

FINANCIAL INTERMEDIARY VERSUS PRODUCTION APPROACH TO EFFICIENCY OF MARKETING DISTRIBUTION SYSTEMS AND ORGANIZATIONAL STRUCTURE OF INSURANCE COMPANIES

Patrick L. Brockett
William W. Cooper
Linda L. Golden
John J. Rousseau
Yuying Wang

ABSTRACT

An examination of the efficiency of the marketing distribution channel and organizational structure for insurance companies is presented from a framework that views the insurer as a financial intermediary rather than as a "production entity" which produces "value added" through loss payments. Within this financial intermediary approach, solvency can be a primary concern for regulators of insurance companies, claims-paying ability can be a primary concern for policyholders, and return on investment can be a primary concern for investors. These three variables (solvency, financial return, and claims-paying ability) are considered as outputs of the insurance firm. The financial intermediary approach acknowledges that interests potentially conflict, and the strategic decision makers for the firm must balance one concern versus another when managing the insurance company. Accordingly, we investigate the efficiency of insurance companies using data envelopment analysis (DEA) having as insurer output an appropriately selected (for the firm under investigation) combination of solvency, claims-paying ability, and return on investment as outputs. These efficiency evaluations are further examined to study stock versus mutual form of organizational structure and agency versus direct marketing arrangements, which are examined separately and in combination. Comparisons with the "value-added" or

Patrick L. Brockett, William W. Cooper, Linda L. Golden, and John J. Rousseau are at the University of Texas at Austin. The authors can be contacted via e-mail: brockett@mail.utexas.edu, cooperw@mail.utexas.edu, mklg@mail.utexas.edu, jjrousseau@mail.utexas.edu. Yuying Wang is at the Department of Information Technology, American Airlines Headquarters. The author can be contacted via e-mail: yuying.wang@aa.com. Support for this research by the IC² Institute and the Program for Risk Management and Insurance at the University of Texas at Austin is gratefully acknowledged. We thank Dr. Honghui Deng for performing the RAM model computations concerning the production approach to efficiency.

“production” approach to insurer efficiency are presented. A new DEA approach and interpretation is also presented.

INTRODUCTION

This article uses the nonparametric properties of data envelopment analysis (DEA) coupled with distribution-free rank-order statistics to study the relative efficiency of the different organizational structures used by U.S. property and liability insurance companies (cross classified by their marketing distribution systems). Additionally, this article extends the interpretation of DEA toward a goal-directing technique with the goals as outputs rather than simply having a “product” as an output. This provides another focus and interpretation for DEA analysis in the insurance literature. We also use a form of DEA (the Range-Adjusted Measure, or RAM, model), new to the insurance literature, which is able to provide ordinal level efficiency scoring that allows for subsequent nonparametric statistical analysis such as regression, rank statistical analysis, etc. to be performed incorporating efficiency score as an explanatory variable in subsequent analysis.¹

We dichotomize our results by organizational form into mutual versus stock companies to examine whether these two organizational structures might have differential managerial strategic focus in terms of goals, and have different efficiency and slack variables when using solvency propensity, return on investment, and claims-paying ability as output goals. One might expect potential differences in efficiency between stock and mutual insurers due to the different incentive structures inherent in the two types of organizational forms; in stock companies return on shareholder investment dominates incentives, whereas solvency and claims-paying ability considerations can dominate considerations of mutual insurance company decision makers. Possible efficiency differences between mutual and stock types of organization are intrinsically intertwined with the use of the agency versus direct sales type of marketing distribution systems² and these dichotomies are also correlated to emphasis in commercial versus personal lines of insurance. Finally, the differences that can occur by using different DEA formulations (production approach considering losses as the output versus the financial intermediary approach of this article) are explored and discussed.

¹ Usual forms of DEA, such as the CCR (Charnes, Cooper, and Rhodes, 1978) or BCC (Banker, Charnes, and Cooper, 1984) models provide a relative efficiency for each decision making unit, however, this measure is not ordinal in the sense that if DMU A has relative efficiency of 0.8 by reference to efficient DMUs E and F, and DMU B has efficiency of 0.85 by reference to the efficient DMUs G and H, one cannot necessarily claim that DMU A is less efficient than DMU B since their efficiency scores are computed relative to different reference sets. This problem has been overlooked in some articles that use CCR or BCC DEA models and do regressions or *t*-tests involving the CCR or BCC efficiency score. The RAM DEA model of this article alleviates this problem and provides a framework wherein efficiency can be used in subsequent statistical analysis.

² For the marketing system variable, we designate two marketing distribution types as given by Rejda (1992, pp. 588-589). The “Agency” type consists of independent agents, which can represent more than one insurer. We distinguish this from the other types, which we refer to as “Direct.” The “Direct” form of distribution directly represents a single insurer and includes exclusive agencies (which can represent only one company or one company group), direct writers (wherein the sales person is an employee of the insurer) and mass media marketing and order taking (e.g., mail order, telemarketing, or internet order taking).

THE RAM DEA MODEL³

There is a theoretical problem in using DEA efficiency numbers from the standard CCR or BCC models for subsequent statistical analysis because, while DEA evaluates the efficiency of each firm, the comparison set for each firm may be different producing potentially nonmetric level data. Accordingly, to address this problem, we introduce here to the insurance literature a new form of the DEA model that was selected for its suitability to the problems that are of interest here. This new model possesses some very desirable properties vis-a-vis other DEA models that have been used in the insurance literature (cf., Brockett and Xia, 1996). This model is a variant of the "additive DEA model" first presented in Charnes et al. (1985), and is discussed in detail in Cooper, Park, and Pastor (1999). To make the current article self-contained we briefly present this model that is formulated as follows:

$$\begin{aligned} & \max \frac{\sum_{i=1}^m \left(\frac{s_i^-}{R_i^-} \right) + \sum_{r=1}^s \left(\frac{s_r^+}{R_r^+} \right)}{m + s} \\ & \text{subject to} \\ & x_{i0} = \sum_{j=1}^n x_{ij} \lambda_j + s_i^-, \quad i = 1, \dots, m \\ & y_{r0} = \sum_{j=1}^n y_{rj} \lambda_j - s_r^+, \quad r = 1, \dots, s \\ & \sum_{j=1}^n \lambda_j = 1 \\ & 0 \leq \lambda_j, s_i^-, s_r^+, \quad \text{all } i, j, r. \end{aligned} \tag{1}$$

In the DEA literature the entities responsible for converting input resources into outputs are referred to as decision-making units (DMU) and $j = 1, \dots, n$ indexes the entities being compared and contrasted for relative efficiency determination,

$$\begin{aligned} x_{ij} &= \text{amount of input } i = 1, \dots, m \text{ used by DMU}_j \\ y_{rj} &= \text{amount of output } r = 1, \dots, s \text{ yielded by DMU}_j, \end{aligned} \tag{1a}$$

³ There are a variety of DEA models available (cf., Brockett, Yu, and Wei, 1996) but this new Range Adjusted Measure (RAM) has advantages for examining efficiency of the financial intermediaries in this article. Some of these advantages include location and scale variance and a uniform set of weights, making ranking of the examined firms by efficiency possible. These properties and the mathematical proofs are presented explicitly in Cooper, Park, and Pastor (1999). See also Charnes et al. (1993) for detailed discussions of DEA and its uses. See also its discussion of computer codes and the extensive body of references to more than 800 publications in DEA (and its uses), which are contained in the bibliography that accompanies this book. A complete discussion of DEA along with computer disks for doing the computations can be found in Cooper, Seiford, and Tone (2000).

whereas x_{i0} , y_{r0} represent the corresponding input and output values for DMU_0 , the DMU whose efficiency to be evaluated. The optimization in (1) is over the variables $0 \leq \lambda_j, s_i^-, s_r^+$.

We note that any choice of x 's that results in $x_{i0} > \sum_{j=1}^n x_{ij}\lambda_j$ is interpreted to mean that the empirical evidence shows that with some (convex) combination of inputs *other* DMUs could have improved this input in amount $s_i^- = x_{i0} - \sum_{j=1}^n x_{ij}\lambda_j > 0$ without worsening any other input or output. In this instance DMU_0 is identified as having used an excessive amount of this input. Similarly, $s_r^+ = \sum_{j=1}^n y_{rj}\lambda_j - y_{r0}$ identifies a shortfall in output characteristic r , in amount s_r^+ , by reference to the outputs recorded for this same convex combination of other DMU_j 's. In each case, these nonzero "slack" variables' values provide an estimate of the input excesses and the output shortfalls that could be improved without worsening any other input or output, and the nonzero λ_j 's tell which other DMUs, and in what amounts, should be used to produce more output for the given input levels.

Returning to (1), we see that the objective is to maximize the slack values that ensures that *all* such inefficiencies are identified. Hence we have a definition of efficiency: DMU_0 is fully efficient if and only if all slacks are zero at an optimum in (1). This indicates that for this DMU_0 no other DMU (or combination of DMUs) can produce the same output with smaller amounts of inputs, or can use the same set of inputs to produce more output.

A "dimensionless" measure of inefficiency can be obtained because we divided each slack variable by the range of the slack variable R_i^- or R_r^+ where

$$\begin{aligned} R_i^- &= \overline{x_{ij}} - \underline{x_{ij}}, \quad i = 1, \dots, m \\ R_r^+ &= \overline{y_{rj}} - \underline{y_{rj}}, \quad r = 1, \dots, s \end{aligned} \quad (1b)$$

with $\overline{x_{ij}}, \overline{y_{rj}}$ denoting the highest and $\underline{x_{ij}}, \underline{y_{rj}}$ the lowest of the $j = 1, \dots, n$ values in rows i and r , respectively.

Since $\sum_{j=1}^n \lambda_j = 1$, as given in (1), it can be shown that

$$0 \leq \frac{\sum_{i=1}^m \left(\frac{s_i^-}{R_i^-} \right) + \sum_{r=1}^s \left(\frac{s_r^+}{R_r^+} \right)}{m + s} \leq 1. \quad (2)$$

So this quantity can be used as a measure of *inefficiency* for DMU_0 in which (a) the lower bound is achieved only when no inefficiencies are detected via (1) (i.e., no nonzero slacks in inputs or outputs) and (b) the upper bound is achieved only when $s_i^{-*} = R_i^{-*}$ for all $i = 1, \dots, m$ and $s_r^{+*} = R_r^{+*}$ for all $r = 1, \dots, s$. It is clear that the measure is invariant to changes in location or scale of both inputs and outputs and, as noted in Cooper, Park, and Pastor (1999), it is also strongly monotonic, so it can be used for rankings of DMUs. Ranking of the evaluated entities according to their efficiency is a frequent managerial desire and use of DEA, and is useful for subsequent statistical analysis.

Having a measure of inefficiency, we construct a measure of efficiency by taking its complement, i.e.,

$$0 \leq \Gamma = 1 - \frac{\sum_{i=1}^m \left(\frac{s_i^-}{R_i^-} \right) + \sum_{r=1}^s \left(\frac{s_r^+}{R_r^+} \right)}{m + s} \leq 1, \quad (3)$$

which Cooper, Park, and Pastor (1999) refer to as RAM of efficiency. It is also strongly monotonic and not dependent on the units in which the inputs and outputs are measured. This invariance to linear transformations allows us to deal with the possibility of negative values in this DEA model—such as losses compared to profits—without losing contact with results from prior research in DEA that generally assume an absence of negative values in the observations.

DATA AND VARIABLE SELECTIONS FOR EMPIRICAL ANALYSIS

The companies covered in our study consist of 1,114 stock and 410 mutual companies based on data obtained from the 1989 property and liability tapes secured from the A. M. Best Company and the NAIC annual statement data. This total of 1,524 companies decomposed into 1,201 using “Agency” and 323 using “Direct” types of marketing and this enables us to study both efficiency and solvency in the various combinations of company and marketing system types represented in Table 1.

DISCUSSION OF SELECTION OF INPUTS AND OUTPUTS FOR EFFICIENCY ANALYSIS: PRODUCTION VERSUS FINANCIAL INTERMEDIARY APPROACHES

In addition to the choice of DEA model form discussed above, the selection of variables to represent inputs and outputs is also crucial to the validity of the analysis, and is particularly difficult for financial services firms (as opposed to manufacturing firms that use physical natural resources to produce physical completed products as outputs). Generally speaking, the inputs represent resources that a DMU employs in order to conduct its operations. The outputs reflect the results that are desired from the inputs utilized. This interpretation of inputs being facilitating quantities and outputs being desired outcomes or goals of the decision-making entity provides a useful perspective on the DEA methodology.

TABLE 1

Decomposition of Company Type and Marketing Distribution Systems

Organizational Structure	Marketing	Number of Companies	Total (%)
All stock companies		1,114	73
All mutual companies		410	27
All agency companies		1,201	79
All direct companies		323	21
Stock	Agency	919	60
Stock	Direct	195	13
Mutual	Agency	282	19
Mutual	Direct	128	8

The most important characteristic of inputs and outputs is still as discussed originally by Charnes and Cooper, namely, that *ceteris paribus*, an increase in an output or alternatively, a decrease in input should be desirable and should improve the efficiency score. When trying to see if a particular variable is an input or an output, it is important for the validity of the analysis to ascertain whether, all other things being held constant, an increase in the quantity is desirable or undesirable.⁴

The above criteria for input and output selection provide general guidance but more is needed for the output and input choices to evaluate insurance company (or financial services firms) performances. Here we adopt the viewpoint that regards an insurance company as a financial intermediary, and the input and output selections are determined accordingly.

It is worth noting that the financial intermediary approach to efficiency determination of insurance companies is not uniformly adopted. The alternative approach (referred to as the “production approach” by Berger and Humphrey [1997]), would have financial institutions treated just as a manufacturing company would be treated. For example, under the production approach, a steel manufacturing company uses capital and labor (inputs) to produce steel ingots (output). Several articles in the insurance literature have used this “production approach” to efficiency (cf., Cummins and Weiss, 1993; Cummins, Weiss, and Zi, 1999; and the discussions therein). In the context of insurance companies, this production approach might use premiums, investment income-supplied capital and labor costs, as inputs and use losses paid as an output (saying that the payment of losses is the “product” being sold). We disagree with adopting this approach for modeling the insurer; since if losses changed upward dramatically—say due to a hurricane, or an earthquake, or a terrorist attack, or an environmental catastrophe, or all four simultaneously—with no change in inputs, this would be bad (not good for the company) and not “efficiency” enhancing. At the ultimate extreme, a firm that suffers (and pays) great losses due to a hurricane without a corresponding change in input resources to make these loss payments would become insolvent, not suddenly efficient. This cause of insolvency has happened to insurers, for example, after Hurricane Andrew in 1994. A major catastrophe that shakes the foundations of the insurance industry does not suddenly make the insurers more efficient—only less stable.

Additionally, using losses as the output measure ignores other desirable goals or outputs that really drive the survival of an insurance firm and describe the operations of the firm such as return to stakeholders (among others). If income from investment increased with no changes in loss payments, it would be a good rather than a bad happening, and should be included as an output. On the other hand, no insurance firm would try to encourage their employees to perform in a manner that engendered large losses while charging premiums that are the same as their competitors.

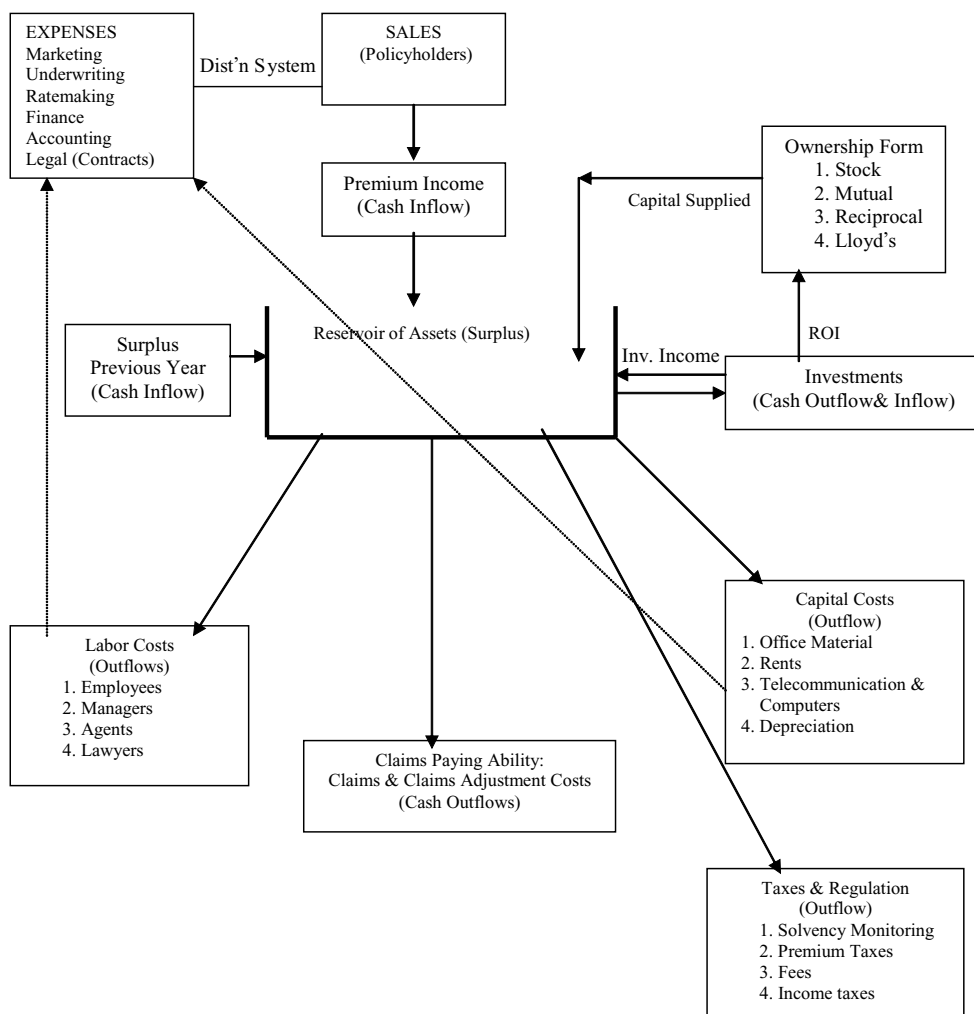
⁴ A rule of thumb is that, *ceteris paribus*, if it is desirable to increase the quantity of the variable, it is an output, and if it is undesirable to have an increase in its value, it is an input. Thus, in an insurance company context, holding income and premiums received fixed, it is undesirable to suddenly have “losses paid” increase. Thus, “losses paid” would not be considered as an output in standard DEA analysis.

In the financial intermediary view an insurance firm provides a bundle of attributes to the stakeholders, only one component of which may be promise of an end loss payment from an insurance firm at some uncertain future date. Indeed, the promise of future contingent payment of losses can be considered as a vehicle or intermediate step by which the insurers collect money, investors get rewarded, consumers get a valued promise of quick claim payment, and consumers, regulators, and employees get a promise of future solvency of the firm (making the insurance IOU worth paying for in the first place). It serves a role similar to savings deposits in a bank, being the vehicle (in the case of insurance, the promised indemnification) justifying or creating the financial profits resulting from investing the premiums received. Berger and Humphrey (1997, p. 197) differentiate the “production approach” from the “intermediation approach.” They believe the intermediation approach is best used to evaluate entire financial institutions (firms) that are concerned with “intermediating funds between savers and investors.” The production approach is most useful, they say, for evaluating efficiency of branches or subsidiaries. *Ceteris paribus*, large losses payments are negatively, not positively, related to the goals of an insurer and its stakeholders and should not, in our view, be considered as an output.

In this article we are evaluating entire companies and use an intermediation approach. Figure 1 (adapted from Brockett et al., 2004) summarizes the view of the insurance company as a financial intermediary, which we further simplify for our modeling.

As a financial intermediary, an insurer issues contingent claims to policyholders and uses the proceeds to purchase a portfolio of assets. Management is charged with investing these assets not only to maximize a risk-adjusted return on capital but also to do this in a way that maximizes the value of ownership claims. This is one objective to be considered in evaluating performance. In offering insurance an insurer effectively levers ownership capital by “borrowing” from the policyholders. A critical role of equity capital is therefore the creation of “insurer surplus” to serve as a buffer against the possibility that losses may exceed the net premiums collected plus the interest and dividends earned between the time of premium receipt and the time of disbursement. The greater an insurer’s capital, the more certain policyholders can be that they will receive compensation for insured losses. Competition in insurance markets requires premiums to be set at levels that compensate policyholders for the use of their funds and also provide a competitive return to the shareholders or owners as compensation for their role as residual risk bearers.

The choice between a “production” and an “intermediary” approach also applies to banks and other financial institutions. However, as pointed out by McCabe and Witt (1980), Lai and Witt (1992), and Staking and Babbel (1995), differences between insurers and other financial intermediaries must be taken into account in analyzing the structure of the property–liability insurance industry. Thus, although the claim against the insurer by policyholders is similar to the claims of depositors and debtors at other financial institutions, it also differs because the claim of each individual policyholder is contingent upon experiencing a loss. Furthermore, insurance contracts are usually set up to cover losses incurred during a specified time period, while actual loss payments are made over a much longer time period. Effectively, policyholders are purchasing a long-term financial commitment by the insurer. They cannot cancel past coverage and obtain refunds if they perceive that the riskiness of the insurer is increasing, or if

FIGURE 1**Simplified Cash Flow View of the Insurer as a Financial Intermediary**

the insurer becomes insolvent. Future business may be transferred to another insurer, but past exposures cannot be transferred without payment of additional premiums. Entities seeking insurance can become uninsurable over time making it impossible to start over, and consequently requiring regulators to monitor solvency in a manner not used in manufacturing firms. Premium payments are made before (often long before) the delivery of service (claims are paid), so the future claims-paying ability of the insurer is of interest to customers and regulators. The potential risk of insolvency not only concerns the regulators, but policyholders will pay less for coverage from a lower rated firm, and investors will demand a greater return on investment for such firms.

The special nature of the fiduciary relations in insurance and the importance of insurance to economic and social performances, as well as the regulatory contexts in which

TABLE 2

Inputs and Output Selections—Financial Intermediary Approach

No.	Inputs	Outputs
1	Surplus previous year	Rate of return on investments (ROI)
2	Change in capital and surplus	Liquid assets to liability (claims-paying ability)
3	Underwriting and investment expenses	Solvency scores
4	Policyholders supplied debt capital	

insurance companies operate, make it advisable to recognize that a single objective such as “maximize profit” or “paying all of this year’s claims” does not provide an adequate basis for evaluating performance, especially from the perspective of multiple stakeholders (cf., Brockett, Chang, Rousseau, Semple, and Yang, 2004 for an illustration of how the choice of inputs and outputs can be different depending upon the perspective to be considered). We therefore use multiple goals that include not only profitability, but also short-term claim-paying ability and the longer-term ability to discharge fiduciary responsibilities as represented by solvency. This leads us to the four inputs and three outputs selected for this study and listed in Table 2, which we now discuss.

Input 1: Surplus Previous Year. Surplus, the excess of assets over obligations, represents the owners’ stake or equity in the firm. This surplus is the total of capital and unassigned funds, including voluntary and general reserved funds, plus special reserved funds that are not in the nature of liabilities. It represents the amount beyond liabilities available to meet obligations to policyholders.

Input 2: Change in Capital and Surplus. Change in capital and surplus includes the following items: net income (both investment and underwriting), net realized capital gain or loss, change in excess of statutory reserve over statement reserves, and so on.

Note that input 1 (surplus previous year) plus input 2 (change in capital and surplus) together provide the amount that is available to the insurer in the current year. We include them separately, however, because of the additional information this can provide. If losses are high, this change is a large negative number (a bad thing), consistent with the usual interpretation of inputs and outputs.

Input 3: Underwriting and Investment Expenses. Underwriting expenses are the costs to an insurance company that arise from the function of underwriting. Investment expenses are the costs associated with the productive employment of capital under conditions that provide reasonable assurance of both income and repayment of the principal. Both types of expense are incurred to accomplish the objectives of an insurance company.

Input 4: Policyholders-Supplied Debt Capital. The policyholders-supplied debt capital (debt capital of insurers) consists primarily of funds borrowed from policyholders.

In our study, these funds are quantified as the sum of unpaid net losses, unpaid loss adjustment expenses (these first two together represent a company's obligations for unpaid losses), and unearned premium reserves (which represent the company's obligations for premiums held for coverage not yet provided and which provides a benefit to be recognized only when the service is supplied at some future date). Note that all three components of policyholder-supplied debt capital represent future costs (rather than current costs) and have negative effects on a company's solvency and rate of return on investments (ROI), which leads us to take the complement of the observed values of this particular input.

Referring back to Table 2, in order to maintain comparability with our use of probabilities to represent solvency as output 3, the other two outputs are also put on a 0–1 scale by stating them in ratio form as follows:

Output 1: Rate of Return on Investments. Rate of return on investment⁵ is a general indicator of the quality of a company's investment performance. Called "investment yield" by the National Association of Insurance Commissioners (NAIC), it is defined as net investment income divided by the average amount of cash and invested assets for current and prior year. Since insurance companies compete in the capital markets for funds (especially stock insurance companies), their output to investors must also be competitive. Investors may care only about insurance company losses as they affect their own investment returns—lower (not higher) losses *ceteris paribus* yielding larger ROI to the investor (and being desirable from their perspective).

*Output 2: Liquid Assets to Liabilities.*⁶ Liquid assets are cash and short-term investments in securities. We follow the NAIC definition where liquid assets is defined to be the sum of deferred premiums booked but not yet due, cash, invested assets, and accrued investment income, minus investment in affiliated companies, and excess of real estate over 5 percent of assets. Liabilities are the probable future sacrifices of economic benefits stemming from present legal, equitable, or constructive obligations incurred to transfer assets or to provide services to other entities in the future as a result of past events affecting the corporation. This ratio reflects a company's claim-paying ability without expensive "disintermediation" of funds. Especially for consumers (and mutual insurance company executives and regulators) this is an important output.

Output 3: Solvency Scores. Insolvency within the insurance industry remains a major issue of public debate and concern, and techniques for identifying potentially troubled firms continue to be a major regulatory and research objective. Indeed, the Reliance Insurance Company, which was placed into liquidation on October 3, 2001 had an estimated \$5 billion in claims and liabilities to be paid and was incurring losses at the rate of \$2–4 million per day. This has only heightened the concerns of the regulators, consumers, and investors about solvency and claims-paying ability (cf., Harrington

⁵ This is IRIS ratio 5. Although the IRIS *system* is not very good for early warning of insurer insolvency, this does not mean that certain IRIS *ratios* are not useful for *efficiency* determination.

⁶ This is the reciprocal of IRIS ratio 7.

and Niehaus, 1998). The relative impact of solvency on efficiency has been studied in Brockett, Cooper, Golden, Rousseau, and Wang (2004).

As a regulatory goal, solvency propensity may be considered as a management goal for the insurers, especially for closely held firms and mutual insurers. Because it is a different type of output than the rest, it deserves more discussion. To quantify this variable, we want to estimate the probability that the firm will remain solvent (and consequently be able to meet its obligations to its stakeholders) for the next 3 years. This brings up the question of how it should be measured. Multivariate statistical methods applied to the NAIC's IRIS ratios is one possibility for measuring this propensity (cf., Barrese, 1990). Another possibility is to use the NAIC's FAST variables as described in Cummins, Grace, and Phillips (1999). Reviews of the literature can be found in BarNiv and Raveh (1989), Brockett, Golden, and Xia (1997), and Brockett and Cooper (1990). To our knowledge, the best performing model for predicting property or liability insurer insolvency is the neural network model detailed in Brockett et al. (1994). This model used eight financial and operational variables available from the annual statements filed with the NAIC: policyholders surplus, capitalization ratio, change in invested assets, investment yield based on average invested assets, ratio of significant receivable from parent and subsidiaries, significant increases in current year net underwriting loss, surplus aid to surplus, and liabilities to liquid assets. The neural network model produced a single scalar probability measure which we use to reflect solvency propensity for the firm.

In the above financial intermediary approach, companies can, through policy actions within certain guidelines trade off one output for another. For example, by investing in higher-risk investments, one might increase the first output while decreasing the third output. It is the goal of management to make such parsimonious trade-offs, and different companies, organizational forms, etc. may give greater or lesser emphasis to one versus another output, or to utilize one input more than another input.

In contrast to the above financial intermediary approach, Cummins, Weiss, and Zi (1999) examined a similar issue to that examined here, but used a "production" rather than financial intermediary approach. They also used a different DEA model (the CCR model for DEA, which assumes constant returns to scale, and as noted previously, does not produce metric-level efficiency scores capable of being used in subsequent statistical analysis). A summary of the variables they used are given in Table 3.

TABLE 3
Variables Used by Cummins, Weiss, and Zi (1999)
in the Production Approach

	Variables
Inputs	Labor expense Business services Equity capital Debt capital
Output	Losses

As in Cummins and Weiss (1993), losses in this “production” approach are used as the output of the insurance firm—the more losses a company pays, the more efficient it is declared to be, holding the other inputs fixed. Of course, as mentioned previously, an earthquake such as happened in 1992, a hurricane such as happened in 1994, or a terrorist attack such as happened in 2001, can make a large number of companies become declared “more efficient,” having nothing to do with how well they are run, even as they become financially more troubled. This is counter to the general notion of efficiency.

An analysis of property and liability insurers for the years 1992 (Northridge earthquake in California) and 1994 (Hurricane Andrew in the east coast) was run using the “production” approach with losses as outputs. To be consistent (and so the comparison was based on choices of inputs and outputs rather than the choice of DEA models, and because we feel the most appropriate DEA model for this analysis is the RAM model, and not the CCR model), we ran the analysis of the production approach also using the RAM model. For the “catastrophe years” of 1992 and 1994, for example, the number of highly efficient firms using losses as the output was very large (58.6 percent and 76.2 percent of firms having efficiency score >0.999 and for 1992 and 1994, respectively), clearly reflecting the effect of using losses as an output makes firms experiencing losses more efficient and not weaker.

RESULTS OF THE FINANCIAL INTERMEDIARY APPROACH

Removing Technical Inefficiency to Obtain a Pure Comparison of Organizational Forms and Marketing Distributions Differences

We begin by noting that most comparative studies of the efficiency of stock versus mutual organizational forms do not first eliminate the effects of managerial inefficiencies within each organizational form type prior to comparison, and hence their conclusions cannot be relied upon as actually relating to pure performance of the organizational forms when operating at their most efficient level for that particular form (e.g., Fama and Jensen, 1983). It is possible that one form is better at its optimal performance, but has many more inefficiently performing units so as to make the average comparisons misleading concerning the efficiency of the form itself. A similar comment pertains to comparisons of agency versus direct marketing systems. There can be good managers in bad programs and bad managers in good programs.

We overcome this “contamination” deficiency by using the following formulas, as obtained from the DEA literature, to project the original observations for the inefficient firms onto the points on the efficiency frontier for their particular organizational form. This results in an organizationally efficient firm (new DMU), which shows the output which would have resulted for the inefficient companies *if they had behaved efficiently for their organizational form*. The projection formulas are

$$\begin{aligned}\hat{x}_{i0} &= \sum_{j=1}^n x_{ij} \lambda_j^* = x_{i0} - s_i^{-*}, \quad i = 1, \dots, m \\ \hat{y}_{r0} &= \sum_{j=1}^n y_{rj} \lambda_j^* = y_{r0} + s_r^{+*}, \quad r = 1, \dots, s.\end{aligned}\tag{4}$$

Variants of formula (4), as first given in Charnes, Cooper, and Rhodes (1978) are referred to as “CCR projection formulas” because they project the original observation into a new point with coordinates $\hat{x}_{i0} \leq x_{i0}$ and $\hat{y}_{r0} \geq y_{r0}$.⁷ These new coordinates correspond to a point on the efficiency frontier. In fact, this is the point on the efficiency frontier used to evaluate DMU₀. A comparison of the groups of DMUs which have been projected to their respective efficiency frontiers by this projection method is now a comparison of the attributes of the groups and not confounded by the relative inefficiencies with the groups (since each DMU is now efficient relative to its own group). This projection has eliminated managerial or technical inefficiency from the comparison. For the empirical analysis, it is useful to note that the efficiency scores obtained from the RAM model are invariant to changes in the units in which inputs and outputs are measured as well as to the choice of origin so we eliminate the negative values for “Change in surplus” by adding a constant to the data in this row and rescale all inputs and outputs to more convenient units.

Statistical Comparisons

Results that compare the magnitudes of the inefficiencies of the different groups (stock versus mutual, direct versus agency) or the percentage of group members which are efficient in each group do not determine if the differences observed are statistically significant or are possibly attributable to chance differences. Moreover, it is possible to have a “better” marketing distribution system or organizational form with a disproportionate number of bad managers making the comparison of average or percentages misleading with respect to the superiority of the distributional system or organizational form. Accordingly, this section summarizes the results of Brockett and Golany (1994) for obtaining a statistical significance test of the observed efficiency differences.

To illustrate this approach, we restrict our immediate discussion to evaluate the relative efficiency of stock versus mutual types of organization and describe the procedure used by Brockett et al. (1997) as follows: At stage 1, the two types of organizational forms (stock and mutual) are considered separately. Separate individual efficiency frontiers for the set of stock and mutual firms, respectively, are then determined by separate DEA analysis so that (4) can be applied to bring each DMU to the full efficiency that the frontiers allows for its type of organization (stock or mutual). Having removed managerial or technical inefficiency by this projection method, the thus adjusted (fully efficient) DMUs are then combined for simultaneous treatment by (1) so that a new (third) combined data frontier can be used to identify inefficiencies and yield a resulting efficiency score for all DMUs considered together. If the two organizational forms are equally efficient (the efficiency frontier for the two are the same) then running the DEA with all the projected DMUs should yield this common efficiency frontier with any inefficiencies equally interchangeable between the two groups (organizational forms). After the final “combined projected” DEA analyses, those scores that are less than unity (the inefficient firms) are then reassociated with

⁷ See also Charnes, Cooper, and Rhodes (1981) and Brockett and Golany (1994) where this type of projection formula was used to distinguish whether one program was better than another in the education of disadvantaged children (Project Head-Start).

their own "types" of organization and we obtain a measure of relative efficiency performance after managerial inefficiencies—i.e., inefficiencies due to the way in which each type was managed—have been eliminated. If at their best performance (projected efficiency) one of the two types is more efficient than the other, then this type will have an efficiency frontier above the other and will be more likely to be on the combined data efficiency frontier and less likely to have firms far from this efficiency frontier.

Although we could simply examine the number of inefficiency firms of each type, this does not provide a sufficiently rigorous answer to whether or not such differences might have arisen due solely to chance. Traditional parametric statistics (such as *t*-tests) are inappropriate because the efficiency measures are ordinal but not interval level in data quality. However, as previously noted, our RAM version of DEA produces a measure that lends itself to ranking by reference to the efficiency score that it provides. This enables us to use a rank-order statistical test in order to determine whether one type of organization is statistically significantly more efficient than the other and, of course, the same procedures can be applied to determine whether one member of each type for the pairs listed in Table 1 is more efficient than the other.

Following Brockett and Golany (1994) we use the Mann-Whitney rank-order test statistic for these purposes because it provides a rank-based nonparametric statistic that can be used to statistically assess whether or not one efficiency frontier curve lies above another. Assume we have two groups of size, n_1 and n_2 for a total of $n = n_1 + n_2$ DMUs, which we rank⁸ in ascending order according to their efficiency ratings in the combined sample DEA analysis after each member of each group was projected onto its own group efficiency frontier. We then compute the sum of the rankings for the first subgroup of size n_1 after which we compute the Mann-Whitney rank-order test statistic

$$U = n_1 * n_2 + \frac{n_1 * (n_1 + 1)}{2} - R, \quad (5)$$

where R is the sum of the ranks in the first subgroup.

To test whether the two subgroups have the same distribution of efficiency values within the pooled collection of n DMU efficiency values, we may use a normal approximation,

$$Z = \frac{U - \frac{n_1 * n_2}{2}}{\sqrt{\frac{n_1 * n_2 * (n_1 + n_2 + 1)}{12}}} = \frac{\frac{n_1 * (n + 1)}{2} - R}{\sqrt{\frac{n_1 * n_2 * (n + 1)}{12}}}. \quad (6)$$

At level α we reject the hypothesis that the two subgroups have the same distribution of efficiency scores at this significance level if either $Z \geq Z_{\alpha/2}$ or $Z \leq -Z_{\alpha/2}$, where $Z_{\alpha/2} \geq 0$ is obtained from a normal distribution table. Moreover, since large values of Z will be associated with large values of U and small values of R (sum of the ranks

⁸ Use the midrank for DMUs tied in efficiency.

TABLE 4

Mann-Whitney Rank Statistic Results Concerning Group Efficiency Differences

No.	Subgroup A	Subgroup B	Z	p-Value	Conclusion
1	Stock	Mutual	-24.48	<0.000000001	Stock > mutual
2	Stock and agency	Mutual and agency	-24.37	<0.000000001	Stock and agency > mutual and agency
3	Stock and direct	Mutual and direct	-4.05	<0.00001	Stock and direct > mutual and direct
4	Agency	Direct	-19.67	<0.000000001	Agency > direct
5	Stock and agent	Stock and direct	-17.28	<0.000000001	Stock and agency > stock and direct
6	Mutual and agent	Mutual and direct	2.73	<0.006	Mutual and direct > mutual and agency
7	Stock and agency	Mutual and direct	-16.22	<0.000000001	Stock and agency > mutual and direct
8	Stock and direct	Mutual and agency	-6.32	<0.000000001	Stock and direct > mutual and agency

from lowest to highest in the first subgroup), one-sided tests be used to identify which subgroup is more efficient.

The results of these analyses presented in Table 4 can be summarized as follows: (1) Stock companies are more efficient than mutual companies (row 1) and (2) agency is more efficient than direct (row 4). The other rows contain information on the combinations spelled out in Table 1.

Stock and Agency > Stock and Direct > Mutual and Direct > Mutual and Agency where ">" means "more efficient than."

DEA Outcomes and Slack Variables

The DEA model presents more than simply efficiency analysis: it also allows us to determine the sources of inefficiency and to determine if there are different "causes" of inefficiency in each group. This kind of detailed information available from the RAM model DEA analysis concerning sources of inefficiencies is portrayed graphically in Figures 2–5. Here the average value of the nonzero slacks, that represent the inefficiencies in each input and output is shown for inefficient stock and mutual organizational forms, and for agent and direct marketing distributional systems.⁹

As can be seen, the stock firms tend to have much more inefficiency (over utilization) in the input dimension than does the mutual organizational form, particularly in the inputs of surplus and expenses. On the other hand, mutual insurers show a much higher shortfall in all areas of outputs. Mutual insurance companies' underproduction of ROI may be attributable to their different goals as described in the introduction.

⁹ A similar analysis of sources of input/output inefficiency for each of the possible combinations of organizational structure and marketing distribution type as listed in Table 1 are available from the first author.

FIGURE 2
Average Output Shortfalls for Inefficient Firms

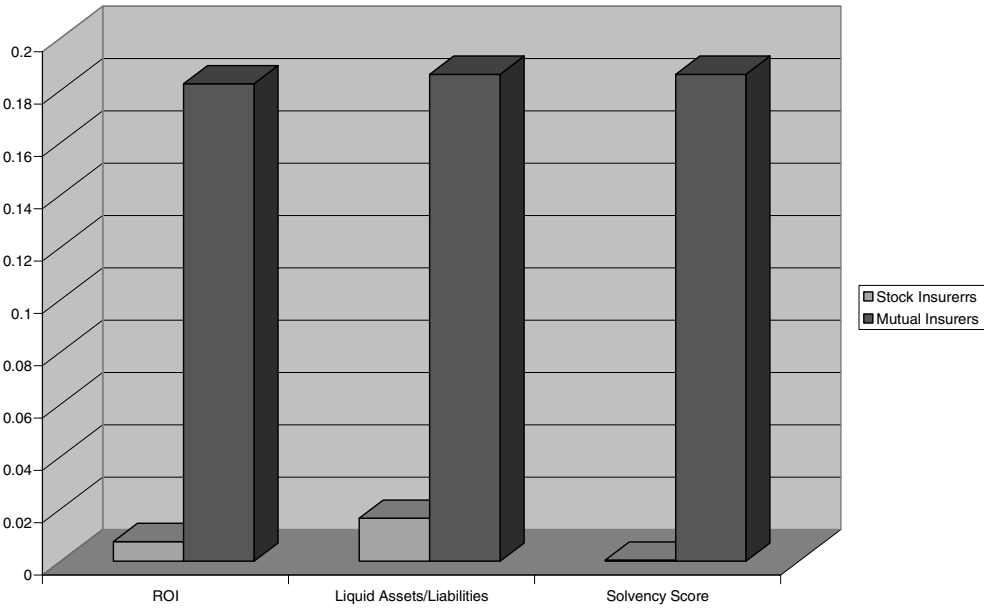


FIGURE 3
Average Extra Surplus Input Surplus by Inefficient Firms

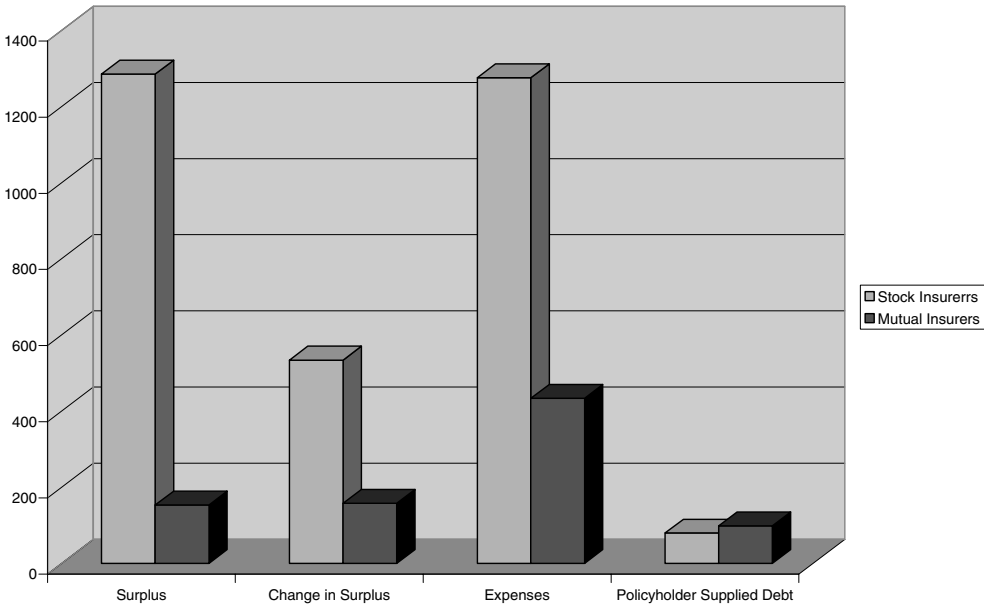


FIGURE 4
Average Output Shortfall for Inefficient Firms

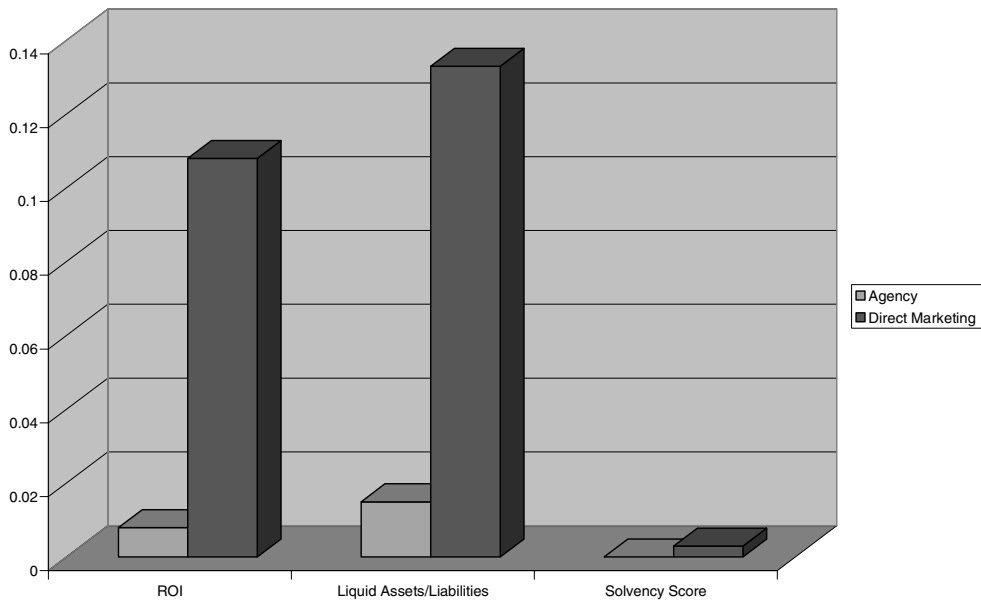
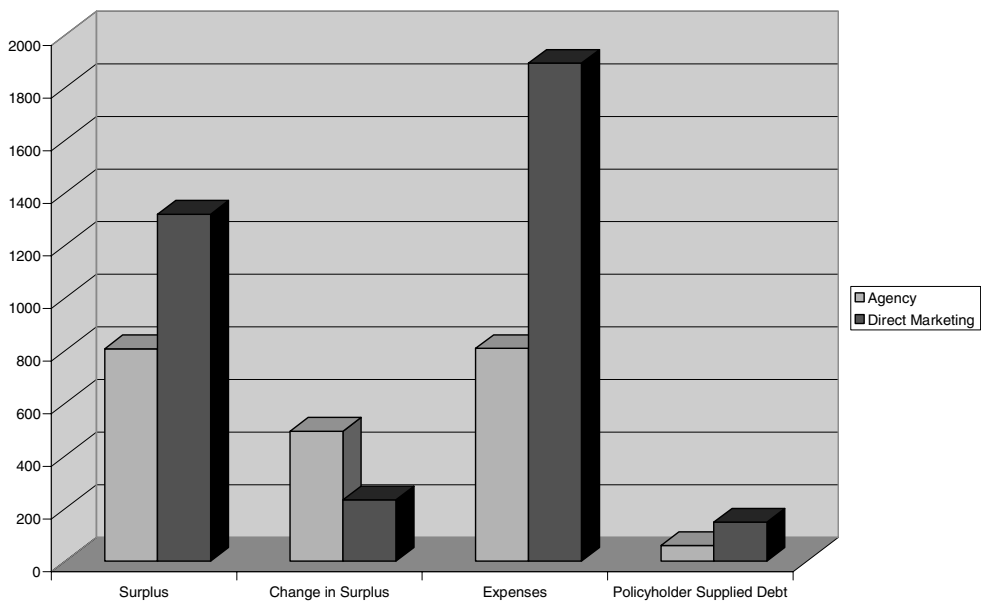


FIGURE 5
Average Extra Surplus Input Used by Inefficient Firms



Concerning agency versus direct marketing distribution systems, we see no similar dichotomy in where slack variables appear, as direct marketing systems have more inefficiencies than does the agency system in terms of both input over utilization and output shortfalls.

This sort of information is also useful managerially in addressing sources of inefficiency for any particular inefficient firm. On the other hand, using the "production" approach, finding that the firm is inefficient because of output shortfall where the output is losses leads to the remedy of increasing losses, a clearly inadvisable strategic solution in the long run.¹⁰

SUMMARY AND CONCLUSION

Here, we have presented the financial intermediary approach to the determination of efficiency of the marketing distribution channel and organizational structure for insurance companies. This has been compared to the "production entity" that produces "value added" through loss payments. Within this financial intermediary approach, three outputs are used: return on investments, claims-paying ability, and solvency propensity. There is naturally a conflict between the relative importance of these three goals, and the managers making strategic decisions balance one concern versus another. On the other hand, under the production approach losses are considered as the output, even if they are beyond the managers' control (e.g., catastrophic losses). We have argued that the production approach is inappropriate for the determination of efficiency of decision making in the insurance firm.

In presenting our analysis, we have used a new DEA model (RAM measure) and allowed the interpretation of outputs as goals of the decision makers. Our use of the new RAM model also makes it easy to summarize the results into a scalar efficiency score which is capable of being used to rank the firms in terms of efficiency and hence allows for the application of rank-based statistical significance tests, such as the Mann-Whitney statistic for determining if there are statistically significant differences in efficiency between stock and mutual firms (there is) and between agent and direct marketing systems (there is). Finally, we were able to extend our tests to examine actual behavior between stock and mutual firms and agent and direct marketing systems on an input-by-input and output-by-output basis, yielding managerially relevant information for benchmarking (cf., Brockett et al., 2001).

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¹⁰ In the DEA literature, losses from natural catastrophes, such as might significantly increase output (and hence efficiency) in the production approach, would be considered nondiscretionary and not subject to managerial control. On the input side these nondiscretionary variables can be handled (cf., Banker and Morey, 1986) but as output variables, nondiscretionary variables are quite problematic to justify including conceptually.

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