ORGANIZATIONAL FORM AND EFFICIENCY: AN ANALYSIS OF STOCK AND MUTUAL PROPERTY-LIABILITY INSURERS

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ABSTRACT

This paper analyzes the efficiency of stock and mutual organizational forms in the property-liability insurance industry using non-parametric frontier efficiency methods. We test the managerial discretion hypothesis, which predicts that the market will sort organizational forms into market segments where they have comparative advantages in minimizing the costs of production, including agency costs. Both production and cost frontiers are estimated. The results indicate that stocks and mutuals are operating on separate production and cost frontiers and thus represent distinct technologies. The stock technology dominates the mutual technology for producing stock output vectors and the mutual technology dominates the stock technology for producing mutual output vectors. However, the stock cost frontier dominates the mutual cost frontier for the majority of both stock and mutual firms. The finding of separate frontiers and organization specific technological advantages is consistent with the managerial discretion hypothesis, but we also find evidence that stocks are more successful than mutuals in minimizing costs suggesting the existence of agency problems in the mutual organizational form.

Organizational Form And Efficiency:
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In the modern theory of the firm, agency costs provide an explanation for the structure of organizations, with the organizations that survive in any economic activity being the ones that deliver the desired product at the lowest possible price while covering agency costs and the costs of production (e.g., Jensen and Meckling, 1976). The insurance industry provides an interesting environment for studying agency theoretic hypotheses because different organizational forms coexist in the industry. This paper focuses on the two most important organizational forms in the property-liability insurance industry -- stock insurers, which are owned by shareholders, and mutual insurers, which are owned by policyholders. We test hypotheses regarding the relative efficiency of the stock and mutual organizational forms using nonparametric frontier efficiency methods.

Agency theory arguments have led to the development of several hypotheses about organizational form, stemming from the observation that stocks and mutuals have comparative advantages in dealing with different types of agency costs. The stock ownership form provides more effective mechanisms for controlling owner-manager conflicts than the mutual ownership form. Stock firms have alienable ownership claims, giving rise to control mechanisms such as proxy fights, hostile takeovers, and executive stock options that can reduce opportunistic behavior by managers. The control mechanisms available to mutual owners are much weaker. On the other hand, the owner-policyholder conflict is likely to be relatively high in the stock ownership form because stockholders have an incentive to expropriate value from policyholders by taking actions such as changing the risk-characteristics of the firm after policies have been issued. The mutual ownership form eliminates the owner-policyholder conflict by merging the ownership and policyholder functions.

Perhaps the most influential agency theoretic hypothesis about stocks and mutuals is the *managerial discretion hypothesis* (e.g., Mayers and Smith 1988). According to this hypothesis, the degree of managerial discretion required to operate in a given line of insurance is the primary determinant of the organizational form likely to succeed in that line. The hypothesis predicts that the stock ownership form will be dominant in lines of insurance where managers must be given a relatively large amount of discretion in pricing and underwriting, such as commercial coverages, and in operating over wider geographical areas. The stock form of ownership is likely to have a comparative advantage in these types of operations because of its superior mechanisms for owners to control managers. Mutuals, on the other hand, are likely to be more successful in lines that require less managerial discretion such as personal lines, where the need for individualized pricing and underwriting is relatively low. Where managerial discretion is limited, the elimination of the owner-policyholder conflict is likely to give mutuals a comparative advantage over stocks. Similarly, mutuals are predicted to be relatively successful in lines such as liability insurance with lengthy claims settlement lags, because a longer time horizon gives stock managers more opportunity to exploit policyholder interests. This is known as the *maturity hypothesis*.

Because the available mechanisms for controlling owner-manager conflicts in the mutual ownership form are relatively weak, the costs of managerial opportunism in the mutual ownership form are expected to be higher than in the stock ownership form. One potentially important type of managerial opportunism is "expense preference" behavior, where managers generate unnecessary costs through the consumption of perquisites. According to the *expense preference hypothesis*, mutuals are expected to be less successful than stocks in minimizing costs because of higher perquisite consumption or, more generally, the failure to choose the optimal input mix.

These hypotheses are not mutually exclusive; e.g., mutuals could be more successful in low managerial discretion or longer-maturity lines of insurance, even though mutual managers exhibit expense preference behavior. This outcome would imply that higher costs due to the use of suboptimal input combinations are not sufficient to offset the mutuals' advantage from eliminating the policyholder-owner conflict.

The managerial discretion and maturity hypotheses predict that firms with different organizational forms will be sorted into market segments where they have comparative advantages in minimizing production and agency costs. According to this hypothesis, one would not necessarily observe differences in efficiency among organizational forms after controlling for production technology and business mix. The expense preference hypothesis, on the other hand, predicts that mutual firms will have higher costs than stock firms after controlling for other firm characteristics.

In this paper, we test these agency theoretic hypotheses by using frontier efficiency methodologies to compare the efficiency of stock and mutual property-liability insurers. Our analysis is based on non-parametric, "best practice" production and cost frontiers estimated for a sample of 211 mutual and 206 stock insurance companies over the period 1981-1990. We use data envelopment analysis (DEA) (see Charnes, et al., 1994) to estimate production and cost frontiers and Malmquist indices (e.g., Grosskopf, 1993) to measure productivity growth over time.

The fundamental idea behind our hypothesis tests is that the stock and mutual organizational forms represent different technologies for producing insurance, where technology is defined as including the contractual relationships that constitute the firm as well as physical technology choices. If the managerial discretion and maturity hypotheses are correct, stocks and mutuals should be operating with different production and cost frontiers. Furthermore, the stock technology should dominate the mutual technology for producing stock outputs; and the mutual technology should dominate the stock technology for producing mutual outputs. If the expense preference hypothesis is correct, mutuals are expected to be less successful than stocks in minimizing costs.

The principal papers to deal organizational form in the insurance industry using frontier efficiency methods are Fecher, et al. (1993), Gardner and Grace (1993), Fukuyama (1997), and Cummins and Zi (1998). Our analysis extends this prior literature by providing the first frontier efficiency analysis of organizational form in the U.S. property-liability insurance industry, by measuring the efficiency of stocks and mutuals relative to the other group's frontiers (cross-frontier analysis), and by explicitly testing the managerial discretion and expense preference hypotheses.

Hypotheses Test Procedures and Methodology

Hypothesis Test Procedures

As mentioned above, the managerial discretion and maturity hypotheses predict that stocks and mutuals represent different technologies for producing insurance and, therefore, that stocks and mutuals are expected to operate on different frontiers. Furthermore, if these hypotheses are correct, then the stock and mutual technologies should be respectively superior in producing stock and mutual output vectors. The expense preference hypothesis predicts that mutuals will be less successful than stocks in minimizing costs. We test the hypotheses by estimating "best practice" production and cost frontiers. The production frontier represents the minimum quantity of inputs needed to produce a given output vector; while the cost frontier represents the minimum costs required to produce a given output vector, conditional on input prices.

We first test the null hypothesis that stock and mutual insurers are operating on the same frontier against the alternative hypothesis that they operate on different frontiers. Rejection of the null hypothesis in this case would be consistent with the managerial discretion and maturity hypotheses in that it supports the view that the two groups of firms are using different technologies. The rejection of this null hypothesis also would imply that comparing efficiencies based on the pooled frontier is not informative because the two groups of firms operate on separate frontiers. Because this null hypothesis is rejected, we do not present a separate analysis of the pooled frontier.

To provide more direct information on the hypothesis that firms are sorted into groups with comparative efficiency advantages, we conduct a second set of tests. In this set the null hypothesis is that each group's output vector could be produced with equal efficiency using the other group's production technology. This involves computing the efficiency of the firms in each group with reference to the other group's production or cost frontier. Rejection of this null hypothesis for both groups would imply that stocks and mutuals have developed dominant technologies for producing their respective output vectors. This would provide evidence in favor of our efficiency-based interpretation of the managerial discretion and maturity hypotheses. This set of tests permits us to provide evidence on which frontier is dominant for each observation in the sample by measuring the distance between the stock and mutual frontiers for each firm's vector of inputs and outputs.

Measuring both production and cost frontiers provides evidence on the expense preference hypothesis by separating the effect on costs of the choice of production technology from the choice of input mix, conditional on the technology.[1] Even if stocks and mutuals are sorted into market segments where they have technological advantages, such advantages could be eroded if firms fail

[1]The Farrell cost efficiency analysis conducted here decomposes *cost efficiency* (i.e., the ratio of the minimum costs the firm could have realized by operating on the efficient cost frontier to the actual costs incurred) into *technical efficiency*, a measure of the distance of the firm from the efficient production frontier, and *allocative efficiency*, a measure of the firm's success in choosing the cost-minimizing combination of inputs.

to choose cost- minimizing combinations of inputs (i.e., exhibit allocative inefficiency), an outcome that has been interpreted as evidence of expense preference behavior (Mester, 1989). Expense preferencing could coexist with the sorting of firms into efficient groups based on technology. For example, mutual managers could consume higher costs up to the point where the mutuals' cost advantage over stocks due to their superior technology is nearly eliminated.[2]

The third part of our analysis, which looks at the growth in productivity over time, also sheds light on the expense preference hypotheses. The use of Malmquist indices permits us to separate the growth in productivity into technical efficiency change and technical change, where technical efficiency change refers to change in a firm's distance from the production frontier and technical change refers to shifts in the frontier over time. We analyze the growth in productivity separately for the stock and mutual segments of the industry. If mutual managers have less incentive to operate efficiently, the inter-temporal performance of mutuals is likely to be inferior to that of stocks with regard to either technical efficiency change or technical change.

Methodology

Distance Functions and Efficiency. To analyze production frontiers, we employ the input-oriented distance function. Suppose producers use input vector $x = (x_1, x_2, \ldots x_k)^T \in \mathbb{R}_+^k$ to produce output vector $y = (y_1, y_2, ..y_n)^T \in \mathbb{R}_+^n$, where T denotes the vector transpose. A production technology which transforms inputs into outputs can be modeled by an input correspondence $y \rightarrow V(y) \subseteq \mathbb{R}_+^k$. For any $y \in \mathbb{R}_+^n$, V(y) denotes the subset of *all* input vectors $x \in \mathbb{R}_+^k$ which yield at least y. The input-oriented distance function for a specific decision making unit (DMU) is

[2]This type of outcome would require some limitation on competition that permits the survival of inefficient firms. Evidence of maintained efficiency differences over time in banking and insurance, respectively, is provided by Cummins and Weiss (1993) and Berger and Humphrey (1992).

$$D(y,x) = sup\{\theta : (y, \frac{x}{\theta}) \in V(y)\} = (inf\{\theta : (y, \theta x) \in V(y)\})^{-1} \quad \textbf{(1)}$$

The input distance function is the same as the reciprocal of the minimum equi-proportional contraction of the input vector x, given outputs y, i.e., Farrell's measure of input technical efficiency T(y,x), where T(y,x) = 1/D(y,x). The quantity D(y,x) must be $\geq$ 1, and T(y,x) is $\leq$ 1 but > 0.

Distance functions can be estimated with respect to frontiers characterized by constant returns to scale (CRS), variable returns to scale (VRS), and non-increasing returns to scale (NIRS). In this paper, we work exclusively with CRS frontiers. This is the approach used most commonly in the literature because it represents the optimal outcome from an economic perspective, i.e., with CRS, firms are not consuming unnecessary resources because they are too large or too small. The CRS approach measures departures from optimal scale as inefficiency.

We can also define a minimum cost function or cost frontier using the distance function approach (Lovell, 1993). Let $w = (w_1, w_2, \ldots, w_K)^T$ denote the input price vector corresponding to the input vector x. Then the cost frontier is defined as:

$$c(y,w) = \min_x \{w^T x : D(y,x) \geq 1\} \quad \textbf{(2)}$$

where c(y,w) = the cost frontier. The optimal input vector x^* minimizes the costs of producing y given the input prices w. Cost efficiency is calculated as the ratio $\eta = w^T x^* / w^T x$, where x represents actual input usage and $0 < \eta \leq 1$. With estimates of cost efficiency and technical efficiency, we can back out estimates of allocative efficiency using the relationship C(y,x) = T(y,x)*A(y,x), where C(y,x) is cost efficiency, T(y,x) is technical efficiency, and A(y,x) is allocative efficiency.

The Malmquist index approach is used to measure technical efficiency change and technical change. Technical efficiency refers to the reciprocal of the distance from the production frontier and technical change refers to movements in the frontier over time. To define the Malmquist index for the production frontier, we modify equation (1) to incorporate time and define input distance functions with respect to two different time periods, as follows:

$$D^{t}(y^{t+1}, x^{t+1}) = sup\{\theta : (y^{t+1}, \frac{x^{t+1}}{\theta}) \in V(y^{t})\} \qquad \textbf{(3)}$$

$$D^{t+1}(y^{t}, x^{t}) = sup\{\theta : (y^{t}, \frac{x^{t}}{\theta}) \in V(y^{t+1})\} \qquad \textbf{(4)}$$

In equation (3), the input-output bundle in time period t+1 is evaluated relative to the technology of time period t; while in equation (4) the input-output bundle observed in period t is evaluated relative to the technology of time t+1. Malmquist productivity indices can be defined relative to either the technology in period t or the technology in period t+1, as follows:

$$M^{t} = \frac{D^{t}(y^{t}, x^{t})}{D^{t}(y^{t+1}, x^{t+1})} \quad or \quad M^{t+1} = \frac{D^{t+1}(y^{t}, x^{t})}{D^{t+1}(y^{t+1}, x^{t+1})} \qquad \textbf{(5)}$$

where M^t measures productivity growth between periods t and t+1 using the technology in period t as the reference technology, while M^{t+1} measures productivity growth with respect to the technology in period t+1. The input-oriented Malmquist productivity index is the geometric mean of M^t and M^{t+1}, which can be factored as follows:

$$M(y^{t+1}, x^{t+1}, y^{t}, x^{t}) = (\frac{D^{t}(y^{t}, x^{t})}{D^{t+1}(y^{t+1}, x^{t+1})}) [(\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^{t}(y^{t+1}, x^{t+1})})(\frac{D^{t+1}(y^{t}, x^{t})}{D^{t}(y^{t}, x^{t})})]^{\frac{1}{2}} \qquad \textbf{(6)}$$

The first factor in equation (6) represents technical efficiency change, i.e., the relative distance of the input-output bundle from the frontier in periods t and t+1. The second factor in equation (6) represents technical change (shifts in the frontier) between periods t and t+1. If technical improvement occurs, the frontier will shift in a favorable direction, and both ratios comprising the geometric mean will exceed 1. Thus, values of the second factor > 1 imply technical progress and values < 1 imply technical regress.

To test the hypotheses investigated in this study, we need to estimate distance functions for stock and mutual insurers with respect to several reference sets. In the following discussion, subscripts on D indicate the reference set of firms used to construct the frontier. E.g., $D_s(y_s, x_s)$ is the input distance function for stock firm s, measured with respect to a reference frontier consisting only of stock firms, where s = 1, 2, . . ., S, and S = the number of stock firms in the sample. Likewise, $D_m(y_m, x_m)$ represents the input distance function for mutuals, where m = 1, 2, . . ., M, and M = the number of mutual firms. The pooled frontier for stock and mutual firms is denoted $D_p(y_i, x_i)$.

We also compute distances of mutuals from the stock frontier and distances of stocks from the mutual frontier, i.e., each group of firms is used as the reference set for the other group. This method requires the estimation of *cross-frontier* distance functions:

$$D_m(y_s, x_s) = sup\{\theta : (y_s, \frac{x_s}{\theta}) \in V(y_m)\},\ s = 1,2,\ldots,S \quad \textbf{(7)}$$

I.e., $D_m(y_s, x_s)$ is the input distance function for stock firm s relative to mutual frontier. $D_s(y_m, x_m)$ is defined similarly. This enables us to measure the efficiency of the firms with a particular organizational form relative to a best practice frontier based on the alternative organizational form.

Whereas the distance function values for firms relative to their own group must be ≥ 1, the distances relative to the other group's frontier can be >, =, or < 1. This is illustrated in Figure 1, which shows isoquants for two hypothetical firms producing a single output with two inputs. The isoquant for stocks is labeled $L^S(y)$, and the isoquant for mutuals is labeled $L^M(y)$. The isoquants represent the best technology for the respective groups of firms, i.e., firms operating on the isoquants are on the production frontier and thus are fully efficient (T(y,x) = 1). To illustrate the group-specific frontiers, consider stock firm s, which operates at point b. This firm could reduce its input usage by moving to the frontier and operating at point a. Its distance function value is $D_s(y_s, x_s)$ = 0b/0a > 1. Likewise, the input distance function value for mutual firm m, operating at point e, is $D_m(y_m,x_m)$ = 0e/0d > 1. The stock and mutual isoquants in Figure 1 have been drawn so that they intersect. This means that neither technology dominates the other for all combinations of inputs. The distance of the stock firm from the mutual frontier is $D_m(y_s,x_s)$ = 0b/0c < 1, and the distance of the mutual from the stock frontier is $D_s(y_m,x_m)$ = 0e/0f < 1, i.e., each firm is using an input vector that dominates the other group's technology. If the stock isoquant is to the left of the mutual isoquant for all input combinations, then the stock technology is dominant for producing output level y and $D_s(y_m,x_m)$ would always exceed 1.

Since technical efficiencies are obtained as reciprocals of input distance functions, these results imply that the group-specific efficiencies must be ≤ 1, i.e., a firm cannot do better than to operate on the frontier, but the cross-frontier efficiencies can be less than, equal to, or greater than 1. A cross-frontier efficiency greater than 1 means that a firm's input-output bundle is infeasible using the other group's technology. In terms of Figure 1, the output-input combination (y_s,x_s) is infeasible using the mutual technology and the output-input combination (y_m,x_m) is infeasible using the stock technology.

Under the managerial discretion and maturity hypotheses, one would expect to observe stock (mutual) firms operating in the region where stock (mutual) technology dominates. To measure dominance with respect to the production frontiers, we compute the distance between the frontiers for each firm in the sample. For example, for mutual firms we define the distance as:

$$F_t(y_m, x_m) = 1 - \frac{D_s(y_m, x_m)}{D_m(y_m, x_m)} = 1 - \frac{T_m(y_m, x_m)}{T_s(y_m, x_m)} \quad \textbf{(8)}$$

For the mutual firm portrayed in Figure 1, $F_t(y_m,x_m)$ = 1-0d/0f = (0f-0d)/0f, which provides a measure of the distance between the frontiers expressed as a ratio to the quantity of inputs required to produce the firm's output vector under the stock technology.[3] Likewise, for the stock firm in Figure 1, $F_t(y_s,x_s)$ = (0a-0c)/0c. A value of $F_t(y_i,x_i) < 0$ implies that the stock technology is dominant for input-output vector (y_i,x_i), while a value of $F_t(y_i,x_i) > 0$ implies that the mutual technology is dominant. Intuitively, if the mutual firm, for example, has higher efficiency with respect to its own frontier than it does with respect to the stock frontier, it would have to improve more to become fully efficient relative to the stock frontier, and thus a stock firm producing its output vector would be more efficient. The comparable measure based on cost efficiency $F_c(y_i,x_i)$ is defined similarly.

Estimating Efficiency. DEA efficiency is estimated by solving linear programming problems. For example, the technical efficiency with respect to the pooled frontier is estimated by solving the following problem, for each firm, i = 1,2,... S+M, in each year of the sample period:

$$(D_p(y_i, x_i))^{-1} = T_p(y_i, x_i) = \min \theta_i$$
$$\textit{subject to}: \quad Y_p \lambda_i \geq y_i; \quad X_p \lambda_i \leq \theta_i x_i; \quad \lambda_i \geq 0. \quad \textbf{(9)}$$

where $\mathbf{Y_p}$ is an N x (S+M) output matrix and $\mathbf{X_p}$ a K x (S+M) input matrix for all firms in the sample, y_i is an N x 1 output vector and x_i a K x 1 input vector for firm i, and λ_i is an (S+M) x 1 intensity

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[3]Because we are interested primarily in the sign of $F_t(x_i,y_i)$, the conclusions would be the same if we normalized the frontier distance to the input quantity needed to produce y_i under the mutual technology.

vector. Efficiencies for the stock and mutual samples, $T_s(x_s,y_s)$ and $T_m(x_m,y_m)$ are estimated similarly. The constraint $\lambda_i \geq 0$ imposes constant returns to scale.

Cross-frontier efficiencies of stock firms with respect to the mutual reference set are obtained by solving the following linear programming model, for each stock firm in each time period:

$$(D_m(y_s, x_s))^{-1} = T_m(y_s, x_s) = \min \theta_s \qquad (10)$$

Subject to: $Y_m \lambda_s \geq y_s$, $X_m \lambda_s \leq \theta_s x_s$, $\lambda_s \geq 0$,where $\mathbf{Y}_m$ is an N x M output matrix and $\mathbf{X_m}$ a K x M input matrix for all *mutual* firms, y_s is an N x 1 output vector and x_s a K x 1 input vector of the *stock* firm s, and λ_s an M x 1 intensity vector of mutuals with respect to stock firm s. The efficiency $D_s(y_m,x_m)$ is estimated similarly.

For technical efficiency, we estimate two input distance functions ($D_s(x_s,y_s)$ and $D_m(x_s,y_s)$) for 206 stock firms and two input distance functions ($D_m(x_m,y_m)$ and $D_s(x_m,y_m)$) for 211 mutual firms. The pooled distance function $D_p(x_p,y_p)$ is also estimated to test our first null hypothesis.

The following problem is solved as the first step to obtain cross-frontier cost efficiencies of mutuals with respect to the stock frontier:

$$\underset{x_m}{Min} \quad w_m^T x_m \qquad \mathbf{(11)}$$

subject to: $Y_s\lambda_m \geq y_m$, $X_s\lambda_m \leq x_m$, $\lambda_m \geq 0$, where Y_s and X_s are output and input matrices for all stock firms and y_m and x_m are output and input vectors for mutual firm m, m = 1, 2, . . ., M, and λ_m is an intensity vector for stocks relative to the mutual firm. The solution x_m* is the cost-minimizing input vector for firm m. The second step is to calculate cost efficiency $\eta_m = w_m^T x_m^* / w_m^T x_m$, where x_m* is the cost-minimizing input vector for mutual firm m with respect to the stock reference set. Own-frontier cost efficiency is calculated similarly.

3. Outputs, Inputs, and Sample Selection

Measuring Outputs, Inputs, and Input Prices. Consistent with most of the recent financial institutions literature, we adopt a modified version of the value-added approach to measure property-liability insurer outputs. The value-added approach counts as important outputs those that have significant value added, as judged using operating cost allocations (see Berger and Humphrey, 1992).

We follow the recent insurance efficiency literature in defining insurance output as the present value of real losses incurred (e.g., Cummins and Weiss, 1993, Berger, Cummins, and Weiss, 1997). The rationale for the use of losses to proxy for insurance output is that the primary function of insurance is risk pooling, i.e., the collection of funds from the policyholder pool and the redistribution of funds to those pool members who incur losses. Losses are also a good proxy for "real services" provided by insurers such as coverage design and providing legal defense in liability suits. Because underwriting risk and service intensity vary by line of business, we disaggregate losses into four categories: short-tail personal lines, short-tail commercial lines, long-tail personal lines, and long-tail commercial lines.[4] Because insurers report their losses incurred at undiscounted values, we discount the losses to present value using estimated industry-wide payout patterns.[5] Losses are deflated to the base year 1982 using the Consumer Price Index (CPI).

In addition to pooling losses and providing insurance services, insurers also perform a financial intermediation function by borrowing funds from policyholders and then investing the

[4]The designations "long-tail" and "short-tail" refer to the length of the lag between the policy inception and loss payment dates. E.g., liability insurance is a "long-tail" line and auto collision a "short-tail" line.

[5]Payout patterns are estimated from data reported in *Best's Aggregates and Averages* (A.M. Best Company, Oldwick, NJ, various years). The discount rates are based on the U.S. Treasury yield curves reported by Coleman, Fisher, and Ibbotson (1989), updated through 1990 using data from other sources.

funds in marketable securities. Our output measure for the intermediation function is total invested assets, expressed in real 1982 dollars by deflating by the CPI.

Insurance inputs can be classified into four groups: labor, business services, debt capital, and equity capital. Our labor costs variable is the sum of salaries, employee benefits, payroll taxes, and other employment-related costs. The quantity of labor input is defined as labor costs divided by a salary deflator, which indexes average weekly employee wages for Standard Industrial Classification (SIC) Class 6331, Fire, Marine, and Casualty Insurers . The salary deflator is interpreted as the price of labor input. The business services category is dominated by outside business services such as agents' commissions and loss adjustment expenses.[6] The input price index for business services is calculated similarly to the labor price index using SIC 7399, Business Services.

The debt capital of insurers consists primarily of funds borrowed from policyholders. These funds are measured in real terms as the sum of loss reserves and unearned premium reserves, deflated to the base year 1982 using the CPI. The cost of policyholder-supplied debt capital is estimated as the ratio of total expected investment income minus expected investment income attributed to equity capital divided by average policyholder-supplied debt capital. Equity capital is an input for the risk-pooling function because it provides assurance that the company can pay claims even if they are larger than expected. Thus, the real value of equity capital (deflated to 1982 by the CPI) is considered an input category. The cost of equity capital is estimated as the ratio of the insurer's expected net income to the average value of equity capital.[7] To summarize, we use four

[6]The costs of physical capital (mainly rental expenses and computers) are small relative to the other inputs. Accordingly, physical capital is incorporated into the business services category.

[7]Since net income tends to fluctuate due to the randomness of loss payments, we computed the expected cost of capital as the predicted value of the ratio of net income to equity from a pooled cross-

inputs: labor, materials, policyholder supplied debt capital, and equity capital.

Sample Selection. Our primary data source consists of the regulatory annual statements filed by insurers with state insurance commissioners. To estimate the evolution of efficiency and technical change in the industry, we selected a complete panel of insurers with data continuously available over the sample period, 1981-1990. The decision making units (DMUs) in the insurance industry consist of groups of affiliated insurers under common ownership and individual, unaffiliated insurers. The sample consists of all groups and unaffiliated insurers for which meaningful data were available over the entire sample period -- 206 stock insurers and 211 mutuals. The insurers in the sample accounted for 90 percent of industry assets during our sample period.

Summary statistics are presented in Table 1. Stock firms on average are larger than mutuals in terms of costs, input and output quantities, and invested assets. Stocks also produce more commercial lines output (53 percent of insurance output versus only 25 percent for mutuals). Long-tail personal lines such as personal auto liability represent 51 percent of the mutuals' insurance output. These patterns of business mix are consistent with the managerial discretion and maturity hypotheses. Also consistent with the managerial discretion hypothesis, stocks on average have lower geographical Herfindahl indices than mutuals, where the indices are based on the proportions of net premiums written by state.

4. Results

Average Efficiencies

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section time-series regression of this variable on variables representing insurer characteristics. Regressors include the proportions of bonds and stocks in the investment portfolio, insurance output quantities, leverage (the premiums-to-surplus ratio), the intermediate-term government bond yield, and year dummy variables.

Our first null hypothesis is that stocks and mutuals are operating on the same frontier, i.e., that a pooled frontier can be used to analyze differences in efficiency between the two organizational forms. The test involves estimating the pooled frontier as well as the group-specific mutual and stock frontiers and then testing the hypothesis that the pooled and group-specific frontiers are identical. The Wilcoxon, Savage and Van der Waeden non-parametric tests as well as ANOVA overwhelmingly reject the hypothesis that the mutual production frontier is identical to the pooled production frontier based on the input distance function results. The tests did not lead to rejection of the hypothesis that the stock frontier differs from the pooled frontier. Nevertheless, the strong rejection with respect to mutuals implies that technical efficiency comparisons should be based on separate mutual and stock frontiers; and, because cost efficiency depends on technical efficiency, the results also imply that cost efficiency comparisons should be based on separate frontiers.

The technical efficiency scores based on separate mutual and stock frontiers are shown in the columns headed $T_s(y_s,x_s)$ and $T_m(y_m,x_m)$ in Table 2.[8] Mutuals are significantly more efficient with respect to the mutual frontier, in comparison with the efficiency of stocks relative to the stock frontier, in every year of the sample period; and the dispersions of the mutual efficiency scores within each year of the sample period are lower than the dispersions of the stock scores. The findings with respect to both average efficiencies and dispersions would be consistent with stocks' operating in more complex and heterogeneous lines of business as predicted by the managerial discretion hypothesis. Efficiencies might be lower in complex lines because it is easier to make

[8]Asterisks between pairs of columns give the results of significance tests for differences between the results in the corresponding cells of the two columns. Reported significance levels are based on analysis of variance (ANOVA). Non-parametric tests, including the Kruskal-Wallis, Van der Waerden, and Savage tests, produced similar results.

mistakes in designing technologies when underwriting and pricing complicated or individualized insurance policies. These results cannot be interpreted as implying that the output of stock insurers would be produced more efficiently by mutuals, however, because the firms are using different technologies, reflected in different production frontiers.

We also compute the technical efficiencies of the mutuals relative to the stock frontier and the technical efficiencies of stocks relative to the mutual frontier, i.e., the *cross-frontier efficiencies*. This provides evidence on our second major null hypothesis, that each group of firms is dominant on average in producing the output vectors chosen by members of the group. These results are shown in the columns of Table 2 headed $T_m(y_s,x_s)$ and $T_s(y_m,x_m)$, respectively. The stock relative-to-mutual-frontier average scores ($T_m(y_s,x_s)$) are consistently greater than 1, implying that it is not feasible, on average, to replicate stock input-output combinations using the mutual technology, i.e., the stock technology dominates mutual technology for producing the stock firms' output vectors. The mutual technical efficiencies with respect to the stock frontier ($T_s(y_m,x_m)$) are also greater than 1 in 8 of 10 years and on the average, although the mutual-to-stock-frontier scores are lower than the stock-to-mutual-frontier scores. Thus, the mutual technology weakly dominates stock technology in producing mutual outputs.[9]

The significance tests reported in the last two columns of Table 2 show that stock technical efficiencies relative to the stock frontier are significantly lower than stock efficiencies relative to the mutual frontier, providing further evidence that the stock technology is dominant in producing the

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[9]Our estimates of economies of scale indicate that 52 percent of stocks and 61 percent of mutuals are operating at constant returns to scale and that almost all of the remaining firms operate at decreasing returns to scale. Thus, the smaller technological advantage of mutuals over stocks in producing mutual outputs in comparison to the technological advantage of stocks over mutuals in producing stock outputs does not appear to be attributable to differences in scale efficiency.

stock output vectors. Likewise, mutual efficiencies relative to the mutual frontier are consistently and significantly lower than mutual efficiencies relative to the stock frontier, again suggesting that the mutual technology is dominant in producing mutual output vectors.

The cost efficiency results are shown in Table 3. Statistical testing led to the strong rejection of the null hypotheses that the stock and mutual frontiers are identical to the pooled frontier. Consequently, we focus on the stock and mutual frontier results. The cost efficiencies for the stock and mutual samples based on their respective frontiers are shown in the first and second columns of Table 3, headed $C_s(y_s,x_s)$ and $C_m(y_m,x_m)$, respectively. For the sample period as a whole, mutual efficiency averaged 68.2 percent, while stock efficiency averaged 61.7 percent. These results imply that mutuals could have reduced their costs by 31.8 percent, on average, if they had been operating with full efficiency, and that stocks could have reduced their costs by 38.3 percent; but, as above, the results are not correctly interpreted as suggesting that mutuals are more cost efficient than stocks.

The cross-frontier cost efficiency comparisons are presented in the columns headed $C_m(y_s,x_s)$ (stocks compared to the mutual frontier) and $C_s(y_m,x_m)$ (mutuals compared to the stock frontier). None of the individual year averages of $C_m(y_s,x_s)$ or $C_s(y_m,x_m)$ exceeds 1, implying that both stocks and mutuals on average operate inside of both cost frontiers. The loss of efficiency relative to the technical frontiers is due to allocative inefficiency – the choice of suboptimal input combinations.

The efficiencies of the stocks relative to the mutual frontier ($C_m(y_s,x_s)$) are significantly higher than the efficiencies of the stocks relative to the stock frontier ($C_s(y_s,x_s)$) in nine of ten years and overall, paralleling the technical efficiency results, and implying that the stock cost frontier dominates the mutual frontier for the stock firms' output vectors. However, average cost efficiencies of mutuals relative to the stock frontier ($C_s(y_m,x_m)$) are significantly *lower* than the efficiencies relative to the mutual frontier ($C_m(y_m,x_m)$) during the first four years of the sample period and overall. Mutual efficiencies relative to the stock frontier are significantly higher than their efficiencies relative to the mutual frontier in only one year (1988). This implies that the stock frontier dominates the mutual frontier in terms of cost efficiency.

To summarize, the technical efficiency results presented in this section imply that stocks and mutuals are using different technologies and that the stock (mutual) technology is superior on average to the mutual (stock) technology for producing the stock (mutual) firms' output vectors. This is consistent with the managerial discretion hypothesis. However, the stocks' comparative advantage in producing stock outputs exceeds the mutuals' comparative advantage in producing mutual outputs. This is as expected if the stock firms are engaged in more complex operations where technical superiority is important. Both types of firms experience erosion of their technological advantage due to suboptimal input combinations (allocative inefficiency). For stocks, allocative inefficiency reduces but does not eliminate their comparative advantage in producing stock output combinations. However, due to the smaller technological advantage of mutuals, allocative inefficiency leads to dominance of the mutual cost frontier by the stock cost frontier for the mutuals' output combinations. Thus, overall, the mutual form of ownership is inferior to the stock form of ownership in terms of cost minimization.

Cross-Frontier Efficiency: Further Analysis

In this section we conduct further analysis of the cross-frontier efficiency results using the statistics $F_t(y_i,x_i)$ and $F_c(y_i,x_i)$ defined in equation (8). Recall that if $F_i(y_i,x_i) < 0$ ($i = t, c$) for (y_i,x_i), then stocks dominate mutuals for that output-input vector, and if $F_i(y_i,x_i) > 0$, mutuals dominate stocks. We first investigate production and cost cross-frontier dominance by size quartile to determine whether the same conclusions hold for firms in various size categories. And, second, we conduct regression analysis to test predictions of the managerial discretion and maturity hypotheses.

The quartile results are presented in Table 4, which shows $F_t(y_i,x_i)$ and $F_c(y_i,x_i)$ for each size group as well as significance tests of the null hypothesis that the averages are equal to zero. The results in the production frontiers section of Table 4 confirm our inference that stock technologies are superior in producing stock output vectors and mutual technologies are superior in producing mutual output vectors. Stock superiority exceeds that of mutuals in all size quartiles, and for both organizational forms technical dominance is declining in size. The results in the cost frontier section of Table 4 show that the average values of $F_c(y_i,x_i)$ are significantly less than zero for all four size quartiles and both organizational forms.

Cross-frontier allocative efficiency results, also shown in Table 4, allow us to make an inference regarding the expense preference hypothesis. Allocative efficiency problems are often interpreted as evidence of expense preference behavior in the sense that management is over-consuming some inputs and under consuming others (e.g., Mester, 1989). The results in the allocative efficiency section of Table 4 show that stocks dominate mutuals in the production of mutual output vectors overall and in all size quartiles, whereas mutuals dominate stocks overall and in the three smaller size quartiles in the production of stock output vectors. However, the degree of stock allocative dominance over mutuals is significantly larger than the degree of mutual allocative dominance over stocks in all quartiles and overall.[10] E.g., the overall mean for stock dominance over mutuals is -0.156, nearly twice as large in absolute value as the mean mutual dominance over stocks

[10]This is based on tests of differences between absolute values of the means in the stock and mutual cross-frontier allocative efficiency columns in Table 4. The z-statistics are 2.75, 2.58, 3.49, and 5.25 for quartiles 1 through 4, respectively, and 6.82 overall.

(0.082). Thus, in this specific sense, mutuals are less successful than stocks in choosing optimal input combinations, providing support for the expense preference hypothesis. It is also interesting that mutuals do not dominate stocks in the largest size quartile in terms of cross-frontier allocative efficiency and that their dominance is progressively larger the smaller the size quartile. This suggests that large mutuals are more likely to suffer from agency problems than smaller mutuals, i.e., that the stock organizational form's superior control mechanisms are more important in larger organizations.

The managerial discretion hypothesis predicts that mutuals are likely to have a comparative advantage in personal lines such as private passenger auto insurance where the need for managerial discretion is low. In addition, the maturity hypothesis predicts that mutuals will have a comparative advantage in long-tail lines because the owner-policyholder conflict is relatively strong in such lines. To analyze the comparative advantages of the stock and mutual ownership forms by line of business, we regress $F_t(y_i,x_i)$ and $F_c(y_i,x_i)$, respectively, on a set of independent variables representing organizational form, size, and business mix. The regression results are presented in Table 5. Three models are presented for each dependent variable. Model 1 includes a dummy variable for the stock form of ownership (STOCK = 1 for stocks, 0 for mutuals), dummy variables representing the second, third, and fourth size quartiles (the first quartile is the smallest), interaction terms between the organizational form and size dummies, and the proportion of total insurance output in the long-tail commercial lines (LTC%), short-tail personal lines (STP%), and short-tail commercial lines (STC%). Model 2 adds interaction terms between the organizational form dummy (STOCK) and the business mix variables to allow the effects of organizational form to differ by line. Model 3 adds interactions between the business mix variables and size, where size is measured by the log of total insurance output, and between business mix, size, and organizational form.

The comparative advantage of the two ownership forms by line of business is seen most clearly in Model 2 by considering the interactions between the business mix variables (LTC%, STP%, and STC%) and the dummy variable STOCK in both the technical and cost regressions. The omitted category, LTP%*STOCK, reflects the proportion of insurance output in the long-tail personal lines. The negative coefficients on the stock organizational form/business mix interaction terms imply that stocks tend to have a comparative advantage in writing these lines relative to long-tail personal lines, i.e., an increase in the proportion of business in these lines tends to shift the stock frontier to the left of the mutual frontier. This is consistent with the agency theoretic prediction that mutuals dominate in long-tail personal lines. The coefficient on the long-tail commercial/stock interaction term (LTC%*STOCK) is lower (in absolute value) than the coefficient on the short-tail commercial/stock interaction (STC% *STOCK) in the technical dominance version of Model 2, consistent with the argument that the comparative advantage of stocks is relatively low in long-tail lines (these coefficients are about the same in the cost version of Model 2). The significant negative coefficient on the short-tail personal/stock interaction (STP%*STOCK) provides further evidence that mutuals have an advantage in long-tail lines.

We also conduct a Malmquist index analysis to measure productivity change for stock and mutual insurers during our sample period. Based on the Malmquist analysis, we decompose productivity growth into efficiency change and technical change components. Favorable efficiency change is interpreted as evidence of "catching-up" to the frontier, while favorable technical change is interpreted as innovation. The Malmquist analysis is based on a comparison of adjacent years, i.e., indices were estimated for 1981-1982, 1982-1983, . . ., 1989-1990.

For both stocks and mutuals, technical efficiency and technical change indices fluctuate in a narrow range about 1.0, and the geometric mean of the nine year-to-year changes in the Malmquist index and its two components also is close to 1.0. Analysis of variance tests reveal virtually no significant differences between stocks and mutuals in efficiency change, technical change, or total factor productivity growth. Thus, the technical efficiency and productivity changes over the period were not dramatic and did not vary significantly by organizational form. The Malmquist results reinforce our earlier findings that the most significant differences between stocks and mutuals arise in comparisons of cost efficiency and also reinforces the inference that slippages due to allocative inefficiency account for the dominance of the mutuals by the stocks in terms of cost efficiency.

5. Conclusions

In this paper, we test three agency theoretic hypotheses about stock and mutual organizational forms in the insurance industry: (1) The managerial discretion hypothesis, which predicts that stock insurers have a comparative advantage in lines of insurance where relatively high levels of managerial discretion are required because the stock ownership form affords superior mechanisms for owners to control managers; (2) the maturity hypothesis, which predicts that mutuals have a comparative advantage in lines of insurance with relatively long payout periods because the owners' incentive to exploit policyholder interests is eliminated by merging the owner and policyholder functions; and (3) the expense preference hypothesis, which predicts that mutuals will be less efficient than stocks because the weaker control mechanisms in the mutual ownership form permit managers to engage in excessive consumption of perquisites. The first two hypotheses imply that the mutual and stock forms of ownership represent different technologies for producing insurance, where technology includes contractual relationships as well as physical technology choices.

This paper provides evidence on these hypotheses by estimating technical and cost efficiency for stock and mutual property-liability insurers representing nearly 90 percent of industry revenues over the period 1981-1990. We first test the hypothesis that the mutual and stock ownership forms represent different technologies by testing whether pooled technical and cost frontiers are identical to group-specific frontiers, where mutual (stock) efficiencies are measured with mutuals (stocks) as the reference set. The hypotheses that the two groups of firms are operating on the same production and cost frontiers are strongly rejected consistent with the two organizational forms representing distinct technologies.

We seek stronger evidence regarding the managerial discretion, maturity, and expense preference hypotheses by conducting cross-frontier efficiency estimations where each stock (mutual) firm's efficiency is measured relative to a reference set consisting of all mutual (stock) insurers. By comparing the cross-frontier estimates with the group-specific frontier estimates, we can determine which technology (mutual or stock) is dominant for producing each output vector observed in our sample. If a specific firm's efficiency score relative to its group-specific frontier is greater than its cross-frontier efficiency score, then its group's technology is dominated by the technology of the other group. Intuitively, this firm would have to improve more to achieve full efficiency using the alternative technology than to achieve full efficiency using its own technology.

The analysis of <u>production frontiers</u> implies that the mutual frontier dominates the stock frontier for producing the mutual firms' output vectors, while the stock frontier dominates the mutual frontier for producing the stock firms' output vectors. This supports the managerial discretion and maturity hypotheses because it implies that the two organizational forms have been sorted into activities where they have comparative technological advantages. Regression analysis reveals that mutuals have a comparative advantage in writing long-tail personal lines, providing further support for the hypotheses.

Analysis of <u>cost frontiers</u>, on the other hand, shows that the stock technology tends to dominate the mutual technology in terms of cost efficiency not only for stock firms but also for mutuals. Cost efficiency encompasses both technical efficiency and allocative efficiency, where the latter measures the firm's success in employing the cost-minimizing combination of inputs. Thus, taken together, the production and cost frontier results suggest that mutuals have developed a superior technology for producing their output vectors but that this advantage is dissipated because of their failure to minimize costs. Although the stock firms' technological advantage is also eroded due to allocative inefficiency, their greater superiority in technical efficiency allows the stocks' cost frontier to be dominant for both types of firms. The dominance of the stocks in terms of cost efficiency is consistent with the expense preference hypothesis. This finding is reinforced by the cross-frontier allocative efficiency analysis.

Our findings suggest a richer interpretation of organizational form in insurance markets than provided by previous researchers. The sorting of stock and mutual firms into market segments where they have comparative advantages and the long-term coexistence of the two types of firms are not necessarily inconsistent with the mutuals' being less successful than stocks in minimizing costs. Search costs (Dahlby and West, 1986), slow diffusion of information in insurance markets, and private information (D'Arcy and Doherty, 1991) provide possible explanations for the survival of less efficient mutuals.

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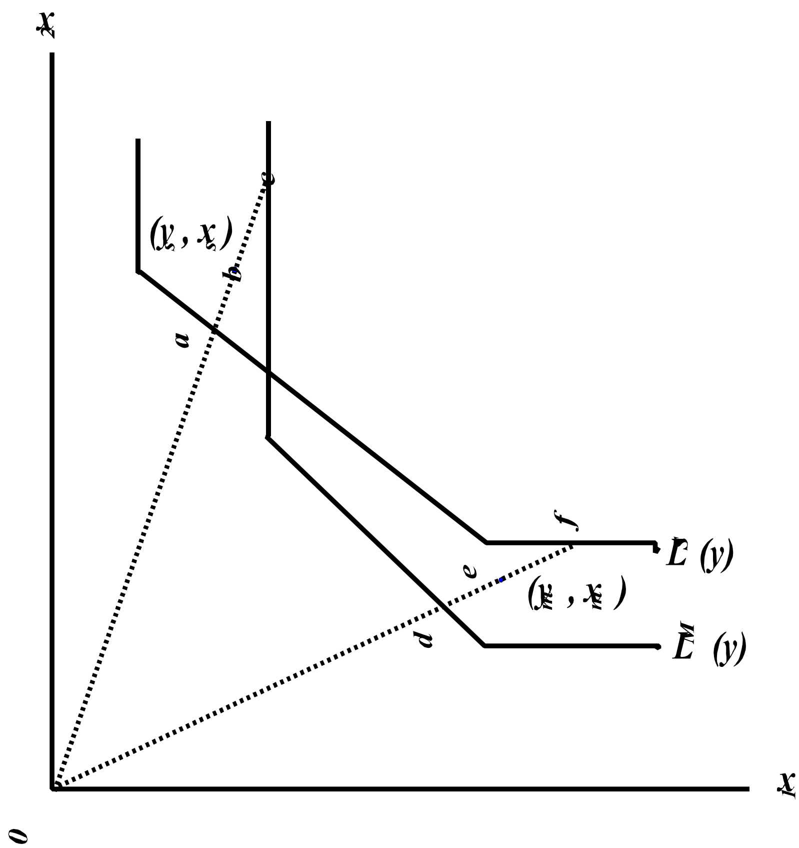

Figure 1

Stock and Mutual Production Frontiers and Input Distance Function Under Constant Returns to Scale

$D_s(y_s, x_s) = 0b/0a > 1$
$D_m(y_s, x_s) = 0b/0c < 1$
$D_m(y_m, x_m) = 0e/0d > 1$
$D_s(y_m, x_m) = 0e/0f < 1$

Table 1
Summary Statistics for Stock and Mutual Samples

Variable Definition	Sample Means: Pooled	Stock		Mutual
Number of Firms	417	206		211
Total Cost	177.2	247.6	***	114.3
Price of labor input	0.986	0.986		0.986
Price of materials input	1.218	1.218		1.218
Price of equity capital input	0.0970	0.1011	***	0.0935
Price for policyholders' funds	0.0614	0.0613		0.0615
Labor input	34.3	46.3	***	23.5
Materials input	76.3	107.6	***	48.3
Equity capital input	185.1	241.9	***	134.2
Policyholders' debt capital input	413.0	608.1	***	238.4
Short tail personal lines output	29.9	29.8		30.0
Short tail commercial output	25.8	41.7	***	11.5
Long tail personal lines output	68.3	72.9		64.3
Long tail commercial lines output	46.1	75.1	***	20.2
Short tail personal lines price	0.645	0.718	***	0.582
Short tail commercial price	0.863	0.801	**	0.917
Long tail personal lines price	0.646	0.596	***	0.689
Long tail commercial lines price	1.094	1.013	***	1.164
Real invested assets	506.8	701.8	***	332.2
Return on assets	0.033	0.027		0.038
Herfindahl index (geographic: by state)	0.589	0.527	***	0.644
Herfindahl index by line (direct premiums written)	0.440	0.461	**	0.421
Premiums-to-surplus ratio	1.846	1.939	***	1.763

Note: All output and input quantities are in millions of 1982 dollars. Output volume is the present value of real losses (1982 dollars).
*******Statistically significant difference between stocks and mutuals at the 1% level.
******Statistically significant difference between stocks and mutuals at the 5% level.

TABLE 2
TECHNICAL EFFICIENCY RESULTS: 1981-1990

Year	Ts(ys,xs)		Tm(ym,xm)	Tm(ys,xs)		Ts(ym,xm)	Ts(ys,xs) vs. Tm(ys,xs)	Ts(ym,xm) vs. Tm(ym,xm)
1981	0.8930	***	0.9400	1.3490	***	0.9920	***	***
	(0.105)		(0.073)	(0.967)		(0.228)		
1982	0.8910	***	0.9390	1.3010	***	1.0380	***	***
	(0.113)		(0.071)	(0.915)		(0.482)		
1983	0.8830	**	0.9050	1.2090	***	1.0220	***	***
	(0.121)		(0.088)	(0.756)		(0.393)		
1984	0.8880	*	0.907	1.2180	*	1.0880	***	***
	(0.119)		(0.099)	(0.823)		(0.523)		
1985	0.8770	***	0.9310	1.3200	***	1.0520	***	***
	(0.118)		(0.083)	(0.958)		(0.617)		
1986	0.8690	***	0.9150	1.3900	***	1.0150	***	***
	(0.127)		(0.091)	(1.050)		(0.352)		
1987	0.8740	***	0.9290	1.3010	***	1.0170	***	**
	(0.125)		(0.077)	(0.956)		(0.544)		
1988	0.8750	***	0.9180	1.2690	***	1.0610	***	***
	(0.127)		(0.085)	(0.931)		(0.359)		
1989	0.8850	***	0.913	1.1570		1.0660	***	***
	(0.113)		(0.086)	(0.713)		(0.505)		
1990	0.8710	***	0.921	1.1720	***	0.9980	***	***
	(0.111)		(0.082)	(0.689)		(0.356)		
Mean	0.8804	***	0.9216	1.2669	***	1.0351	***	***
	(0.1185)		(0.0847)	(0.8841)		(0.4514)		

Numbers in parentheses are standard deviations.

NOTE: Tk = Technical Efficiency for frontier (reference set) k
k = s = stock frontier
k = m = mutual frontier
Xs, Ys = Input and output for stock firms, respectively
Xm, Ym = Input and output for mutual firms, respectively

***Statistically significant at 1 percent level or better; **statistically significant at the 5 percent level; *statistically significant at the 10 percent level.

TABLE 3
COST EFFICIENCY RESULTS: 1981-1990

Year	Cs(ys,xs)		Cm(ym,xm)	Cm(ys,xs)		Cs(ym,xm)	Cs(ys,xs) vs. Cm(ys,xs)	Cs(ym,xm) vs. Cm(ym,xm)
1981	0.6265	***	0.7533	0.7871	***	0.6524	***	***
	(0.1974)		(0.1580)	(0.3009)		(0.1621)		
1982	0.6503	***	0.7415	0.7655	***	0.6621	***	***
	(0.1990)		(0.1550)	(0.2838)		(0.1662)		
1983	0.6255	***	0.7088	0.7355	***	0.6606	***	***
	(0.1989)		(0.1655)	(0.2813)		(0.1781)		
1984	0.5907	***	0.6625	0.7163	***	0.6297	***	*
	(0.1960)		(0.1772)	(0.3041)		(0.1828)		
1985	0.6346	**	0.6770	0.6882		0.6871	**	
	(0.2060)		(0.1624)	(0.2906)		(0.1915)		
1986	0.6166	***	0.6885	0.7171	*	0.6726	***	
	(0.1964)		(0.1700)	(0.3151)		(0.1995)		
1987	0.6328		0.6600	0.6956		0.6662	**	
	(0.2107)		(0.1773)	(0.3561)		(0.2087)		
1988	0.6090		0.5968	0.5924	***	0.6826		***
	(0.2039)		(0.1743)	(0.2665)		(0.2206)		
1989	0.5822	***	0.6659	0.6497		0.6600	**	
	(0.2186)		(0.1882)	(0.3072)		(0.2233)		
1990	0.6077	***	0.6632	0.6589		0.6639	**	
	(0.2089)		(0.1782)	(0.2992)		(0.2158)		
Mean	0.6172	***	0.6815	0.6997	***	0.6638	***	***
	(0.2043)		(0.1758)	(0.3054)		(0.1963)		

Numbers in parentheses are standard deviations.
NOTE: Ck = Cost Efficiency for frontier k
k = s = stock frontier
k = m = mutual frontier
ys, xs = Output and input for stock firms, respectively
ym, xm = Output and input for mutual firms, respectively
*****Statistically significant at 1 percent level or better; **** Statistically significant at the 5 percent level; ***Statistically significant at the 10 percent level.

TABLE 4

FRONTIER DIFFERENCES BY SIZE QUARTILE

		PRODUCTION FRONTIERS:		CROSS-FRONTIER ALLOCATIVE DIFFERENCE:		COST FRONTIERS:	
		STOCK	MUTUAL	STOCK	MUTUAL	STOCK	MUTUAL
QUARTILE	Mean	-0.770	0.090	0.159	-0.224	-0.145	-0.023
	T-Test	-11.976	11.383	12.376	-11.167	-10.702	-3.623
QUARTILE	Mean	-0.490	0.056	0.094	-0.162	-0.159	-0.059
	T-Test	-11.305	8.159	7.832	-6.966	-10.662	-7.471
QUARTILE	Mean	-0.324	0.036	0.076	-0.142	-0.133	-0.063
	T-Test	10.208	5.285	7.296	-8.944	-12.597	-9.543
QUARTILE	Mean	-0.204	0.026	-0.002	-0.096	-0.112	-0.034
	T-Test	-9.174	5.084	-0.191	-6.089	-17.275	-6.108

Quartile 1 = smallest size quartile.

Note: Upper entries for each quartile and organizational forms are averages of F(yi , xi) (production), Fa(yi , xi) (allocative) and Fc(yi,xi) (cost). Lower entries are t-tests of the null hypothesis that averages are equal to zero.

TABLE 5: REGRESSION ANALYSIS: TECHNICAL AND COST DOMINANCE STATISTICS: 1981-1990

	TECHNICAL DOMINANCE: F(y,x)						COST DOMINANCE: $F_C(y,x)$					
	MODEL 1		MODEL 2		MODEL 3		MODEL 1		MODEL 2		MODEL 3	
YEAR	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio
Constant	0.3595	9.032	0.0826	1.875	0.0596	1.538	0.1304	10.684	0.0701	5.203	0.0487	3.820
DSIZE2	-0.0108	-0.321	-0.0394	-1.173	-0.0393	-1.049	0.0409	-3.963	-0.0613	-5.890	-0.0625	-5.074
DSIZE3	-0.0021	-0.062	-0.0614	-1.768	-0.0742	-1.558	-0.0342	-3.246	-0.0632	-5.880	-0.0770	-4.920
DSIZE4	0.0077	0.220	-0.0545	-1.488	-0.1002	-1.472	-0.0139	-1.292	-0.0502	-4.421	-0.0984	-4.400
STOCK	-0.6385	-15.843	-0.0212	-0.331	0.0711	1.045	-0.0341	-2.756	0.1084	5.477	0.0769	3.434
DISZE2*STOCK	0.1635	3.123	0.1136	2.192	-0.0153	-0.267	-0.0378	-2.353	-0.0298	-1.859	-0.0073	-0.386
DSIZE3*STOCK	0.3304	6.292	0.3202	6.139	0.1037	1.483	-0.0103	-0.639	0.0092	0.568	0.0495	2.153
DSIZE4*STOCK	0.4104	7.909	0.3794	7.213	0.0438	0.449	-0.0243	-1.529	-0.0036	-0.219	0.0825	2.576
LTC%	-0.1342	-3.555	0.1120	2.238	-0.1957	-0.600	-0.0771	-6.661	0.0072	0.462	-0.2537	-2.365
STP%	-0.9417	-14.830	-0.0225	-0.212	-0.9093	-1.280	-0.2997	-15.393	-0.0009	-0.028	-1.0576	-4.529
STC%	-0.6190	-14.818	0.0038	0.061	0.4098	0.957	-0.3453	-26.962	-0.2530	-13.067	0.0892	0.633
LTC%*STOCK			-0.4430	-5.956	-0.1620	-0.375			-0.1622	-7.044	0.2037	1.432
STP%*STOCK			-1.4689	-11.139	-4.5526	-5.301			-0.4657	-11.407	0.0252	0.089
STC%*STOCK			-1.0679	-12.943	-2.6371	-5.233			-0.1689	-6.612	0.1619	0.977
LTC%*Ln(Insout)					0.0206	0.986					0.0177	2.574
STP%*Ln(Insout)					0.0578	1.280					0.0668	4.497
STC%*Ln(Insout)					-0.0248	-0.908					-0.0223	-2.483
LTC%*Ln(Insout)*STK					-0.0138	-0.506					-0.0225	-2.507
STP%*Ln(Insout)*STK					0.2058	3.734					-0.0295	-1.628
STC%*Ln(Insout)*STK					0.1046	3.260					-0.0211	-1.999
Adjusted R^2	0.254		0.291		0.305		0.323		0.344		0.372	

Note: LTC% = proportion of insurance output in long-tail commercial lines; STP% = proportion of insurance output in short-tail personal lines; STC% = proportion of insurance output in short-tail commercial lines; DSIZE2 = 1 if insurer is in size quartile 2 (quartile 1 = smallest insurers), 0 otherwise; DSIZE3 = 1 if insurer is in size quartile 3, 0 otherwise; DSIZE4 = 1 if insurer is is in size quartile four, 0 otherwise; STOCK = STK = 1 if insurer is a stock insurer, 0 otherwise; Insout = total insurance outuput (1982 $, billions). Year dummies not sho