets to each other, then under the same environments,

Table 7. The top ten efficient life insurance companies before and after adjustments.

Before adjustments		After adjustments	
Name	**OTE ranking**	**Name**	**OTE ranking**
New China Life Insurance (CN)	1	China Life Insurance (CN)	1
Taikang Life Insurance (CN)	2	Cathay Life Insurance (TW)	2
China Postal Life Insurance (TW)	3	China Ping An Insurance (CN)	3
Kuo Hua Life Insurance (TW)	4	Nan Shan Life Insurance (TW)	4
Allianz President Insurance (TW)	5	Shin Kong Life Insurance (TW)	4
China Pacific Life Insurance (CN)	6	China Pacific Life Insurance (CN)	6
Cathay Life Insurance (TW)	7	China Postal Life Insurance (TW)	7
Shin Kong Life Insurance (TW)	8	ING Antai Life Insurance (TW)	8
Metropolitan Life Insurance (CN)	9	Taikang Life Insurance (CN)	9
China Life Insurance (CN)	10	Fubon Life Assurance (TW)	10

CN: Mainland China-based; TW: Taiwan-based.

Table 8. The distribution of adjusted OTE scores for life insurance companies in mainland China and Taiwan (Unit: %).

Year	OTE = 1.000		0.500 ≤ OTE < 1.000		0.100≤ OTE < 0.500		OTE < 0.100	
	Mainland China	**Taiwan**	**Mainland China**	**Taiwan**	**Mainland China**	**Taiwan**	**Mainland China**	**Taiwan**
2002	3.85	4.76	7.69	4.76	26.92	14.29	61.54	76.19
2003	3.57	3.33	10.71	6.67	32.14	6.67	53.57	83.33
2004	3.57	3.13	7.14	3.13	42.86	12.5	46.43	81.25
2005	3.57	2.78	7.14	2.78	42.86	13.89	46.43	80.56
2006	0.00	5.13	10.71	0.00	42.86	7.69	46.43	87.18
2007	3.70	2.70	7.41	8.11	48.15	5.41	40.74	83.78
Mean	3.04	3.64	8.47	4.24	39.3	10.07	49.19	82.05

the performance rankings of these life companies may drastically change.

Table 8 shows the distribution of adjusted OTE scores of these life insurance companies. If the two markets are further open to each other, up to 78.3% of mainland- based life insurance companies will have extremely low OTE scores less than one, compared to the extremely inefficient Taiwan-based insurance companies, only accounting for 25.71% among them. Under a homogeneous environment, the Taiwan-based life insurance companies will perform more efficient than those mainland-based ones. Therefore, if both sides across the Taiwan Strait reach a memorandum of understanding for financial markets in the near future, in the short run, the Taiwan-based life insurance companies may enjoy more market expansion than the mainland-based ones.

CONCLUDING REMARKS

This paper applies the three-stage approach proposed proposed by Fried et al. (2002) to analyze the efficiency of life insurance companies in the Mainland and Taiwan areas. This approach adjusts the input slacks obtained by data envelopment analysis via the stochastic frontier analysis. This approach compares the managerial efficiency of these life insurance companies under similar environment and luck. Our major empirical findings are listed thus:

1) Efficiency scores of life insurance companies in

both areas are significantly affected by both environmental factors and statistical noises. After input slack adjustments, the average efficiency score drops for 72.17%.
2) Compared to those companies in the Taiwan area, the life companies in the Mainland area have a large diversion in efficiency scores which range from less than 10 to 78.3%.
3) Debt equity has a significant effect to increase efficiency, indicating that increases in the market share and financial leverage ratio help promote efficiency.
4) Ownership types have different advantageous effects on different inputs.
5) The years since establishment have no significant effects on efficiency, indicating that the younger mainland Chinese life insurance companies do not have disadvantages because of it in an open and competitive market environment.
6) Under a similar environment, Taiwan-based life insurance companies are more efficient than mainland-based ones.

It is worth noting that in 2007, savings amount in Mainland China has been up to 2529.41 billion US dollars, accounting for 50% of the people's income. This paper finds a strong adverse effect of per capita savings ratio on efficiency of life insurance companies since personal savings is a substitute for life insurance. It is very important to educate the people in mainland China to select and use life insurance to cover their own risk. Moreover, this paper finds that the input slacks and managerial efficiency of life insurance companies in Taiwan and mainland China are significantly affected by environmental factors, showing that institutional reform does matter for improving the efficiency of financial institutions. If mainland China wants to further attract more overseas investment, it should continue to reform and open its financial markets.

Since different ownership types have different advantage in using different inputs, it is hard to ex ante judge which ownership type is superior to others. The best way to promote managerial efficiency is hence to have an open and transparent life insurance market such that fair competition can continuously improve managerial efficiency.

Moreover, both sides across the Taiwan Strait are trying to reach a memorandum of understanding on financial markets. Once after the life insurance markets are open to each side, this research expects Taiwan-based companies to be more efficient in the short run. However, via competition and cooperation among the life insurance companies in mainland China and Taiwan, the managerial efficiency of mainland Chinese ones can also be promoted.

Due to data limitation, the DEA model in this paper does not incorporate the service quality and investment risks. This limitation also exists in the previous literature using the DEA approach to study insurance companies. This limitation may make the computed efficiency scores be in favor of the life insurance companies in mainland China which have much larger output scales. It is generally agreed that the insurance companies in Taiwan have be-tter service quality and risk management. The efficiency scores of Taiwan's life insurance companies should further improve if the service quality and investment risks are included into the DEA model.

ACKNOWLEDGEMENTS

The authors are indebted to the chief editor and two anonymous referees of this journal and the participants at 2010 Cross-Strait Boao Forum for their helpful comments. Also, thanks go to National Science Council in Taiwan for partial financial support (NSC96-2415-H-009-002-MY2).

REFERENCES

Charnes A., Cooper WW, Rhodes E (1981). Evaluating program and managerial efficiency: an application of data envelopment analysis to program follow through. Manage. Sci., 27: 668-697.
Chen IS, Chen JK (2010). How to manage knowledge well? evidence from the life insurance industry. Afr. J. Bus. Manage., 4: 3605-3617.
Chen YC, Chiu YH, Huang CW (2010a). Measuring super-efficiency of financial and nonfinancial holding companies in Taiwan: An application of DEA models. Afr. J. Bus. Manage., 4: 3122-3133.
Chen LF, Hsiao CH, Tsai CF (2010b) Three-stage-DEA model selections and managerial decision. Afr. J. Bus. Manage., 4: 3046-3055.
Chen CT, Hu JL, Liao JJ (2010c). Tourists' nationalities and the cost Efficiency of international tourist hotels in Taiwan. Afr. J. Bus. Manage., 4(16): 3440-3446.
China Insurance Yearbook, 2003-2008, Beijing.
Coelli T, Rao DSP, O'Donnell CJ, Battese GE (2005). An Introduction to Efficiency and Productivity Analysis, 2nd ed., New York: Springer.
Cummins JD, Tennyson S, Weiss MA (1999). Consolidation and efficiency in the US life insurance industry. J. Bank. Financ., 23: 325-357.
Cummins JD, Zi H (1998). Comparison of frontier efficiency methods: an application to the U.S. life insurance industry. J. Prod. Anal., 10: 131-152.
Fecher, F, Kessler D, Perelman S, Pestieau P (1993). Productive performance of the French insurance industry. J. Prod. Anal., 4: 77-93.
Fried HO, Lovell CAK, Schmidt SS, Yaisawarng S (2002). Accounting for environmental effect and statistical noise in data envelopment analysis. J. Prod. Anal., 17: 157-174.
Fukuyama H (1997). Investigating productive efficiency and productivity changes of Japanese life insurance companies. Pacific-Basin Financ. J., 5: 481-509.
Lu YH, Shen CC, Ting CT, Wang CH (2010). Research and development in productivity measurement: An empirical investigation of the high technology industry. Afr. J. Bus. Manage., 4: 2871-2884.
Noulas AG, Hatzigayios T, Lazaridis J, Lyroudi K (2001). Non-parametric production frontier approach to the study of efficiency of non-life insurance companies in Greece. J. Financ. Manage. Anal., 14: 19-26.
Taiwan Insurance Year Book, 2003-2007, Taipei.
Toivanen O (1997), Economies of scale and scope in the Finnish non-life insurance industry. J. Bank. Financ., 21: 759-779.
Tsay WJ, Huang CJ, Fu TT, Ho IL (2009). Maximum likelihood estimation of censored stochastic frontier models: an application to the three-stage DEA method. IEAS Working Paper, No. 09-A003, Taipei: Academia Sinica.
Yang C, Chen TY (2010). Evaluating the efficiency of intellectual capital management for Taiwan IC design industry. Afr. J. Bus. Manage., 4: 3366-3373.