APPLICATIONS OF MANAGEMENT SCIENCE

Edited by Kenneth D. Lawrence
and Dinesh R. Pai

APPLICATIONS OF
MANAGEMENT SCIENCE

VOLUME 21

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APPLICATIONS OF MANAGEMENT SCIENCE VOLUME 21

APPLICATIONS OF MANAGEMENT SCIENCE

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SECTION A

DATA ENVELOPMENT ANALYSIS

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INSURANCE COMPANY EFFICIENCY ANALYSIS THROUGH DATA ENVELOPMENT ANALYSIS (DEA) DURING COVID-19 PANDEMIC

Gao Niu, John Quinn and Alan Olinsky

ABSTRACT

In this chapter, we applied Data Envelopment Analysis (DEA) to a group of property and casualty insurance companies' data from 2018 to 2020. The calculated relative efficiencies were compared with selected traditionally used financial measures. We conclude that DEA and its relative efficiency calculation provide a consistent measure with selected IRIS ratios. The result and method can be used for situations when multiple ratios and change-based financial metrics provide inconsistent conclusions.

Keywords: Data envelopment analysis (DEA); Insurance regulatory information system (IRIS) ratios; relative efficiency; property and casualty insurance; COVID-19; financial efficiency

INTRODUCTION

Data Envelopment Analysis (DEA) is a widely used linear programming (LP) model that was initially presented by Charnes, Cooper, and Rhodes (1978) based on concepts in the paper by Farrell (1957). Førsund and Sarafoglou (2002) bridged the gap in the economic literature between these two seminal papers. DEA has seen a large number of studies in the evaluation of insurance companies. For example, Malhotra, Malhotra, and Dania (2017) utilized DEA to explore the relative efficiencies of health and life insurance companies in 2009 and 2014, to investigate the effects of the economic crisis during the years from 2007

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to 2009. They found that the average 2014 results were better than 2009. Wu et al. (2007) developed a new DEA model to examine the performance of Canadian life and health insurance companies. They considered the years from 1996 to 1998 and found that there was a consistent performance over that time span. Some other recent studies that illustrate the extensive utilization of DEA include applications to the Malaysian Insurance Industry (Bao, Ramlan, Mohamad, & Yassin, 2018), Turkish life insurance and private pension companies (Dalkiliç & Ada, 2014), Pakistan's insurance companies (Taib, Ashraf, & Razimi, 2018), and Saudi Arabian insurance companies (Naushad, Faridi, & Faisal, 2020). Kaffash et al. (2020) provided a comprehensive review of 132 studies of DEA studies applied to the insurance industry. The publications spanned from 1993 to July 2018.

In this paper, DEA is applied to a group of property and casualty insurance companies' data from 2018 to 2020. Traditionally used financial metrics such as Insurance Regulatory Information System (IRIS) ratios are ratio or changed based. They use two or three financial measures to calculate those ratios. Sometimes ratios provide inconsistent indications. For example, one ratio may indicate that the company is in a situation at a financial disadvantage but another ratio may indicate something significantly different, even though the data were from the same company in the same year. This is because those ratios measure various characteristics of company from different business perspectives such as profitability, stability, and business growth.

A more comprehensive approach such as DEA modeling that measures the overall company's relative efficiency can avoid the inconsistencies provided by the ratios. It will provide an overall measure and take into consideration all of the available financial metrics.

The remainder of the chapter consists first of a description of the data used in this study. Then the DEA model is provided. The calculated relative efficiencies and their comparisons with traditionally used financial ratios are discussed. The conclusion is that DEA is a valuable tool to provide an overall company business practice efficiency measure.

DATA DESCRIPTION

The data set consists of 1,134 property and casualty insurance companies that operated in the United States during the years of 2018, 2019, and 2020. Each represents their operations prior to the COVID-19 pandemic (2018 and 2019) in the United States and during the pandemic (2020). Ten key financial measures of these insurance companies are investigated.

Overall Industry

Overall, the property and casualty industry grew from 2018 to 2020. From Table 1 and Fig. 1, it can be seen that the total assets increased by 8.90% from 2018 to 2019 (2,024 billion to 2,204 billion), then increased by 6.93% to 2,356 billion in 2020. The total industry surplus increased by 14.32% from 2018 to 2019

Table 1. US Property and Casualty Insurance Overall Financial.

US Property and Casualty Insurance Overall Financial			
	2018	2019	2020
Total liabilities (billion)	1,266.96	1,338.65	1,427.65
Liability change		5.66%	6.65%
Total surplus (billion)	756.73	865.10	928.87
Surplus change		14.32%	7.37%
Total assets (billion)	2,023.69	2,023.75	2,356.52
Assets change		8.90%	6.93%

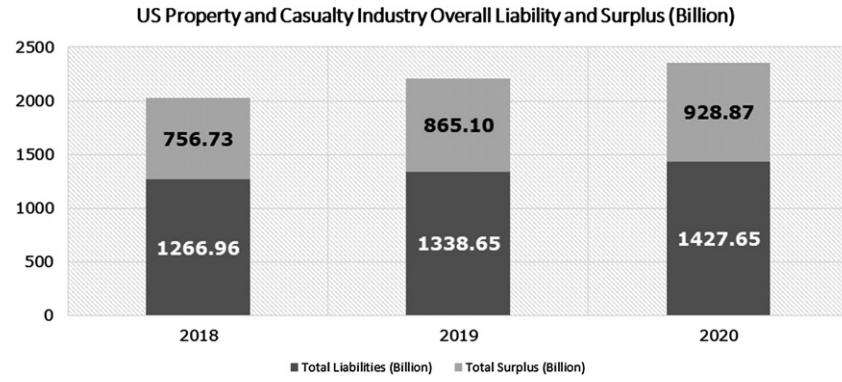

Fig. 1. US Property and Casualty Industry Overall Liability and Surplus.

(757 billion to 865 billion), then increased by 7.37% to 929 billion in 2020. Both total asset and total surplus increased but at a decreasing rate. In addition, total liability increased by 5.66% from 2018 to 2019 (1,267 billion to 1,338 billion), then increased by 6.65% to 1,428 billion in 2020. Total liability increased for two consecutive years at an increasing rate.

Selected Company Ratios

Several ratios were calculated for each company that provide measures of performance. These were Net Written Premium (NWP) to Policyholder Surplus (PHS) ratio, Change in Net Written Premium ratio, and Gross Change in Policyholder Surplus ratios. The three ratios are among the 13 ratios that are called Insurance Regulatory Information System (IRIS) ratios. These ratios had been used by insurance regulators as indicators to identify insurance companies that are in need of regulatory attention to avoid insolvency (Odomirok, McFarlane, Kennedy, & Brenden, 2013).

Net Written Premium to Policyholder Surplus (NWP-to-PHS) Ratio
Fast growth of net written premiums is one of the leading reasons that insurance companies go insolvent. If the NWP-to-PHS ratio is more than 300%, it will trigger the regulator's attention. All top 35 companies within this study have a ratio less than 300%. From Table 2, it can be seen that Progressive consistently has the highest ratio, and State Compensation Ins. Fund consistently has the lowest ratio. The companies with the top NWP-to-PHS ratios are quite consistent during the years 2018 and 2020.

Change in Net Written Premium
The normal range for change of NWP is from −33% to 33%. From Table 3 it is shown that Swiss Re, Sompo, and AXA SA have an above threshold growth from the year 2019 to 2020, and Allianz has an above threshold growth from the year 2018 to 2019. Fast written premiums could subject a company to loosened underwriting standards, which will have a long-term negative impact on the company financials. On the other hand, Allianz and Swiss Re have below threshold changes in NWP, and further investigation is needed. Possible reasons could be damage to company reputation, tightened underwriting standards, financial status deterioration, etc. Swiss Re has an extreme change from 2018 to 2020. It has a significant decrease before the COVID-19 pandemic (−72.21%), but catches up significantly during the pandemic (+77.37%).

Table 2. New Written Premium to Policyholder Surplus Ratio for Top 5 and Bottom 5 Selected Insurance Companies.

Net Written Premium to Policyholder Surplus						
	2020		2019		2018	
1st	Progressive	263.97%	Progressive	270.81%	Progressive	276.14%
2nd	Farmers Insurance	206.99%	Farmers Insurance	218.35%	Farmers Insurance	219.97%
3rd	Allstate Corp	158.82%	Allstate Corp	169.39%	Allstate Corp	179.59%
4th	American Family Insurance	149.52%	American Family Insurance	163.10%	Liberty Mutual	161.22%
5th	Liberty Mutual	144.14%	Liberty Mutual	157.52%	Great American Insurance	151.74%
31st	Auto Club Exchange	47.39%	Sentry	39.19%	Zurich	57.86%
32nd	Sentry	39.19%	Swiss Re	58.69%	Sentry	45.08%
33rd	FM Global	30.59%	FM Global	30.59%	FM Global	32.28%
34th	Berkshire Hathaway Inc.	23.66%	Berkshire Hathaway Inc.	23.66%	Berkshire Hathaway Inc.	30.74%
35th	State Compensation Ins Fund	16.70%	State Compensation Ins Fund	16.70%	State Compensation Ins Fund	19.62%

Table 3. Change in New Written Premium.

Change in Net Written Premium				
	2019–2020		2018–2019	
1st	Swiss Re	77.37%	Allianz	53.59%
2nd	Sompo	46.72%	Markel	21.49%
3rd	AXA SA	34.44%	Progressive	15.05%
4th	FM Global	17.23%	Everest Re	14.75%
5th	Zurich	16.07%	Alleghany	14.46%
31st	American Family Insurance	−2.57%	Chubb	−6.73%
32nd	The Hartford	−2.97%	Zurich	−7.77%
33rd	State Compensation Ins Fund	−10.76%	State Compensation Ins Fund	−10.08%
34th	AIG	−15.43%	AXA SA	−30.30%
35th	Allianz	−42.97%	Swiss Re	−72.21%

Change in Policyholder Surplus

The normal range for changes in Policyholder Surplus is from −10% to 50%. From Table 4 it can be seen that all selected companies have the ratio within the normal range, which indicates the major property and casualty insurance companies are stable from the policyholder surplus perspective one year before and after the pandemic beginning.

Table 4. Change in Policyholder Surplus.

Change in Policyholder Surplus				
	2019–2020		2018–2019	
1st	Everest Re	41.10%	Berkshire Hathaway Inc.	34.72%
2nd	Auto Club Exchange	16.36%	Swiss Re	25.64%
3rd	Erie Insurance	13.30%	FM Global	21.94%
4th	FM Global	12.04%	The Hartford	19.25%
5th	Auto-Owners Insurance	11.56%	Auto Club Exchange	18.84%
31st	Old Republic Insurance	−0.96%	AIG	−0.30%
32nd	State Compensation ins Fund	−2.23%	State Compensation Ins Fund	−3.54%
33rd	Alleghany	−2.80%	Chubb	−5.37%
34th	Swiss Re	−2.96%	American Family Insurance	−6.27%
35th	Zurich	−5.70%	Allianz	−9.56%

DEA ANALYSIS

Model Description

DEA is a method that can compare the relative efficiencies of units in a group, e.g., hotels in a chain, franchisees in a restaurant chain, or in this case, insurance

companies. Liner programming is often used to generate these relative efficiencies. Although it is not a natural application of LP, it is a very useful tool. However, it should be pointed out that efficiencies that are calculated are relative to others in the chain. That is, the absolute efficiencies of any of the units are not actually measured. Nevertheless, this comparison of relative efficiencies can be extremely useful.

In this LP formulation, the weights are the decision variables. The sum of the product of the output variables and the weights are maximized. The weights are optimized to let each unit put its "best foot" forward. It is also necessary to run an LP problem for each of the units in the chain. Therefore, using a macro in Excel® (Microsoft Corporation, 2016) is often helpful. The authors used Analytic Solver® (Frontline Systems, 2021), an add-in to Excel, by Frontline Solver in Incline Village, Nevada. It is a superset of the Solver that comes with Excel that adds many additional features, including the ability to run several models automatically and store the results, namely, the relative efficiencies and the weights for all of the units.

In addition to the objective function, the constraints shown below in the model description, which are based on the input and output variables, are added. The output variables are such that a larger value is better, e.g., net income. The input variables go into the betterment of the unit, e.g., labor hours. With the input variables, a smaller value is better, e.g., the labor hours.

Model Explicit Description

$$\text{Efficiency of Unit } i = \frac{\text{Weighted Sum of Unit } i\text{'s Outputs}}{\text{Weighted Sum of Unit } i\text{'s Inputs}}$$

Maximize: $\sum$[Output Variables*Weights]

Subject to: $\sum$[Output Variables*Weights] $\leq \sum$[Input Variables*Weights]

$\sum$[Input Variables*Weights] = 1, for proper scaling

All the weights must be non-negative.

Model Symbolic Description

The model can be represented mathematically below as described in Ragsdale (2014).

$$\text{Efficiency of Unit } i = \frac{\sum_{j=1}^{N_o} O_{ij} * w_j}{\sum_{i=1}^{N_I} I_{ij} * v_j}$$