Efficiency Comparisons Between Mutual and Stock Life Insurance Companies*

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Abstract

This research examines the relationships between firm efficiency and choice of organizational form using a seven year panel data set of 586 life insurers. Our study window is from 1985 to 1991. We began the study with two questions in mind: "Do stocks and mutuals use different production technologies?" and "Are stocks and mutuals equally efficient or is one form relatively more efficient than the other?" Using some cost and error structure tests that resemble those found in recent efficiency studies, we find evidence that stocks and mutuals have distinctive cost structures and production technologies. Results also show that efficiency varies with organizational form, with stocks being more scale efficient than mutuals but mutuals being more X-efficient than stocks.

1. Introduction

According to the American Council of Life Insurance (ACLI), stock and mutual firms jointly accounted for most (about 98 percent) of the life insurance business in force in the United States in 1989.[*] Fraternal organizations, mutual savings banks and certain federal government insuring organizations accounted for the remaining two percent. Stocks are more prevalent than mutuals, as evidenced by the fact that at the end of 1989, over 94 percent of the 2,270 U.S. life insurance firms were stock insurers and almost five percent (117 firms) were mutuals. However, mutuals are, on average, much older and larger than stock firms, accounting for about 46 percent of all assets held by life insurance companies and 38 percent of all life insurance business in force in 1989.[**] In sum, these statistics suggest that neither form dominates the market, and leaves open the possibility that each serves a distinct and economically important function.

If the two forms serve separate functions, then one might expect them to use different production technologies and through duality, have distinctive cost structures. Differences in input requirements, output choices or market forces might distinguish the technologies, for example. A simple way of testing for such differences is to use a "dummy variable approach"--allow organizational form to affect linearly the two forms cost structures, production technologies or error terms through one or more dummy variables. The

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[*]Unless otherwise denoted, all statistics cited in this section are from the 1990 Life Insurance Fact Book, American Council of Life Insurance, 1990.

[**]Most mutual firms have been in existence for more than 25 years, and about 20 percent began writing business before the turn of the century. In comparison, most stock insurers (about 70 percent) are relatively young firms, having been established since 1965 [ACLI 1990].

dummies are typically used to test for differences in a subset of the regression or likelihood function parameters (e.g., see methods used in Grace and Timme [1992] and Gardner and Grace [1993] in considering the relationship between organizational form and life insurer costs). However, the dummy variable approach may not provide accurate results, if organizational form influences or is influenced by all aspects of the cost/production relationship.

One way of overcoming the deficiencies is by allowing all cost/production function parameters and the error term to vary with organizational form. We use this approach in considering the relationship between organizational form and efficiency.

We begin by using a series of cost structure tests developed by Mester [1993] to attempt to determine whether stocks and mutuals do indeed employ differing production technologies. We find that cost structures and production technologies differ significantly between the two forms and cannot be accurately modeled using a single cost or production function. In the second part, we use some cost and error structure tests to consider whether stocks and mutuals are equally efficient or whether one form has a clear efficiency advantage over the other. Results show that mutuals are on average more X-efficient than stocks but that stocks are more scale efficient than mutuals.

The remainder of the paper is organized in the following way. Section 2 discusses some similarities and some potential differences between stocks' and mutuals' production technologies. Section 3 explains the paper's cost function and error term decomposition methodology. Sections 4 and 5 contain the cost structure and error term comparison test results, respectively. Section 6 concludes the paper.

2. Background and Review of the Literature

Until recently, extant research often relied on narrative descriptions, conventional comparisons of means tests, or regression methodologies in considering the relationship between life insurer efficiency and organizational form. Such methods were used by Houston and Simon [1970], Spiller [1972], Geehan [1977]

and [Boose (1990)] in examining differences in stock and mutual insurer performance, by Hetherington [1969] and Kreider [1972] in considering the merits of policyowner control (mutuals) versus shareholder control (stocks), and by Mayers and Smith [1986] and McNamara and Ghee [1990] in studying motivations for demutualization--converting from mutual to stock form for example. The research provides much assistance in understanding life insurer expense behaviors. However, its usefulness in understanding the relationships among costs, efficiency and organizational form is limited by the fact that it does not employ an econometric cost/production function methodology.

Some recent studies have employed a production/cost methodology in examining the relationship between organizational form and firm cost structures [Grace and Timme (1992)] and [Gardner (1992)]. Using an agency theory framework and cost data from the National Association of Insurance Commissioners (Grace and Timme use data from 1987, Gardner, from 1990), the researchers hypothesize that average total costs should be higher in mutuals than in stocks. Both studies use two maximum likelihood estimates of hybrid translog cost functions to determine whether total costs seem to depend in part on organizational form. One likelihood function allows organizational form to affect output quantities and input prices linearly; the other allocates any organizational form effects to the error term. Results from F-tests reveal that output cost efficiencies such as size and product mix efficiencies appear to be influenced by organizational form.[***]

This finding was not confirmed by a recent study conducted by Gardner and Grace [1993]. In that research, we used six years of NAIC data (1985-1990) and estimated cost functions for each year, allowing any organizational form effects to be captured in the error terms. We then performed a series of econometric tests on the error term and found that firm efficiency was not strongly related to organizational form. In other words, stocks and mutuals may be equally efficient operators, everything else the same. This result leaves

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□□□An implication of this result is that firms having the less efficient form theoretically should either switch to the more efficient form or exit the market. In practice, it is interesting to note that some (about 15) mutual insurers have converted to stock form, while at least two insurers have changed from stock to mutual in the past 25 years [ACLI 1990]. A.M. Best (1992) reports that while stock companies account for 94 percent of all industry firms, they account for 97 percent of all insurance company failures during the period 1976-1991.

open the possibility that stocks and mutuals co-exist because they serve different purposes in the U.S. life insurance market.[****] If such is the case, then it seems reasonable to expect production technologies and through duality, cost structures to differ between the two forms. As Mester [1993] argues, such differences may be evidenced empirically by dissimilarities in cost function parameters, error terms, or both.

[****]Such an argument has been made by Mayers and Smith [1983] with respect to the U.S. property and liability insurance market and by Hansmann [1985] with respect to the life insurance market. However, Hansmann provided no empirical tests of his hypothesis, leaving an interesting void in the literature.

3. Methodology

3.1 Data Sources

This study employs cross-sectional data gathered for 586 firms operating in the U.S. life insurance market during 1985-1991.[*****] All sample firms had complete and economically tractable variable information and collected premiums (and in many cases, annuity considerations) during each year from 1985-1991.

Three sources provide the data: (1) the National Association of Insurance Commissioners (NAIC) life insurance company data tapes (1984-1991), (2) Best's Key Rating Guide, and (3) the Bureau of Labor Statistics. Most of the data needed for the study were gathered from the NAIC data tapes. Organizational form information was obtained from Best's Key Rating Guide and state wage rate information was gathered from the Bureau of Labor Statistics.

3.2 Variable Definitions

Given recent findings, it seems possible that differences in organizational form may account for at least part of any disparities between observed and efficient costs. An important question left unanswered by their research is "how do differences in organizational form account for differences in firm costs?" One way might be that stocks and mutuals use dissimilar production technologies. Stocks and mutuals may also differ in the types of inputs they use (e.g., labor; as Mayers and Smith [1988] suggest the decision-making skills of mutual managers may differ from those of stock managers) and the types and amounts of outputs they produce, for instance. If such is the case, it is possible that stocks and mutuals may be using different but equally efficient technologies. However, some cost structure differences may not be efficient. For instance, mutuals may make inefficient decisions about labor input usage--they may be paying labor "too much" or may

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[*****] The initial sample consisted of all life insurance companies with financial information reported on the NAIC 1985, 1986, 1987, 1988, 1989, 1990, and 1991 data tapes. Firms with missing or negative values for any output or input variable, or organizational form designation were deleted from the sample as were insurers with otherwise suspect data. As a result we have 586 firms with data for all seven years for every variable employed in the study. Our sample firms account for approximately 42 percent of the direct premiums written in the U.S. life insurance industry during the time period considered.

be employing "too many" workers to produce a certain level of output. Either practice increases actual costs above efficient levels and is evidence of the well-known agency-theory perquisite problem. In contrast, the market for corporate control may force stock insurer management to employ inputs in a cost-minimizing (share-holder wealth maximizing) way, thereby mitigating the management perquisite problem [Hansmann (1985)]. Finally, it is also possible that organizational form does not significantly affect firm costs.

Our analysis tests the null hypothesis that organizational form does not significantly affect firm cost structures or error terms. We begin by estimating several cost functions. To do so, we need information about the prices that life insurers pay for inputs, the quantities of outputs produced and production costs. Each set of information is described in a subsection below.

Outputs

Like the products of other financial services firms, the outputs produced by life insurers are intangible and therefore are difficult to measure.[******] We follow convention and define outputs as the dollar amounts of: (1) ordinary life insurance premiums (y_1), (2) group life insurance premiums (y_2), (3) ordinary annuity considerations (y_3), (4) group annuity considerations (y_4), and (5) group accident and health premiums (y_5). This approach is consistent with that used by several authors, including Houston and Simon [1970], Blair, Jackson and Vogel [1975], Colenutt [1977], Weiss [1986], Grace and Timme [1992]. We recognize the firm's investment function with a sixth output, the dollar amount of securities investments (y_6). Securities investments arguably represent an intermediate and not final output for life insurers. We include them in the study because they represent a major activity for most companies and may account for a significant portion of the firm's operating expenses. Note that some previous studies on the cost behaviors of financial intermediaries also define an investments output [e.g., see Gilligan and Smirlock (1984) and Mester (1987)]. Table A summarizes the outputs definitions.

[******]The literature provides several useful discussions about the difficulties encountered in determining appropriate output definitions and aggregation measures. We do not repeat these discussions but refer the reader to Geehan [1986] and O'Brien [1991].

[INSERT TABLE A ABOUT HERE]

Input Prices

Outputs are produced using three inputs: (1) labor, (2) physical capital, and (3) miscellaneous items. Labor consists of home, regional, and field office personnel, and agents and brokers enlisted by the company to distribute its products. Labor expenses include salaries, wages, benefits, other employee welfare expenditures, and commissions on direct business. The price of labor (w_1) is computed by multiplying the average statewide salary of insurance workers reported by the Bureau of Labor Statistics by the portion of business written in the state, and summing across all states.

Physical capital includes furniture and equipment, and the office space that houses home, regional, and in some cases, field operations. The amount of physical capital used by the firm in producing outputs is measured by the value of physical capital assets. The price of physical capital (w_2) equals physical capital expenses divided by the value of physical capital assets. Physical capital expenses encompass building rental costs, equipment rental costs and depreciation, and furniture depreciation.

The miscellaneous items input is a broadly defined item that envelops most factors used in producing outputs other than labor and physical capital. The input consists of several diverse items, such as books and periodicals, and postage for example. The price of miscellaneous items is difficult to ascertain from the NAIC data. For empirical purposes, the input's price is assumed to be constant across all firms. Input price definitions are shown in table A.

Costs

We define total costs as operating costs, where operating costs equal the sum of labor, physical capital, and miscellaneous expenses. Operating costs should vary with input prices and the factors of production. This

definition is helpful because it allows us to consider how differing firm attributes might affect the cost of managing firm operations.

We initially specify three cost functions. The function first will use data from all sample firms and will allocate any organizational form effects on costs to an error term. We subsequently refer to this cost function as the pooled total cost function, or c^p. The second will represent average total costs for the sample's mutual firms (the mutuals' total cost function, or c^m); the third will reflect average total costs for stock insurers (the stocks' total cost function, or c^s).

The pooled cost function is an appropriate way to represent costs if organizational form does not influence the underlying cost structures (mathematically, $\theta^m = \theta^s = \theta^p$, where θ^k is a cost function parameter vector) or the error structures (in other words, $\sigma^m_u = \sigma^s_u = \sigma^p_u$ and $\sigma^m_v = \sigma^s_v = \sigma^p_v$, where σ^k_u and σ^k_v are the standard deviations of u and v, respectively). If, however, stocks and mutuals use distinctive production technologies, then the dual nature of the production/cost relationship implies that the cost structures of stock firms are distinctive from those of mutuals, or $\theta^m \neq \theta^s \neq \theta^p$.

We use the superscript *k* where k=m,p, or s, to identify the appropriate function. Total costs are mathematically represented as:

$$\ell n c^k_{rt} = \ell n f(y^k_{rt}, w^k_{rt}, \theta^k_t) + \ell n \epsilon^k_{rt} \qquad \textbf{(1)}$$

where ln is natural logarithm, c^k_{rt} is the operating cost incurred by firm *r* in time period *t*, y^k_{rt} is the firm's output vector in time t, w^k_{rt} is the vector of input prices paid by the firm, θ^k is the vector of cost function parameters and ϵ^k_{rt} is an error term.

Using a standard error term decomposition approach found in the cost efficiency literature, we define, $\ln \epsilon^k_{rt}$ as the sum of two random variables: $\ln \epsilon^k_{rt} = \ln v^k_{rt} + \ln u^k_{rt}$ (see e.g., Berger [1992]). The disturbance $\ln v^k_{rt}$ is assumed to be an independently distributed normal random variable. The term $\ln v^k_{rt}$ should account for differences between actual and efficient costs that are attributable to luck and observation and measurement

error. We assume that E [ln v^k_{rt}] = 0, since differences in luck and observation and measurement error should be zero over time. We assume the distribution of ln v^k_{rt} is two-sided because random noise may either increase or decrease observed costs above actual levels.

Prior to cost function estimation, we make no distributional assumptions about ln u^k_{rt}. We assume that ln u^k_{rt} reflects persistent differences between observed and minimum costs. Such disparities may be attributed to differences in management quality (i.e. good versus bad management decisions) or market pressure from the firm's environment, for example. An important advantage of this "distribution-free" approach (DFA) is that available software algorithms permit the distribution of u_{rt} to be specified ex post, rather than ex ante. In contrast, algorithms for similar technologies such as the stochastic frontier often require that a distributional assumption about u_{rt} be made ex ante. Available distributions include half-normal, exponential and gamma, for example. Our analysis in this and other research (see Gardner and Grace [1993]) suggests that the distribution of EFF_r appears to be chi-square. This distribution is not included in many algorithms, but can be easily accommodated using "distribution-free" methodologies.

4. Cost Function Estimation and Empirical Cost Structure Test Results

4.1 Cost Function Estimation

We use the hybrid translog approximation to a multiproduct cost function to estimate total costs. As compared to other functional forms, the hybrid translog has several properties that make it well-suited for examining the firm's cost structure.*******

The hybrid translog cost function employs the Box-Cox metric to transform output values prior to estimation: $Y_i = (y_i^{\lambda} - 1)/\lambda$. The general form of the hybrid translog for firm *r* producing outputs **y** using inputs **x**, available at fixed prices **w** in time period t is:

□□□□□□□ Such properties are often cited in the cost efficiency literature (e.g. Mester [1987], and LeCompte and Smith [1990]).

$$\ell\Box\Updownarrow_r^k = \alpha_0^k + \sum_{i=1}^{n} \alpha_i^k \Box_{ir}^k + \sum_{j=1}^{m} \beta_j^k \ell\Box_{-jr}^k + \left(\frac{1}{2}\right) \sum_{i=1}^{n}\sum_{f=1}^{n} \eta_{if}^k \Box_{ir}^k \Box_{fr}^k + \left(\frac{1}{2}\right) \sum_{j=1}^{m}\sum_{g=1}^{m} \gamma_{jg}^k \ell\Box_{-jr}^k \ell\Box_{-gr}^k + \sum_{i=1}^{n}\sum_{j=1}^{m} \rho_{ij}^k \Box_{ir}^k \ell\Box_{-jr}^k + \ell\Box\epsilon_r^k \quad \textbf{(2)}$$

where *ln* is natural logarithm, c_r is cost, Y_{ir} represents transformed output quantities, k is p (pooled), s (stock) or m (mutual), and ϵ_r is an error term.[********]

We estimate each of the three average total cost functions (c^m, c^p, and c^s) and accompanying share equations[*********] using full information maximum likelihood estimation (FIML).[**********] The estimates are obtained using an appropriate algorithm from the econometric software package SHAZAM. Table B shows the representative parameter estimates for mutuals, stocks and pooled cost functions (c^m, c^s and c^p).[***********]

[INSERT TABLE B ABOUT HERE]

Table C shows means operating costs for stocks and mutuals over the seven year study period.[************] It is interesting to note that average costs for both forms seem to decline slightly over the interval. The reductions might be attributed to gains in input or output choice efficiencies, or changes in the

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[********]For the sake of simplicity, we did not include time period subscripts in equation (2).

[*********]Because the parameters in the share equations are a subset of those contained in the cost function, the degrees of freedom for the system of equations will be larger than the degrees of freedom for the cost function. Thus, estimates should be more efficient when the cost functions and share equations are estimated jointly than when the cost function is estimated separately.

[**********]The share equations, by definition, must sum to one. That is $S_1 + S_2 + S_3 = 1$. Accordingly, joint estimation of the share equations will yield a singular disturbance covariance matrix. Singularity can be avoided if one share equation is eliminated from the model. Results gained through maximum likelihood estimation should be invariant to which share equation is dropped (Barten 1970). The general administrative items share equation (S_3) is eliminated from the model. Estimates for the share of costs accounted for by general administrative items can be obtained from estimates of the other two share equations using the following relationship: $1 - S_1 - S_2 = S_3$.

[***********]Parameter estimates for c^m, c^p and c^s for each year are available from the authors.

[************]We perform no tests of statistical significance on the data shown in table B and urge the reader to interpret it with caution.

firms' operating environments, for instance. The data also suggest that average operating costs for the mean mutual insurer seem to be lower than those for the average stock firm. This observation is consistent with the existence of separate cost functions for stocks and mutuals.

[INSERT TABLE C ABOUT HERE]

4.1.a Input Shares

We derive share equation values by taking the first order partial derivative of equation (2) with respect to input *j*:[**********]

$$S_j = \frac{\partial \ell C}{\partial \ell P_j} = \beta_j + \sum_{g=1}^{m} \gamma_{jg} \ell P_{jg} + \sum_{t=1}^{n} \rho_{tj} T_{ts} + \epsilon_{js} \qquad \textbf{(3)}$$

Mean input share values for mutuals, stocks, and the pooled sample are shown in table D. Note that labor expenses account for the largest share of total operating costs[**********] and that the labor shares increase over time. One possible explanation for the increase may be that labor prices increased more rapidly than other input prices during the time period studied. However this explanation seems unlikely, given the input prices shown in table E. Another explanation is that firms are changing their input allocations by using relatively more labor and less of another input (say, miscellaneous items) over time. Such a change might be observed in firms having significant allocative inefficiencies and may be efficiency-enhancing; it might also be evidence of a bad management decision and be efficiency-reducing.[**********]

[**********]Economic theory requires that well-behaved cost functions have non-negative input demand functions and that input demand functions be homogenous of degree zero in input prices. The first restriction was met by requiring the share equations to be non-negative and the second was met by specifying cost as a function of relative rather than absolute prices before the cost functions were estimated.

[**********]This result is unsurprising, given that life insurers are financial services firms. A similar result was found by Mester (1987) and Cummins and Weiss (1993) in examining the cost structures of savings and loans and property and liability insurers, respectively.

[**********]Much of this study is exploratory research. No tests of statistical significance have been applied to the data shown in tables D and E and we once again encourage the reader to interpret the data with great caution.

[INSERT TABLE D ABOUT HERE]

[INSERT TABLE E ABOUT HERE]

The data in table D also shows that the physical capital shares are nearly constant over time and differ little between stocks and mutuals. The data in table E suggest that stocks and mutuals appear to pay about the same average price for physical capital. In sum, the data do not seem to show that organizational form differences have significantly affected physical capital usage during the study period.

4.1.b Price Elasticities

Economic theory requires that the matrix of first order partial derivatives of the input demands of well-behaved cost functions be negative semi-definite. This restriction was met by (1) imposing symmetry prior to cost function estimation; (2) obtaining non-positive estimates of the own-price elasticity; and (3) obtaining positive cross-price elasticities of demand between at least two inputs.

We use information from the share equations and cost functions to derive the own-price elasticity of demand equations:

$$\sigma_{ii} = \frac{\gamma_{ii}}{S_i} + S_i - 1 \quad \textbf{(4)}$$

and the Allen-Uzawa cross-price elasticity of demands:

$$\sigma_{ij} = \frac{\gamma_{ii}}{S_i * S_j} + 1 \quad \textbf{(5)}$$

As the results shown in Table F indicate, the own-price elasticities of demand (σ_{ii}) are negative for capital and labor for each cost function, and the cross-price elasticities of demand (σ_{ij}) are positive, indicating that capital and labor are substitutes. The estimates were derived using the relationships shown in equations (2) and (3), and correspond to a reasonable, concave cost function. Nearly all estimates are significant at the $\alpha = 0.01$ level.

[INSERT TABLE F ABOUT HERE]

Table F also reports several interesting differences between stocks' and mutuals' own- and cross-price elasticity of demands estimates. For example, the Allen-Uzawa labor for capital cross-price elasticity estimates for mutuals are relatively inelastic whereas the estimates for stock insurers are about unitary elastic. The differences are noticeable for all study years and statistically significant for the last three. An implication is that stocks may be more likely than mutuals to make a change in input mix in response to an increase in the price of labor or capital. Other interesting differences can be found between estimates of stocks and mutuals own-price elasticity of demands for labor and for physical capital. While the labor and physical capital estimates for both forms are relatively inelastic, the mutuals' estimates are more inelastic than those for the stocks. The differences in labor input price demands are statistically significant at the $\alpha = 0.01$ level from 1985-1991; for physical capital, they are statistically important from 1989-1991. An implication of the own-price comparisons is that stocks are more likely than mutuals to change the amount of a production input (say labor) in response to an input price (say p_l) increase.

4.2 Cost Structure Tests

Following Mester (1993), we use a likelihood ratio test to determine whether stocks and mutuals appear to use similar production technologies and therefore, share the same cost function (c^p), or seem to employ distinctive technologies and thus operate on separate cost functions (c^m and c^s). We test the null hypothesis H_o: $\theta^m = \theta^s = \theta^p$ using the usual likelihood ratio significance test.********** Table G reports the test results.

[INSERT TABLE G ABOUT HERE]

For each year considered we find that statistical differences exist between the restricted and unrestricted models. All differences are significant at the $\alpha = 0.01$ level. Thus, we reject the null hypothesis

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□□□□□□□□□□□□□Similar research often uses dummy variable tests in considering the effects of organizational form on a subset of the hybrid translog's cost function parameters (e.g., α_0 α_i and β_j). An important limitation of the approach is that it does not recognize any organizational form effects on the cost function's second-order terms. The test used in this research is less restrictive than the dummy variable approach because it allows organizational form to influence the estimates of all cost function parameters (in this case, α_0 and all α_i, β_j, η_{if} γ_{jg} and ρ_{ij}).

that $\theta^m = \theta^s = \theta^p$. We find that stocks and mutuals have distinctive cost structures and, through the dual nature of the cost/production relationship, employ distinctive production technologies. This finding is consistent with the notion that mutuals and stocks co-exist in the U.S. life insurance market because they serve different purposes. An econometric implication is that the cost structures and production technologies of stocks and mutuals should be estimated using separate rather than pooled cost/production functions.

4.3 Output Choice Efficiencies

Estimates or ray scale economies (RSCE) are shown in table H. The stock (mutual) estimates measure the elasticity of cost with respect to output, taken along a ray emanating from the origin to the mean output bundle for stock (mutual) firms. Results show that statistically significant increasing returns to scale (RSCE < 1) appear to be present for the average mutual firm for all years considered and for the mean stock company for most (five of seven) years examined. In other words, firms of either form can realize efficiency gains by increasing overall output, ceteris paribus. Scale inefficiencies range from slight (about 6 percent) to economically important (about 15 percent). The size of inefficiency seems to be related to organizational form; inefficiency estimates average about 12 percent for mutuals and close to eight percent for stocks. Differences in equity structures and thus, financing options may explain this result. Mutuals or stocks may use premium and investment income or retained earnings to finance output growth; however, stocks may also raise growth funds by selling equity shares on the capital market. Because output growth financing options are more limited for mutuals than for stocks, the later form should be more likely to attain optimal scale than the former. Thus, scale inefficiencies should be higher for mutuals than for stocks, ceteris paribus.

[INSERT TABLE H ABOUT HERE]

5. Error Structure Comparisons

In the second part of our methodology, we use the parameters from c^m and c^s and Berger's X-efficiency measure to determine whether mutuals and stocks are equally efficient, or stocks are more efficient than

mutuals, or vice-versa. Berger [1992] defines X-efficiency as the difference between the firm's and the industry's persistent error terms. We adopt this definition and modify it to allow for our logarithmic specification of costs and organizational form differences (we add a k(k) superscript, where k(k) = s(s) if a stock's cost function parameters and data are used, and k(k) = m(m) if a mutual's cost function parameters and data are used). Thus, we define X-efficiency as:

$$XEFF_{rt}^{k(k)} = \exp\left(\ell_t^{\min k(k)} - \ell_{rt}^{k(k)}\right) \qquad \textbf{(6)}$$

When k(k)=m(m), this measure is the antilog of the differences between the log of the most efficient mutual firm's persistent inefficiency term and the log of the persistent inefficiency term for mutual firm r, all in time period t.

We average the $XEFF_{rt}^{k(k)}$ values over the seven year sample period to reduce the effects of any year-specific outliers:

$$XEFF_{r}^{k(k)} = \frac{\Sigma XEFF_{rt}^{k(k)}}{n} \qquad \textbf{(7)}$$

This approach will probably not eliminate all outliers since differences in luck or adverse circumstances may exist during the entire time period studied. We follow Berger and truncate the distributions of $XEFF^{k(k)}$ to reduce the effects of the remaining outliers. We truncate the average efficiency rates at the one, five, and 10 percent levels and compare the means and frequency distributions of the resulting measures to determine where they seem to stabilize. Table I shows the means and the frequency distributions for $XEFF^{m(m)}$ and $XEFF^{s(s)}$. In each case, we conclude that a five percent truncation level is optimal.

[INSERT TABLE I ABOUT HERE]

The XEFF measure is used to make relative comparisons between the average efficiency levels of stock and mutual companies. Efficiency scores shown in Table I indicate that the mean mutual insurer's average operating costs are about 30 percent higher than those of the most efficient mutual; the average stock insurer's costs are 50 percent higher than those of the "best practice" stock company. Thus, the average mutual insurer appears to be relatively more efficient than the average stock insurer.

To facilitate further comparisons of cost function residuals between firms using distinctive technologies, we construct two other efficiency measures, $TEFF^{k(k)}$ and $TEFF^{k(d)}$. The measures are created by modifying XEFF and include a common reference point, $\min(k(k), k(d))$. In words, the reference point is the lesser of: (1) the minimum persistent error term for actual firms of form k (once again, stock) and (2) the minimum persistent error term for synthetic firms of form k (also stock). The synthetic firm uses form k's (stock insurer) technology and the cost data for form d (where d is the opposite form--in this example, mutual). We include the reference point to facilitate efficiency comparisons between actual and synthetic firms.

We define $TEFF_r^{k(k)}$ as:

$$TEFF_r^{k(k)} = \exp\left[\min(k(k), k(d)) - \ln u_r^{k(k)}\right] \quad \textbf{(8)}$$

This measure gauges average efficiency for firm r of form k.

Our third measure compares the persistent residual term for the most efficient firm (actual or synthetic) using k's technology with the persistent error term for a synthetic firm of form k. To construct $TEFF_r^{k(d)}$, we modify $TEFF_r^{k(k)}$ by adding a k(d) superscript, where k(d) = s(m) if the stocks' average total cost function parameters and a mutual insurer's data is used, and k(d) = m(s) if the mutuals' average total cost function parameters and a stock insurer's data is employed. We use $TEFF_r^{k(d)}$ to measure average efficiency for a synthetic firm:

$$TEFF_r^{k(d)} = \exp\left[\min(k(k), k(d)) - \ln u_r^{k(d)}\right] \quad \textbf{(9)}$$

In words, $TEFF_r^{k(d)}$ is the antilog of the difference between the persistent residual ($\ln u_t^{k(k)}$) for the most efficient firm (actual or synthetic) using k's technology, and the persistent residual that would exist if a firm of form d would have, (where d = s for stock and d = m for mutual, and denotes the opposite organizational form (stock or mutual) not denoted by k) had it employed the same technology as a firm of form k. This measure holds technology constant, but varies with data differences (i.e., stock versus mutual). The synthetic residual should capture differences in efficiency that can be attributed to differences in total costs between the two organizational forms.

The values of $TEFF_r^{k(k)}$ and $TEFF_r^{k(d)}$ range from zero (least efficient) to one (most efficient). The measures have the same numerator and both hold technology constant. Thus, efficiency differences found by comparing the distribution of $TEFF_r^{s(s)}$ ($TEFF_r^{m(m)}$) with that of $TEFF_r^{s(m)}$ ($TEFF_r^{m(s)}$) should reflect differences in data but not technology.

Truncating the distributions of $TEFF^{k(k)}$ and $TEFF^{k(d)}$ at one, five, and 10 percents yields the $TEFFk^{k(k)}(.0X)$ and $TEFF^{k(d)}(.0X)$ values shown in tables J (k=m) and K (k=s). In each case, we conclude that a five percent truncation level is optimal.

[INSERT TABLE J ABOUT HERE]

[INSERT TABLE K ABOUT HERE]

Figure 1 provides a graphic comparison of the frequency distributions for $TEFF^{m(m)}(.05)$ and $TEFF^{m(s)}(.05)$. The distribution of $TEFF^{m(m)}(.05)$ is almost normal, with a mean efficiency score of about 57 percent. In comparison, $TEFF^{m(s)}(.05)$'s distribution looks like chi-square, with a mean of about 27 percent and a mode of less than 20 percent. The data show that on average, mutuals perform considerably better than stocks using mutual insurer technology (the synthetic firms m(s)). This finding is consistent with our cost structure test results and supports the finding that stocks and mutuals have separate cost structures and use distinctive production technologies.

[INSERT FIGURE 1 ABOUT HERE]

[INSERT FIGURE 2 ABOUT HERE]

A graphic comparison of the distributions of $TEFF^{s(s)}(.05)$ and $TEFF^{s(m)}(.05)$ is shown in figure 2. The results are analogous to those discussed above. The distribution of $TEFF^{s(s)}(.05)$ is approximately normal whereas $TEFF^{s(m)}(.05)$'s distribution seems to be chi-square. The mean efficiency score is higher for the actual firm (s(s)) than for the synthetic company (s(m)). In short, the data show that stocks perform better, on average, than mutuals using stock insurer technology--a finding that again validates the likelihood ratio test results.

6. Summary and Conclusion

This research investigates differences in the cost structures of stock and mutual life insurance companies. In the first part, we estimate three average total cost functions (c^m, c^p, and c^s) and use a likelihood ratio test to determine whether stocks and mutuals appear to use similar production technologies and therefore, share the same cost function (c^p), or seem to employ distinctive technologies and thus operate on separate cost functions (c^m and c^s). We find that stocks and mutuals have distinctive cost structures and, through the dual nature of the cost/production relationship, employ different production technologies. Results from tests for price elasticity differences support this finding. Such results are consistent with the notion that stocks and mutuals serve distinctive functions in the market. An econometric implication of our results is that the cost structures and production technologies of stocks and mutuals should be estimated using separate rather than pooled cost/production functions.

In the second part of this study, we use some cost and error structure tests to consider whether stocks and mutuals are equally efficient or whether one form has a clear efficiency advantage over the other. Results show that stocks are more scale efficient than mutuals but that mutuals are on average more X-efficient than stocks. Error term distributions seem to depend importantly on organizational form. Such findings emphasize the need to consider separately the cost structures and production technologies of stocks and mutuals in future efficiency studies.

Evidence presented here suggests that stocks and mutuals do have distinctive cost structures and efficiency problems. The research should be extended to include examinations of potential sources of these differences, including product mix, market concentration and labor expense preferences, for instance. Such research should assist in further understanding why stocks and mutuals co-exist in the United States life insurance market.

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Table A Variable Definition and Source

Variable Name	Description	Source (NAIC Life/Health Company Financial Statement unless otherwise noted)
Y1	Ordinary Life Premiums	Page 5 Line 1, Col. 3
Y2	Individual Annuities	Page 5, Line 1, Col. 4
Y3	Group Life Premiums	Page 5, Line 1, Col. 7
Y4	Group Annuities	Page 5, Line 1, Col. 8
Y5	Group Accident and Health	Page 5, Line 1, Col. 9
Y6	Securities	Page 2, Col. 1, Lines 1, 2.1, 2.2, 3, 4.1, 4.2, 4.3, 8.2 and 9
w_1	Price of Labor	Computed using a weighted average of state wage rates from BLS, and total premiums and annuity considerations from Schedule T.
w_2	Price of Capital (physical capital as a percentage of the value of assets)	Page 9, Col. 5, Lines 1, 5.5, 5.6, Page 14, Exhibit 14, Line 3 divided by Page 2, Col., Line 34.
w_3	Price of miscellaneous inputs (postage, advertising, etc)	Assumed to be the same for all firms

Table B Typical Stock and Mutual Cost Function (1988)
Panel A Stock Cost Function (t ratio in parenthesis)

Variable	Parameter Estimate	Variable	Parameter Estimate	Variable	Parameter Estimate
intercept	0.170 (2.424)	q2*q2	0.025 (3.698)	p1*q1	0.008 (2.521)
p1	0.607 (47.096)	q2*q3	0.000 (0.090)	p1*q2	-0.003 (-0.130)
p1*p1	-0.001 (-0.185)	q2*q4	-0.002 (-0.830)	p1*q3	0.003 (1.593)
q1	0.109 (4.694)	q2*q5	-0.004 (-1.288)	p1*q4	0.001 (0.065)
q2	0.113 (4.608)	q2*q6	-0.001 (0.007)	p1*q5	-0.006 (-2.895)
q3	-0.055 (-2.074)	q3*q3	-0.001 (-0.158)	p1*q6	-0.009 (-1.309)
q4	0.020 (0.713)	q3*q4	-0.004 (-1.270)	λ	0.079 (4.694)
q5	0.082 (3.605)	q3*q5	0.004 (1.467)		
q6	0.644 (9.656)	q3*q6	-0.12 (-1.561)		
q1*q1	0.022 (2.473)	q4*q4	-0.004 (0.813)		
q1*q2	0.000 (0.000)	q4*q5	0.001 (0.426)		
q1*q3	0.004 (1.078)	q4*q6	0.014 (1.371)		
q1*q4	-0.005 (-1.027)	q5*q5	0.011 (2.553)		
q1*q5	-0.005 (-1.509)	q5*q6	-0.013 (-1.853)		
q1*q6	-0.004 (0.453)	q6*q6	-0.054 (-1.542)		

Panel B Mutual Cost Function Estimates (t ratio in parenthesis)

Variable	Parameter Estimate	Variable	Parameter Estimate	Variable	Parameter Estimate
intercept	0.098 (1.22)	q2*q2	0.002 (0.757)	p1*q1	0.008 (1.639)
p1	0.687 (40.957)	q2*q3	0.002 (0.903)	p1*q2	-0.000 (-0.274)
p1*p1	0.358 (3.893)	q2*q4	-0.001 (-0.607)	p1*q3	0.000 (0.265)
q1	-0.036 (-0.508)	q2*q5	0.002 (1.106)	p1*q4	-0.001 (-0.506)
q2	0.050 (1.666)	q2*q6	0.030 (2.052)	p1*q5	-0.001 (-0.403)
q3	-0.115 (-3.967)	q3*q3	-0.010 (-1.810)	p1*q6	-0.027 (-3.051)
q4	0.003 (1.485)	q3*q4	-0.011 (-0.417)	λ	0.214 (0.967)
q5	0.032 (1.485)	q3*q5	0.000 (0.270)		
q6	0.927 (8.687)	q3*q6	0.017 (1.173)		
q1*q1	0.062 (2.165)	q4*q4	0.002 (0.567)		
q1*q2	-0.035 (2.436)	q4*q5	-0.000 (-0.345)		
q1*q3	-0.011 (-0.975)	q4*q6	0.002 (0.587)		
q1*q4	0.016 (1.260)	q5*q5	-0.000 (-0.033)		
q1*q5	0.000 (0.030)	q5*q6	0.009 (0.947)		
q1*q6	-0.035 (-1.795)	q6*q6	-0.056 (-1.406)		

Panel C Pooled Cost Function Estimates (t ratio in parenthesis)

Variable	Parameter Estimate	Variable	Parameter Estimate	Variable	Parameter Estimate
intercept	0.170 (2.424)	q2*q2	0.025 (3.699)	p1*q1	0.008 (2.521)
p1	0.607 (47.096)	q2*q3	0.000 (0.080)	p1*q2	-0.000 (0.131)
p1*p1	0.008 (2.521)	q2*q4	-0.002 (0.830)	p1*q3	-0.000 (1.593)
q1	0.109 (3.173)	q2*q5	-0.004 (1.288)	p1*q4	0.000 (0.065)
q2	0.1136 (4.609)	q2*q6	-0.001 (0.141)	p1*q5	-0.006 (2.895)
q3	-0.055 (2.074)	q3*q3	-0.001 (0.158)	p1*q6	-0.009 (1.310)
q4	0.020 (0.713)	q3*q4	-0.004 (1.271)	λ	0.079 (0.017)
q5	0.082 (3.605)	q3*q5	0.004 (1.467)		
q6	0.644 (9.656)	q3*q6	-0.012 (1.561)		
q1*q1	0.022 (2.473)	q4*q4	0.004 (0.812)		
q1*q2	0.000 (0.016)	q4*q5	0.001 (0.426)		
q1*q3	0.004 (1.078)	q4*q6	0.014 (1.371)		
q1*q4	-0.005 (1.027)	q5*q5	0.001 (2.553)		
q1*q5	-0.566 (1.509)	q5*q6	-0.013 (1.853)		
q1*q6	-0.004 (0.544)	q6*q6	0.054 (1.542)		

Table C Mean Average Cost for Stocks and Mutuals

Year	Stock Mean Average Cost	Mutual Mean Average Cost
1985	0.142	0.054
1986	0.063	0.052
1987	0.059	0.170
1988	0.056	0.051
1989	0.053	0.051
1990	0.055	0.051
1991	0.054	0.050
n	499	87

Table D Input Shares for Stock and Mutuals

Year	Labor Share		Capital Share	
	Stock	Mutual	Stock	Mutual
1985	0.61	0.66	0.13	0.14
1986	0.60	0.66	0.13	0.14
1987	0.62	0.67	0.13	0.14
1988	0.64	0.67	0.13	0.14
1989	0.64	0.68	0.13	0.14
1990	0.64	0.68	0.13	0.14
1991	0.65	0.69	0.13	0.13

Table E Mean Input Prices for Stocks and Mutuals

Year	Stock		Mutual	
	Price of Labor	Price of Capital	Price of Labor	Price of Capital
1985	$21,246	0.014	$21,364	0.008
1986	23,440	0.008	23,799	0.007
1987	24,801	0.009	25,160	0.010
1988	24,801	0.009	25,160	0.007
1989	26,029	0.008	26,535	0.007
1990	27,278	0.008	27,791	0.007
1991	28,773	0.008	29,179	0.007
n	499		87	

Table F Input Elasticity Estimates
(number in parenthesis is the asymptotic z score)

Year	Stock†			Mutual†			Combined†			Statistical Difference††		
	σ_{ll}	σ_{kk}	σ_{kl}	σ_{ll}	σ_{kk}	σ_{kl}	σ_{ll}	σ_{kk}	σ_{kl}	σ_{ll}	σ_{kk}	σ_{kl}
1985	-0.368 (35.023)$^{***}_{**}$*	-0.752 (14.962)$^{***}_{**}$*	0.800 (9.620)***	-0.249 (10.827)$^{***}_{**}$*	-0.408 (-3.686)***	0.307 (3.310)***	-0.361 (40.112)$^{***}_{**}$*	-0.752 (17.419)$^{***}_{**}$*	0.805 (11.432)$^{***}_{**}$*	+***	+	-
1986	-0.381 (37.167)$^{***}_{**}$*	-0.792 (16.602)$^{***}_{**}$*	0.870 (10.999)$^{***}_{**}$*	-0.247 (9.808)***	-0.531 (4.031)***	0.497 (2.473)***	-0.373 (16.864)$^{***}_{**}$*	-0.876 (11.363)$^{***}_{**}$*	0.875 (11.363)	+***	+	-
1987	-0.377 (40.139)$^{***}_{**}$*	-0.876 (19.131)$^{***}_{**}$*	1.007 (13.713)$^{***}_{**}$*	-0.214 (8.180)***	-0.275 (2.128)**	0.113 (0.597)	-0.369 (39.354)$^{***}_{**}$*	-0.867 (18.941)$^{***}_{**}$*	0.993 (13.682)$^{***}_{**}$*	+***	+	-
1988	-0.362 (35.493)$^{***}_{**}$*	-0.879 (17.545)$^{***}_{**}$*	1.105 (12.869)$^{***}_{**}$*	-0.236 (10.799)$^{***}_{**}$*	-0.443 (-4.187)***	0.3844 (2.224)***	-0.357 (35.250)$^{***}_{**}$*	-0.878 (17.633)$^{***}_{**}$*	1.014 (13.137)$^{***}_{**}$*	+***	+	-
1989	-0.395 (36.924)$^{***}_{**}$*	-0.860 (17.985)$^{***}_{**}$*	0.984 (13.146)$^{***}_{**}$*	-0.217 (9.180)***	-0.361 (3.130)***	0.266 (1.507)	-0.353 (36.545)$^{***}_{**}$*	-0.856 (18.028)$^{***}_{**}$*	0.980 (13.315)$^{***}_{**}$*	+***	+***	-***
1990	-0.358 (33.660)$^{***}_{**}$*	-0.888 (16.679)$^{***}_{**}$*	1.027 (11.859)$^{***}_{**}$*	-0.238 (10.776)$^{***}_{**}$*	-0.476 (4.271)***	0.4338 (2.660)***	-0.353 (41.550)$^{***}_{**}$*	-0.887 (20.880)$^{***}_{**}$*	1.027 (15.719)$^{***}_{**}$*	+***	-	+
1991	0.345 (33.414)$^{***}_{**}$*	-0.855 (15.065)$^{***}_{**}$*	0.971 (11.895)$^{***}_{**}$*	-0.216 (9.489)***	-0.377 (3.167)***	0.2875 (9.663)***	-0.338 (44.008)$^{***}_{**}$*	-0.847 (21.359)$^{***}_{**}$*	0.961 (15.924)$^{***}_{**}$*	+***	+*	-***

†This is a test of whether the price elasticities derived from the respective cost functions are significantly different from 0.
††This difference was tested using a model estimating both stocks and mutuals together with dummy variables distinguishing mutual input prices. As applied, the test determines whether the stocks elasticity differs from that of mutuals.

***significant at the 0.01 level.
**significant at the 0.05 level.
*significant at the 0.10 level.

Table G Likelihood Ratio Tests for Differences in the Cost Functions

Year	Stock	Mutual	Combined model	Statistical Difference† χ^2 (37)
1985	-114.786	105.233	-86.036	191.178***
1986	-88.379	99.571	-58.436	94.448***
1987	-84.757	74.986	-77.104	173.75***
1988	-75.204	100.627	-75.204	99.562***
1989	-125.610	97.426	-101.528	259.424***
1990	-135.153	101.982	-110.580	254.331***
1991	-117.767	92.357	-93.704	238.228***

†Statistical difference test employed was a likelihood ratio test: $\Lambda = [ln|\Omega_r| - ln|\Omega_u|]$ s.t. $-2ln\Lambda \sim \chi^2(r)$ with degrees of freedom equal to the number of restrictions and r, $ln|\Omega|$ is the absolute value of the log of the likelihood function, and r and u refer to the restricted and unrestricted samples respectively.

***significant at the .01 level.
**significant at the .05 level.
*significant at the .10 level.

Table H Scale Economy Estimates
(number in parenthesis is absolute value of asymptotic z score)

	Mutual	Stock
Year	Ray Scale Economies	Ray Scale Economies
1985	0.923 (1.887)**	0.918 (1.054)
1986	0.867 (3.889)***	0.906 (2.778)***
1987	0.845 (3.884)***	0.931 (1.775)*
1988	0.861 (4.520)***	0.896 (2.897)***
1989	0.876 (3.606)***	0.925 (2.174)**
1990	0.897 (4.250)***	0.942 (1.450)
1991	0.887 (-3.152)***	0.904 (2.653)***

***significant at the .01 level.
**significant at the .05 level.
*significant at the .10 level.

Table I Efficiency Scores for Mutuals and Stocks

Decile	Mutuals [m(m)]			Stocks [s(s)]		
	XEFF(.01)*	XEFF(.05)**	XEFF(.10)***	XEFF(.01)*	XEFF(.05)#**	XEFF(.10)***
.00-.10	0	0	0	10	0	0
.11-.20	0	0	0	116	0	0
.21-.30	2	0	0	192	74	0
.31-.40	10	0	0	106	96	77
.41-.50	30	7	0	40	118	69
.51-.60	25	13	0	17	84	95
.61-.70	15	25	21	6	51	79
.71-.80	1	19	24	5	32	59
.81-.90	2	17	15	0	10	37
.91-1.00	2	6	27	7	34	83
mean	.515	.704	.804	.291	.499	.639
n	87	87	87	499	499	499

*efficiency score was truncated at the one percent level.
**efficiency score was truncated at the five percent level.
***efficiency score was truncated at the 10 percent level.

Table J Efficiency Scores for Firms Using Mutuals' Technology

Decile	Mutuals [m(m)]			Stocks As Mutuals [m(s)]		
	TEFF(.01)*	TEFF(.05)**	TEFF(.10)***	TEFF(.01)*	TEFF(.05)**	TEFF(.10)***
.00-.10	35	0	0	427	148	83
.11-.20	51	0	0	46	140	139
.21-.30	1	0	0	10	75	78
.31-.40	0	7	0	4	39	51
.41-.50	0	19	2	3	20	39
.51-.60	0	29	5	1	14	17
.61-.70	0	24	14	1	14	13
.71-.80	0	4	23	0	9	9
.81-.90	0	0	16	0	4	8
.91-1.00	0	4	27	7	36	62
mean	.108	.569	.798	.067	.265	.350
n	87	87	87	499	499	499

*efficiency score was truncated at the one percent level.
**efficiency score was truncated at the five percent level.
***efficiency score was truncated at the 10 percent level.

Table K Efficiency Scores for Firms Using Stocks' Technology

Decile	Mutuals as Stocks [s(m)]			Stocks [s(s)]		
	TEFF(.01)*	TEFF(.05)**	TEFF(.10)***	TEFF(.01)*	TEFF(.05)**	TEFF(.10)***
.00-.10	74	0	0	337	0	0
.11-.20	4	46	0	144	20	0
.21-.30	1	16	50	9	74	33
.31-.40	1	5	12	9	92	48
.41-.50	0	4	3	0	125	71
.51-.60	0	5	2	0	75	92
.61-.70	1	2	4	0	46	71
.71-.80	0	0	4	0	22	58
.81-.90	0	0	1	0	11	34
.91-1.00	6	9	11	0	34	92
mean	.119	.303	.428	.093	.476	.633
n	87	87	87	499	499	499

*efficiency score was truncated at the one percent level.
**efficiency score was truncated at the five percent level.
***efficiency score was truncated at the 10 percent level.

Figure 1

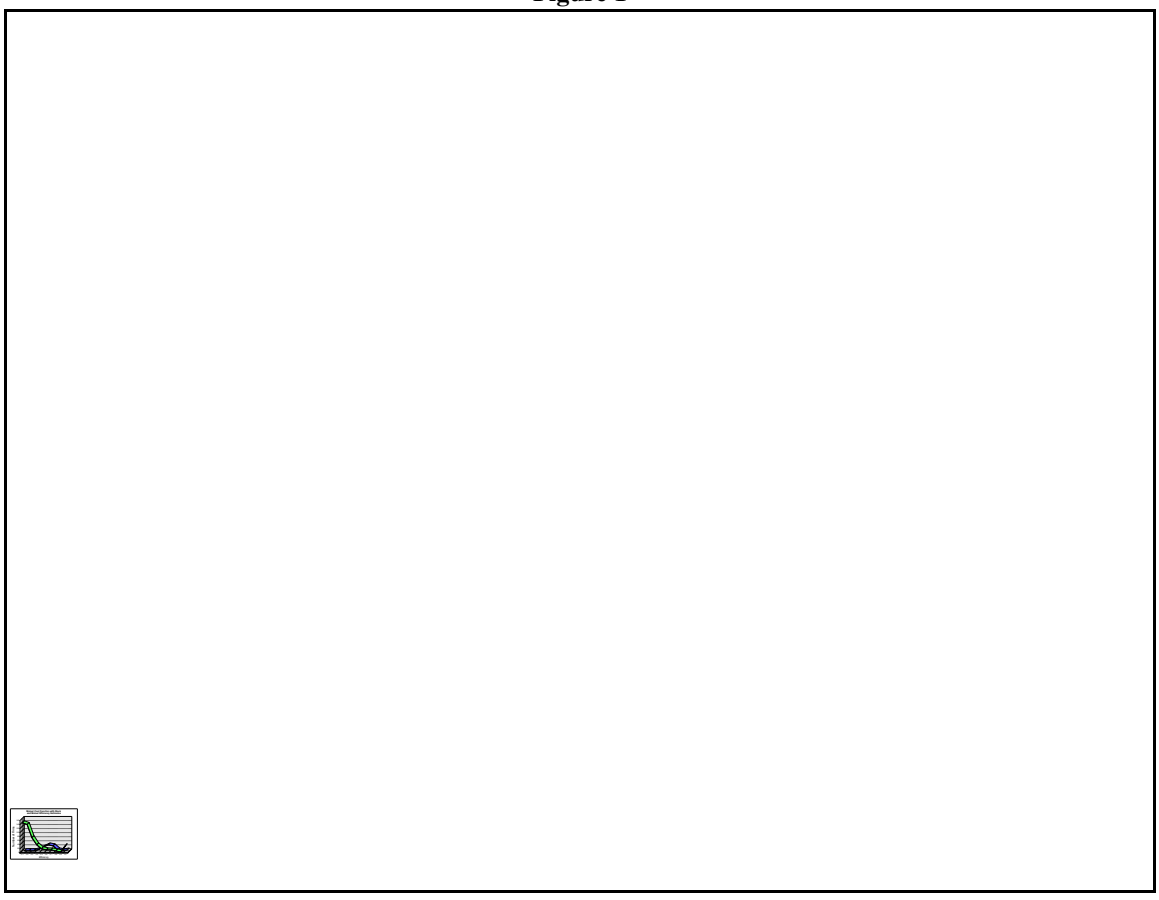
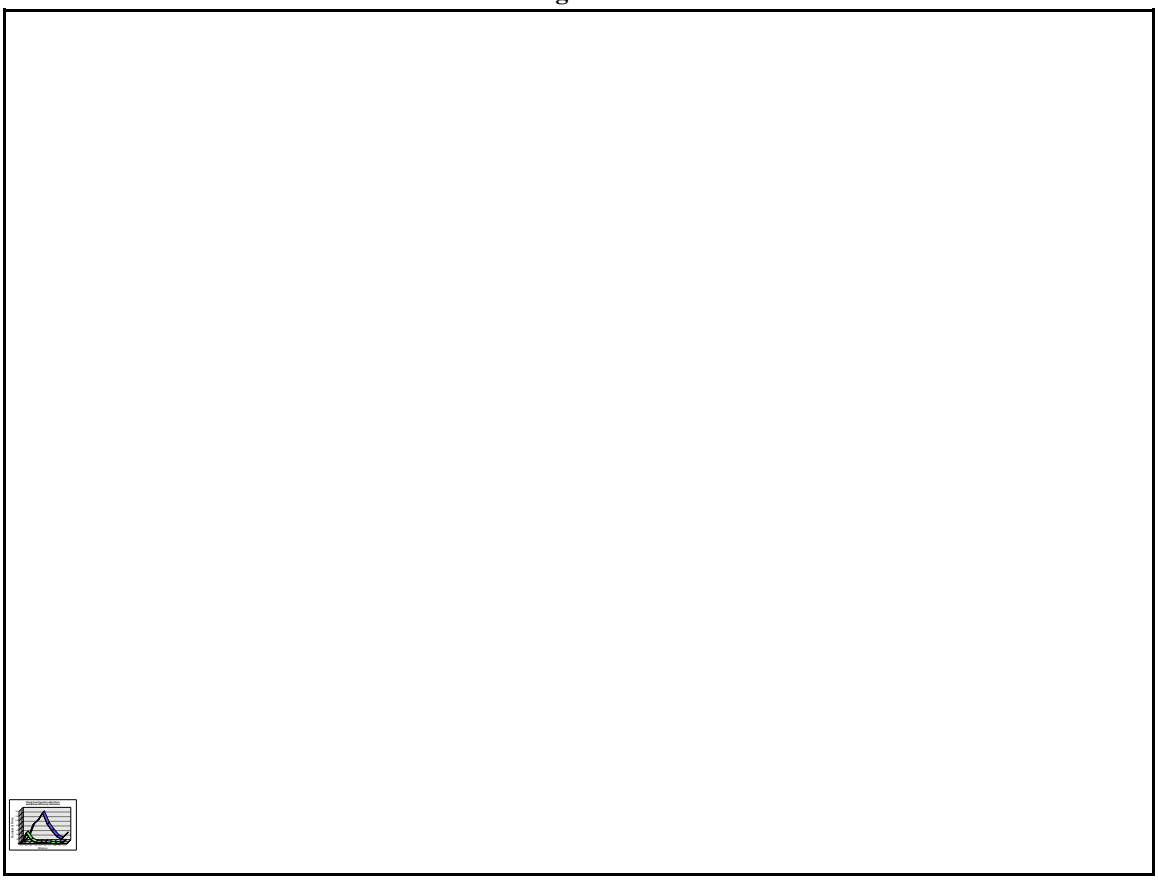
Figure 2