# TECHNICAL AND SCALE EFFICIENCY IN THE U.S. PROPERTY-CASUALTY INSURANCE INDUSTRY

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## ABSTRACT

The United States property – casualty insurance industry is shown here to have suffered a decline in earnings efficiency that began after 1986 and continued through 2001, the concluding year of the study. The decline is attributed to unproductive availability of both bond holdings (and in the late 1990's of stock holdings) and policyholder surplus. Data Envelopment Analysis (DEA) is proposed here as a method to compare organizational efficiency values over time. The technique is modified to compare the United States property-casualty industry aggregate earnings over discrete time periods. Returns to scale are shown to mostly be nonconstant over the time period of the study.

## INTRODUCTION

The property – casualty insurance industry is vitally important to the economy and the population of the country. It touches the lives of the entire population. Coverage includes such diverse instrumentalities as homeowners, auto, medical malpractice, credit, business continuation, shipping, boilers and liability. Coverage availability has become a virtual necessity for individuals and businesses alike. The viability of the industry is essential to individual and business financial security. It is with this concern in mind that the question of the efficiency of the industry is opened. In the event of declining financial efficiency, insurance providers have incentive to restrict capacity. This can be done through such things as increasing deductibles and exclusions and restricting qualifications for coverage. All such actions work contrary to the general public need for coverage. Therefore, a declining financial efficiency can work a general harm to the public as well as to the property-casualty industry. Data Envelopment Analysis (DEA) is typically used to compare the relative efficiency of each of a set of operating units. These operating units are usually called decision–making units (DMUs).

The work done here proposes to track the efficiency of the entire aggregate United States property – casualty insurance industry over the 24 years 1978 – 2001. The purpose is to observe if earnings efficiency has remained relatively constant or if there appears to be any trend toward either higher or lower efficiency over time. We proceed with the analysis as follows: in section II we define the data to be used in this analysis; section III outlines the DEA model and section IV outlines the results of the model. Finally, section V provides some concluding comments concerning the results and the implied implications for the property casualty industry.

### U.S. Property – Casualty Insurance Data

The work developed here will monitor industry earnings efficiency over time through the use of six variables, two output variables and four input variables. Operating efficiency is measured as a ratio of outputs relative to a set of inputs. Real values of these variables are used in order to make them comparable over the entire time horizon of the study. They are obtained by dividing the nominal value by the urban household consumer price index (CPI), 1981-82 = 100.

The output variables are real underwriting profit and real investment income. The input variables are real lagged bond holdings, real lagged total common and preferred stock holdings real lagged policyholder surplus and real underwriting operating expense.

**Data Envelopment Analysis**

The formal DEA model for any year i is:

Minimize: $Z = E_i$ (Ia)

Subject to:

$$\sum_{i=1}^{n} w_i = 1 \qquad \text{(1b)}$$

$$\sum_{i=1}^{n} v_{ij} w_i \geq v_{ij} \qquad \text{all outputs j} \qquad \text{(Ic)}$$

$$\sum_{i=1}^{n} u_{ij} w_i \leq u_{ij} E_i \qquad \text{all inputs j} \qquad \text{(Id)}$$

all $w_i$, $E_i \geq 0$

Here, $E_i$ is the efficiency index of outputs relative to a set of inputs for the i = 1, …, n DMUs. For each year (DMU) i the parameter $v_{ij}$ is the observed level of output j and $u_{ij}$ is the observed level of input j.

Three versions of model (I) will be established. The first one does not include constraint (Ib). This model obtains an efficiency measure known as overall technical efficiency. It incorporates the assumption of constant returns to scale. This is important because long-term optimal scale of operation is had only when returns to scale are constant.

The second version does include (Ib). This allows variable returns to scale. The efficiency measure that results from this version is known as pure technical efficiency. The variable scale returns come about because of the forced convexity of the efficiency frontier (Aly, et.al, 1990). The third formulation has a version of (Ib) that has the upper bound be given as $\leq 1$. When this is present the returns to scale are taken to be only to be nonincreasing.

Denote the constant returns to scale efficiency measure in year i as $T_i$ and the variable returns to scale efficiency value as $PT_i$. Then $S_i = T_i / PT_i$ is the percentage of input usage that would be needed if constant returns to scale were attained. It is called scale efficiency. If $S_i = 1$ then constant returns to scale are obtained, and if $S_i < 1$ then returns to scale are not constant, being either increasing or decreasing (Aly, et. al., p.213).

**Model Results**

Table 1 lists the annual efficiencies and the scale efficiency for the various years of the study. In 1978 and in 1997 the scale efficiency was equal to 1. Therefore, with respect to IDEAL, these years both exhibit constant returns to scale for the outputs. However, for all other years the scale efficiency $S_i$ was less than 1.

Pure technical efficiency (PT) is the percentage of input value that would be required to obtain the given outputs if 100% efficiency was obtained. Table 1 shows that these values drift downward steadily over time. This suggests that to a growing extent, the inputs real bond holdings, real stock holdings, real policyholder surplus and real operating expenses are failing to yield expected outputs real investment income and real underwriting gain or loss. Stated more precisely, the realized annual real output levels could be obtained with decreasing percentages of actual real annual levels of the inputs that are actually available. Similar numerical efficiencies are seen under the requirement that scale returns be constant.

Annual scale efficiency $S_i$ is also seen in table 1 to be mostly less than 1, but with no discernible regular trend. This suggests that annual departures from constant real returns to scale are not consistent. Therefore, the industry does not appear to be settling into an ideal level of constant returns to scale.

Table 1 also shows that the efficiency model (NT) index value is equal to that of model (T) in all cases. The ratio S is $< 1$ for all years except for 1978 and 1997, so $NT_i$ is less than $PT_i$ for all years except for 1978 and 1997. Therefore, in all other years except those two, returns to scale are nonconstant.

Interested readers are invited to obtain from the author the complete paper, including all references, listings, tables and figures.