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A two-stage DEA model to evaluate the overall performance of Canadian life and health insurance companies

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Abstract

A two-stage data envelopment analysis (DEA) model is created to provide valuable managerial insights when assessing the dual impacts of operating and business strategies for the Canadian life and health (L&H) insurance industry. This new model allows integration of the production performance and investment performance for the insurance companies and provides management overall performance evaluation and how to achieve efficiency systematically for the insurers involved. The results also show that the Canadian L&H insurance industry operated fairly efficiently during the period examined (the year 1998). In addition, the scale efficiency in the Canadian L&H insurance industry is found in this study.

Keywords: Data envelopment analysis; Efficiency; Life and health insurance industry; Production; Investment

1. Introduction

The Canadian insurance industry plays an important role in the financial markets in Canada. Two insurance categories are identified, based on the type of risk underwritten: life and health (L&H), and property and casualty (P&C). This research focuses on business operations in the L&H industry.

The Canadian L&H insurance industry offers various financial security products to protect about 32 million Canadians. Moreover, the insurance companies serve as both institutional investors and providers of loans to the government and various industries in the financial markets. The industry has $227.2 billion in assets under management, and 129 companies competed aggressively at the end of 1998 [1]. Over the last two decades the Canadian insurance industry has gone through intense changes and faces more challenges. As a result of deregulation and the convergence of banks, insurance firms, trust companies, and investment dealers, the L&H segment faces unprecedented competition from non-traditional providers. Banks have become strong competitors in terms of their vast networks of branches. However, Federal legislation enacted in 1992 denied banks the right to transact insurance business directly through their branch networks; however, it allowed the big banks to own insurance companies [1]. In addition, foreign companies started to enter the Canadian market as a result of globalization.

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The competitive pressures forced many insurance companies to change corporate strategies in order to reduce operating costs while maintaining or improving the quality of their services. As the marketplace continues to evolve at a rapid pace, it is imperative to find a tool to help managers identify the companies that are best positioned to respond to and thrive in a changing environment. Therefore, evaluating performance in the insurance industry remains an important objective and has always been the subject of considerable interest.

A number of different approaches can be used to assess the insurance industry. Each of them is used to obtain a different aspect of efficiency measures. The most important two approaches are the production evaluation and the investment evaluation. This research proposed a new two-stage data envelopment analysis (DEA) model which can integrate the production performance and investment performance and consider the compromise between these two aspects for the Canadian L&H insurance industry. The paper successfully provides a comprehensive evaluation for Canadian insurance companies. In addition, this paper also indicates how to improve production efficiency and/or investment efficiency in order to achieve overall best practice.

The rest of the paper is organized as follows. Section 2 gives a brief review of DEA. Section 3 discusses the models used for the insurance industry in literature. Section 4 provides the models and methodology utilized in this paper. Section 5 gives the DEA results and further discussion. Section 6 compares the two-stage DEA model with other approaches. Section 7 presents how management can make use of the results from this study. Finally, our conclusions are presented in Section 8.

2. Data envelopment analysis basics

DEA is used to establish a best practice group among a set of observed units and to identify the units that are inefficient when compared with the best practice group. DEA also indicates the magnitude of the inefficiencies and improvements possible for the inefficient units. Consider n DMUs to be evaluated, $\text{DMU}_j (j = 1, 2, \ldots, n)$, that consume the amounts $X_j = \{x_{ij}\}$ of m different inputs $(i = 1, 2, \ldots, m)$ and produces the amounts $Y_j = \{y_{rj}\}$ of r outputs $(r = 1, \ldots, s)$. The input oriented efficiency of a particular DMU_0 under the assumption of variable–returns-to-scale (VRS) can be obtained from the following linear programs (input-oriented BCC model [2]):

$$\min_{\theta,\lambda,s^+,s^-} z_0 = \theta - \varepsilon \cdot \vec{1}s^+ - \varepsilon \cdot \vec{1}s^- \tag{1}$$

$$\begin{aligned} \text{s.t. } & Y\lambda - s^+ = Y_0 \\ & \theta X_0 - X\lambda - s^- = 0 \\ & \vec{1}\lambda = 1 \\ & \lambda, s^+, s^- \geq 0 \end{aligned}$$

where s^+ and s^- are the slacks in the system.

Performing a DEA analysis requires the solution of n linear programming problems of the above form, one for each DMU. The optimal value of the variable θ indicates the proportional reduction of all inputs for DMU_0 that will move it onto the frontier that is the envelopment surface defined by the efficient DMUs in the sample. A DMU is termed efficient if and only if the optimal value θ^* is equal to 1 and all the slack variables are zero. This model allows variable–returns-to-scale. The dual program of the above formulation is illustrated by:

$$\max_{\mu,\nu} w_0 = \mu^T Y_0 + u_0 \tag{2}$$

$$\begin{aligned} \text{s.t. } & \upsilon^T X_0 = 1 \\ & \mu^T Y - \upsilon^T X + u_0\vec{1} \leq 0 \\ & -\mu^T \leq -\varepsilon \cdot \vec{1} \\ & -\upsilon^T \leq -\varepsilon \cdot \vec{1} \\ & u_0 \text{ free.} \end{aligned}$$

If the convexity constraint ($\vec{1}\lambda = 1$) in (1) and the variable u_0 in (2) are removed, the feasible region is enlarged, which results in a reduction in the number of efficient DMUs, and all DMUs are operating at constant–returns-to-scale (CRS). The resulting model is referred to as the CCR model [3]. A number of extensions to basic DEA models