Efficiencies of Life Insurers in China

An Application of Data Envelopment Analysis

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Abstract

Using Data Envelopment Analysis (DEA), we analyzed the relative efficiency of Chinese life insurers between 2000 and 2003, identify the drives of technical efficiency, and discuss the characteristic of the life insurance industry in China. This paper also compares the technical efficiencies, pure technical efficiencies, and scale efficiencies between different groups of life insurers. Through these comparisons, the styles of development and the characteristics of operation are identified. In addition, with the advantage of DEA, this paper also discusses the topics of scale economies, shadow price, improvement space, and Malmquist index. We believe our work is beneficial for researchers and practitioners to better understand the Chinese life insurance industry. Some of our suggestions are presented at the end of the paper.

1. Introduction

Data Envelopment Analysis (DEA) is introduced by A. Charnes and W.W. Cooper in 1978. The method is to identify and analyze the relative efficiency of decision making units (DMU). Charnes, Cooper and Rhodes (1978) raised the first model of DEA: C^2R model. This model can work with multi-inputs and multi-outputs, and is later utilized in many areas.

The DEA model has good economic implications, such as the efficiency measurement of different lines of business and the identification of production function. Actually, production function could be properly and strictly measured only after DEA was used. Furthermore, technical progress also concerns researchers and practitioners. Since technical progress is closely related with the production function, many researches also use DEA to calculate the technical progress. Besides

that, DEA has been greatly used in efficiency measurement. The targets range from air force to non-profit institutions, from hospitals to banking industry.

In the insurance area, Cummins et al (1993, 1998, and 1999) measured the efficiency of insurance industry and insurance companies in United States. They compared the efficiencies of different types of life insurers (mutual insurers vs. stock insurers). Their results challenged the Principle Agent Theory and the Incentive Theory. With DEA, Cummins also evaluated the trend of M&A in US life insurance industry. His paper argued that M&A eliminated some life insurers with bad performance but increasing return to scale. At the same time, it enhanced the efficiency of the whole industry. Their research also justified that the trend of M&A in US life insurance industry is driven by the economic interest. Fukuyama (1997) measured the efficiency of Japanese life insurers. He also compared the results of mutual insurers and stock insurers. In addition, the efficiency results from different periods are also discussed in his paper. Diacon et al (2002) regarded a country's insurance industry as a decision making unit. Using the DEA method, he evaluated the efficiencies of insurance industries in UK, Germany, France, Netherlands, Switzerland and Italy. His result showed that UK had the most efficient insurance industry, while Italian insurance industry had the worst performance. Other similar works with DEA include: Rai (1996) conducted the comprehensive efficiency measurement among the 106 insurers around the world; Brockett et all (1997, 2005) measured the efficiencies of US property and liability insurers, and discussed the relationship between efficiency and solvency.

We note that there are few papers on the efficiency of Chinese insurance industry. Hui and Li (2003) measured the relative efficiencies of only 9 insurers in China. But their paper regards life insurer and property-liability insurer as the same kind of decision making units, which weakens their

results. Also their paper focused too much on the methodology, but talked little about the economic implications. Zhao (2003) analyzed the efficiencies of 14 insurers in China between 1997 and 2001 and raised some suggestions. However, that paper did not cover the topic of shadow price, scale economies, and technical progress. In addition, he selected profit as the indicator of output, which does not satisfy the requirement of DEA. Actually, profit can only be regarded as the difference between output and input. Hou and Zhu (2004) followed the method of Cummins and conducted the empirical analysis on the efficiencies of property insurers in China. They also discussed the shadow price and the relationship between efficiency and profitability. Li (2005) is the only DEA paper focusing on Chinese life insurers. In his paper, Li not only measured the relative efficiency of life insurers, but also calculated the Malmquist Index and technical progress. However, there is little discussion on the economic implication. Another weakness of that paper is the indicator selection of inputs and outputs.

In our paper, we use the data from 2000 to 2003, and analyze the relative efficiencies of life insurers in China. In addition, the efficiency drives, scale economies, shadow improvement, Malmquist Index, and technical progress are also discussed in details. Through the empirical work, we have identified many useful economic implications, which provide much insight of the Chinese life insurance industry. Our paper is structured as below:

Section 2 introduces and evaluates the DEA method; Section 3 discusses the practical meaning of DEA in insurance, as well as the selection of inputs and outputs; Section 4 explains the empirical results, and extends the economic implications; Section 5 is the conclusion and suggestion.

2. Data Envelopment Analysis

2.1 Relative Efficiency

2.1.1 Qualitative Definition of Relative Efficiency

Relative efficiency is the comprehensive efficiency that a decision making unit (DMU) is able to transform the inputs into the outputs. “Relative” implies that a DMU is compared with other DMUs or the convex combination of all the DMUs. First of all, an efficient DMU will be identified. This efficient DMU produces the most outputs with fixed inputs, or requires the minimum inputs to get some certain outputs. “Efficiency” is defined as Technical Efficiency (TE) in our paper, which is the product of Pure Technical Efficiency (PTE) and Scale Efficiency (SE). Pure Technical Efficiency reflects the efficiency of the resource allocation and the management. In another word, it shows whether the DMU could reach the maximum production under certain restrictions. Scale efficiency indicates the effect of scale: small companies may not assemble the production or obtain the synergy, while many big companies often move slowly and do not show the harmony. Consequently, the scale can also affect the efficiency of a DMU. According to the above discussion, the technical efficiency can therefore be regarded as the measurement that inputs are transformed into outputs, or just the output/input ratio.

2.1.2 Quantitative Definition of Relative Efficiency

Consider N samples (each sample constitutes a DMU). Each sample produces J different outputs with I different inputs. Here, I could be more than, less than, or just equal to J. In order to measure the efficiency that a DMU, DEA raises the method to maximize the ratio that weighted averaged outputs is divided by weighted averaged inputs. The restriction is that the same ratio of other DMUs cannot be more than 1. The idea can be mathematically expressed as:

$$\max e^0 = \frac{\sum_{j=1}^{J} u^0{}_j y^0{}_j}{\sum_{i=1}^{I} v_i^0 x_i^0}$$

$$s.t. \frac{\sum_{j=1}^{J} u^0{}_j y^n{}_j}{\sum_{i=1}^{I} v_i^0 x_i^n} \le 1; n = 1, ..., N \qquad (1)$$

$$u^0{}_j, v_i^0 \ge 0; i = 1, ..., I; j = 1, ..., J$$

$y^n{}_j$ and $x^n{}_i$ are the output and input of the n_{th} DMU. $v^0{}_i$ and $u^0{}_j$ are the weights. We use 0 to indicate the DMU that is to be measured. By solving the mathematical programming (1), we could get the maximized e^0, which is just the efficiency score of DMU^0. Repeating the same calculation on other DMUs, we could get all the efficiency scores. If $e^0=1$, DMU^0 satisfy the necessary requirements of DEA efficiency. Otherwise, it will be considered technical inefficient. By calculating the weights derived from (1), we can also get the information on scale economies. The above talks about the original C^2R model of DEA, which is computationally intractable. However, in the practice, the non-linear programming problem is usually turned into linear programming (BBC model) by Charnes-Cooper Transformation. In our paper, we will use the model with non-Archimedean infinitude, which is shown in (2).

2.2 Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency

Usually, only efficiency score is not enough. Technical efficiency needs to be broken up, so that the drives of the technical efficiency can be identified. According to the above discussion, technical efficiency can be regarded as the product of pure technical efficiency and scale efficiency. In the following, we will show how this decomposition is realized.

For convenience, we only consider the case of one input (x) and one output (y). In Figure 1, OE

denotes the production frontier with constant return to scale. AB and CD are both production frontiers with variable return to scale. ABCD depicts how the production moves from increasing return to scale to constant return to scale, and to decreasing return to scale. Assume that U is the actual production point of a DMU. We have the following formula:

Technical Efficiency = RS/RU

The definition of technical efficiency in this circumstance is: requiring a certain output, the actual input is divided by the input at the frontier with constant return to scale. This definition is based on input. With the similar thinking, we can also get the definition based on output. Here, the frontier with constant return to scale denotes the efficient production. Any point on this frontier is technical efficient.

Pure Technical Efficiency = RT/RU

The definition of pure technical efficiency is: requiring the same level of output, the actual input is divided by the input at the production line with variable return to scale. Note that in pure technical efficiency, production line with variable return to scale is used. From the perspective of economics, this will release the restrictions of scale. Therefore, the inefficiency only lies in the factors such as productivity, resource allocation and management.

Scale Efficiency = RS/RT

The definition of scale efficiency is: requiring the same level of output, the input at the production frontier with constant return to scale is divided by the input at the production line with variable return to scale. In contrary to the case of pure technical efficiency, only the factor of scale is effective here, while the factors of productivity, resource allocation and management are excluded.

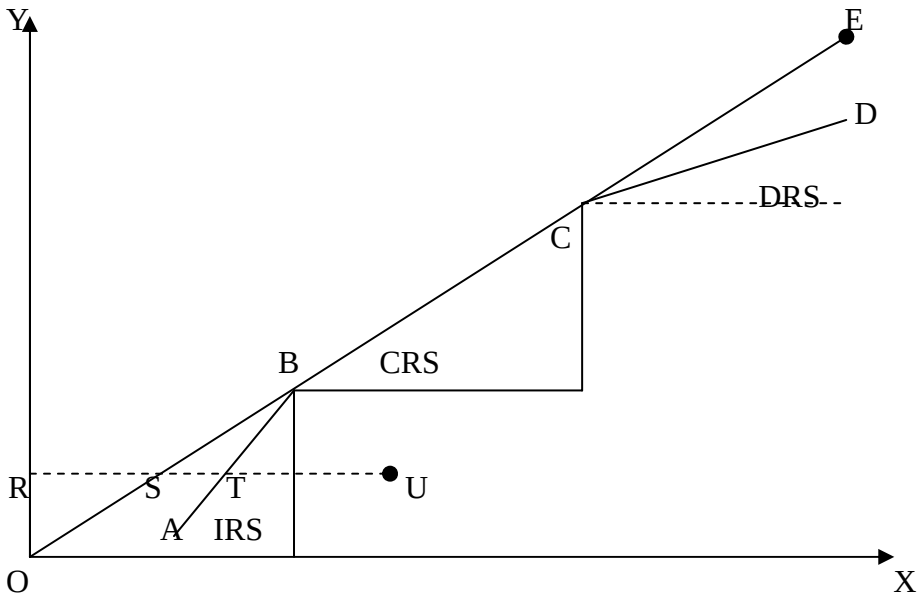

Figure 1: How Technical Efficiency Is Broken Up

2.3 The Evaluation of Data Envelopment Analysis

2.3.1 Advantage of DEA

Among the researches of production frontier, DEA is a typical non-parametric method. Compared to the econometric methods, DEA does not require the assumption of production function, and therefore avoids many subjective factors. Traditional econometric methods have to assume the production function and the random errors. Based on those assumptions, regressions and tests can be conducted, and the modified production frontier can be finally fixed. Next, the distance between the actual production point and the frontier will be measured, which will result in the efficiency score. However, DEA directly compares a DMU with other DMUs or their convex combination. Many subjective errors can be avoided in this process.

DEA is also convenient for the calculation. All the anomalous programming can be finally

transformed into linear programming. Also many soft wares specialized on DEA have been developed. Furthermore, DEA allows the researchers and practitioners to select input and output variables according to their particular goals. DEA can also work well with multi-inputs and multi-outputs, which means the DEA score contains much more information than the normally used ratio analysis.

2.3.2 Disadvantage of DEA

The most important problem with DEA is this method ignores the random errors in its model. That means the result of DEA is not accurate from the perspective of statistics. Some departures from the frontier line are not due to the inefficiency. They may be actually caused by inaccurate data resource, measurement errors, and such random factors. In statistics, these random factors cannot be regarded as inefficiency. Cummins and Zi (1998) showed that the efficiency scores with the econometric methods are generally higher than those with DEA. They argued this was caused by the fact that DEA regards all the departure from frontier line as inefficiency.

3. Efficiency Measurement of Life Insurers in China

3.1 Meaning and Importance of DEA in the Efficiency Measurement

3.1.1 From the Prospective of Regulator

DEA provides a comprehensive and scientific system to evaluate the insurers. Regulator can identify the relative position, the operation efficiency, as well as the weakness of each insurer. Meanwhile, through the analysis on the drives of efficiency, regulator is able to see the development style of each insurer. For example, it can be distinguished whether an insurer relies on pure technical efficiency or relies on scale efficiency. Another example is to identify the characteristics of insurers with different ownership (mutual insurers vs. stock insurers), insurers with at different status

(traditional insurers vs. new-coming insurers), and insurers with different backgrounds (Chinese state owned insurers vs. joint venture insurers). According to the information that DEA can provide, regulator can see the market structure and market trend more clearly. Therefore, DEA provides important information for the regulator to set the regulatory policy.

In addition, DEA can also help regulator to identify the problems in the insurance market. For example, US life insurance industry experienced a series of M&A in the beginning of 1990s. It was hard to judge whether the trend of M&A would benefit or hurt the market. Cummins, Tennyson and Weiss (1999) used the DEA method and calculated the change of efficiency before and after the M&A. They also measured the Malmquist Index and the productivity of the whole industry. Their work provided a scientific evaluation of the trend, and justified that efficiency and productivity were enhanced after the M&A.

3.1.2 From the Prospective of Managers

DEA can provide the information of strategy, competition, and efficiency. The information from DEA is straight forward, comprehensive, and more acceptable by the managers. For the efficiency score is derived from multi-inputs and multi-outputs, it must contain the information of all the inputs and outputs. Therefore, DEA could satisfy some particular requirements: on one hand, managers usually need the concise result, and long research report is generally not good; on the other hand, managers also need the result to contain as much information as possible, so that they could set the proper judgments of their enterprises and their competitors.

Through the shadow analysis, DEA could identify the specific input and output that lead to the inefficiency. It can also suggest where to improve and how much to improve. In another word, the extra-input and deficient output can be found and measured by DEA. This provides important

information for the managers of life insurers. The management of life insurance is complicated work. Even experienced managers will meet difficulties to figure out the most important and most useful information, especially to identify what is extra-input and what is deficient output. DEA can compare the DMU with the frontier line in every dimension, and therefore is able to point out the potential improvement in each dimension. Consequently, DEA gives very important evidence and information for the managers.

DEA can also work with the scale efficiency. It can measure the development status and scale economies, which is regarded as crucial information of the corporate strategy. The theory of enterprise management tells that a typical enterprise will experience a growing period with increasing return to scale, a stable period with constant return to scale, and a vanishing period with decreasing return to scale. Different status corresponds with different strategy and development style. It is important for the managers to identify the status of their enterprise. However, the complexity of operation and market may easily confuse the managers. Especially, the growth on the surface often gives serious delusion. DEA can exclude many confusing variables, and measure the scale efficiency. It also provides a useful instrument to deal with the topic of development status in management science.

3.1.3 From the Prospective of Consumer

DEA can provide the consumers with comprehensive information of insurers. It can rank the insurers according to their efficiencies, so that consumers have a simple and clear indicator when they make a choice. Meanwhile, Brockett et al (1997) shows that efficiency is significantly and positively related to solvency. This means consumers can also get the information of solvency from the DEA analysis.

3.2 Life Insurers in China and Data Selection

This paper focuses on the life insurers in China mainland between 2000 and 2003. The reasons are described in the following:

1) Life insurer and property-liability insurer are quite different in the sense of output, operations, and development. Therefore, they cannot be regarded as the same kind of DMUs.
2) Hou and Zhu (2004) have discussed the efficiency of property-liability insurers in China. Although Li (2005) used DEA on the life insurers in China, that paper didn't select proper input and output variables. Neither did it have enough discussion on the economic implications.
3) Before 2000, Chinese insurance industry was highly monopolized. There were very few life insurers at that time. Therefore, we could not have enough samples for the calculation if the before 2000 is included.
4) According to the literature, researchers usually use the same sample set across different years, so that the comparison of efficiency scores in different years will make sense. Cummins et al (1999) selected only 445 life insurers that continuously existed between 1988 and 1992, and disregarded the insurers that could not go through the period. However, since Chinese life insurance industry is growing very fast and a lot of new players came into the market during the sample period, many important players and much market information would be excluded if we stick to the panel data. Also we want to address some characteristics of the fast growing market. Therefore, this paper includes all the insurers existing in each year, and our dataset shows different sample size in

different years. In doing this, we may meet difficulties when the time-series efficiency scores are compared. However, it allows the effective comparison within each year and makes the efficiency scores much more reliable.

3.3 Variables of Inputs and Outputs

3.3.1 Inputs

According to the current literature, researchers have general agreement on the selection of input indicators in the insurance area. Normally, labor, capital, materials are selected. This is shown in Grace and Timme (1992), Gardner and Grace (1993), Cummins and Zi (1998).

Amount of Labor (X1): Labor is the most important input in the financial service industry. In insurance companies, no raw materials are required, and cost of labor is the major component of cost. Since it's not possible to get the salary data of life insurers in China, and the amount of labor is positively related with the cost of labor, we will use the amount of labor as the first indicator of input.

Equity Capital (X2): According to the theory of corporate finance, invested capital which includes long term debt and equity capital should be the best indicator for capital. However, reserve constitutes almost all the long term debt of life insurers, and at the same time the debt is not stable in the financial reports. Therefore, we cannot say that life insurers use this long term debt to support their business. In this paper, we use the equity capital as the second indicator of input, which can be found in the balance sheet of life insurers.

Agent Cost and Others (X3): This third input includes the cost of agent, the cost of daily operation, and all the other cost. The details can also be found in the balance sheet of life insurers.

3.3.2 Outputs

There have been conflicts on the indicator of output. Two major points of view appeared in the literature: premium vs. benefit payment. Houston and Simon（1970）thinks premium to insurers is what income to manufacturers, and therefore can be regarded as the indicator of output. Similar arguments appeared in: Praetz（1980），Fields and Murphy（1989），Grace and Timme（1992），Gardner and Grace（1993），Rai（1996），Diacon（2001），Li（2005）. However, Doherty（1981），Yuengert（1993），Cummins and Zi（1998）thinks premium cannot reflect the quantity of output, and the output of insurer should be measured by the service that consumers have received. Consequently, they prefer benefit payment as the indicator of output. The only problem is how to explain the insurers want to maximize the output of benefit payment. In the following, we will discuss the indicators used in our paper.

When writing this paper, we interviewed some practitioners, consultants, and regulators in the insurance industry. Most of them support that benefit payment is the proper indicator of output. To our point of view, benefit payment is proportional to the underwritings. It is also important indicator of development status, because it measures the function of risk pooling and redistribution. Larger benefit payment may show that the insurer is at advantage in the competition. Therefore, this papers uses benefit payment as the indicator of output. We do not separate individual insurance and group insurance, for we do not want too many output variables. In DEA, the sample size should be at least 3 times larger than the number of input and output variables. Therefore, we finally use two indicators here: 1) Annuity Payment; 2) Benefit of Death, Injury and Medical Treatment.

Like benefit payment, reserve is also a measurement of the function of risk-pooling and redistribution. The increase of reserve reflects the stronger solvency in the future. In addition, just

like the deposit of banks, reserve shows the function of financial intermediary, and the money of reserve will be invested in the capital market. In our paper, the addition of reserve is calculated and is regarded as the third indicator of output.

Investment of a life insurer shows how much cash value the insured could get and how much the stockholders could gain. From this perspective, yield of investment is also regarded as an important output.

According to the above discussion, we have four indicators of outputs:

- Annuity payment--- Y1
- Benefit of death, injury and medical treatment--- Y2
- Addition to reserve--- Y3
- Yield of investment--- Y4

4. Empirical Results and Economic Implications

With the software named LINGO, we solve the mathematical programming of the DEA model with non-Archimedean infinitude. Another reason to use this model is that the shadow improvement can be discussed through the analysis of slacks in the model. The expression of our model is:

$$
\begin{aligned}
&\min[\theta - \varepsilon(e^T s^- + e^T s^+)] = V_{D_\varepsilon} \\
&s.t. \\
&\sum_{j=1}^{n} \lambda_j x_j + s^- = \theta x_0 \\
&\sum_{j=1}^{n} \lambda_j y_j - s^+ = y_0 \\
&\lambda_j \geq 0,\ j = 1, 2, 3 \ldots\ldots, n \\
&s^- \geq 0, s^+ \geq 0
\end{aligned}
\qquad (2)
$$

4.1 Empirical Results and Analysis on Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency

Table 1 shows the result of technical efficiency and scale economy between 2000 and 2003.

Generally speaking, the efficiency scores of life insurers in China are diversified, and relatively stable. For example, China Life and AIA Shanghai are technical efficient in all the four sample years, while some small insurers who just entered the market are not efficient in any year.

Since technical efficiency is the product of pure technical efficiency and scale efficiency, we can see from Table 1 that although some technical inefficiency is caused by the problems of pure technical efficiency, more are caused by the problems of scale efficiency. In addition, compared with the results of other researches, our paper argues that the proportion of efficient life insurers is much larger in China. In other words, there are relative more life insurers that stand at the frontier line in China. We have two explanations for this:

First, Chinese life insurance industry is developing at an early stage. It is being transformed from a monopolized market into a competitive market. Under the framework of WTO, 2005 is the first year that Chinese insurance market is fully exposed to the world. Before 2005, there were strong entry barriers and strict regulation in Chinese insurance industry. China Insurance Regulatory Commission (CIRC) not only serves as regulator, but also takes the responsibility to develop the insurance industry in China. With the strict regulation of CIRC, it's very hard to realize perfect competition. All the above factors result in a distorted insurance market in China: traditional monopolies keep their advantage in brand, resource, market share and regulation policy, while the new players suffer from the high investment at the early stage, high agent cost, low brand reputation and so on. The monopolies are therefore efficient among all the sample years and Chinese life

insurance market is still a one-side market.

Secondly, from the perspective of technique, the small sample size also contributes to the result of the one-side market. Without many sample points, the comparison among the DMUs cannot be thorough. Therefore, the frontier is not fully extended and some DMUs will stand at the frontier line. Other papers on DEA and insurance usually obtain 400 to 1,000 samples, which is far more than the requirement of DEA. Consequently, the frontier line is more accurate and fewer DMUs can behave to be efficient in those researches. However, the Chinese life insurance industry is still at an early stage, and our sample size has to be small. The sample problem is caused by the special market situation in China.

Table 1： Results of Efficiencies and Scale Economies

	2000					2001				
	TE	PT	SE	Σ λ	Return to Scale	TE	PT	SE	Σ λ	Return to Scale
China Life	1	1	1	1	Constant	1	1	1	1	Constant
China United	0.67	0.91	0.74	0.17	Increasing	0.66	0.99	0.66	0.07	Increasing
China Pacific Life	0.73	0.95	0.77	2.05	Decreasing	1	1	1	1	Constant
Ping An	1	1	1	1	Constant	0.6	0.61	1	0.2	Increasing
New China	1	1	1	1	Constant	1	1	1	1	Constant
Taikang	0.82	0.85	0.97	0.64	Increasing	0.83	0.83	1	0.99	Increasing
Tianan	0.15	0.26	0.59	0.08	Increasing	0.11	0.26	0.44	0.07	Increasing
Manulife-Sinochem	0.45	1	0.45	0.1	Increasing	0.5	0.85	0.59	0.08	Increasing
Pacific-Antai	0.21	0.77	0.28	0.05	Increasing	0.21	0.58	0.36	0.06	Increasing
Allianz Dazhong	0.31	1	0.31	0.04	Increasing	0.51	0.91	0.57	0.05	Increasing
AXA-Minmetals	0.2	1	0.2	0.04	Increasing	0.15	0.77	0.2	0.03	Increasing
China Life CMG						0.67	1	0.67	0.03	Increasing
Citic Prudential						0.13	0.71	0.18	0.02	Increasing
John Hancock						0.74	0.98	0.75	0.06	Increasing
AIA, Shanghai	1	1	1	1	Constant	1	1	1	1	Constant
AIA, Guangzhou	1	1	1	1	Constant	0.82	1	0.82	0.09	Increasing
AIA, Shenzhen	0.41	1	0.41	0.03	Increasing	0.17	1	0.17	0.02	Increasing
	2002					2003				
China Life	1	1	1	1	Constant	1	1	1	1	Constant
Taiping Life	1	1	1	1	Constant	0.52	0.54	0.97	0.51	Increasing
Minsheng Life						0.99	1	0.99	0.54	Increasing
China United	0.61	0.85	0.72	0.04	Increasing	0.09	0.13	0.71	0.01	Increasing
China Pacific Life	1	1	1	1	Constant	1	1	1	1	Constant
Ping An	1	1	1	1	Constant	1	1	1	1	Constant
New China	1	1	1	1	Constant	0.89	0.97	0.92	7.68	Decreasing
Taikang	0.7	0.72	0.97	0.52	Increasing	0.45	0.45	0.99	1.47	Decreasing
Tianan	0.11	0.3	0.36	0.05	Increasing	0.07	0.1	0.72	0.04	Increasing
Sino Life						1	1	1	1	Constant
Manulife-Sinochem	0.33	0.49	0.67	0.13	Increasing	0.44	0.52	0.83	0.42	Increasing
Pacific-Antai	0.24	0.37	0.67	0.15	Increasing	0.3	0.37	0.81	0.21	Increasing
Allianz Dazhong	0.27	0.87	0.32	0.04	Increasing	0.38	0.54	0.7	0.1	Increasing
AXA-Minmetals	0.15	0.4	0.38	0.02	Increasing	0.32	0.53	0.59	0.05	Increasing
China Life CMG	0.24	0.98	0.25	0.01	Increasing	0.35	1	0.35	0.05	Increasing
CITIC Prudential	0.18	0.37	0.49	0.06	Increasing	0.21	0.28	0.75	0.09	Increasing
John Hancock	0.32	0.91	0.35	0.03	Increasing	0.25	0.64	0.4	0.05	Increasing
Generali China Life	0.06	0.83	0.07	0.01	Increasing	0.22	0.45	0.48	0.04	Increasing
Sunlife Everbright	0.06	0.76	0.08	0.01	Increasing	0.1	0.18	0.53	0.36	Increasing
Hair-New York Life	0	1	0	0	Increasing	0.24	0.63	0.38	0.04	Increasing
ING-Capital Life						1	1	1	1	Constant
Aegon-CNOOC Life						0.05	0.39	0.14	0.01	Increasing
CIGNA & CMC						0.3	1	0.3	0.04	Increasing
Aviva-Cofco Life						0.8	1	0.8	0.16	Increasing
Nissay-SVA Life						0.12	1	0.12	0.02	Increasing
AIA, Shanghai	1	1	1	1	Constant	1	1	1	1	Constant
AIA, Guangzhou	0.92	1	0.92	0.5	Increasing	1	1	1	1	Constant
AIA, Shenzhen	0.28	1	0.28	0.04	Increasing	1	1	1	1	Constant
AIA, Beijing	0.23	0.93	0.25	0.02	Increasing	0.34	0.55	0.62	0.13	Increasing
AIA, Suzhou	0.55	1	0.55	0.02	Increasing	0.38	0.93	0.41	0.06	Increasing
AIA, Dongguan						0.17	1	0.17	0	Increasing
AIA, Jiangmen						0.34	1	0.34	0	Increasing

4.2 Analysis on Different Types of Life Insurers in China

4.2.1 Chinese Life Insurers vs. International Life Insurers

Table 2： Efficiencies of Chinese Life Insurers and International Life Insurers

		Mean of TE	VAR of TE	Mean of PTE	VAR of PTE	Mean of SE	VAR of SE
2000	All life insurers in China	0.64	0.34	0.91	0.20	0.69	0.31
	Chinese life insurers	0.77	0.30	0.85	0.27	0.87	0.17
	International life insurers	0.51	0.35	0.97	0.09	0.52	0.34
2001	All life insurers in China	0.60	0.33	0.85	0.21	0.67	0.31
	Chinese life insurers	0.74	0.32	0.81	0.28	0.87	0.23
	International life insurers	0.49	0.31	0.88	0.15	0.53	0.29
2002	All life insurers in China	0.49	0.38	0.82	0.25	0.58	0.35
	Chinese life insurers	0.80	0.32	0.86	0.25	0.88	0.23
	International life insurers	0.32	0.29	0.79	0.25	0.42	0.30
2003	All life insurers in China	0.51	0.36	0.73	0.31	0.69	0.30
	Chinese life insurers	0.67	0.39	0.69	0.39	0.92	0.12
	International life insurers	0.45	0.33	0.74	0.29	0.60	0.30

According to the background, the life insurers in China can be separated into two groups: 1) the state-owned Chinese insurers; 2) the international insurers and the joint ventures by a Chinese company and an international insurer. Actually, only AIA is allowed to set the independent business in China, and other international insurers are required to enter the Chinese market in the form of joint venture. For convenience, we use “Chinese life insurers” for the first group, and “international life insurers” for the second group.

The mean of all the technical efficiency (TE) scores tends to decrease year by year. Numerically, the sample mean is 0.64, 0.60, 0.49, and 0.51 from 2000 to 2003. This decreasing trend should be caused by those new players, who cannot be efficient at the very beginning. Recently, many international insurers came into China and built their joint ventures. However, one characteristic of the life insurance is that life insurer has to invest a lot at the early stage and cannot get return quickly. Therefore, it’s reasonable to see the new players usually have low efficiency scores. Those low scores finally lead to a low mean of the sample. This trend was reinforced through the years. Also note that the sample variance is close to the sample mean, which shows the life insurers in China get very different scores, and the market is diversified.

In the comparison, it is found that international life insurers are better at pure technical

efficiency, but this advantage is vanishing. However, the scale efficiency of international life insurers is obviously much lower than that of Chinese insurers. This can also be justified through the analysis of scale economies: most international life insurers have strong increasing return to scale. These new players need to build their brand, develop their business, and gain the market share as soon as possible, so that they can improve in the scale efficiency.

Through the identification of the efficiency drives, we have the following conclusions: the inefficiency of Chinese life insurers is caused both by pure technical inefficiency and by scale inefficiency, while the inefficiency of international life insurers is caused almost solely by scale inefficiency. That means those new joint ventures take the advantage of their international partners, and show good skills in corporate management and resource allocation. Therefore they behave well in pure technical efficiency. Take the year of 2002 as example, the average pure technical efficiency of the international life insurers is 0.79, but the average scale efficiency is only 0.42. This provides the evidence that life insurers with different backgrounds meet different problems: those Chinese insurers need to improve the business, as well as improve the efficiency; neither can be ignored or carelessly treated. However, those international insurers need to first solve the problems of scale and market share; they have to survive in order to develop in the future.

The distribution of technical efficiency is diversified, and we cannot claim that insurers with different backgrounds show different efficiency scores. However, we divide the efficiency scores into three ranges: 0-0.5, 0.5-0.99, and 1. It is easy to see that in 2003, there was nearly the same amount of Chinese life insurers in each range. But before that, few Chinese life insurers were in the range of 0-0.5, which means this group got some inefficient players included during the sample years.

For the pure technical efficiency, the mean score of Chinese life insurers is decreasing. There are two possible reasons for this phenomenon. On one hand, the low efficiency scores of new comers affect the average performance. On the other hand, some international life insurers improve their efficiency during the sample years. Their improvement extended the frontier line, making some other insurers who used to stand at the frontier line now leave the frontier. New China Life Insurance is an example who left the frontier line in 2003. International life insurers also show a decreasing trend in the pure technical efficiency. The decreasing trend indicates the market situation that competition is

becoming more serious in this industry.

The distribution of scale efficiency is more meaningful. At the beginning of the sample period, international life insurers could be clearly further divided into two groups. Some foreign insurers (i.e. AIA Shanghai, AIA Guangzhou) who entered Chinese market years ago relied on their brand and management experience, and already gained some market share. These insurers also successfully limited their inputs and therefore behaved well in the scale efficiency. However, most international life insurers were new players in the market. They needed time to adapt themselves and had to invest a lot at the early stage. All these counteract their advantage of marketing and management experience outside China, and result in the inefficiency of scale. However, it is also shown in our empirical result that the scale efficiency of international life insurers was improving during the years. For example, in 2003, there are already 35% of international insurers whose scale efficiency scores lied in the range of 0.50-0.99, and 22% of them in the range of 1. More specifically, the life insurers that improved in the scale efficiency were just those came into the market a little earlier. For Chinese life insurers, the distribution of the scale efficiency score is not stable. In 2003, there were 44% of them who were scale efficient, while 33% lied in the range of 0-0.50, and 22% lied in the range of 0.50-0.99. Those scale inefficient insurers include both new players (i.e. Haier New York Life) and old players (i.e. China Life CMG). It will be an interesting research topic to analyze why the old life insurers would become scale inefficient.

4.2.2 Traditional Life Insurers vs. New-coming Life Insurers

Table 3： Efficiencies of Traditional Insurers and New-coming Insurers

		Mean of TE	VAR of TE	Mean of PTE	VAR of PTE	Mean of SE	VAR of SE
2000	All life insurers in China	0.64	0.34	0.91	0.20	0.69	0.31
	Traditional life insurers	0.78	0.29	0.90	0.23	0.85	0.20
	New-coming life insurers	0.28	0.10	0.94	0.12	0.30	0.09
2001	All life insurers in China	0.60	0.33	0.85	0.21	0.67	0.31
	Traditional life insurers	0.75	0.29	0.85	0.24	0.85	0.21
	New-coming life insurers	0.37	0.26	0.85	0.16	0.41	0.25
2002	All life insurers in China	0.49	0.38	0.82	0.25	0.58	0.35
	Traditional life insurers	0.77	0.33	0.84	0.25	0.86	0.22
	New-coming life insurers	0.28	0.26	0.80	0.25	0.36	0.27
2003	All life insurers in China	0.51	0.36	0.73	0.31	0.69	0.30
	Traditional life insurers	0.69	0.39	0.72	0.38	0.92	0.12
	New-coming life insurers	0.43	0.31	0.73	0.29	0.59	0.30

In the following discussion, we regard the life insurers registered before 1998 as traditional life insurers, and those registered after 1998 as new-coming life insurers. We will address the efficiency characteristics of each group. From the empirical result, it is found that efficiency of traditional life insurers is obviously higher than that of new-coming life insurers. From 2000 to 2003, the average differences between the two groups were 0.50, 0.28, 0.49, and 0.26. We can see the difference was becoming smaller, which means the new comers were catching up, and the advantage of traditional insurers was disappearing. The improvement of the new comers also extended the frontier line, so that some traditional life insurers were forced to leave the frontier. For example, there were 40% of the traditional life insurers whose technical efficiency scores lied in the range of 0-0.50. The proportion of which had doubled from the situation in 2000.

For the pure technical efficiency, our results show that new comers are not at all worse than the traditional insurers. This means although new comers started late, they owned the advantage of corporate management and international experience. All these advantages make them perform well in pure technical efficiency.

For the scale efficiency, new-coming life insurers behave much worse than traditional insurers. From 2000 to 2003, the average scale efficiency of traditional life insurers was 0.55, 0.43, 0.50, and 0.33 higher than that of new-coming life insurers. Take the scale efficiency scores in 2003 as example, 45% of the new-coming life insurers were in the range of 0-0.50, while half the traditional life insurers are in the range of 0.50-0.99, and the other half lie in the range of 1.

Overall, the new-coming life insurers are worse in the efficiency performance than traditional life insurers. This is not only caused by the different time of development, but also caused by the following reasons. First, the monopolized market distorts the economic behaviors of life insurers. Actually, from the aspect of little insurers, we can say that Chinese life insurance market is over “competitive”. Some new-coming insurers have to enhance the agent fees or reduce the benefit payment, in order to survive and gain the market share. These anomalous behaviors increase the cost, and at the same time decrease the efficiency. Second, the regulation on premium constrains the innovation of life insurers. They cannot develop distinct products and gain the new market. Actually, the small insurers have to compete with the traditional insurers within a limited series of products, and cannot realize the advantage of international experience and product design. In addition, most

joint ventures have good knowledge of investment, but under the current regulation, they can only invest in a very limited ways, and cannot realize that advantage either. Therefore, the new-coming life insurers are not able to show the same level of efficiency as the traditional insurers do.

4.3 Analysis of Scale Economies

By DEA, we can also get the information of scale economies. Overall speaking, most life insurers in China are of increasing return to scale. Each year there may have 5-8 insurers that are of constant return to scale. Very few samples are of decreasing return to scale, which means that Chinese life insurance industry is still at an early stage, and there is great potential for the life insurers to improve. Compared with the results of other researches, the percentage of the samples with increasing return to scale is much larger in China than in western countries. This also supports our conclusion that Chinese life insurance industry has not been thoroughly developed.

Also note that in 2003, there were already 2 life insurers with decreasing return to scale. This shows us the signal that the industry is becoming mature. For the reason of competition, the insurers with decreasing return to scale will finally appear in the market. This point of view should concern the regulators and the managers of insurance companies. Although the whole industry is growing rapidly, careless development will finally hurt the efficiency and performance.

Table 4： Scale Economies of Life Insurers in China

		Return to Scale		
		Increasing	Constant	Decreasing
2000	All Life Insurers in China	8	5	1
	Chinese life insurers	3	3	1
	International life insurers	5	2	0
2001	All Life Insurers in China	13	4	0
	Chinese life insurers	4	3	0
	International life insurers	9	1	0
2002	All Life Insurers in China	17	6	0
	Chinese life insurers	3	5	0
	International life insurers	14	1	0
2003	All Life Insurers in China	22	8	2
	Chinese life insurers	4	3	2
	International life insurers	18	5	0
2000	All Life Insurers in China	8	5	1
	Traditional life insurers	4	5	1

	New-coming life insurers	4	0	0
2001	All Life Insurers in China	13	4	0
	Traditional life insurers	6	4	0
	New-coming life insurers	7	0	0
2002	All Life Insurers in China	17	6	0
	Traditional life insurers	5	5	0
	New-coming life insurers	12	1	0
2003	All Life Insurers in China	22	8	2
	Traditional life insurers	3	5	2
	New-coming life insurers	19	2	0

Table 4 shows the distribution of scale economies in different groups. From the table, we argue that international life insurers have better trend of scale economies than Chinese insurers. Firstly, the international insurers were transforming quickly from increasing to constant return to scale, which means that those insurers were becoming scale efficient. From 2000 to 2003, the number of efficient international life insurers increased from 1 to 5, while at the same time the number of efficient Chinese life insurers decreases from 5 to 3. Secondly, all the insurers with decreasing return to scale are of Chinese background. This shows that Chinese insurers need to be very careful in the future development, otherwise the company may become too big and the efficiency will be hurt.

According to Table 4, the new-coming life insurers tend to be of increasing return to scale. In 2002 and 2003, there are only 1 and 2 new-coming life insurers that are not of increasing return to scale respectively. However, different traditional life insurers show different statuses of scale economies. There are 4-5 traditional life insurers that are of constant return to scale in each sample year. In 2000 and 2003, there are also traditional life insurers with decreasing return to scale.

5. Shadow Analysis and Improvement Direction

In DEA, the shadow process is the process to increase certain outputs or decrease certain inputs, so that the DMU will be drawn to the frontier. In other word, with shadow analysis, we can figure out which output or input to improve, and how much to improve in order that the DMU can move to the frontier. This particular method provides important market and enterprise information.

Through the shadow analysis, we get the necessary improvement of each input and output for each DMU from 2000 to 2003.

Table 5: Improvement Direction and Improvement Space

	2000							2001						
	X1	X2	X3	Y1	Y2	Y3	Y4	X1	X22	X3	Y1	Y2	Y3	Y4
China Life	0	0	0	0	0	0		0	0	0	0	0	0	0
China United	194	133	23	0	0	5		511	139	29	18	0	80	0
China Pacific Life	332	547	929	14	0	0		0	0	0	0	0	0	0
Ping An	0	0	0	0	0	0		156	125	225	760	0	869	503
New China	0	0	0	0	0	0		0	0	0	0	0	0	0
Taikang	191	162	42	0	122	0		134	147	86	72	0	0	0
Tianan	555	456	149	0	24	0		826	469	210	6	0	0	0
Manulife-Sinochem	69	214	73	0	0	12		69	290	103	1	2	0	0
Pacific-Antai	148	157	63	1	0	0		243	168	112	6	6	0	0
Allianz Dazhong	83	154	24	0	21	0		67	137	21	5	1	0	0
AXA-Minmetals	96	160	54	1	28	0		120	193	67	3	1	0	0
China Life CMG								18	162	7	3	0	25	0
Citic Prudential								156	197	81	2	1	0	0
John Hancock								19	157	8	6	2	49	0
AIA, Shanghai	0	0	0	0	0	0		0	0	0	0	0	0	0
AIA, Guangzhou	0	0	0	0	0	0		78	65	101	50	0	5	0
AIA, Shenzhen	75	96	18	0	17	0		141	97	48	3	0	0	0
	2002							2003						
China Life	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taiping Life	0	0	0	0	0	0	0	786	889	297	34	51	0	0
Minsheng Life	420	182	52	21	0	222	0	82	11	1	5	15	0	0
China United	0	0	0	0	0	0	0	186	181	397	7	8	0	0
China Pacific Life	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ping An	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New China	149	238	435	112	236	0	0	435	154	250	3	139	0	0
Taikang	330	478	207	6	0	0	0	350	464	145	87	188	0	0
Tianan	144	474	144	1	0	0	5	572	484	537	8	9	0	1
Sino Life	352	454	182	8	4	0	0	0	0	0	0	0	0	0
Manulife-Sinochem	124	175	44	5	1	0	0	142	455	124	0	1	0	0
Pacific-Antai	127	491	60	2	0	0	0	336	474	184	4	0	0	0
Allianz Dazhong	46	199	17	1	0	11	0	137	124	48	2	4	0	0
AXA-Minmetals	215	494	120	3	0	4	11	138	493	70	0	5	63	0
China Life CMG	72	197	28	1	3	25	0	46	131	14	0	1	0	0
CITIC Prudential	110	197	45	1	0	0	0	336	489	172	2	0	0	0
John Hancock	159	199	82	1	1	6	0	76	149	34	1	2	11	0
Generali China Life	40	200	12	0	0	0	0	123	495	56	1	0	25	2
Sunlife Everbright	0	0	0	0	0	0	0	199	464	516	1	4	0	0
Hair-New York Life	0	0	0	0	0	0	0	79	215	44	1	3	0	0
ING-Capital Life								0	0	0	0	0	0	0
Aegon-CNOOC Life								124	189	61	0	1	7	0
CIGNA & CMC								65	139	8	0	1	11	0
Aviva-Cofco Life								24	443	14	3	12	168	0
Nissay-SVA Life								57	263	9	0	0	4	0
AIA, Shanghai	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIA, Guangzhou	38	41	20	33	0	296	61	0	0	0	0	0	0	0
AIA, Shenzhen	155	91	68	5	0	0	4	0	0	0	0	0	0	0
AIA, Beijing	73	198	21	1	1	4	0	113	182	67	2	5	0	0
AIA, Suzhou	50	198	5	1	1	16	0	48	124	17	1	1	8	0
AIA, Dongguan								56	1	17	0	0	0	0
AIA, Jiangmen								43	1	16	0	0	2	1

Generally, most technical inefficient life insurers should make more effort to limit the input. Compared to the input, there is not much space for the output to improve. As is shown in the above table, all technical inefficient insurers have a lot to improve in the dimension of input. However, the potential improvement in the dimension of output is very limited, and many outputs actually cannot be improved, which means modifying the outputs will not be effective to the life insurers in China. Take 2003 as example, the only output of the Manulife-Sinochem that can be improved is Y2 (Benefit of Death, Injury and Medical Treatment) and the improvement space is only 1. However, 142, 455, and 124 can be improved in the three dimensions of inputs, so that the Manulife-Sinochem can be moved to the frontier line.

The above analysis provides some important information. Managers can get the picture where their company stands and how far their position is to the frontier. They can also identify the direction and space of improvement. Overall, the life insurers in China need to control the cost, avoid waste, and pay attention to the extra employment. Especially, there is necessary for them to control the agent cost.

In Table 6, we divide the scale of improvement by the actual input and output, and get the relative improvement space.

Table 6: Improvement Direction and Relative Improvement Space

	2000							2001						
	X1	X2	X3	Y1	Y2	Y3	Y4	X1	X22	X3	Y1	Y2	Y3	Y4
China Life	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
China United	32.52%	86.44%	32.52%	0.00%	0.00%	50.71%		79.61%	90.39%	34.18%	-	0.00%	133.97%	0.00%
China Pacific Life	27.28%	27.28%	27.28%	4.13%	0.00%	0.00%		0.00%	0.00%	0.00%	-	0.00%	0.00%	-
Ping An	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		59.58%	57.23%	39.65%	106.83%	0.00%	-	-
New China	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Taikang	17.82%	20.27%	17.82%	0.00%	23.32%	0.00%		58.55%	18.32%	16.91%	289.55%	0.00%	0.00%	0.00%
Tianan	84.52%	91.01%	84.52%	0.00%	63.42%	0.00%		93.69%	93.50%	88.50%	-	0.00%	0.00%	0.00%
Manulife-Sinochem	54.92%	71.20%	70.49%	0.00%	0.00%	156.08%		49.58%	96.51%	73.22%	13.41%	37.67%	0.00%	0.00%
Pacific-Antai	78.52%	78.52%	78.52%	57.16%	0.00%	0.00%		79.12%	84.20%	79.12%	-	-	0.00%	0.00%
Allianz Dazhong	69.08%	76.96%	69.08%	-	99.66%	0.00%		52.14%	68.73%	48.53%	-	642.45%	0.00%	0.00%
AXA-Minmetals	80.15%	80.15%	80.98%	-	256.81%	0.00%		84.76%	96.30%	84.76%	-	91.33%	0.00%	0.00%
China Life CMG								32.69%	80.98%	32.69%	-	1027.05	1228.33	0.00%
Citic Prudential								87.26%	98.32%	87.36%	-	88.10%	0.00%	0.00%
John Hancock								26.20%	78.68%	26.20%	-	35454.27	3139.77	0.00%
AIA, Shanghai	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
AIA, Guangzhou	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		17.84%	64.63%	43.17%	99779.74	0.00%	1.65%	0.00%
AIA, Shenzhen	59.27%	96.29%	59.27%	0.00%	1340.56	0.00%		86.64%	97.29%	82.55%	-	0.00%	0.00%	0.00%
	2002							2003						
China Life	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Taiping Life	0.00%	0.00%	0.00%	-	0.00%	0.00%	0.00%	47.68%	88.86%	47.68%	1673.18	218.04%	0.00%	0.00%
Minsheng Life	64.77%	90.95%	39.06%	71344.57	0.00%	233.78%	0.00%	27.58%	1.29%	1.29%	-	-	0.00%	0.00%
China United	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	92.03%	90.51%	90.51%	-	358.90%	0.00%	0.00%
China Pacific Life	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ping An	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
New China	29.79%	29.79%	29.79%	125.12%	1433.43	0.00%	0.00%	11.04%	12.87%	11.04%	1.74%	65.36%	0.00%	0.00%
Taikang	98.01%	95.25%	89.13%	-	4.51%	0.00%	0.00%	55.28%	55.28%	59.37%	245.72%	478.43%	0.00%	0.00%
Tianan	67.28%	94.75%	74.87%	30.56%	0.00%	0.00%	33.96%	97.12%	96.43%	92.68%	-	641.34%	0.00%	11.67%
Sino Life	75.64%	90.78%	75.64%	4242.24	64.85%	0.00%	0.00%	0.00%	0.00%	0.00%	-	-	0.00%	0.00%

Manulife-Sinochem	72.59%	87.64%	72.59%	-	122.51%	0.00%	0.00%	56.28%	91.09%	56.28%	0.00%	6.43%	0.00%	0.00%
Pacific-Antai	84.93%	98.28%	84.93%	-	0.00%	0.00%	0.00%	69.90%	94.77%	69.90%	437.46%	2.51%	0.00%	0.00%
Allianz Dazhong	84.36%	99.33%	75.98%	-	69.85%	220.53%	0.00%	70.05%	61.84%	61.84%	1254.44	190.29%	0.00%	0.00%
AXA-Minmetals	82.25%	98.72%	82.25%	-	0.00%	5.31%	107139%	68.45%	98.61%	69.83%	0.00%	460.31%	123.80%	0.00%
China Life CMG	77.82%	98.37%	68.05%	-	1109.83	188.27%	0.00%	71.53%	65.33%	65.33%	-	85.03%	1.08%	0.00%
CITIC Prudential	94.12%	98.28%	94.12%	-	0.00%	0.00%	0.00%	78.81%	97.85%	78.81%	-	0.00%	0.00%	0.00%
John Hancock	95.11%	99.36%	94.10%	-	945.13%	59.01%	0.00%	76.14%	74.54%	74.54%	-	353.78%	41.82%	0.00%
Generali China Life	99.83%	99.99%	99.65%	-	-	-	0.00%	78.31%	98.96%	78.31%	-	0.00%	42.87%	175.34%
Sunlife Everbright	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	90.33%	92.75%	90.33%	2892.27	171.29%	0.00%	0.00%
Hair-New York Life	0.00%	0.00%	0.00%	-	0.00%	0.00%	0.00%	76.04%	97.86%	76.04%	-	1668.93	0.00%	0.00%
ING-Capital Life								0.00%	0.00%	-	-	0.00%	0.00%	-
Aegon-CNOOC Life								94.93%	94.67%	94.67%	-	1384.35	205.50%	0.00%
CIGNA & CMC								84.62%	69.56%	69.56%	-	-	8665.68	0.00%
Aviva-Cofco Life								19.78%	86.69%	19.78%	-	5520.21	2388.48	0.00%
Nissay-SVA Life								90.96%	87.56%	87.56%	-	-	2070.69	0.00%
AIA, Shanghai	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
AIA, Guangzhou	7.72%	40.49%	7.72%	-	0.00%	61.29%	182.62%	0.00%	0.00%	0.00%	-	0.00%	0.00%	0.00%
AIA, Shenzhen	72.26%	91.00%	72.26%	-	0.00%	0.00%	124.43%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
AIA, Beijing	87.76%	99.20%	76.51%	-	3474.21	25.01%	0.00%	65.90%	91.00%	65.90%	-	644.29%	0.00%	0.00%
AIA, Suzhou	83.71%	99.23%	44.80%	-	13656.41	673.16%	0.00%	66.61%	61.82%	61.82%	-	105.57%	31.85%	0.00%
AIA, Dongguan								96.32%	82.55%	96.10%	-	0.00%	0.00%	2296.81
AIA, Jiangmen								89.65%	65.97%	89.81%	-	0.00%	43.53%	-

Table 6 also supports our conclusion: life insurers in China need to control the inputs, but the potential improvement of outputs are limited. However, we also find an important phenomenon: although most inputs can be improved, the relative improvement space is usually less than 100%. By contraries, although most outputs cannot be improved, those with improving potential all have relative large space to improve: most are more than 100%, and some are even more than 1000%. From the perspective of technique, this can be caused by the special status of Chinese life insurance industry. Many insurers are still at an early stage and they do not have much output in some dimensions, for example addition to reserve and yield of investment. For this reason, the frontier in the dimension of output has been not extended thoroughly and is close to most DMUs. The consequence is most DMUs show efficiency in the dimension of outputs. However, some traditional outputs (i.e. benefit payment) have generally reached a certain level, but at the same time some small insurers still do not behave well in these outputs. Consequently, the frontiers in these dimensions are extended thoroughly, but the DMUs of small insurers are relatively far from the frontier line and have a lot to improve in these dimensions. From the perspective of economics, the outputs of life insurers in China concentrate on risk pooling and benefit payments. Other outputs (i.e. yield of investment) are limited due to the strict policy and regulation.

6. Malmquist Index and Technical Progress

Another advantage of DEA is to distinguish technical progress from the change of technical efficiency. When output increases with fixed input, or input decreases with fixed output, we can say the Malmquist index or the productivity is improved. However, this improvement can be driven by two factors: 1) technical progress, which means to break the technical restrictions and extend the frontier; 2) change of technical efficiency, which means the technical restrictions are not broken, but

DMUs move toward the frontier. It is meaningful to separate the two factors, and important information can be got from the process.

Next, we will define the Malmquist index based on DEA:

With a certain period $t=1,2,...,T$, technical production set GR^t is the set of all the possible vector of inputs and outputs. That is $GR^t=\{(x^t,u^t):x^t \text{ can produce } u^t\}$。At a time t, we have $x^t\in R_+^{N_t}$ and $u^t\in R_+^{M_t}$. We define the input set $N=\max_t\{N_t\}$ and output set $M=\max_t\{M_t\}$. Next, we define D_o^t as a distance function at time t. This can be understood as the distance between a DMU and the optimal production point.

$$D_o^t(x^t,u^t\mid C,S)=\inf\{\theta:(x^t,u^t/\theta)\in(GR^t\mid C,S)\}.....(3-1)$$

To define Malmquist index，we give another distance function with items from different times：

$$D_o^t(x^{t+1},u^{t+1}\mid C,S)=\inf\{\theta:(x^{t+1},u^{t+1}/\theta)\in(GR^t\mid C,S)\}.....(3-2)$$

This function describes how much (x^{t+1},u^{t+1}) can produce with the technology at t. This is also defined as the ratio that actual production is divided by optimal production. Similarly, the opposite distance function $D_o^{t+1}(x^t,u^t)$ describes how much (x^t,u^t) can produce with the technology at t+1. To avoid dispute, Malmquist index is defined as the geometric average of the two distance functions. Therefore, the mathematical expression of Malmquist index is:

$$M^{t+1}(u^{t+1},x^{t+1},u^t,x^t)=\left[\frac{D_o^{t+1}(u^{t+1},x^{t+1})}{D_o^{t+1}(u^t,x^t)}\bullet\frac{D_o^t(u^{t+1},x^{t+1})}{D_o^t(u^t,x^t)}\right]^{\frac{1}{2}}.....(3-3)$$

The formula（3-3）can be regarded as the product of two factors:

$$\text{Change of Technical Efficiency}=\frac{D_o^{t+1}(u^{t+1},x^{t+1})}{D_o^t(u^t,x^t)}.....(3-4)$$

And

$$\text{Technical Progress}=\left[\frac{D_o^t\left(u^{t+1},x^{t+1}\right)}{D_o^{t+1}\left(u^{t+1},x^{t+1}\right)}\bullet\frac{D_o^t\left(u^t,x^t\right)}{D_o^{t+1}\left(u^t,x^t\right)}\right]^{\frac{1}{2}}\quad\text{.....(3-5)}$$

Note that when Malmquist index is calculated, we need the same sample size in each year, so that the comparison across years can be realized. Therefore, we modify our data set here: the life insurers that existed in 2000 are the base sample. From 2000 to 2003, we collect the input and output data of those insurers, and get the result in Table 7.

Overall, the number of life insurers with increasing Malmquist index goes up during the sample years. This shows that as the market is changed and the competition is introduced, the operation and management of life insurers have been improved. The players are greatly motivated in the current situation. They are all experiencing reformation or modification in order to survive and develop in the future.

We can also figure out the drives of Malmquist index, which is shown in Table 7 and 8.

Table 7: Malmquist Index and the Drives

	2000-2001			2001-2002			2002-2003		
	Change of Technical Efficiency	Technical Progress	Malmquist Index	Change of Technical Efficiency	Technical Progress	Malmquist Index	Change of Technical Efficiency	Technical Progress	Malmquist Index
China Life	1	3.18	3.18	1	0.99	0.99	1	1.1	1.1
China United	0.66	1.84	1.21	0.88	0.88	0.78	0.24	1.77	0.43
China Pacific Life	1.38	2.98	4.09	1	0.59	0.59	1	1.49	1.49
Ping An	0.44	1.21	0.53	2.27	0.74	1.67	1	2.59	2.59
New China	1	0.84	0.84	1	0.97	0.97	0.89	1.39	1.23
Taikang	1.01	0.88	0.89	0.85	0.84	0.71	0.64	2.39	1.52
Tianan	0.7	0.99	0.7	1	0.91	0.91	0.67	2.1	1.41
Manulife-Sinochem	1.12	1.63	1.82	0.82	0.82	0.67	1.04	1.48	1.55
Pacific-Antai	0.97	1.16	1.12	1.35	0.91	1.23	1.06	1.49	1.59
Allianz Dazhong	1.66	0.59	0.99	0.61	0.74	0.46	1.21	1.58	1.92
AXA-Minmetals	0.77	0.78	0.6	1.1	0.94	1.04	1.52	1.34	2.03
AIA, Shanghai	1	1.66	1.66	1	0.95	0.95	1	0.99	0.99
AIA, Guangzhou	0.44	2.14	0.94	1.35	0.89	1.2	1.36	0.89	1.21
AIA, Shenzhen	0.34	1.67	0.56	1.8	0.85	1.53	4.04	2.07	8.37

Table 8: Life Insurers with Different Drives of Malmquist Index

		Life insurers driven by different factors
2000 - 2001	Driven by Technical Efficiency	Tianan
	Driven by Technical Progress	China Life, New China, Taikang, Manulife-Sinochem, Pacific-Antai, AIA Shanghai
	Driven by both	China United, China Pacific Life, Ping An, Allianz Dazhong, AXA-Minmetals, AIA Guangzhou, AIA Shengzhen
2001 - 2002	Driven by Technical Efficiency	Pacific-Antai , AXA-Minmetals
	Driven by Technical Progress	China Life, China Pacific Life, New China, Tianan, AIA Shanghai
	Driven by both	China United, Ping An, Taikang, Manulife-Sinochem, Allianz Dazhong, AIA Guangzhou, AIA Shenzheng
2002 - 2003	Driven by Technical Efficiency	
	Driven by Technical Progress	China Life, China Pacific Life, Ping An, Manulife-Sinochem, Pacific-Antai, AIA Shanghai
	Driven by both	China United, New China, Taikang, Tianan, Allianz Dazhong, AXA-Minmetals, AIA Guangzhou, AIA Shengzhen

The above result shows that some insurers are driven solely by technical progress, while some others are driven both by technical progress and by technical efficiency. However, there are few samples that are driven solely by technical efficiency. Meanwhile, what drives each insurer does not change much across the years, and most insurers are affected by the same factors. This result tells us that technical progress has already become the major factor that drives the Malmquist index in Chinese life insurance industry. This, at the same time, reflects the characteristic that Chinese life insurance industry is growing rapidly and turning into a mature market, because only in the growing market, the insurers can frequently break the restrictions and the frontier can be continuously extended, in which case technical progress is realized.

Also note that the change of technical efficiency is an effective only in half of the life insurers. Even to these insurers, technical efficiency usually co-works with technical progress. Those life insurers, in which technical efficiency is not a major driving factor, are nearly all the old brand insurers (i.e. China Life and AIA Shanghai). They have developed for many years and gained some market. At the same time, they are already close to the frontier line and therefore their technical efficiency cannot be further enhanced. As a consequence, these life insurers have to rely on technical progress for the further development.

7. Conclusion

Data envelopment analysis can provide much important information of life insurers and insurance market. This information will benefit regulators and managers, for they can get useful evidence and insights from the DEA analysis.

Generally, technical efficiency scores of life insurers in China are dispersed. Some traditional life insurers are technical efficient during the three sample years. This reflects the market situation that traditional life insurers still have the monopolizing power, and smaller life insurers are not competitive enough. The empirical result also shows that the average technical efficiency of the life insurance industry is decreasing year by year. On one hand, the efficiency of new-coming insurer is forced to be low by the large investment and slow return. On the other hand, together with the result of Malmquist index, it shows that life insurers are facing more furious competition and greater challenge nowadays in China.

The international life insurers have advantage in pure technical efficiency, but this advantage is

vanishing year by year. However, those foreign insurers and joint venture insurers are relatively weak in scale efficiency. Our empirical result shows that the inefficiency of Chinese life insurers is caused both by pure technical inefficiency and by scale inefficiency, but neither is serious. However, the main problem with international insurers is their scale inefficiency. Although those foreign insurers and joint venture insurers can efficiently allocate the resource, their scale does affect the performance. The new-coming insurers have the very similar problems.

Most of the life insurers in China, especially the smaller joint venture insurers, are of increasing return to scale. Further improvement will be beneficial to the players. However, regulator and managers should note that those small insurers with increasing return to scale are good targets for M&A. The big insurers may think M&A and taking over small insurers are convenient ways for them to further increase.

The shadow analysis shows that life insurers in China need to limit the cost, but the relative improvement space is usually less than 100%. However, there are also some outputs that can be improved, but the relative improvement space is usually very large. This reflects that the life insurers in China do not perform well in controlling cost and extra employment. From the aspect of output, most insurers concentrate on a few products. The development of the industry needs to be diversified and balanced.

The result of Malmquist index tells that more and more life insurers in China have improved the productivity. This improvement is mainly driven by technical progress, although some is driven by both technical efficiency and technical progress. This reflects the situation that it may be hard for the Chinese life insurance industry to improve through optimizing the resource allocation. To gain the further development, the industry has to break the restrictions, such as concept, and regulation, in order to gain the technical progress. Only in that way the productivity can be finally enhanced.

According to the above conclusions, we have some suggestions:

1. Chinese life insurance industry is growing fast and still not mature. The Chinese life insurers need to optimize the current resource allocation and enhance the productivity. At the same time they have to be careful about the careless expanding, which may finally hurt the efficiency. International insurers and small insurers need to improve as fast as they can, so that their scale efficiency can be improved and they can survive in the market.
2. To move toward technical efficiency, the life insurers in China need to control the cost and avoid the extra investment in capital, employment and instruments. For output, the insurers need to identify their specific weakness and cannot concentrate on the current business. They need to gain more innovation and develop creative products. Only in this way, the industry will not be over competitive and the customers can be better served.
3. To enhance the productivity of life insurers in China, regulation needs to be more moderate. Many restrictions can be released, so that the insurers can gain the technical progress and finally enhance the productivity. We believe that life insurers in China can adapt themselves to the market environment.

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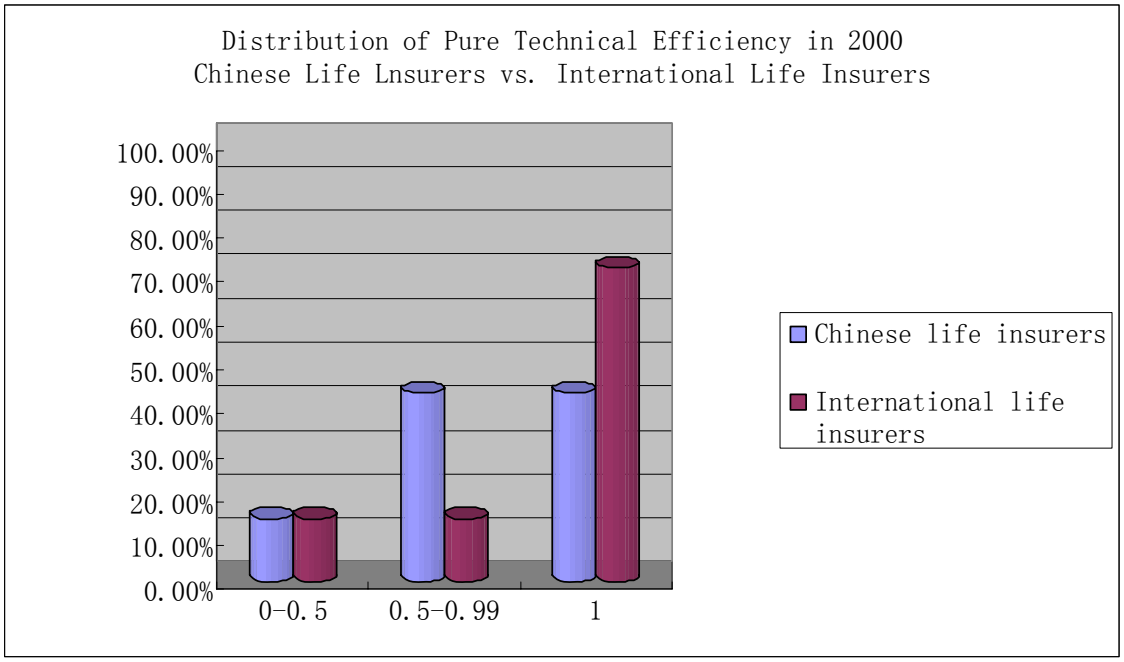
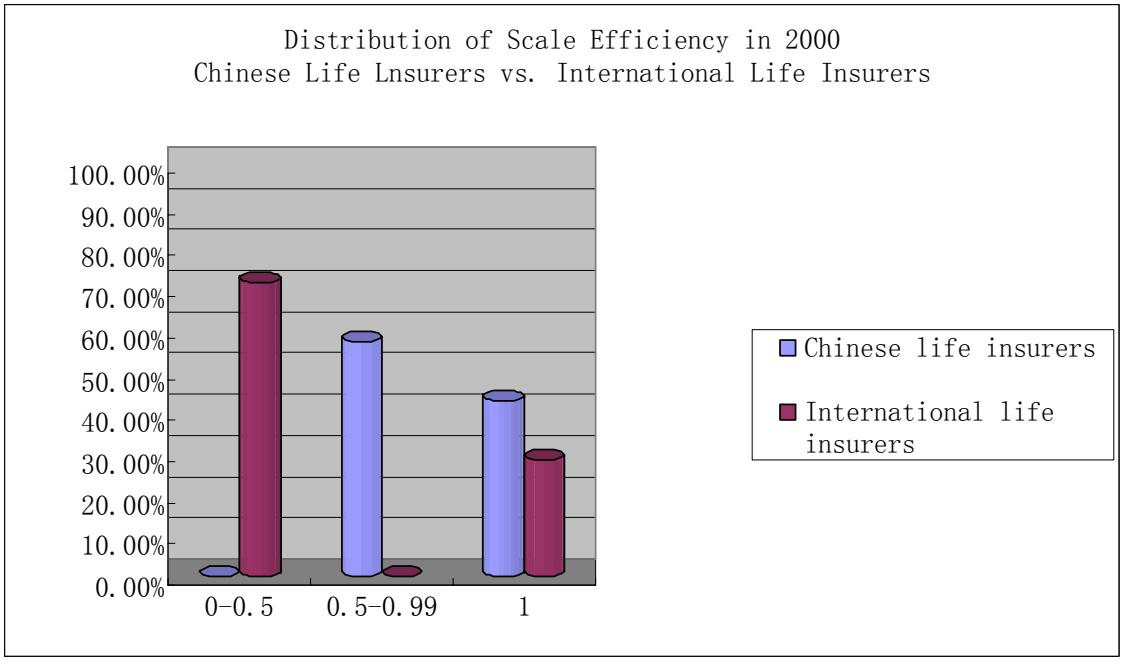
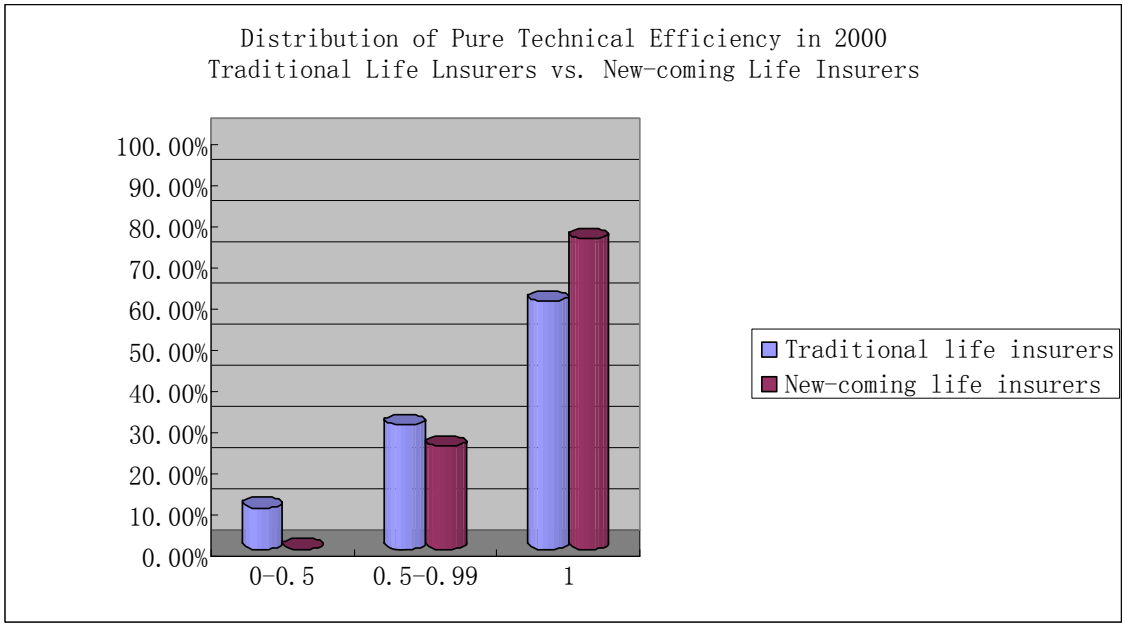
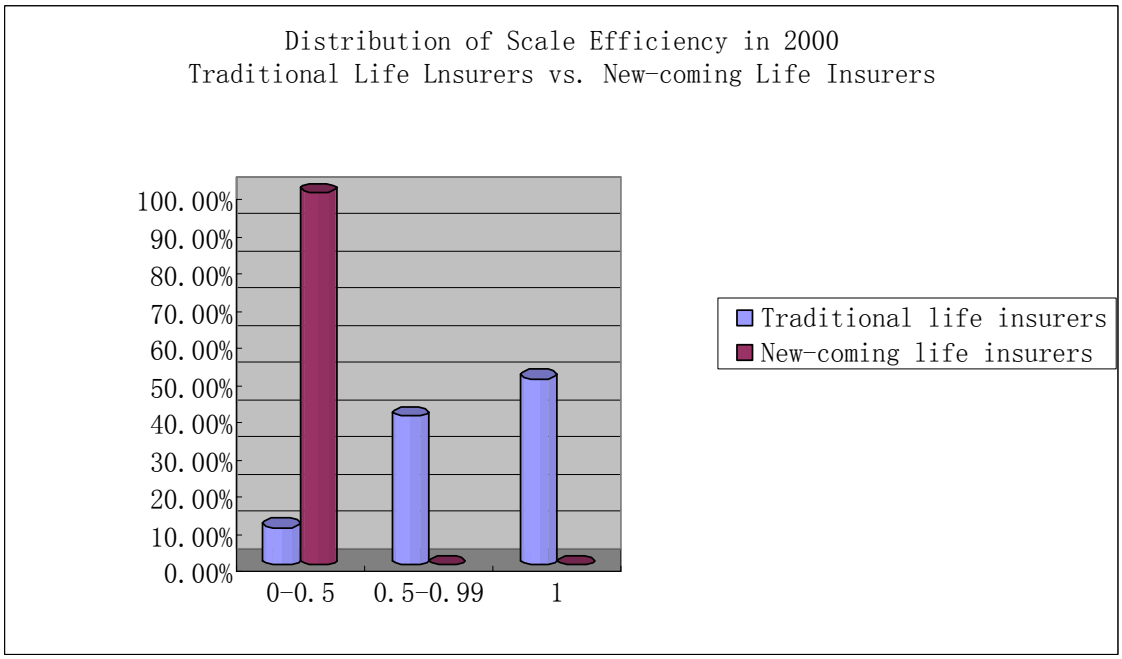
Appendix: Some Typical Distributions of Efficiency Scores






Distribution of Pure Technical Efficiency in 2000
Traditional Life Lnsurers vs. New-coming Life Insurers
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0-0.5
0.5-0.99
1
Traditional life insurers
New-coming life insurers


Distribution of Scale Efficiency in 2000
Traditional Life Lnsurers vs. New-coming Life Insurers
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0-0.5
0.5-0.99
1
Traditional life insurers
New-coming life insurers