Decomposition and Super-efficiency in the Korean Life Insurance Industry Employing DEA

Hyung-Suk Lee
Division of Business Administration
Pusan National University, Busan, 609-735, Korea

Ki-Seog Kim
Division of Business Administration
Pusan National University, Busan, 609-735, Korea

ABSTRACT

The Korean life insurance industry has undergone profound changes, such as the beginning of the variable insurance in July 2001 and the bancassurance enforcement in August 2003. However, little empirical research has analyzed data that includes the bancassurance of life insurance companies operating in Korea. In response to this lack of research, this paper applies DEA (data envelopment analysis) models to measure and decompose their efficiency. We discovered that life insurance companies operating in Korea are a little different in their composition ratio of inputs and outputs, due to the increased variety of distribution channels and new products. We provided efficiency scores, return to scale, and reference frequencies. We also decomposed CCR, BCC, and SBM efficiency into scale efficiency and MIX efficiency. So, we try to investigate whether the sources of inefficiency were caused by the inefficient operation of DMU, disadvantageous conditions, the difference of the composition ratio in inputs and outputs with reference sets, or any combination of the above. Most companies in the sample display had either constant or decreasing returns to scale. The efficiency rankings were less consistent among models and efficient DMUs. In response to this problem, we used the super-efficiency model to rank them and then compared the rankings of the DMUs among the various models. It was also concluded that the availability of panel data, rather than cross-sectional data, would greatly improve the validity of the efficiency estimates.

Keywords: *Korean Life Insurance Industry, Decomposition of Efficiency, Super-efficiency, DEA (Data Envelopment Analysis).*

1. INTRODUCTION

For over a decade, the Korean life insurance industry has undergone profound changes, which include the IMF crisis, the beginning of the variable insurance in July 2001, and the bancassurance enforcement in August 2003. The industry has also found various new distribution channels, such as the increase of telemarketing, home shopping, and internet shopping. In addition, the pattern of profit and loss has varied among life insurance companies. In particular, banks such as KB Life Insurance Companies, have emerged as strong new competitors in the area of distribution channels. Insurers have also encountered competitors from foreign companies, so the Korean insurance industry has been facing a more competitive market structure. In this situation, it would be advantageous to conduct an exact and multidimensional efficiency analysis. It is important to note that such an analysis must identify the sources of inefficiency in order to produce more efficient companies.

Though research into the efficiency of the insurance industry has been conducted, there has been little empirical research that has analyzed data, which includes the bancassurance of life insurance companies operating in Korea. Jung and Lee (2003) and Lee et al. (2004) analyzed efficiency before and after the introduction of bancassurance, but this research was limited in so far as it used imitation data. In turn, while a variety of additional research has been conducted, such research has relied upon the previous research of Fecher et al. (1993), Cummins et al. (1996), Diacon et al. (2002), and Cummins and Rubio-Misas (2006). This research addressed the European countries, which introduced the bancassurance a little earlier than other countries.

The purpose of this paper is to measure, analyze and decompose the relative efficiency of life insurance companies operating in Korea in order to identify the causes of inefficiency. We estimated their efficiency in 2005 and investigated the sources of inefficiency that a DMU might have. We used the super-efficiency model to rank and compare the DMUs among the models.

The rest of paper proceeds as follows. In Section 2, we

* *Corresponding author. E-mail : sjjeong@bu.ac.kr*
Manuscript received Sep. 30, 2008 ; accepted Oct. 21, 2008

briefly review the DEA models used in this paper. Section 3 contains the analysis procedure and our results, which analyze life insurance companies operating in Korea. Section 4 concludes the paper.

2. DEA MODEL

Over the last few decades, many DEA models were developed which expanded the DEA in terms of theory, methodology, and application. We employed CCR, BCC, SBM, and Super-efficiency models. The DEA models can be distinguished according to whether they are input-oriented or output-oriented. The input-oriented model aims to minimize inputs while satisfying at least the given output levels. The output-oriented model attempts to maximize outputs without requiring any more of the observed input values (Cooper et al, 2006). We decided that the input-oriented models should be chosen as the basis for the analysis undertaken herein. This decision was made due to the fact that it is more desirable to improve inputs, rather than outputs, such as premium incomes and invested assets. Accordingly, we choose the input-oriented model.

2.1 DEA Model

2.1.1 CCR Model

The CCR model was initially developed by Charnes, Cooper and Rhodes in 1978. It assumes a constant return to scale (RTS). The input-oriented CCR model is treated in the following LP problem where the value of θ^* is less than 1, and it refers to the CCR efficiency.

$$
\begin{aligned}
\min \quad & \theta \\
\text{s.t.} \quad & \theta x_o - X\lambda \geq 0 \\
& y_o - Y\lambda \leq 0 \\
& \lambda \geq 0
\end{aligned}
$$

Where θ : CCR efficiency in DMUo

x_o, y_o : vector of inputs and outputs in DMUo

X, Y : matrics of inputs and outputs in entire DMU

λ : weight vector

The lower the value of θ^*, the less efficient a DMU is. A DMU is efficient if and only if the optimal value θ^* is equal to 1. If not, the DMUo is inefficient. In a case where there is the inefficiency in any DMU, more efficient DMUs exist. These DMUs refer to the reference set for the inefficient units. As the inefficient units are projected onto the envelopment surface, the targets defined by the efficient projections give an indication of how this DMU can be improved in order to be efficient. The reference set consists of the linear combination of $\lambda_j^* \succ 0$.

The text must be in English. The submitted typeset scripts of each contribution must be in their final form and of good appearance because they will be printed directly without any editing. It is essential that the "camera-ready copies" be absolutely clean and unfolded. The copy should be evenly printed on a high quality (300 dots/inch or higher) laser printer. There should not be corrections made on the printed pages. Your paper must be printed actual size (exactly how it is to appear in the Journals) in two columns. The document you are reading is printed in the format that should be used in your paper.

2.1.2 BCC Model

Since the very beginning of DEA studies, various extensions of the CCR model have been proposed. The BCC model developed by Bank et al. (1984) is representative of such an extension. The BCC model assumes a variable return-to-scale because it has its production frontiers spanned by the convex hull of the existing DMUs. The input-oriented BCC model is treated in the following LP problem, where e is a row vector, and where all elements equal 1.

$$
\begin{aligned}
\min \quad & \eta \\
\text{s.t.} \quad & \eta x_o - X\lambda \geq 0 \\
& y_o - Y\lambda \leq 0 \\
& e\lambda = 1 \\
& \lambda \geq 0
\end{aligned}
$$

The value of η^* is less than 1, and it refers to the BCC efficiency. The difference with the CCR model is occurred by the convexity condition about each DMU that the size of reference set is limited as 1. In other words, it includes the increasing return to scale (IRS), the constant return to scale (CRS), and the decreasing return to scale (DRS) for adding constraint '$e\lambda = 1$'.

2.1.3 Slacks-based Measure (SBM) Model

The SBM Model was developed by Tone (2001). Because the CCR and the BCC models were evaluated by a radial form, it doesn't reflect slacks in the efficiency score, and the nonzero slacks may be higher than the value of 1-θ^*. In order to eliminate this deficiency, we employed the SBM model. The SBM model evaluates efficiency more exactly due to the inclusion of slacks in the efficiency score. The SBM model is treated in the following LP problem, where m is the number of inputs.

$$
\begin{aligned}
\min \quad & \rho = 1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io} \\
\text{s.t.} \quad & x_o = X\lambda + s^- \\
& y_o = Y\lambda - s^+
\end{aligned}
$$

$\lambda \geq 0, s^- \geq 0, s^+ \geq 0$

The value of ρ^* is less than 1, it refers to the SBM efficiency.

2.2 Efficiency Decomposition and Super-efficiency

2.2.1 Efficiency Decomposition

In this section, we decompose the efficiency using θ^*, η^*, ρ^* to investigate the sources of the inefficiency (Cooper et al, 2006). The scale efficiency (SE) of a DMU is measured using $SE = \frac{\theta^*}{\eta^*}$. It is less than 1, because the CCR efficiency is less than the BCC efficiency. While the CCR efficiency is called the technical efficiency (TE), since it takes no account of the scale-effect, the BCC efficiency measures the pure technical efficiency (PTE), due to the assumption that the return to scale will variable. If a DMU is fully efficient in the CCR and BCC scores, it is operating according to the most productive scale-size. Using these concepts, the decomposition of efficiency is demonstrated in the following, and we can demonstrate that the sources of inefficiency are caused by the inefficient operation (PTE) of a DMU, the disadvantageous condition (TE), or both.

Technical Efficiency (TE) = Pure Technical Efficiency (PTE) × Scale Efficiency (SE)

On the other hand, the MIX efficiency of a DMU is measured using $MIX = \frac{\rho^*}{\theta^*}$. Because ρ^* includes slacks to the CCR efficiency, it has a $\rho^* \leq \theta^*$ relationship. Thus, it can be determined that a DMU has no slacks if and only if the optimal value, θ^*, is equal to ρ^*, and $\rho^* \leq \theta^*$ means slacks exist. Using these concepts, we can decompose and combine the scale efficiency. The decomposition shows the sources of the inefficiency, whether they are caused by the inefficient operation of the DMU, disadvantageous conditions, or the difference of the composition ratio in inputs and outputs with reference sets.

SBM efficiency (SBM) = Technical efficiency (TE) × MIX efficiency (MIX) = Pure Technical efficiency (PTE) × Scale efficiency (SE) × MIX efficiency (MIX)

2.2.2 Super-efficiency Model

The super-efficiency model was developed by Anderson and Petersen (1993) to rank DMUs. When a DMUo evaluates efficiency using the super-efficiency model, the level of efficiency is obtained by eliminating the data on the DMUo to be evaluated from the solution set. Thus, the efficiency score of a DMUo can be over 1, and we can compare their levels of efficiency to efficient DMUs. For example, let us begin with four DMUs (A, B, C, D) using two inputs (x1, x2) and one output (y), as seen in Figure 1. The efficient frontier of the CCR Model consists of A, B, C, and D. Because the super-efficiency of B is evaluated by OP/OB, the efficiency score can be over 1.

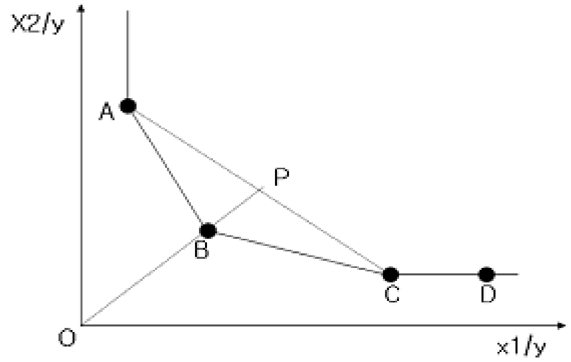


Fig. 1. Super-efficiency example.

On the other hand, infeasibility may occur regarding a DMUo in the super-efficiency model. For example, let us begin three DMUs (A, B, C) using one input and one output, as shown in Figure 2. In this situation, if we evaluate DMU A using the input-oriented super-efficiency, it is evaluated in terms of QA'/QA. If we evaluate it using the output-oriented super-efficiency, infeasibility occurs due to don't have any reference DMU. On the other hand, if we evaluate DMU C using the input-oriented efficiency, infeasibility occurs due to don't have any reference DMU.

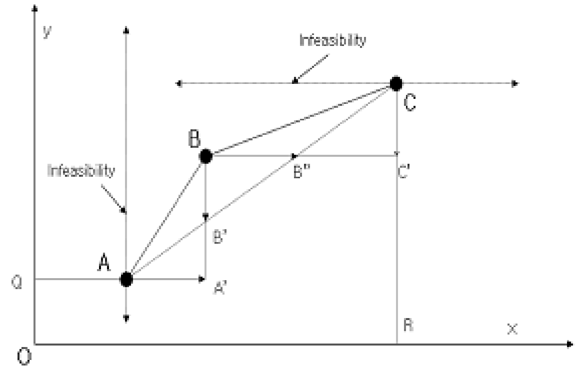


Fig. 2. Infeasibility example.

source: Zhu (2003)

Because there are CCR, BCC, and SBM efficient DMUs in this paper, we employed these models. The CCR and BCC super-efficiency models are treated in the following LP problem.

(CCR Super-efficiency) min θ_S

s.t. $\theta_S x_o - \sum_{j=1,\neq 0}^{n} \lambda_j x_j \geq 0$

$$y_o - \sum_{j=1,\neq 0}^{n} \lambda_j y_j \leq 0$$
$$\lambda \geq 0$$

(BCC Super-efficiency) min η_S

s.t.
$$\eta_S x_o - \sum_{j=1,\neq o}^{n} \lambda_j x_j \geq 0$$
$$y_o - \sum_{j=1,\neq o}^{n} \lambda_j y_j \leq 0$$
$$\sum_{j \neq o} \lambda_j = 0$$
$$\lambda \geq 0$$

The SBM super-efficiency is treated in the following LP problem, where $\phi_i = \frac{\bar{x}_i - x_{io}}{x_{io}} (i = 1, \cdots, m)$, and $\bar{x}_i$ is the input value of the reference set, with the exception of the DMUo.

(SBM Super-efficiency) min $\rho_S = 1 + \frac{1}{m} \sum_{i=1}^{m} \phi_i$

s.t.
$$\sum_{j=1,\neq o}^{n} x_{ij} \lambda_j - x_{io} \phi_i \leq x_{io} (i = 1, \cdots, m)$$
$$\sum_{j=1,\neq o}^{n} y_{rj} \lambda_j \geq y_{ro} (r = 1, \cdots, s)$$
$$\phi_i \geq 0 (\forall_i), \lambda_j \geq 0 (\forall_j)$$

In here, θ_S, η_S, ρ_S means the CCR, BCC, and SBM super-efficiency models, respectively, and it has a nonegative value. It is the super-efficiency of a DMUo.

3. DECOMPOSITION OF EFFICIENCY AND SUPER-EFFICIENCY

3.1 Selection of Inputs, Outputs and Data Collection

This section briefly describes our data and discusses the measurement of the inputs and outputs used in our analysis. In order to analyze the efficiency of life insurance companies, it is important to select inputs and outputs. In this paper, the selection of variables is based on the previous research applied the European countries, which introduced bancassurance earlier than other countries. Accordingly, the inputs that we selected operating expenses, shareholder's equity, and liabilities while the outputs were premium incomes, claims paid, policy reserves, and invested assets.

3.1.1 Inputs

In order to select the inputs, we referred to previous research. Table 1 provides factors reflecting the selection of the previous researcher's variables, which were applied to the European countries. We selected three inputs: operating expenses, shareholder's equity, and liabilities. The operating expenses consisted of acquisition expenses, administration expenses, and collection expenses, all of which have been used by many researchers. It identified principal services that insurers provide, and it contributed heavily to the performance of insurance companies. The shareholders' capital and liabilities have played an important role in financial research, and has been considered by many researchers. The shareholders' capital is a primary input into the risk-pooling and risk-bearing function, because insurers must maintain it to pay losses. The liabilities mainly consisted of money lending and the promise to pay the claims.

Table 1. Factors in inputs of previous research.

Researcher	Inputs			
	Office workers	Operating expenses	Capital	Liabilities
Fecher et al.(1993)	∨		∨	
Cummins et al.(1996)		∨	∨	
Cummins et al.(2002)	∨	∨	∨	∨
Diacon et al.(2002)		∨	∨	∨
Cummins and Rubio-Misas(2006)	∨	∨	∨	∨

Note: ∨ is factors used to analyze efficiency of life insurance companies used by previous researchers.
In order to classify simply, the operating expenses include the reinsurance cost, the miscellaneous cost and so on.

3.1.2 Outputs

Many previous researchers have noted that insurance companies function primarily as providers of services, many of which are intangible and heterogeneous. This makes it is difficult to determine outputs. In order to select the outputs, we referred to the previous research. Table 2 shows factors reflecting the selection of the previous researcher's variables, which were applied to the European countries. Four outputs have been used to measure the efficiency in this paper: premium incomes, claims paid, policy reserves, and invested assets.

Cummins et al. (1996), Cummins et al. (1999), Cummins and Rubio-Misas (2001), and Cummins et al. (2002) were among previous researchers who suggested that life insurance companies provide three services. The first service consists of financial intermediation. Insurers contract insurance policies and invest assets into investment regions, such as bonds, securities, and real estate. The second service is risk-pooling and risk-bearing. The insurers provide policyholders with risk-reduction services by paying claims for losses. Third, insurers provide real financial services. Insurers use their expertise to provide a variety of real services for policyholders, such as financial planning. In spite of these definitions, most researchers contend that it is difficult to select output variables.

The premium income has been used as a proxy for the risk-bearing and real insurance services output in insurance efficiency studies. It can be called "the sales of insurance companies". In fact, it is really a form of revenue (price×quantity), not the quantity of output (Yuengert, 1993). As such, the systematic differences in price across insurers may lead to misleading inferences. Furthermore, Doherty (1981) critiqued the use of premiums because it results in a simultaneous equation bias. However, we selected this because the premium rate is similar in Korea. The claims paid play an important role as a proxy for risk-pooling. The life insurance companies collect the premium income from their clients and redistribute most of the funds to those policyholders who sustain losses to share risk. Thus, the claims paid would serve as an adequate variable. The claims paid is also a satisfactory proxy for the amount of real services provided (cummins et al., 1996). The policy reserves play an important role as proxies for the intermediation service that complete insurance policy to customers. They represent the insurer's major liability to its policyholders and correspond to the future obligations contained in the life insurance contract. We also accounted for invested assets as providing the intermediary function. Because insurers pay money to insureds, the insurers invest assets into investment regions such as securities, and real estate. They also produce outputs through insurance and financial work, Thus, the size of the invested assets is important in the financial function, in so far as it is directly relevant to the profit of insurance companies.

Table 2. Factors in outputs of previous research.

Researcher	Outputs				
	Premium income	Policy reserves	Invested asset	Claims paid	Country
Fecher et al.(1993)	∨				France
Cummins et al.(1996)		∨	∨	∨	Italy
Cummins et al.(2002)	∨	∨	∨	∨	Spain
Diacon et al.(2002)	∨		∨		Europe
Cummins and Rubio-Misas(2006)		∨	∨	∨	Spain

3.1.3 Data Collection

The data used in this study is described from the website of the Korea Life Insurance Association (http://www.klia.or.kr). There were 22 registered companies in 2005. In this paper, we used these for the efficiency analysis. The descriptive statistics of samples is shown in Table 3. On the other hand, we must interpret the DEA results carefully, due to the fact that a DMU is BCC-efficient if it has a minimum input value for any input item, or a maximum output value for any output item (Cooper et al, 2006).

Table 3. Descriptive statistics.

Unit: a billion won

		Max	Min	Mean	Std. Dev.
Inputs	*Operating Expenses*	1,188	11	183	274
	Shareholders' Equity	8,250	21	776	1,761
	Liabilities	91,379	236	10,105	20,403
Outputs	*Premium Income*	20,561	114	2,794	4,697
	Claims Paid	13,972	20	1,617	3,287
	Policy Reserves	73,617	51	8,224	16,526
	Invested Assets	80,683	57	8,459	17,830

3.2 Efficiency Decomposition and Super-efficiency

3.2.1 CCR, BCC, SBM Efficiency

We analyzed the efficiency using the input-oriented CCR, BCC, and SBM models. As seen in the previous section, Table 4 provides the results of the efficiency analysis, the return to scale, and the reference frequency using the data of the 22 life insurance companies. We used the DEA-SOLVER that Cooper et al. (2006) provides.

Table 4. Results of efficiency analysis.

DMU	Efficiency			RTS	Reference frequency		
DMU	BCC	CCR	SBM	RTS	BCC	CCR	SBM
Korea	1.00	1.00	1.00	CRS	0	1	1
Allianz	1.00	1.00	1.00	CRS	1	1	0
Samsung	1.00	1.00	1.00	CRS	0	1	2
Hungkuk	1.00	1.00	1.00	CRS	2	3	1
Kyobo	1.00	1.00	1.00	CRS	2	4	6
Lucky	1.00	1.00	1.00	CRS	2	4	2
MiraeAsset	0.93	0.91	0.77	DRS	0	0	0
Kumho	0.95	0.95	0.85	IRS	0	0	0
Dongbu	0.94	0.87	0.84	DRS	0	0	0
Tongyang	1.00	1.00	1.00	CRS	0	0	3
MetLife	1.00	0.69	0.65	DRS	0	0	0
Prudential	1.00	0.98	0.71	DRS	0	0	0
Shinhan	1.00	0.98	0.93	DRS	0	0	0
PCA	0.91	0.86	0.55	DRS	0	0	0
NewYork	1.00	0.94	0.64	IRS	0	0	0
ING	1.00	1.00	1.00	CRS	1	1	1
Hana	1.00	0.99	0.92	IRS	0	0	0
KB	1.00	1.00	1.00	CRS	4	10	10
SH&C	1.00	1.00	1.00	CRS	2	1	2
Green Cross	1.00	1.00	1.00	CRS	1	3	0
LINA	1.00	1.00	1.00	CRS	2	6	0
AIG	1.00	0.96	0.76	DRS	2	0	0
Mean	0.99	0.96	0.89				

The efficiency scores are summarized in Table 4. The average BCC, CCR, and SBM efficiency scores in the samples were 0.988, 0.961, and 0.892, respectively. Most life insurance companies showed a high efficiency score. Among 22 companies, BCC, CCR, and SBM efficient companies were 18, 12 and 12, respectively, which indicate that they operate efficiently. In fact, Samsung, Korea, Kyobo, and ING gained marginal profit (354, 341, 241, 173 billion, respectively) in operating expenses for the FY 2005. Tongyang achieved the highest ordinary income since its foundation. Foreign companies (e.g., ING, Alianz, Metlife, PCA, NewYork, Purdential, LINA) had grown from 16.5% in the FY 2004 to 18.3% in the FY 2005 in the market share. On the other hand, PCA showed the lowest BCC efficiency score. We found that the CCR efficiency score was lower than the BCC efficiency score because it didn't consider the scale. The CCR efficiency score for Metlife was the lowest. On the other hand, the SBM efficiency score was lower than the CCR efficiency score, because the SBM efficiency score considered slacks in the efficiency score. All CCR-efficient companies were SBM-efficient. Conversely, the SBM efficiency scores of Metlife, Purdential, PCA, and NewYork were 0.652, 0.714, 0.549, and 0.64, respectively. The CCR efficiency score of PCA was 0.863, and the SBM efficiency score was 0.64, which indicates that it is a little different from other companies in the composition of inputs and outputs. In actually, PCA operated at a loss for the FY 2005 in Korea. From Figure 3, one may note that the efficiency scores of most companies distributes highly. Conversely, Metlife and PCA ranked the lowest in the CCR and SBM efficiency scores.

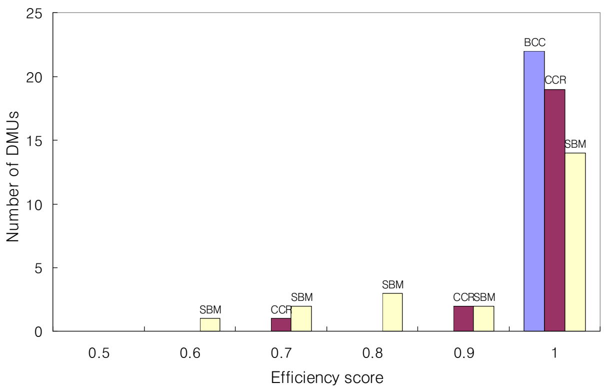


Fig. 3. Distribution of DEA efficiency.

We next determined whether an increasing or decreasing return to scale (IRS or DRS) was the primary cause of inefficiency. We discovered that there were three IRS companies (Kumho, NewYork, Hana) and seven DRS companies (MiraeAsset, Dongbu, MetLife, etc). It can be interpreted that IRS and DRS companies are expected to show improvement in efficiency through the scale increase or scale decrease, respectively. On the other hand, we discovered that there were more DRS companies than IRS companies.

If any DMU is inefficient, then there are more efficient virtual DMUs, and they consist of efficient DMUs referred to in the reference set. Because a DMU belonging to the reference set is similar to the composition of inputs and outputs with the inefficient DMU, it is used as a target for benchmarking. Table 4 provides the reference frequency of efficient DMUs. We discovered that the KB Life Insurance Company is the most frequent reference set. As a subsidiary company of Kookmin Bank, it was established in April 2004 and grew to 292 billion in premium incomes in the FY 2005.

3.2.2 Decomposition of Efficiency

We decomposed the efficiency using the CCR, BCC, and SBM efficiency scores. Table 5 provides the results of the scale efficiency and the MIX efficiency.

Table 5. Decomposition of Efficiency.

DMU	*SBM*	*CCR*	*BCC*	*MIX*	*SE*
	ρ	*TE*	*PTE*		
Korea	1.00	1.00	1.00	1.00	1.00
Allianz	1.00	1.00	1.00	1.00	1.00
Samsung	1.00	1.00	1.00	1.00	1.00
Hungkuk	1.00	1.00	1.00	1.00	1.00
Kyobo	1.00	1.00	1.00	1.00	1.00
Lucky	1.00	1.00	1.00	1.00	1.00
MiraeAsset	0.77	0.91	0.93	0.85	0.98
Kumho	0.85	0.95	0.95	0.89	1.00
Dongbu	0.84	0.87	0.94	0.96	0.93
Tongyang	1.00	1.00	1.00	1.00	1.00
MetLife	0.65	0.69	1.00	0.94	0.69
Prudential	0.71	0.98	1.00	0.73	0.98
Shinhan	0.93	0.98	1.00	0.94	0.98
PCA	0.55	0.86	0.91	0.64	0.95
NewYork	0.64	0.94	1.00	0.68	0.94
ING	1.00	1.00	1.00	1.00	1.00
Hana	0.92	0.99	1.00	0.93	0.99
KB	1.00	1.00	1.00	1.00	1.00
SH&C	1.00	1.00	1.00	1.00	1.00
Green Cross	1.00	1.00	1.00	1.00	1.00
LINA	1.00	1.00	1.00	1.00	1.00
AIG	0.76	0.96	1.00	0.79	0.96
Mean	0.89	0.96	0.99	0.97	0.93

As you can see in Table 5, we evaluated the scale efficiency (SE) and the MIX efficiency (MIX) using the BCC, CCR, and SBM efficiency scores. We calculated the scale efficiency using $SE = \frac{\theta^*}{\eta^*}$. We discovered twelve scale efficient companies and could interpret that these companies were operating efficiently and that the scale was adequate. However, MetLife showed the biggest difference, in so far as the BCC efficiency and the scale efficiency were 1 and 0.694, respectively. This means that it operated efficiently, but it is at a disadvantageous scale. Although MiraeAsset and Kumho had lower than average BCC and CCR efficiency scores, the scale efficiency was higher than the average scale efficiency, as 0.981 and 0.988, respectively. Though we might interpret them as operating inefficiently, the scale shows on advantageous situation. Actually, Kumho was given an award by the Korean Management Awards in 2005 and showed excellence in the operation of invested assets. Figure 4(a) provides the distribution of scale efficiency. The efficiency score of most companies was high, but Metlife was the lowest.

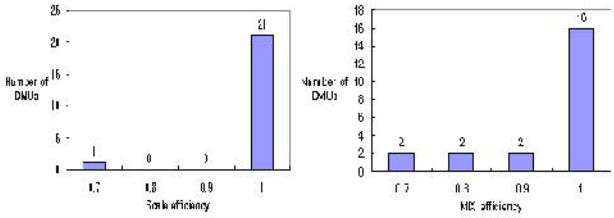


Fig. 4. Distribution of DEA efficiency

On the other hand, as you can see in the previous section, we calculated the MIX efficiency using $MIX = \frac{\rho^*}{\theta^*}$ and SBM= [PTE] × [SE] × [MIX]. We discovered twelve SBM efficient companies. Conversely, the PCA was lower than the mean in all efficiency scores, except for the scale efficiency and the SBM efficiency, which were particularly severe. We can interpret the sources of inefficiency as caused by inefficient operation, as well as the difference of the composition ratio in inputs and outputs. The low for Mirae Asset, Kumho, Purdential, New York, and AIG is attributed to the low MIX efficiency. The causes of this inefficiency may be due to the difference of the composition ratio in inputs and outputs. Actually, Purdential only sells life insurance products through life planners and doesn't use other distribution channels, such as telemarketing or home shopping networks. On the other hand, AIG spent more on acquisition costs from 2003 to 2005. The low SBM efficiency of Dongbu is attributed to the BCC and scale efficiency. We can interpret that the causes of the inefficiency can be attributed to inefficient operation. Figure 4(b) provides the distribution of MIX efficiency. The efficiency score of most companies is high; PCA and New York were the lowest.

When we review five efficiency scores, the relative efficiency of most companies is high, and the SBM efficiency is the lowest, which indicates that life insurance companies operating in Korea are different in the composition ratio in inputs and outputs. Actually, each company establishes the different strategies through a variety of distribution channels and new products.

3.2.3 Super-efficiency

As you can see in Table 4, there are many efficient companies. Accordingly, in order to rank DMUs, we employ the super-efficiency model. Table 6 provides the results of the super-efficiency.

Table 6. Results of super-efficiency.

DMU	Super BCC	Super CCR	Super SBM	Mean	Rank
Korea	1.07	1.03	1.01	1.04	11
Allianz	1.07	1.07	1.03	1.05	10
Samsung	1.00	1.36	1.13	1.16	6
Hungkuk	1.04	1.03	1.01	1.03	14
Kyobo	2.40	1.22	1.16	1.60	3
Lucky	1.98	1.67	1.46	1.70	1
MiraeAsset	0.93	0.91	0.77	0.87	20
Kumho	0.95	0.95	0.85	0.92	17
Dongbu	0.94	0.87	0.84	0.88	19
Tongyang	1.05	1.03	1.02	1.03	13
MetLife	1.01	0.69	0.65	0.78	21
Prudential	1.02	0.98	0.71	0.91	18
Shinhan	1.01	0.98	0.93	0.98	16
PCA	0.91	0.86	0.55	0.78	22
NewYork	1.72	0.94	0.64	1.10	8
ING	1.25	1.03	1.02	1.10	7
Hana	1.32	0.99	0.92	1.08	9
KB	1.53	1.43	1.30	1.42	4
SH&C	1.61	1.37	1.20	1.39	5
Green Cross	1.05	1.04	1.02	1.04	12
LINA	1.85	1.84	1.28	1.66	2
AIG	1.23	0.96	0.76	0.98	15
Mean	1.27	1.10	0.97	1.11	

The average BCC, CCR, and SBM super-efficiency scores of life insurance companies are 1.269, 1.103, 0.966, respectively. Kyobo had the highest efficiency score (2.403) in the BCC super-efficiency. However, Samsung, Metlife, and Sinhan were similar to the previous results, as shown in Table 4. Lina had the highest efficiency score (1.839) in the CCR super-efficiency, and Lucky had the highest efficiency score (1.458) in the SBM super-efficiency. On the other hand, we ranked DMUs using the mean of three efficiency scores. Lucky was the first ranking, and the efficiency score of Metlife and PCA were the lowest. Although Hungkuk is efficient in the BCC, CCR and SBM scores, the average efficiency score (1.029) is 14th ranking.

4. CONCLUSION

The Korean life insurance industry has undergone profound changes, such as the beginning of the variable insurance and the increase of a variety of distribution channels, such as telemarketing, home shopping, and internet marketing. Bancassurance has played a particularly important role in the life insurance industry. However, little empirical research has analyzed data, which addresses the bancassurance of life insurance companies operating in Korea. In response to this lack of data, this paper has applied data envelopment analysis model to measure and decompose the efficiency of these companies. We estimated the efficiency of 22 registered companies in 2005 and investigated the sources of the inefficiency that a DMU might have. We employed the CCR, BCC, SBM, and super-efficiency models in order to provide our data.

We discovered that the number of BCC, CCR, and SBM efficient companies were 18, 10, and 10, respectively. We used these results to provide the scale efficiency and the MIX efficiency to estimate the causes of inefficiency. We discovered that life insurance companies operating in Korea are a little different in their composition ratio of inputs and outputs, due to increased variety of distribution channels and new products. On the other hand, the return to scale (RTS) showed that the number of IRS, DRS, CRS companies were 3, 7, and 12, respectively. We provided the frequency of the reference set, which indicated the object for benchmarking. We employed the super-efficiency model to provide rankings of the DMUs.

For future research, it may be necessary to analyze each distribution channel, since the distribution channels of life insurance companies have significantly changed, regarding the usage of bancassurance, telemarketing, home shopping, and internet shopping. On the other hand, future research will need to include the collaboration of a partner, such as a bank or insurance company. A promising future study would be the examination of efficiency over time by applying the window analysis and the Malmquist productivity change index techniques. It also would allow a dynamic view of the multidimensional financial performance within the Korean life insurance companies.

REFERENCES

[1] P. Anderson and N.C. Petersen, "A Procedure for Ranking Efficient Units in Data Envelopment Analysis", *Management Science*, *Vol. 39, No. 10*, 1993, pp. 1261-1264.

[2] R.D. Banker, A. Charnes, and W.W. Cooper, "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science, Vol. 30, No. 9*, 1984, pp. 1078-1092.

[3] A. Charnes, W.W. Cooper and E. Rhodes, "Measuring the Efficiency of Decision Making Units", *European Journal of Operational Research, Vol. 2*, 1978, pp. 429-444.

[4] W.W. Cooper, L.M. Seiford, and K. Tone, Data Envelopment Analysis : A Comprehensive Text with Models, Applications, References and DEA-Solver Software, *Kluwer Academic Publisher*, 2000.

[5] W.W. Cooper, L.M. Seiford and K. Tone, Introduction to Data Envelopment Analysis, *Springer*, 2006

[6] J.D. Cummins and M. Rubio-Misas, "Deregulation, Consolidation, and Efficiency: Evidence From the Spanish Insurance Industry", *Journal of Money, Credit, and Banking, Vol. 38*, *No. 2*, pp. 323-355, 2006.

[7] J.D. Cummins, M. Rubio-Misas and H. Zi, "The Effect of Organizational Structure on Efficiency: Evidence from the Spanish Insurance Industry", *Working Paper*, 2002.

[8] J.D. Cummins, S. Tennyson and M.A. Weiss, "Consolidation and Efficiency in the US Life Insurance Industry", *Journal of Banking & Finance, Vol. 23*, 1999, pp. 325-357.

[9] J.D. Cummins, G. Turchetti and M.A. Weiss, "Productivity and Technical Efficiency Italian Insurance Industry", Working paper, *The Wharton Financial Institutions Center*, 1996.

[10] J.D. Cummins and H. Zi, "Measuring Cost Efficiency in the U.S. Life Insurance Industry: Econometric and Mathematical Programming Approaches", *Working Paper, The Wharton Financial Institutions Center*, 1996.

[11] J.D. Cummins and H. Zi, "Comparison of Frontier Efficiency Methods: An Application to the U.S. Life Insurance Industry", *Journal of Productivity Analysis, Vol. 10*, 1998, pp. 131-152.

[12] S.R. Diacon, K. Starkey and C. O'Brien, "Size and Efficiency in European Long-term Insurance Companies: An International Comparison", *Geneva Papers on Risk and Insurance, Vol. 27, No. 3*, 2002, pp. 444-466.

[13] N. Doherty, "The Measurement of Output and Economies of Scale in Property-liability Insurance", *Journal of Risk and Insurance, Vol. 48, No. 3*, 1981, pp. 390-402.

[14] K.C. Ennsfellner, D. Lewis and R.I. Anderson, "Production Efficiency in the Austrian Insurance Industry: A Bayesian Examination", *The Journal of Risk and Insurance, Vol. 71, No. 1*, 2004, pp. 135-159.

[15] F. Fecher, D. Kessler, S. Perelman and P. Pestieau, "Productive Performance of the French Insurance Industry", *The Journal of Productivity Analysis, Vol. 4*, 1993, pp. 77-93.

[16] H. Fukuyama, "Investigating Productive Efficiency and Productivity Changes of Japanese Life Insurance Companies", *Pacific-Basin Finance Journal, Vol. 5*, 1997, pp. 481-509.

[17] P. Hardwick, M.B. Adams and Z. Hong, "Corporate Governance and Cost Efficiency in the United Kingdom Life Insurance Industry", *EBMS Working Paper*, 2003.

[18] B.J. Lee, S.J. Lee and S.C. Jung, "The Effects of Bancassurance on the Efficiency of Financial Institutions", *Korean Management Review, Vol. 33, No. 2*, 2004, pp. 449-472.

[19] T. Leverty, Y. Lin and H. Zhou, "Firm Performance in the Chinese Insurance Industry", *Working Paper*, 2004.

[20] B. Mahlberg and T. Url, "Effects of the Single Market on the Austrian Insurance Industry", *Empirical Economics, Vol. 28*, 2003, pp. 813-838.

[21] S.A. Mansor and A. Radam, "Productivity and Efficiency Performance of the Malaysian Life Insurance Industry", *Jurnal Ekonomi Malaysia, Vol. 34*, 2000, pp. 93-105.

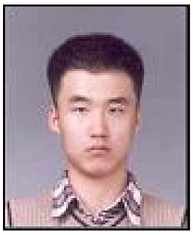
[22] K. Tone, "A Slacks-based Measure of Efficiency in Data Envelopment Analysis", *European Journal of Operation Research, Vol. 130*, 2001, pp. 498-509.

[23] K. Tone, and B.K. Sahoo, "Evaluating Cost Efficiency and Returns to Scale in the Life Insurance Corporation of India Using Data Envelopment Analysis", *Socio-Economic Planning Sciences, Vol. 39*, 2005, pp. 261-285.

[24] A.C. Worthington and E.V. Hurley, "Technical, Allocative and Cost Efficiency in the Australian General Insurance Industry", *Working Paper*, 2000.

[25] A.M. Yuengert, "The Measurement of Efficiency in Life Insurance: Estimates of a Mixed Normal-Gamma Error Model", *Journal of Banking and Finance, Vol. 17*, 1993, pp. 483-496.

[26] J. Zhu, Quantitative Models for Performance Evaluation and Benchmarking, *Kluwer Academic Publishers*, 2003.



Hyung-suk Lee
He is a doctoral student at the Graduate School of Business Administration, Pusan National University, Korea. He is interested in Data Envelopment Analysis, Performance Evaluation, and Supply Chain Management.

Ki-Seog Kim
He is a Professor at the Division of Business Administration, Pusan National University, Korea. He obtained his PhD in Management Science from University of Washington. He has more than 20 years of experience in teaching, research, and consulting. His current research interests include Data Envelopment Analysis, technology management, and Supply Chain Management.