Optimal Capital Utilization by Financial Firms: Evidence from the Property-Liability Insurance Industry

By

J. David Cummins*

Gregory P. Nini

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J. David Cummins*
The Wharton School
3641 Locust Walk
Philadelphia, PA 19104
Phone: 215-898-5644
Fax: 215-898-0310
Email: cummins@wharton.upenn.edu

Gregory P. Nini
The Wharton School
3641 Locust Walk
Philadelphia, PA 19104
Phone: 215-898-5644
Fax: 215-898-0310
Email: greg30@wharton.upenn.edu

*Please address correspondence, page proofs, etc. to David Cummins.

OPTIMAL CAPITAL UTILIZATION BY FINANCIAL FIRMS: EVIDENCE FROM THE PROPERTY-LIABILITY INSURANCE INDUSTRY

Abstract

Capitalization levels in the property-liability insurance industry have increased dramatically in recent years – the capital-to-assets ratio rose from 25 percent in 1989 to 35 percent by 1999. This paper investigates the use of capital by insurers to provide evidence on whether the capital increase represents a legitimate response to changing market conditions or a true inefficiency that leads to performance penalties for insurers. We estimate "best practice" technical, cost, and revenue frontiers for a sample of insurers over the period 1993-1998, using data envelopment analysis, a non-parametric technique. The results indicate that most insurers significantly over-utilized equity capital during the sample period. Regression analysis provides evidence that capital over-utilization primarily represents an inefficiency for which insurers incur significant revenue penalties.

1. Introduction

Insurers hold equity capital to provide assurance to policyholders that claims will be paid if losses are higher than expected or if investment returns fall short of expectations. The objective is to attain an optimal level of insolvency risk that balances the marginal benefits and costs of holding equity capital. There are marginal benefits from holding capital because safer insurers command higher prices and because insurers risk losing customers if insolvency risk is perceived as excessive (Sommer 1996, Cummins and Danzon 1997). However, holding equity capital in an insurance company is costly due to regulatory costs, agency costs from unresolved owner-manager and owner-policyholder conflicts, the costs of adverse selection and moral hazard in insurance underwriting and claims settlement, corporate income taxation (Cummins and Grace 1994), and other market frictions. Hence, insurers do not hold sufficient capital to eliminate insolvency risk; rather, insurers maintain market-driven "safe" or "adequate" levels of capital (Cummins, Grace, and Phillips 1999).[1]

A puzzle has developed in the property-liability insurance industry as capitalization has risen to unprecedented levels in recent years. The ratio of premiums written to surplus, the industry's standard leverage index, traditionally fluctuated around two. Beginning in the mid-1980s, however, the ratio began a precipitous decline and dipped below one at the end of 1999. Likewise, the equity capital-to-assets ratio, traditionally around 25 percent, increased to 35 percent by 1999. These developments raise questions about whether the industry is over-capitalized or whether structural changes in the insurance or capital markets have altered the optimal degree of capitalization.

The objective of this paper is to analyze capitalization in the property-liability industry to provide new evidence on whether insurers are over-utilizing equity capital. We employ a frontier efficiency approach to analyze capital utilization of property-liability insurers over the period 1993-1998. Using data envelopment analysis (DEA), a non-parametric technique, we estimate "best

[1] Regulation, including the National Association of Insurance Commissioners (NAIC) risk-based capital system, specifies minimum levels of capital for insurers. However, the vast majority of insurers maintain significantly higher capital than required by risk-based capital rules (see Cummins, Grace, and Phillips 1999).

practice" technical, cost, and revenue frontiers and measure the efficiency of each firm in the sample relative to the frontiers, producing estimates of technical, allocative, cost, and revenue efficiency.

A key concept that we use in analyzing insurer capital utilization is that of *cost efficiency*, which measures the firm's success in minimizing costs. Cost efficiency is defined as the ratio of the costs that would be incurred by a fully efficient firm producing the firm's outputs to the costs actually incurred by the firm. Thus, fully efficient firms have cost efficiencies of one, and inefficient firms have cost efficiency between zero and one. Cost efficiency can be decomposed into *technical efficiency* and *allocative efficiency*. Technical efficiency measures the firm's success in using state-of-the-art technology, i.e., in operating on the production frontier. Allocative efficiency measures the firm's success in choosing the cost minimizing combination of inputs, conditional on output quantities and input prices. To be fully cost efficient, a firm must operate with full technical and allocative efficiency. We also estimate *revenue efficiency*, which measures the firm's success in maximizing revenues. Revenue efficiency is defined as the firm's actual revenues divided by the revenues of a fully efficient firm that utilizes the same quantity of inputs. As with cost efficiency, technical, allocative, and revenue efficiency equal one for fully efficient firms and are between zero and one for inefficient firms. Lower efficiency scores indicate more inefficient firms.

The concept of allocative efficiency provides a natural way to analyze whether insurers are under- or over-utilizing capital. Allocative efficiency measures the extent to which a firm chooses the correct quantities of inputs in order to produce their outputs. Further, the estimation procedure generates estimates of the optimal input quantities for each firm in the sample. By comparing the actual capital for a given firm with its optimal capital, we can determine whether the firm is under or over-utilizing capital relative to the capital that would be used by a fully efficient firm with the same quantity of outputs.

There are two possible reasons why firms may be measured as under- or over-utilizing capital in our DEA analysis. The first possibility is that measured sub-optimal capital utilization represents a rational response to market factors or firm characteristics that legitimately require differential capital utilization. If this explanation is correct, a firm's performance should not be adversely affected by differences between its actual capital and its measured optimal capital. The second possible explanation is that measured under- or over-utilization of capital represents a true inefficiency that degrades firm performance. To provide information on which explanation is correct, we utilize revenue efficiency and book-value return on equity (ROE) to measure firm performance and estimate the impact of capital utilization on these performance measures. We regress revenue efficiency scores and book-value ROE against a set of explanatory variables, including the ratio of the firms' actual less optimal capital to assets. This ratio, which we call the *sub-optimal capital-to-assets ratio*, represents the amount of capital under- or over-utilization relative to assets. A larger value for this ratio indicates excessive use of capital relative to our measured level of optimal capital. If measured sub-optimal capital utilization represents inefficiency, then we expect the sub-optimal capital to assets ratio to have adverse effects on firm performance, as explained in more detail below.[2]

In addition to measuring the effects of sub-optimal capital on firm performance, we specify and test several hypotheses regarding the characteristics of firms that are likely to be associated with capital utilization. We regress the ratio of the firm’s actual-to-optimal capital against a vector of explanatory variables representing the theoretical hypotheses. These tests enable us to control for differences among firms that may help to explain observed patterns of capital utilization in the industry.

By way of preview, we find that the run-up in equity capital of the past decade is primarily attributable to capital gains on investments. Further, we provide evidence that capital levels in the industry are "sticky" in the sense that insurers are reluctant to pay out capital accumulations as

[2] We also perform similar regressions to test if the effect is symmetric for under and over-utilization of capital. By separating the sub-optimal capital-to-assets ratio into positive and negative components, we test whether any adverse effects of sub-optimal capital utilization differ depending upon whether the insurer is under- or over-capitalized.

dividends, preferring to maintain internal funds to cushion the loss or investment shocks. Finally, we find that insurers are substantially over-utilizing equity capital and that the over-utilization represents inefficiency that leads to significant revenue and cost of capital penalties for inefficient firms.

The remainder of the paper is organized as follows: Section 2 provides an empirical overview of capitalization trends in the property-liability insurance industry to provide background for the subsequent discussion. In section 3, we formulate hypotheses about insurer capital structure and specify the variables used to test the hypotheses. Section 4 discusses hypotheses and variables regarding revenue efficiency and ROE. Section 5 discusses our estimation methodology, and section 6 describes our sample and specifies the inputs and outputs used in the DEA analysis. The results are presented in section 7, and section 8 concludes.

2. CAPITALIZATION TRENDS IN PROPERTY-LIABILITY INSURANCE

Leverage ratios for the property-liability insurance industry for the period 1970-1999 are graphed in Figure 1. Two leverage ratios are shown - the ratio of net premiums written to equity capital (surplus) and the equity capital-to-assets ratio. The former is the traditional leverage ratio used in the industry, while the latter is used more commonly in the financial institutions literature. Both leverage ratios illustrate that equity capitalization in the industry has increased dramatically over the past fifteen years. The premiums-to-surplus ratio was near 2.0 in 1985 but then began an almost uninterrupted decline to less than 1.0 by 1999. The capital-to-assets ratio, which stood at 25 percent in 1985, increased to 37 percent by 1999.

The trends in the leverage ratios are primarily due to growth in insurer equity capital. During the ten-year period 1990-1999, equity capital growth averaged 10 percent per year (on a book basis), while premium growth was only about 3 percent per year. The divergent growth rates in capital and premiums are shown in Figure 2, which graphs the six-year moving averages in the growth rates for these two variables. Except for brief periods such as the mid-1980s, the growth rate in capital has far exceeded the growth rate in premiums. During the 1990s, the capital growth in the industry tracks the bullish stock market (see further discussion below).

What can explain the dramatic changes in capital structure in this industry? There are several possibilities, most of which are explored in more depth below:

(1) The introduction of a risk-based capital (RBC) system by the National Association of Insurance Commissioners (NAIC) in 1994. The introduction of the RBC system was widely anticipated and may have led insurers to accumulate more capital to reduce the probability of incurring regulatory costs under the new system.

(2) The rise in importance of rating agencies. The insurance product market is known to react to ratings downgrades by firms such as the A.M. Best Company, Standard & Poor's, and Moody's. For example, in the commercial lines market, it is necessary for insurers to maintain at least an A rating in order to avoid losing customers to competitors. The rating agencies have played a more aggressive role with respect to insurers following the run-up in insurer insolvencies in the late 1980s and early 1990s. Thus, some insurers may have accumulated additional capital to protect their financial ratings.

(3) The growth in the market for *alternative risk transfer* products, which provide a substitute for conventional insurance. These include self-insurance programs, captive insurance companies, and securitized financial risk transfer instruments. These products have drained many of the more predictable risks out of insurance markets, increasing the overall volatility of insurer liability portfolios. Additionally, the rise of the alternative market has caused premium growth to stagnate, partially accounting for the gap between premium and equity growth.

(4) An increased awareness by insurers of their exposure to catastrophic property losses coupled with inadequate supply of reinsurance for such losses. Following hurricane Andrew in 1992 and the Northridge earthquake in 1994, insurers revised upward their estimates of potential losses due to catastrophes such as hurricanes and earthquakes. Simultaneously, it became apparent that

reinsurance for these large events was inadequate (Swiss Re 1997, Froot 1999). Thus, insurers with significant catastrophe exposure may have added capital to cushion catastrophic loss shocks.

(5) The 1990s bull market in corporate equities, combined with insurer reluctance increase stockholder dividends. There is both theoretical and empirical evidence that there is considerable 'stickiness' among insurers in adjusting dividends in response to increases in equity (Winter 1994, Gron 1994, Cummins and Danzon 1997). The stickiness is driven by informational asymmetries that make it difficult for insurers to raise capital after a loss or investment shock, inducing them to hold onto capital windfalls in anticipation of the next underwriting crisis.

(6) Agency costs and other aspects of insurer organizational and market structure. These factors, including the role played by mutual insurers, are discussed in more detail below.

Tracing the source of the industry's growth in equity capital may provide some initial answers to the capital structure puzzle. Table 1 breaks down the industry's growth in book equity into its sources and uses for the period 1989-1998. Section A of the table shows that total capital grew by \$215.7 billion from 1989-1998, net of \$78.8 billion in stockholder dividends and \$29.4 billion in miscellaneous outflows. These capital disbursements are added back to the net change in capital to give the gross change in capital, and section B of the table shows the percentages of the gross change from each source of capital.

Capital gains provided the most important source of new capital during the ten-year period 1989-1998 and the four-year period 1995-1998, accounting for 51.7 percent during the former period and 57.0 percent during the latter. The second most important source of gross new capital is retained earnings (net underwriting income plus investment income), and the third most important source is new capital paid-in, from new equity offerings or contributions from parent firms. The uses of the gross changes in equity are shown in section C of the table. Insurers paid out as dividends about one-fourth of the total gross change in capital while retaining about two-thirds, with the remainder devoted to miscellaneous uses.

Table 1 provides some support for the capital stickiness hypothesis, i.e., that capital accumulates because insurers are concerned about the feasibility of raising new capital following the next major underwriting or investment shock. The last column in section A of the table shows the dividend payout rate over the period, i.e., the ratio of stockholder dividends paid to the total gross change in capital. The average payout rate is significantly lower in the second half of the sample period than during the first half, even though the second half of the sample period accounted for about 70 percent of the total change in gross capital. This is consistent with the view that insurers are reluctant to reduce capital during periods of capital growth by increasing the dividend payout rate.

3. Hypotheses: Capital Structure and Leverage

In this section, we discuss economic factors that influence insurer decisions about capitalization and formulate hypotheses about insurer capital structure based on financial theory. In addition to discussing the rationale for insurers to hold capital, we also formulate hypotheses about firm characteristics likely to be associated with under- and over-capitalization.

3.1 Financial Distress

The costs of financial distress are a common friction identified as influencing capital decisions. As insurers increase their capital relative to premiums or liabilities, the probability of insolvency declines, reducing the associated expected costs of financial distress. However, holding capital in an insurance company is costly because of various frictions and market imperfections, including agency costs, costs arising from adverse selection and moral hazard, regulatory costs, and corporate income taxation (Merton and Perold 1998). Agency costs for an insurer include the costs of unresolved owner-manager and policyholder-owner conflicts. For example, managers may take actions that are inconsistent with the maximization of firm value such as failure to invest in positive net present value projects whose risk may be a threat to managerial job security. Insurance markets are characterized by adverse selection and moral hazard, which lead to higher costs of capital to the extent that they cannot be fully controlled through contract design, underwriting, and the claims settlement process. Finally, insurers incur significant regulatory costs and costs from corporate income taxation to the extent that these costs cannot be fully passed along to policyholders in premium rates charged for insurance (Cummins, Grace, and Phillips 1999, Cummins and Grace 1994). Because of these and other capital costs, insurers do not hold sufficient capital to reduce the probability of bankruptcy to negligible levels.

Financial distress occurs when an insurer has difficulty honoring commitments to policyholders and other creditors. The associated costs include the transactions costs of bankruptcy, the loss of talented employees, the loss of non-marketable and relationship-specific assets, reputation losses, and other losses to the insurer's franchise value. Further, insurance is priced as risky debt, and the prices an insurer's products command in the market are inversely related to the probability of bankruptcy (Sommer 1996, Cummins and Danzon 1997).

All else equal, as the expected costs of insolvency increase, the marginal benefit from holding equity capital increases, and the optimal leverage ratio (e.g., premiums-to-surplus or liabilities-to-surplus) decreases. For an insurance company, the probability of insolvency is related to an insurer's ability to diversify risk. As proxies for insolvency risk, we define three measures of liability risk and one measure of asset risk.

The first measure of liability risk is the insurer's diversification across geographical areas. Other things being equal, an insurer that is more geographically diversified is expected to have lower insolvency risk than insurers that are more concentrated geographically. To measure geographical diversification, we use a Herfindahl index of insurer premium writings by state. The second measure of liability risk is the insurer's Herfindahl index across lines of insurance based on premium volume.[3] Insurers that are more diversified by line are expected to have lower insolvency risk than insurers concentrating on one or a few business lines. Lower Herfindahl indices imply higher diversification

[3] The Herfindahl indices are, respectively, the sum of squares of the percentages of premiums written by state and the sum of squares of the percentages of premiums written by line.

and, consequently, the geographical and line of business Herfindahl indices are predicted to be positively related to the use of capital.

The third measure of liability risk focuses on the insurer's use of reinsurance. Because reinsurance represents diversification among insurance companies, firms that purchase more reinsurance are expected to have lower insolvency risk. Our measure of the intensity of an insurer's reinsurance activities is the ratio of ceded loss reserves to direct plus assumed loss reserves.[4] We predict an inverse relationship between the reinsurance variable and the utilization of capital.

The measure of asset risk used in our analysis is the percentage of an insurer's assets invested in stocks and real estate, because these assets expose insurers to more volatility risk than their fixed income investments, which tend to be highly rated bonds and notes. We expect a positive relationship between the percentage of assets in stocks and real estate and the utilization of capital. These propositions are stated formally in the following hypotheses.

H1. *The Herfindahl indices of premiums written by state and by line of business will be positively related to capital utilization.*

H2. *Firms with higher ratios of ceded loss reserves to direct plus assumed loss reserves will use less capital.*

H3. *Firms with higher percentages of assets invested in stocks and real estate will use more capital.*

Part of the increase in capitalization levels in the insurance industry may be attributable to changes in the characteristics of insured risks. Buyers have substituted a variety of "alternative risk transfer" mechanisms for insurance, removing the more predictable risks and continuing to insure the more volatile risks such as commercial liability claims. If insurer liability portfolios have become increasingly volatile, this could provide an explanation of recent capitalization trends.[5] Risk levels

[4] Ceded reserves are the liabilities that an insurer transfers to reinsurers. Direct reserves represent the insurer's obligations in the primary insurance market, and assumed reserves reflect its obligations to other insurers as a reinsurer. Larger ratios of ceded loss reserves to direct plus assumed reserves indicate more use of reinsurance.

[5] Changes in asset portfolio risk also could help to explain the changing capitalization levels in the industry. However, except for an increase in the proportion of assets held in corporate equities, primarily due to unrealized capital gains, in general insurer asset portfolios have changed little over our sample period. We control for the

also are expected to differ cross-sectionally among firms in the industry as a function of both underwriting and investment portfolio choices. To control differences in income volatility across insurers, we use the standard deviation of each insurer's book-value ROE computed over the three years preceding each analysis year. We expect this variable to be positively related to capitalization.

H4. *Higher risk, as measured by the standard deviation of ROE, will be associated with higher capital utilization.*

It is well known from statistical and actuarial theory that the average loss in a pool of risks becomes more predictable as the number of risks in the pool increases. This means that the losses of larger insurers are more predictable than those of smaller firms so that large firms should require relatively lower capitalization to achieve a given level of insolvency risk. Although in principle smaller firms should be able to achieve similar results through reinsurance, in practice reinsurance is costly due to frictions such as moral hazard, adverse selection, and the need to provide a profit to the reinsurer. Following the recent insurance efficiency literature (Cummins and Weiss 2000), we use the natural log of firm assets to represent firm size and propose the following hypothesis:

H5. *Capitalization will be inversely related to firm size.*

3.2 Agency Costs

There are two primary sources of agency costs in the insurance industry: owner-manager conflicts and owner-policyholder conflicts. Conflicts between owners and managers arise because managers do not share fully in the residual claim held by owners and have an incentive to behave opportunistically. Conflicts between owners and policyholders arise because policyholders' claims to assets have legal priority over owners' claims. Owners have an incentive to exploit policyholder interests by changing the risk structure of the firm or taking actions that increase the value of equity, perhaps by decreasing the value of the policyholders' debt claim on the firm.

The owner-manager conflict is a classic example of moral hazard, since the non-contractible

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increased importance of corporate equities by including the ratio of stocks and real estate to total assets as an independent variable in our empirical analysis.

effort of the manager directly affects the value of the claim held by the owner. Without possessing a 100 percent ownership stake, managers face a reduced marginal benefit from investing their effort into the firm, altering the incentives for the manager to exert the optimal effort. This creates a significant agency cost that can be reduced by increasing leverage. Holding constant the managers' level of ownership, reducing equity capital increases the managers' stake in the firm, helping to align the interests of owners and managers. Reducing equity also decreases the amount of free cash available for managers to pursue private interests, such as taking on projects that increase the size of the firm but do not maximize the value of equity. Finally, additional leverage increases the probability of bankruptcy (a particularly costly event for managers), making value-destroying pursuits more costly for managers. Mitigating the conflict between managers and owners thus constitutes a benefit from increased leverage.

When owners and policyholders are separate classes of investors, a conflict arises because owners have a claim to firm value only beyond the claims of policyholders. Due to limited liability, equity ownership is equivalent to a call option on the value of the firm, making risky investments attractive to owners. Since policyholders bear much of the consequences of failed investments, policyholders prefer less risky investments. When the opportunistic behavior of owners is anticipated, the effect is incorporated into the price of insurance, and owners bear much of the cost of the incentive conflict. This cost can be reduced by decreasing leverage, which mitigates the price effect by reducing insolvency risk. Further, increasing the amount of equity capital relative to premiums reduces the benefit to owners from substituting riskier investments, making asset substitution less attractive. Mitigating the conflict between policyholders and owners thus constitutes a benefit from decreased leverage.

Jensen and Meckling (1976) argue that the optimal capital structure is determined by trading off the benefits from increased leverage (mitigating the owner-manager conflict) with the benefits from decreased leverage (mitigating the owner-policyholder conflict). When the owner-manager conflict is particularly severe, firms may appear under-capitalized to the extent that agency costs are not fully reflected in the cost of capital used in our efficiency analysis. When the owner-policyholder conflict is severe, firms may appear over-capitalized.

Because both stock and mutual insurers are present in the insurance industry, organizational form provides an excellent proxy for the degree of agency costs inherent in an insurance firm. Compared with stock companies, mutuals control the owner-policyholder conflict by merging these two roles. However, the owner-manager conflict is more severe in the mutual ownership form because the mechanisms available for owners to control managers are much more limited than in the stock ownership form. In a rational market, one would expect the benefits from removing the owner-policyholder conflict to exceed the costs of unresolved owner-manager conflicts in mutual insurance firms. Consequently, the elimination of the owner-policyholder conflict is likely to result in a reduced marginal benefit from holding capital in mutuals, suggesting that mutuals may be less capitalized than stocks, other things equal. Mutuals also may have less need for capital than stocks because they tend to invest in less complex or less risky projects requiring limited managerial discretion in pricing and underwriting (Lamm-Tennant and Starks 1993). On the other hand, mutuals may have a greater tendency than stocks to hoard capital during profitable periods because of their limited ability to access capital markets in the event of a shock to capital. In addition, to the extent that holding additional capital provides benefits to managers (e.g., from controlling larger investment portfolios), mutuals may hold capital in excess of optimal levels because of a misalignment of policyholder and manager interests. Because we do not have an unambiguous prediction about ownership form, we state the following hypothesis in null form:

H6. *Mutuals will not utilize capital more or less intensively than stocks.*

Due to the time lag between payment of premiums and payment of claims, insurance firm managers are in control of policyholder funds for a significant period of time. This time lag offers managers the opportunity for engaging in activities that provide private benefits, possibly to the detriment of the firm and policyholders. As the policy length and claims tail increases, the problem worsens; and there is a benefit to removing excess funds from the firm and increasing the bankruptcy probability. Reducing capital and increasing leverage can accomplish this. An insurer's loss reserve and unearned premium reserve are liabilities for losses not yet paid and premiums received for which service has not yet been provided. The ratio of the sum of loss and unearned premium reserves to incurred losses is used as a proxy for time lag between policy issuance and the payment of claims, with higher ratios indicating longer tailed business. As this ratio increases, the marginal cost of capital increases and firms are predicted to choose lower capital levels. Thus, we hypothesize that:

H7. *The ratio of reserves to losses incurred will be inversely related to capital utilization.*

3.3 Asymmetric Information and Growth Opportunities

If corporate managers possess superior information about the firm's assets in place and new investment opportunities than do owners, Myers and Majluf (1984) argue that these information asymmetries may cause managers to forego positive net present value projects. This results in a "pecking order" theory of financing where managers prefer financing through internal funds and debt rather than issuing new equity. As the degree of asymmetry between managers and investors increases, this under-investment problem worsens and raising equity capital becomes more costly.

The implications of the Myers-Majluf theory for our analysis depend upon the degree of the informational asymmetry problem in the insurance industry and the response to the problem by the firms in the industry. Because property-liability insurers invest primarily in marketable securities, there are minimal informational asymmetries from the asset side of the balance sheet, except perhaps with respect to the credit risk of receivables from agents and reinsurers. The principal informational asymmetry for property-liability insurers arises from uncertainty about the true value of reserves for the payment of unpaid losses, which averages about 65 percent of total liabilities, industry-wide. A substantial component of the loss reserve represents insurer estimates of the claims to be paid in the future on long-tail policies such as commercial liability insurance. Insurers have significant actuarial and accounting flexibility in determining the stated loss reserve, and most of the information needed to evaluate the accuracy of reserve estimates is not available outside the insurer. Hence, there are significant information asymmetries between managers and investors with regard to the liabilities for long-tailed insurance policies, especially in the commercial lines.

Insurers may respond to the informational asymmetry problem by building up slack capital during profitable periods to provide internal funds to invest in attractive future projects. Alternatively, insurers with relatively high information asymmetries may become more highly leveraged, especially during unprofitable phases of the underwriting cycles, because they are at a net disadvantage in raising new equity relative to insurers whose liabilities are more transparent to investors. That is, if insurers with the greatest reserving uncertainty have equal ability to generate retained earnings as insurers with more transparent liabilities, the former group will likely become more highly leveraged over time because its costs of raising external capital are higher. Moreover, firms with higher reserve uncertainty may actually be less successful in generating retained earnings because long-tail lines of insurance tend to generate less income from underwriting than shorter-tail lines. Thus, such insurers may be disadvantaged in raising both internal and external capital, implying that information asymmetries between managers and owners are more likely to lead to higher leverage rather than additional slack capital in the insurance industry. Another implication of the Myers-Majluf theory is that for any given degree of informational asymmetry, firms with more growth opportunities are expected to hold additional capital to avoid the need for raising costly capital in the future. This discussion suggests the following hypotheses:

H8. *Firms with higher information asymmetries between managers and owners will be more highly leveraged than firms with lower information asymmetries*
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H9. *Firms with more growth opportunities will hold relatively more equity capital.*

The standard deviation of ROE over time is used as a proxy for the degree of information asymmetries between managers and investors. Insurers with low earnings volatility are assumed to possess assets and liabilities that change very little over time, making their future profitability easily conveyed from manager to investor. However, insurers with higher volatility have operations that are less predictable, and therefore have more severe information asymmetries than less risky insurers. Based on this rationale, the standard deviation of ROE is predicted to be inversely related to capitalization. Recall, however, that H4 predicts a positive relationship between ROE risk and capital, based on the financial distress costs argument. Thus, the sign of this variable will depend upon the extent to which it measures firm opacity versus the probability of financial distress. The ratio of reserves to losses incurred, discussed in connection with H7, also serves as a proxy for informational asymmetries, to the extent that lengthening the claims payment tail increases uncertainty about reserve accuracy. The reserves variable thus has a predicted negative sign under both H7 and H9.

To proxy for growth opportunities, we use the one-year percentage growth rate in premiums. As the measure of growth increases, it is hypothesized that insurers will be motivated to hold more capital to be able to take advantage of growth opportunities using internal rather than external funds. Thus, the premium growth rate is predicted to be positively related to capital utilization.

3.4 Product Market Interaction

Because the purpose of insurance is to diversify risk and indemnify policyholders for losses due to contingent events, the insurance market is sensitive to insurer insolvency risk, and safer insurers command higher prices. In addition, positive switching costs and private information possessed by the incumbent insurer can create a significant advantage to remaining with the same insurer (Kunreuther and Pauly 1986, D'Arcy and Doherty 1990). Due to economies of scale and the existence of insurance brokers, corporate insurance buyers face significantly lower switching costs than personal buyers, making relationships with corporate buyers more fragile than those with personal buyers. The commercial lines insurance market is considered a "commodity market," where buyers choose insurers on the basis of price, from the set of insurers with adequate (often A or better) financial ratings (i.e., the market is characterized by a tendency for "flight to quality"). Moreover, commercial lines buyers and their brokers are more proficient than individual buyers in assessing insurer financial quality, suggesting the following hypothesis:

H10. *Capitalization will be inversely related to the percentage of an insurer's revenues coming from personal lines of insurance.*

To test H10, we include in the regressions the ratio of the insurer's personal lines premiums to total premiums. This variable is expected to be inversely related to capitalization. We predict a negative coefficient on the personal lines variable based on the flight to quality argument.

3.5 Regulation

In response to an increase in insurer insolvencies in the 1980s and early 1990s, the National Association of Insurance Commissioners (NAIC) instituted risk-based capital (RBC) requirements in 1994. Various regulatory actions are stipulated if the ratio of the insurer's actual capital to risk-based capital falls below a series of thresholds beginning at 200 percent (see Cummins, Grace, and Phillips 1999). The introduction of risk-based capital created a regulatory option that reduced the market value of insurers. Because the option value is inversely related to capitalization, the introduction of RBC is predicted to have increased capitalization levels in the industry. To control for differences in capitalization by year, we include year dummy variables in our regression equations. If capital levels were adjusted following the RBC introduction year (1994), the coefficients of the year dummy variables may be larger in the later years of the sample period. On the other hand, if insurers anticipated the introduction of RBC, any capital adjustments may have occurred prior to our sample period, and the year dummy variable coefficients will have no systematic pattern.

4. Hypotheses: Revenue Efficiency and Return on Equity

In addition to regressions to explain insurer capital structure, we also conduct regressions designed to detect relationships between capital structure and firm performance. We use two indicators of performance - revenue efficiency and book-value return on equity (ROE). In this section, we discuss hypotheses and expected signs for the firm performance regressions.

4.1 Revenue Efficiency

The primary purpose of the revenue efficiency analysis is to determine whether measured capital under- or over-utilization is a rational strategy that is rewarded by the market with additional revenues or a true inefficiency that leads to revenue penalties. The maintained hypothesis about the relationship between capitalization and revenue efficiency is that insurance buyers are sensitive to insolvency risk but that insurance market equilibrium occurs at a non-negligible probability of default. The primary reason is that holding equity capital in an insurance company is costly because of the various market, tax, and regulatory frictions discussed above. Thus, at some point, the marginal benefit of adding capital to reduce insolvency risk falls below the marginal cost of the added capital, producing an optimal capital-to-assets ratio that maximizes firm value.

Our analysis of cost efficiency enables us to estimate the optimal quantity of capital for each firm in the sample. Firms will be rewarded or penalized for measured sub-optimal capital utilization depending upon whether holding capital that deviates from the measured optimum represents a legitimate response to market forces or a true inefficiency. Sub-optimal capital-utilization does not represent a true inefficiency if capital levels reflect legitimate differences in capital requirements across firms because of heterogeneity in underwriting or investment portfolios, corporate governance, or other factors. On the other hand, if deviations from optimal capital represent a true inefficiency, insurers holding sub-optimal amounts of capital are likely to be penalized by the market in terms of lower revenues. This is either because they hold too little capital and thus have higher insolvency risk than buyers find desirable or because they hold too much capital and perhaps try to recover the costs of the excess capital by charging prices that buyers view as too high.

To test the relationship between revenue efficiency and capital utilization, we use as an explanatory variable the *sub-optimal capital-to-assets ratio*, defined as the ratio of actual minus optimal capital-to-assets. If measured capital under- or over-utilization represents legitimate usage of capital, the sub-optimal capital-to-assets ratio is expected to be positively related to revenue efficiency. However, if measured under- or over-utilization reflects inefficiency, the sub-optimal capital-to-assets ratio is expected to be negatively related to revenue efficiency. In order to determine whether the market responds symmetrically to capital under and over-utilization, we define two additional variables based on the sub-optimal capital-to-assets ratio – the *capital over-utilization ratio*, which is equal to the sub-optimal capital-to-assets ratio when that variable is positive and equal to zero otherwise, and *the capital under-utilization ratio*, which is equal to the sub-optimal capital-to-assets ratio when that variable is negative and zero otherwise.

Most of the explanatory variables discussed in the preceding section also are included in the revenue efficiency regressions, primarily as control variables. In most cases, the expected signs of the explanatory variables are ambiguous a priori. For example, the line of business Herfindahl index is predicted to have a negative sign under the *conglomeration hypothesis*, which holds that it is value-maximizing for firms to offer multiple lines of business, either because of diversification benefits or because buyers are willing to pay more for "one-stop shopping." On the other hand, the *strategic focus hypothesis*, which holds that firms can maximize value through focusing on one or a few lines of business where the firm has a comparative advantage, predicts that the line of business diversification variable will have a positive sign, recalling that high Herfindahl indices imply more concentration.[6] Likewise, the geographical Herfindahl index could have a positive or negative sign depending upon whether focusing on a narrower geographical area allows the firm to become more knowledgeable about the market and hence to build stronger relationships with customers versus reducing risk through diversification. Given that there are other variables in the equation relating more directly to insolvency risk, a positive sign on the geographical Herfindahl may be more likely than a negative sign. Interpreting asset risk as indicative of higher insolvency probabilities, we expect the ratio of stocks and real estate to assets to be inversely related to revenue efficiency.

Firm size is expected to be positively related to revenue efficiency if larger firms have lower

[6] The conglomeration and strategic focus hypotheses are further discussed further in Berger, et al. (2000).

insolvency risk and/or are able to earn higher revenues because size conveys market power. The mutual dummy variable is predicted to have a negative coefficient if mutuals are less efficient than stocks due to unresolved agency conflicts that allow managers to behave inefficiently. The premium growth rate is expected to have a positive sign if firms with more growth opportunities tend to generate higher revenues, other things equal. Finally, the proportion of personal lines output to total insurance output is predicted to have a negative sign if commercial lines insurers have lower insolvency risk or higher value-added because of higher service intensity in the commercial lines.

4.2 Return on Equity

The ROE regressions are designed to provide additional information on the relationship between firm performance and capitalization. Again, we seek to determine whether measured capital under- or over-utilization is a rational response to market forces or a true inefficiency.

Financial theory predicts that firms with relatively more equity (lower leverage) are less risky and thus should have lower costs of equity capital. Consequently, to the extent that realized returns on equity are correlated with the ex-ante cost of capital, we expect the ratio of optimal capital-to-assets to have a negative coefficient in the ROE regressions. If holding additional capital above or below the measured optimum is a rational strategy, the ratio of sub-optimal capital-to-assets is also expected to have a negative coefficient of roughly the same magnitude as the coefficient of the optimal capital-to-assets variable. However, if holding too much or too little capital represents inefficiency, the leverage-reducing benefits of holding additional capital will be partially or fully offset by a market penalty for the inefficiency. Hence, the sub-optimal capital-to-assets ratio could be negative with a smaller (in absolute value) coefficient than the optimal capital-to-assets ratio or conceivably could be insignificant or positively related to ROE.

Also included in an ROE regression is the firm's revenue efficiency score and an indicator variable set equal to 1 if an insurer has a Best's rating of A or higher and equal to zero otherwise. To the extent that highly rated firms can charge higher premiums because of buyer perceptions that they have lower insolvency risk, we predict a positive coefficient for the Best's rating indicator variable. The revenue efficiency score is also predicted to be positively related to ROE because revenue efficient firms lose smaller proportions of their revenues due to inefficiency, giving them higher profits, other things equal. The Best's rating variable and revenue efficiency are jointly determined with ROE. Consequently, they are treated as endogenous variables, using an instrumental variables approach discussed below.

The explanatory variables included in the revenue efficiency regressions also are included in the ROE regressions. There are several unambiguous predictions based on the financial theory relationship between risk and return. If geographical and line of business diversification reduce firm risk, the coefficients on the geographical and line of business Herfindahl indices are predicted to be positive in the ROE regressions because higher Herfindahl indices imply less diversification and a higher cost of capital. The ratio of stocks and real estate to total assets also has a predicted positive coefficient due to the hypothesized relationship between risk and the cost of capital. Likewise, if buying more reinsurance reduces firm risk, our reinsurance variable, the ratio of ceded loss reserves to direct plus assumed loss reserves, is predicted to be inversely related to ROE. Firms with more growth opportunities are likely to be viewed favorably by capital markets, predicting a negative sign on the premium growth variable. Based on our argument that commercial lines insurers will be relatively safe compared to personal lines insurers, we predict a positive coefficient on the ratio of personal lines output to total insurance output.

The predicted sign of the size variable in the ROE regression is ambiguous. On the one hand, if larger firms are more diversified than smaller firms, we would expect size to be inversely related to ROE. On the other hand, if larger firms earn higher revenues due to market power, size could be positively related to ROE. In this regard, it would reflect the firm's earning economic rents rather than a higher ex ante cost of capital. The predicted sign of the long tail lines variable (loss reserves divided by losses incurred) is also ambiguous. If long-tail lines are more risky than short-tail lines and/or firms with more long-tail business are more highly levered, a positive coefficient would be predicted. On the other hand, long-tail lines are known to have lower underwriting profits than short-tail lines because long-tail premiums have a higher discount for the time value of money. If this effect dominates, the long-tail lines variable could have a negative coefficient in the ROE regressions. Finally, if mutual firms are more highly levered than stocks, the mutual dummy variable is predicted to have a positive coefficient, but if mutual firms write lower risk business than stock firms (Lamm-Tennant and Starks 1993), the mutual variable could have a negative coefficient.

5. METHODOLOGY

This section discusses the estimation methodologies used in our analysis of firm capital structure and performance. We begin by discussing the economic efficiency concepts underlying our analysis. Next, we discuss the estimation of efficiency utilizing (DEA). The section concludes with a discussion of the regression methodology used to analyze capital structure and the sub-optimal capital utilization on firm performance.

5.1 Efficiency

To analyze production frontiers, we utilize input-oriented distance functions (Farrell 1957, Shephard 1970). Suppose producers use input vector $x = (x_1, x_2, ..., x_K)' \in \Re_+^K$ to produce output vector $y = (y_1, y_2, ..., y_M)' \in \Re_+^M$. The distance function $D(y, x)$ is interpreted intuitively as the distance of a given firm's output-input vector (y, x) from the best practice production frontier. For a single-input, single-output firm, the frontier can be envisioned as an upward sloping line in (x, y) space. The operating points of fully efficient firms, $D(y, x) = 1$, lie on the frontier, indicating that they operate with the minimum amount of inputs needed to produce their quantity of output. Inefficient firms, $D(y, x) > 1$, lie to the right of the frontier, indicating that they could reduce their input consumption while producing the same quantity of output if they operated on the frontier (i.e., were fully efficient).

More formally, we can define the distance function in terms of the production technology that transforms the *K* inputs into *M* outputs. The production technology is represented by the input correspondence $V(y) = \{ x : (y,x)$ is feasible$\}$. The input-oriented distance function for a specific firm as $D(y,x) = \sup\{\theta : \frac{x}{\theta} \in V(y)\}$. $D(y,x)$ is equal to 1 for efficient firms because they are already on the frontier and hence cannot reduce their input usage. $D(y,x) > 1$ for inefficient firms and equals the reciprocal of the minimum equi-proportional contraction of the input vector *x* that can still produce *y*. A similar interpretation can be given to the distance functions with respect to the cost and revenue frontiers discussed below.[7]

The Farrell measure of input technical efficiency reflects the ability of a firm to minimize inputs utilized to produce a given quantity of output. It is defined as

$$TE(y,x) = \frac{1}{D(y,x)} = \inf\{\theta : \theta x \in V(y)\}.$$

The technical efficiency measure θ is equivalent to one minus the equi-proportional reduction in all inputs that still allows production of the same outputs. It follows that $TE(y,x) \leq 1$. The Farrell measure of technical efficiency can be estimated with respect to a production frontier characterized by constant returns to scale (CRS) or variable returns to scale (VRS). From an economic perspective, firms should operate with CRS, so total technical efficiency is given by Farrell efficiency with respect to a CRS frontier, $TE_{CRS}(y,x)$. Pure technical efficiency is given by Farrell efficiency with respect to a VRS frontier, $PTE(y,x) = TE_{VRS}(y,x)$, and scale efficiency is given by the remaining total technical inefficiency not explained by pure technical efficiency, $SE(y,x) = \frac{TE_{CRS}(y,x)}{TE_{VRS}(y,x)}$, where $SE(y,x)$ denotes scale efficiency. Firms with $SE(y,x) = 1$ are operating with CRS.

[7] For further discussion of distance functions and operating frontiers see Charnes, et al. (1994), Grosskopf (1993) and Lovell (1993).

By explicitly modeling the economic objective of cost minimization, we can estimate the cost efficiency of each firm. When the economic objective is to minimize the costs associated with producing a given output, then economic cost efficiency is measured by the ratio of minimum possible cost to actual observed cost. Supposing producers face input prices $w = (w_1, w_2, ..., w_K)' \in \Re^K_{++}$, the minimum cost frontier is defined as $c(y, x) = \min_x \{w' x : D(y, x) \geq 1\}$. The optimal input vector $x*$ minimizes the costs of producing *y* given the input prices *w*. Cost efficiency then is simply defined as:

$$CE(y, x) = \frac{w' x*}{w' x}.$$

Cost efficiency captures pure technical efficiency, scale efficiency, and allocative efficiency. Allocative efficiency measures a firm's ability to minimize costs using inputs in the optimal proportions, given their relative prices. Given a measure of total technical efficiency and cost efficiency, allocative efficiency is determined residually as

$$AE(y, x) = \frac{CE(y, x)}{TE(y, x)}.$$

Therefore, we have the following decomposition of cost efficiency:

$$CE(y, x) = AE(y, x) \cdot PTE(y, x) \cdot SE(y, x).$$

Finally, by specifying the additional economic objective of maximizing revenues, we can estimate the revenue efficiency of each firm. Assuming output prices $p = (p_1, p_2, ..., p_M)' \in \Re^M_{++}$, the objective is revenue maximization, subject to the constraints imposed by input supplies and the production technology. The revenue maximization problem is: $r(y, x) = \max_y \{p' y : D(y, x) \geq 1\}$. Given the optimal outputs $y*$, revenue efficiency is given by the ratio of actual revenue to maximum revenue: $RE(y, x) = \frac{p' y}{p' y*}$.

5.2 Data Envelopment Analysis

Data envelopment analysis (DEA) is a non-parametric mathematical programming approach to estimating distance functions (Charnes, et al. 1994). Assuming the availability of input, output, and price data for each of N firms, DEA can be used to construct a frontier such that all observed points lie on or below the frontier. For the i^{th} firm, let vectors x_i, y_i, and w_i represent the K, M, and K length column vectors of inputs, outputs, and input prices. Define the matrices X, Y, and W as the $K \times N$, $M \times N$, and $K \times N$ matrices of inputs, outputs, and input prices for all firms, $i = 1,..., N$.

To measure technical efficiency with a CRS production frontier, the following linear program is solved for each firm:

$$\min_{\theta_i \lambda_i} \theta_i \quad \text{subject to:}$$

$$\begin{aligned} & y_i \leq Y\lambda_i \\ & \theta_i x_i \geq X\lambda_i \\ & \lambda_i \geq 0 \end{aligned}$$

where λ_i is an $N \times 1$ vector for firm i representing the combination of firms that form the production frontier for firm i. The solution θ_i^* is a scalar representing the equi-proportional reduction in inputs for firm i that would enable it to produce output vector y if it operated on the production frontier. A value of $\theta_i^* = 1$ would imply that the firm is operating on the frontier, i.e., no reduction in inputs is possible for firm i. This program is solved for each firm in the sample, resulting in a technical efficiency score for each firm $TE_i = \theta_i^*$, $i = 1,..., N$. Constraining the λ_i only to be non-negative results in a CRS frontier.

The above program is modified to account for VRS by adding the convexity constraint $\iota_N' \lambda_i = 1$, where ι_N' is an N-element vector of 1s. Solving the linear programming problem with this constraint yields a convex hull that envelops the data more tightly, resulting in an estimate of pure technical efficiency (PTE). Denoting the solution to the modified program by θ_i^{**}, the estimate of pure technical efficiency is given by $PTE_i = TE_{VRS} = \theta_i^{**}$. Scale efficiency is given by the ratio of the two solutions, $SE_i = \frac{\theta_i^*}{\theta_i^{**}}$. Only if $SE_i = 1$ has the firm has achieved CRS.

To estimate cost efficiency, the objective function of the program is altered to capture total firm costs. The linear program is specified as

$$\min_{x_i \lambda_i} w_i^{'} x_i \quad \text{subject to:}$$

$$\begin{aligned} y_i &\leq Y\lambda_i \\ x_i &\geq X\lambda_i \\ \lambda_i &\geq 0 \end{aligned}$$

Letting x_i^* be the cost minimizing vector of inputs for firm *i*, cost efficiency is given by $CE_i = \frac{w_i^{'} x_i^*}{w_i^{'} x_i}$. Given estimates of cost and technical efficiency, allocative efficiency is estimated by the ratio $AE_i = \frac{CE_i}{TE_i}$. The solution of the cost efficiency program provides the cost-minimizing input vector conditional on the observed technology in the sample. If the ratio $\frac{x_{ik}}{x_{ik}^*} < 1$, the firm is under-utilizing input *k*; and if $\frac{x_{ik}}{x_{ik}^*} > 1$, the firm is over-utilizing input *k*.

Revenue efficiency is computed with a similar linear program, where the objective is changed from cost minimization to revenue maximization

$$\max_{y_i \lambda_i} p_i^{'} y_i \quad \text{subject to:}$$

$$\begin{aligned} y_i &\leq Y \lambda_i \\ x_i &\geq X \lambda_i \\ \lambda_i &\geq 0 \end{aligned}$$

Letting y_i^* be the cost-minimizing vector of inputs for firm *i*, revenue efficiency is given by

$$RE_i = \frac{p_i^{'} y_i}{p_i^{'} y_i^*}.$$

5.3 Ex-Post Regression Analysis

After estimating efficiency scores and optimal inputs, we estimate regression models with the ratio of actual-to-optimal capital, revenue efficiency, and ROE as dependent variables. Ordinary least squares (OLS) is used to estimate the revenue efficiency equation and a version of the revenue efficiency and ROE regressions. We also estimate a version of the actual-to-optimal capital regression that includes an indicator variable set equal to 1 if the firms has an A rating or better from the A.M. Best Company, and to zero otherwise. This is based on the hypothesis that a firm's financial rating may help to explain its capital utilization, e.g., firms may add capital in order to be assured of retaining the requisite A rating from Best's. Because the rating variable is jointly determined with the firms actual-to-optimal capital ratio, OLS estimation of the version of the model that includes the Best's variable would yield inconsistent parameter estimates. To correct for this endogeneity problem, the equation which includes the Best's indicator variable is estimated using two alternative methodologies -- the inverse Mill's (IM) ratio approach and an instrumental variables (IV) approach. The estimation techniques are discussed in more detail in an Appendix available from the authors.

In the ROE equation, we include both the Best's indicator variable and the firm's revenue efficiency score as additional explanatory variables. The inclusion of the Best's variable is based on the hypothesis that firms with A ratings or above are likely to earn economic rents because of the perception among buyers that such firms have relatively low insolvency risk. The revenue efficiency variable is included based on the rationale that revenue efficient firms are likely to have higher returns, because they waste less of their potential revenues due to inefficiency than do inefficient firms. Both variables are expected to be jointly determined with the dependent variable and thus are treated as endogenous. Because we have both a dichotomous and a continuous endogenous variable in this equation, we control for endogeneity using the IV approach, again using the fitted value from a probit model as the instrument for the dichotomous Best's rating variable. Revenue efficiency is treated as in standard two-stage least squares estimation.

6. THE SAMPLE, OUTPUTS, AND INPUTS

This section discusses the sample of insurers analyzed in this study. We also define the outputs, inputs, and output and input prices that we use in estimating efficiency.

6.1 The Sample

The primary source of data for the study consists of regulatory annual statements filed by insurers with the National Association of Insurance Commissioners (NAIC) over the period 1993 to 1998. The operating units in the insurance industry consist of groups of affiliated insurers under common ownership and unaffiliated single insurers. The sample consists of all groups and unaffiliated insurers for which meaningful data were available. The number of firms declined from 970 in 1993 to 770 in 1998, primarily due to consolidation in the insurance industry. The firms in the sample account for about 94 percent of net written premiums in the industry.

6.2 Output Quantities and Prices

Consistent with the recent financial institutions literature, the value-added approach is used to define property-liability insurer outputs (Berger and Humphrey 1992). The value-added approach counts as important outputs those with significant value added, as judged using operating cost allocations. Consistent with the recent literature on insurance efficiency (see Cummins and Weiss 2000), the principal outputs we consider are risk pooling/risk bearing, real services, and financial intermediation, briefly defined as follows:

***Risk-pooling and risk-bearing*.** Insurance provides a mechanism through which consumers and businesses exposed to losses can engage in risk diversification through pooling. For consumers, insurance diversification provides value by reducing the uncertainty in their final level of wealth. For business firms, insurance adds value by reducing income volatility; thereby reducing expected tax payments, expected costs of financial distress, and the costs of external finance. The actuarial, underwriting, and related expenses incurred in risk pooling are important components of value added in the industry. Insurers also add value by holding equity capital to bear the residual risk of the pool.

***'Real' financial services relating to insured losses*.** Insurers provide a variety of real services for policyholders, including the design of risk management programs and the provision of legal defense in liability disputes. By contracting with insurers to provide these services, policyholders can take advantage of insurers' expertise to reduce the costs of managing risk.

Financial intermediation. For property-liability insurers, intermediation is an important but somewhat incidental function, resulting from the collection of premiums in advance of claim payments to minimize contract enforcement costs. Insurers' value added from intermediation is reflected in the net interest margin between the rate of return earned on invested assets and the rate credited to policyholders.

Transactions flow data such as the number of applications processed, the number of policies issued, the number of claims settled, etc. are not publicly available for insurers. However, a satisfactory proxy for the quantity of risk-pooling and real insurance services output is the present value of real losses incurred (Berger, Cummins, and Weiss 1997, Cummins, Weiss, and Zi 1999, Cummins and Weiss 2000). Losses incurred are defined as the losses that are expected to be paid as the result of providing insurance coverage during a particular period of time. Because the objective of risk-pooling is to collect funds from the policyholder pool and redistribute them to those who incur losses, proxying output by the amount of losses incurred seems quite appropriate. Losses are also a good proxy for the amount of real services provided, since the amount of claims settlement and risk management services also are highly correlated with loss aggregates.

Because the types of services provided differ between the principal types of insurance and the timing of the loss cash flows also varies, we use as separate output measures the present values of personal lines short-tail losses, personal lines long-tail losses, commercial lines short-tail losses, and commercial lines long-tail losses, where the tail length refers to the length of the loss cash flow stream.[8] Cash flow patterns are estimated from data in Schedule P of the NAIC insurance regulatory statement using the Taylor separation method (see Cummins 1990), and discounting is conducted using U.S. Treasury yield curves obtained from the Federal Reserve Economic Database (FRED) maintained by the Federal Reserve Bank of St. Louis.

Average real invested assets for each year are used to measure the quantity of the

[8] The lines of business are classified as short and long-tail on the basis of their classification in Schedule P of the National Association of Insurance Commissioners (NAIC) regulatory annual statement.

intermediation output. Monetary-valued variables are deflated to real 1989 values using the consumer price index (CPI).

In keeping with the value-added approach to output measurement, the prices of the insurance outputs are defined as: $p_i = \frac{P_i - PV(L_i)}{PV(L_i)}$, where p_i is the price of insurance output *i*, $i = 1,...,4$ for personal short-tail output, personal long-tail output, commercial short-tail output, and commercial long-tail output. The present value of losses is used in computing the price because premiums reflect implicit discounting of the loss cash flow stream. Using present values of losses maintains consistency by recognizing the time value of money both in the premium and loss components of the price.[9] Multiplying the price p_i by the quantity of output, $PV(L_i)$, gives the value-added from the i^{th} insurance output.

For the price of the intermediation output, we need a measure of the expected rate of return on the insurer's assets. Although insurers are primarily fixed income investors, equities represent a significant proportion of invested assets for property-liability insurers. Accordingly, the expected return on assets should incorporate the expected returns on both the debt and equity components of insurer investment portfolios. Because the expected return on bonds and notes generally will be close to the actual return, we use the ratio of actual investment income (minus dividends on stocks) to insurer holdings of debt instruments to represent the rate of return on that component of the portfolio. For stocks, we compute the expected return for a specified year as the 90-day Treasury bill rate at the end of the preceding year plus the long-term (1926 to the end of the preceding year) average market risk premium on large company stocks from Ibbotson Associates (1999). Using this approach assumes that insurers have equity portfolios with a market beta coefficient of 1.0.

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[9] This is a generalization of the insurance unit price concept that has been used extensively in the insurance economics literature (e.g., Pauly, Kunreuther, and Kleindorfer 1986). The conventional unit price measures the cost of delivering $1 of benefits as the ratio of premiums to incurred losses.

The expected portfolio rate of return for each insurer is determined as a weighted average of the debt and equity returns with weights equal to the proportion of the total portfolio invested in debt securities and stocks. Thus, the price of the intermediation output differs across insurers because of variation both in the return on debt instruments and in the debt/equity portfolio proportions.

6.3 Input Quantities and Prices

Insurance inputs are classified into three groups: labor, materials and business services, and financial capital. Because insurers do not report the number of employees or hours worked, the quantity of labor is imputed by dividing the total expenditure on labor by the price of labor. Denoting the quantity of labor by Q_L, the current dollar expenditures as X_L^c, and the current dollar wage rate as w_L^c, the quantity of labor is defined as $Q_L = \frac{X_L^c}{w_L^c}$. The real price of labor is found by deflating the current dollar wage rate, $w_L = \frac{w_L^c}{c}$, where c is the consumer price index (CPI). Multiplying the quantity of labor by the real price of labor thus yields constant dollar labor expenditures.

Current dollar expenditures for labor equal the sum of expenditures for administrative labor and agent labor. Administrative labor expenditures are obtained from insurers' annual statements as the sum of salaries, payroll taxes, and employee relations and welfare expenditures. For agent labor, current dollar expenditures are obtained from the annual statements as the sum of net commissions and brokerage fees plus allowances to agents. The price of the labor input is a weighted average of the prices of administrative labor and agent labor, with weights equal to expenditures on each category of labor divided by total labor expenditures. The price of administrative labor is the U.S. Department of Labor average weekly wage rate for property and liability insurers (SIC 6331) in the state of the insurer's home office. The price of agent labor is the premium-weighted average of Labor Department's insurance agents' weekly wage rates (SIC 6411) in states where the insurer operates, with weights equal to the proportion of the insurer's direct premiums written in each state.

The quantity of materials and business services inputs is also imputed from total expenditures and prices. Current dollar expenditures on materials and business services are obtained from the annual statement as total expenses incurred less all labor costs.[10] The price of materials and business services input is given by a national price index for business services from the U.S. Department of Commerce.

Financial capital is included as an insurer input since it is an essential component of the technology that produces the insurance product. Besides satisfying regulatory requirements, equity capital affects the quality of the insurance product by reducing the probability of default. Viewing insurance as risky debt, insurance prices reflect the expected costs associated with insurer default, so capital levels ultimately affect the revenue and profit of an insurer. Including capital is especially important in the current study, because our objective is to determine whether insurers are allocatively inefficient because of the overuse of equity capital.

The quantity of equity capital for an insurance company is defined as its statutory policyholder surplus augmented by reserves required by statutory (regulatory) accounting but not recognized by generally accepted accounting principles (GAAP).[11] The average of beginning and end-of-year equity capital is used as the insurer's capital for any given year. These values are deflated to current dollars using the CPI.

Because the majority of insurers are not publicly traded, market equity returns are not observed for most firms in the sample. As an estimate of the cost of equity capital, we adopt an approach utilized in prior efficiency research on property-liability insurers (Cummins and Weiss 2000). For a given year, the cost of equity is assumed to be constant for all firms in the industry and

[10] This component of costs captures expenditures on advertising, board and bureau fees, equipment, printing, communications, auditing, and other business expenses. Because expenditures on physical capital such as computers and office space are a small proportion of total insurer expenses, physical capital is included in the materials and business services category rather than being treated separately.

[11] The primary reserves in this category are the "provision for reinsurance" and the "excess of statutory over statement reserves."

equal to the 90 day Treasury bill rate at the end of the preceding year plus the long-term (1926 to the end of the preceding year) market risk premium on large firm stocks as reported in Ibbotson Associates (1999). We recognize that our measure may fail to capture important differences among firms, making the ex-post regression analysis particularly important. Consequently, we include variables known to be related to the cost of capital in our regression analysis.

6.4 Inputs and Outputs: Summary

To summarize, we use five outputs and three inputs. The outputs are the present value of real losses incurred for personal short-tail, personal long-tail, commercial short-tail, and commercial long-tail coverages as well as total assets, representing the intermediation output. The inputs consist of labor, materials and business services, and equity capital.

7. RESULTS

This section presents the results of our empirical analysis of insurer capitalization. We first present summary statistics on the principal variables included in our analysis and then turn to a discussion of the efficiency results. The section concludes by presenting the regression results for the actual-to-optimal capital ratio, revenue efficiency, and ROE.

7.1 Summary Statistics

The inputs, input prices, and expenses of the property-liability insurance industry for the period 1993-1998 are shown in Table 2. Input utilization and expenditures increased over the sample period for all inputs. However, in percentage terms, the use of labor and materials declined over the sample period, whereas the percentage of total expenses attributable to financial capital increased (see the lowest panel in Table 2). The financial capital percentages are computed in two ways - using the yearly input prices and using the average input price for the sample period. The latter calculation was conducted in order to isolate the effect of the increase in the quantity of capital consumed from the change in price over the period. When the yearly prices of capital are used, capital increased from 20.4 percent of total expenses in 1993 to 32.3 percent in 1998. When the average price of capital is used, capital increased from 23.1 percent of expenses in 1993 to 31.1 percent in 1998. Thus, usage of the capital input increased significantly in both absolute and relative terms during the sample period.

Outputs and revenues are shown in Table 3. The quantity of insurance output is roughly evenly divided between the personal and commercial lines. However, the commercial lines have higher prices because these lines are more risky and have higher service intensity than personal lines. Consequently, the majority of insurance revenues are attributable to the commercial lines. The intermediation output also accounts for a significant proportion of total revenues. The last section of the table shows that the percentage of total revenues attributable to the intermediation function has increased from 33 percent in 1993 to 39 percent in 1998.

Additional summary statistics are presented in Table 4, which shows yearly values and averages of variables used in our regression models. Notably, the sub-optimal capital-to-asset ratio (actual minus optimal capital over assets) increased from 13.3 to 15.4 percent over the sample period. Otherwise, there are few pronounced trends in the variables, except for an increase in the ratio of stocks and real estate to total assets from 18.1 percent in 1993 to 21.5 percent in 1998.

7.2 Efficiency Results

The results of the DEA analysis are presented in Table 5. The average scores, shown for each type of efficiency, are comparable to the scores reported in earlier research on property-liability insurers (Cummins and Weiss 1993, Cummins, Weiss, and Zi 1999). Average cost efficiency in the industry is about 40.6 percent, based on the sample period as a whole. Pure technical inefficiency is the primary source of cost inefficiency -- pure technical efficiency averages 57.6 percent, whereas scale and allocative efficiency average 88.8 and 79.8 percent, respectively.[12] The finding with respect to pure technical inefficiency is perhaps not surprising given the rapid pace of technological change in the past few years. Revenue efficiency averages 27.1 percent, indicating a high degree of revenue

[12] Recall that technical efficiency is the product of pure technical and scale efficiency and that cost efficiency is the product of technical and allocative efficiency, although it should be noted that these relationships hold at the individual firm level and only as an approximation for the averages.

inefficiency in the industry, at least on average.

The sources of allocative inefficiency in our sample of insurers are analyzed in Table 6. Part A of the table shows percentage departures from optimal utilization ratios defined as follows: $U_i = 100 \cdot \left(\frac{X_i}{X_i^{opt}} - 1\right)$, where U_i is under- or over-utilization of input *i*, X_i is actual quantity of input *i*, and X_i^{opt} is the optimal quantity of input *i*. If $U_i > 0$, the implication is that inputs are over-utilized and if $U_i < 0$, inputs are under-utilized. Table 6 reveals that insurers on average over-utilize all three inputs. The average over-utilization of labor is 159.7 percent, indicating that inefficient insurers could reduce labor input by about 61.5 percent if they operated as efficiently as the best practice firms in the industry. The over-utilization of materials and business services is substantially less than for labor, 57.2 percent, implying that insurers could reduce materials inputs by 36.4 percent in total if they were fully efficient..[13]

The over-utilization of capital is 85.8 percent on average. The years with the two largest over-utilization estimates are in the second half of the sample period, providing some evidence that over-capitalization has increased over time. On average, insurers could reduce capital by about 46.2 percent if they were fully efficient. Interestingly, if capital is reduced by 46 percent in 1999, the industry's leverage ratios are more aligned with historical averages - 1.6 for the premiums-to-surplus ratio and 0.20 for the capital-to-assets ratio (based on the data underlying Figure 1). This again provides some support for the hypothesis that insurers hoard capital to avoid having to raise external capital following a loss or investment shock. The amount of capital over-utilization in billions of dollars is shown in section B of the Table 6. Over-utilization increased by nearly 90 percent over the sample period, from 66.6 billion in 1993 to 124.2 billion in 1998.

7.3 Regression Analysis

The regression analysis consists of three equations with dependent variables equal to the ratio of the insurer's actual capital to optimal capital, revenue efficiency, and ROE, respectively. The actual-to-optimal capital equation is designed to identify covariates related to the utilization of capital and to test the hypotheses specified in the theoretical discussion presented above.

The actual-to-optimal capital regression equations are presented in Table 7. Three equations are shown in the table. The first equation, which is estimated by OLS, omits the Best's rating indicator variable because it is jointly determined with capital. As mentioned above, the Best's rating variable is set equal to 1 if the firm has an A rating or better from the A.M. Best Company, and to zero otherwise. The other two equations include the Best's rating indicator variable and adjust for its endogeneity using, respectively, the instrumental variables (IV) and the inverse Mill's (IM) methodologies. These methodologies are explained in an Appendix available from the authors.

The regressions presented in Table 7 provide support for most of our hypotheses regarding capital utilization. The Best's A rating indicator variable is positive and significant in the IV and IM regressions, as expected if firms hold more capital in order to protect their financial ratings. The reinsurance variable has a significant negative coefficient in all three equations, as expected if use of reinsurance is a substitute for holding capital in terms of reducing the expected costs of financial distress (H2). The ratio of stocks and real estate to total assets in positive and significant in all three equations, as expected if insurers hold additional capital to compensate for higher asset portfolio risk (H3). The natural log of assets is negative and significant, providing support for H5, i.e., that risk is inversely related to the size of the risk pool so that larger insurers need relatively less equity capital. The mutual dummy variable is negative and significant in all three equations, rejecting H6 and indicating that mutuals are less likely to over-utilize capital than stocks, perhaps because of higher costs of capital due to unresolved agency conflicts.[14] The ratio of insurance reserves to losses

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[13] The smaller total percentage reductions indicate that larger firms are relatively less inefficient.

[14] However, it would not be correct to conclude from these results that mutuals have lower capital-to-assets ratios than stocks. In fact, additional regressions (not shown) with the capital-to-assets ratio as the dependent variable indicate that mutuals have significantly higher capital-to-assets ratios than stocks, most likely to provide a cushion

incurred is negative and significant, as predicted if firms with more long-tail business are more levered in order to discourage managers from taking actions that are contrary to the interests of policyholders (H7).

The standard deviation of book ROE is negative and significant in all three equations. Recall that this variable is predicted to have a positive coefficient if it primarily proxies the probability of financial distress and a negative coefficient if it primarily captures informational asymmetries between managers and investors. The results thus provide evidence consistent with H8, i.e., that firms with higher informational asymmetries will use less equity capital because they face higher costs of external capital. The significant negative coefficient on the ratio of reserves to losses incurred also is consistent with H8 to the extent that this variable captures informational asymmetries in the long-tail lines of business. The results with the standard deviation variable do not provide support for H4, i.e., that firms with higher standard deviations of ROE will hold more capital to reduce the expected costs of financial distress.

The one-year premium growth rate is positive as expected but is not statistically significant. Consequently, the results with this variable do not support H9, that firms with growth opportunities hold more capital to take advantage of positive net present value projects. The ratio of personal insurance output to total insurance output is negative and significant, consistent with the argument that commercial buyers are more sensitive to insolvency risk than personal buyers (H10).

Contrary to expectations, both the geographical and the line of business Herfindahl indices have negative signs in all three equations shown in Table 7, although only one of the coefficients is statistically significant. Thus, the results do not support H1, that firms that diversify geographically and across lines of business need less capital. A possible explanation for these results is that operating over wider geographical areas and more lines of business exposes insurers to more risk

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for future investment and loss shocks because of mutuals' limited ability to raise new external capital. It is correct to conclude from Table 8 that mutuals are significantly less likely to over-utilize capital than stocks.

because of the difficulties in controlling and monitoring the underwriting process in more complex organizations, possibly offsetting the diversification benefits associated with lower Herfindahl indices. In addition, firms that operate in more states and lines of business are likely to be dealing with larger and more complex insurance risks, necessitating that they hold more capital. Finally, Wald tests reveal that there are no significant differences among the intercept terms for the years 1993, 1994, 1995, 1997, and 1998. The intercept for 1996 is significantly different from the intercepts for the other years, but it is difficult to attribute this result to risk-based capital, which went into effect in 1994. The results thus suggest either that risk-based capital had no significant effects on overall capitalization in the industry or that any capital adjustments predated our sample period.

The revenue efficiency and ROE equations presented in Table 8 are primarily designed to provide information on whether measured "sub-optimal" capital utilization represents a legitimate response to market conditions or a true inefficiency that degrades firm performance.

The revenue efficiency equations provide evidence consistent with the view that sub-optimal capital utilization represents a true inefficiency. In the first revenue efficiency equation shown in the table, the sub-optimal capital-to-assets ratio has a significant negative coefficient, implying that capital over-utilization is associated with lower revenue efficiency. The second revenue efficiency equation breaks out the sub-optimal capital-to-assets ratio into its positive and negative components. In this equation, the capital over-utilization ratio has a significant negative coefficient, providing further evidence that firms over-utilizing capital have lower revenue efficiency. However, the capital under-utilization ratio is not statistically significant, suggesting that firms sustain revenue efficiency penalties for capital over-utilization but not necessarily for capital under-utilization, other things equal. Thus, insurers appear to sustain revenue efficiency penalties for over-utilizing capital, perhaps because their prices are too high, reflecting the deadweight costs of holding excess capital.

The insignificant coefficient on the capital under-utilization ratio suggests that firms do not sustain revenue efficiency penalties due to buyers interpreting capital under-utilization as an indicator of excessive insolvency risk, especially considering the presence in the equation of other insolvency risk proxies such as the optimal capital-to-assets ratio and the asset risk variable. The capital under-utilization ratio finding should be interpreted with caution, however, because only 7 percent of the observations in our sample were measured as under-utilizing capital and the average percentage under-utilization is much smaller in absolute value than the percentage over-utilizations. Nevertheless, the strong result with the capital over-utilization ratio supports the hypothesis that over-utilization represents a true inefficiency which leads to revenue efficiency penalties.

The optimal capital-to-assets ratio, included as a control variable, has a significant positive coefficient, implying that firms with higher ratios of optimal capital to assets have higher revenue efficiency, other things equal. A possible explanation for this finding is that some product market segments may have higher optimal capital-to-asset ratios and also, perhaps independently, relatively high price competition, leading to higher revenue efficiency. Such an explanation would seem to fit the commercial lines, where buyers are very sensitive to insolvency risk and price competition is intense.

The results with the other explanatory variables in the revenue efficiency equation are mostly consistent with expectations.[15] The size variable is positive and significant, perhaps suggesting that larger firms have lower insolvency risk or that size conveys advantages in terms of market power. The stock and real estate (asset risk) variable is negative and significant, suggesting that firms with riskier assets are less revenue efficient. Mutuals are less revenue efficient than stocks, supporting the argument that mutuals have higher default risk, and/or suggesting that mutuals are less efficient because of unresolved agency conflicts. The ratio of personal insurance output to total insurance output and the ratio of insurance reserves to losses incurred are negative and significant, probably

[15] The Best's indicator variable is not included in the revenue efficiency regression because we do not have any reason to hypothesize that a firm's financial rating is a driver of its revenue efficiency. Consequently, including the Best's rating variable here would not be appropriate. When the equation was re-estimated with the Best's indicator variable included, the other variables in the equation retained their signs and significance levels.

reflecting higher prices received in commercial lines (see Table 3) and higher complexity in long-tail lines, which often results in lower efficiency. Contrary to expectations, both the geographical and line of business Herfindahl indices are positive and significant, suggesting that more diversified firms have lower revenue efficiencies than less diversified firms. This could suggest that strategic focus is a more successful strategy than conglomeration in terms of maximizing revenues.

The ROE equations also are shown in Table 8. The dependent variable in the regressions is ROE before policyholder dividends and taxes because this variable focuses directly on the firm's market outcome in terms of net income, prior to deduction of the discretionary items, policyholder dividends, and government mandated tax payments.[16] Four versions of the regression are included in Table 8, two OLS versions that exclude the Best's A rating indicator variable and revenue efficiency and two instrumental (IV) variables versions that include these potentially endogenous variables. The two OLS and IV versions differ from one another depending upon whether the sub-optimal capital to assets ratio is included versus including the capital under- and over-utilization ratios separately.

The ROE regressions provide additional evidence that measured sub-optimal capital utilization is a true inefficiency and that capital over-utilization is a more serious problem than capital under-utilization. The optimal capital-to-asset ratio has a significant negative coefficient in the ROE regressions, consistent with the financial theory prediction that better capitalized firms have lower costs of capital. The sub-optimal capital-to-assets ratios in equations ROE1 and ROE3 also have significant negative coefficients. However, the coefficient of this variable is substantially smaller in absolute value than the coefficient of the optimal capital-to-assets ratio. This result is consistent with the view that holding capital in excess of the optimal amount also reduces the firm's cost of capital but by a significantly smaller marginal amount due to a penalty for inefficiency.

In the equations that split the sub-optimal capital-to-assets ratio into its positive and negative components (ROE2 and ROE4), the capital over-utilization ratio is significant and negative with a significantly smaller (in absolute value) coefficient than the optimal capital-to-assets ratio, again supporting the inference that holding excess capital has a smaller effect on the cost of capital than holding optimal capital. However, the capital under-utilization ratio is statistically insignificant, providing further support for the argument that capital under-utilization does not have a statistically significant effect on firm performance, subject to the caveats regarding this variable discussed above.

The signs of the other variables in the ROE models are generally consistent with our theoretical predictions. The Best's indicator variable is positive and statistically significant in equations ROE3 and ROE4, providing evidence that efficient firms with good financial ratings earn higher returns. However, revenue efficiency is not statistically related to ROE after controlling for the endogeneity of this variable. Revenue efficiency could result in higher realized returns or it could be associated with a lower ex ante cost of capital. Perhaps these effects offset, leading to the insignificant result with this variable.

The geographical and line of business Herfindahl indices have significant positive coefficients, consistent with the argument that the cost of capital is inversely related to diversification. The ratio of stocks and real estate to total assets is positive and significant, consistent with the hypothesized positive relationship between risk and the cost of equity capital. Likewise, the reinsurance variable has a significant negative coefficient, supporting the hypothesis that reinsurance reduces default risk. The ratio of personal lines output to total insurance output has a significant positive coefficient, supporting the argument that commercial lines insurers have lower default risk than personal lines firms. The premium growth rate has a negative coefficient in all four equations, but is not statistically significant, providing only weak evidence that firms with growth opportunities have lower costs of capital.

The size variable in the ROE equations has a significant positive sign, consistent with the argument that larger firms earn higher profits, other things equal, perhaps due to market power. The

[16] Robustness checks using ROE after dividends but before taxes and ROE after dividends and taxes support the

long tail lines variable (loss reserves divided by losses incurred) is positive and significant, consistent with the view that the cost of capital is higher for insurers writing long-tail lines, perhaps because information asymmetries are higher for these business lines. Finally, the mutual dummy variable is negative and significant, providing some support for the hypothesis that mutual firms write lower risk business than stock firms (Lamm-Tennant and Starks 1993), or perhaps indicating that mutuals have lower realized returns due to unresolved agency conflicts.

The overall conclusions to be drawn from the regressions presented in Tables 7 and 8 are the following: (1) The majority of the hypotheses about the relationships between firm characteristics and capital utilization are supported by the actual-to-optimal capital regressions. (2) Measured capital over-utilization primarily reflects inefficiency, for which insurers incur a significant penalty in terms of revenues. In addition, holding capital in excess of the optimal amount reduces the cost of capital but by a much smaller marginal amount than holding optimal capital. Capital under-utilization is not significantly related to either revenue efficiency or ROE in our sample. (3) Firms with A or better financial ratings earn higher returns on equity than firms with lower financial ratings.

8. Conclusions

This paper investigates the use of equity capital in the property-liability insurance industry. The investigation is motivated by the sharp decline in industry leverage over the past fifteen years. Our objective is to determine whether the change in relative capitalization represents an over-utilization of capital in the industry or a rational response to changing market conditions.

The primary source of capital growth in the industry over the past ten years is realized and unrealized capital gains, which jointly account for more than 50 percent of the capital increase. Prior theoretical and empirical evidence suggests that insurers may tend to "hoard" capital during profitable times as a hedge against the next underwriting or investment crisis. Our analysis of insurer stockholder dividend payout rates supports this argument -- payout rates were actually less in 1995-

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same conclusions regarding the effects of the optimal and sub-optimal capital to asset ratios on firm performance.

1998 than in 1989-1994, even though capital increased twice as fast in the latter period.

To further investigate the capital over-utilization issue, we estimate technical, allocative, cost, and revenue efficiency in the industry using a non-parametric technique, data envelopment analysis (DEA), for the period 1993-1998. DEA measures the efficiency of each firm in our sample relative to "best practice" efficient frontiers formed by the fully efficient firms in the industry. Fully efficient firms are measured as having efficiency scores of 1, while inefficient firms have scores between 0 and 1.

Cost efficiency averages about 40.6 percent, implying that insurers could reduce costs by about 59.4 percent on average if they were to operate with full efficiency. The primary source of cost inefficiency is pure technical inefficiency. Average pure technical efficiency in our sample is 51.2 percent, whereas technical and allocative efficiency average 89.8 and 79.8 percent, respectively. These results suggest that failure to adopt state-of-the-art technology is the primary source of cost inefficiency in the industry. However, allocative inefficiency is also an important a driver of cost inefficiency for insurers. Revenue efficiency in the industry averages only 27.1 percent during our sample period, indicative of a significant loss of potential revenues by the average firm.

The results indicate that firms on average over-utilize all three inputs (labor, capital, and business services). Based on a weighted average across the industry, insurers could reduce labor by 61.5 percent, materials by 36.4 percent, and capital by 46.2 percent if they were fully efficient. The results thus provide strong support for the argument that insurers over-utilize equity capital. When the ratios of premiums-to-surplus and capital-to-assets are computed using optimal industry capital rather than actual capital, the ratios are much closer to their historical averages than to the actual industry ratios for 1999. This provides further evidence of capital "stickiness" in the industry, i.e., reluctance by insurers to distribute equity capital accumulations as dividends.

The final part of our analysis involves estimating regression equations with three dependent variables - the ratio of actual capital to optimal capital, revenue efficiency, and ROE. The actual-to-optimal capital regression supports most of our economic hypotheses regarding insurer motivations for holding capital. We find evidence supporting the hypotheses that insurers hold equity capital to reduce the expected costs of financial distress. We also find evidence that reinsurance serves as a substitute for equity capital and that insurer size is inversely related to the use of equity capital, as expected if larger insurers are more diversified. Mutual insurers are found to have higher capital-to-asset ratios than stock insurers, but mutuals are less likely than stocks to over-utilize capital, perhaps reflecting higher costs of capital. The results also support the hypothesis that firms with greater information asymmetries between managers and investors face higher costs of capital and therefore are more highly leveraged than firms with lower informational asymmetries. We also find evidence firms writing more commercial lines insurance hold more capital than firms emphasizing personal lines, consistent with greater sensitivity to insolvency risk among commercial insurance buyers.

There are two opposing interpretations that can be given to the measured sub-optimal capital utilization in the industry: (1) Because firms hold capital in response to hypothesized organizational and market characteristics, measured under- or over-utilization represents a rational response to market conditions that is associated with better financial performance; or (2) the measured sub-optimal capital utilization is a true inefficiency that degrades the firm performance. The revenue efficiency and ROE regressions are used to distinguish between these two possibilities.

The results support the second interpretation of measured sub-optimal capital utilization. Revenue efficiency is inversely related to the sub-optimal capital-to-assets ratio (the ratio of actual capital minus optimal capital to assets), implying that measured sub-optimal capital utilization primarily reflects inefficiency. When the sub-optimal capital-to-assets ratio is separated into positive and negative components, we find that revenue efficiency has a significant inverse relationship with capital over-utilization but that the capital under-utilization variable is not statistically significant. This suggests that the revenue efficiency penalties primarily result from using too much capital rather than too little.

Return on equity is inversely related to the optimal capital-to-assets ratio, consistent with the argument that better capitalized firms have lower costs of equity capital. The sub-optimal capital-to-assets ratio also has a negative coefficient, but it is much smaller in absolute value than the coefficient of the optimal capital-to-asset ratio, suggesting that the leverage-reducing benefits of holding above-optimal capital are at least partially offset by a penalty for inefficiency. As in the case of revenue efficiency, the capital over-utilization variable is significantly related to ROE, but the capital under-utilization ratio is not statistically significant.

Overall, we conclude that the run-up in equity capital of the past decade is primarily attributable to capital gains on investments. Further, we provide evidence that capital levels in the industry are "sticky" in the sense that insurers are reluctant to pay out capital accumulations as dividends, preferring to maintain internal funds to cushion the capital shocks. Finally, we find that insurers are over-utilizing equity capital and that the over-utilization primarily represents inefficiency that leads to revenue penalties for inefficient insurers.

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Figure 1
Leverage Ratios: 1970 - 1999

The source of the data is Best's Aggregate and Averages: Property-Casualty Edition (Oldwick, NJ: A.M. Best Co., various years). The horizontal axis measures calendar years. The left vertical axis measures the ratio of net premiums written to equity capital. The right vertical axis measures the ratio of equity capital to assets.

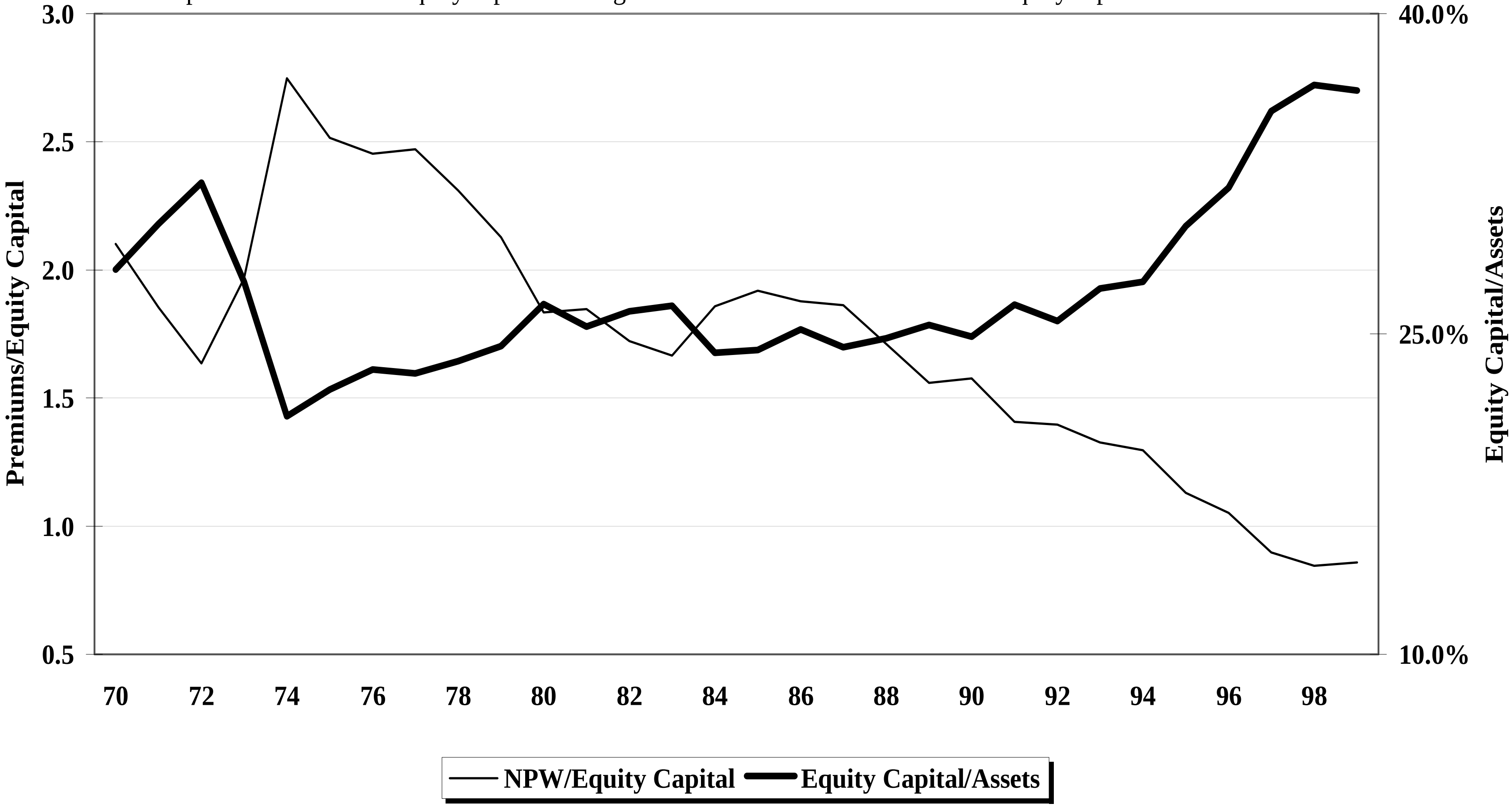

Figure 2
Growth Rates of Premiums and Equity Capital: 6 Year Moving Averages

The source of the data is Best's Aggregate and Averages: Property-Casualty Edition (Oldwick, NJ: A.M. Best Co., various years). The horizontal axis measures calendar years. The vertical axis measures the 6 year moving average of percentage growth.

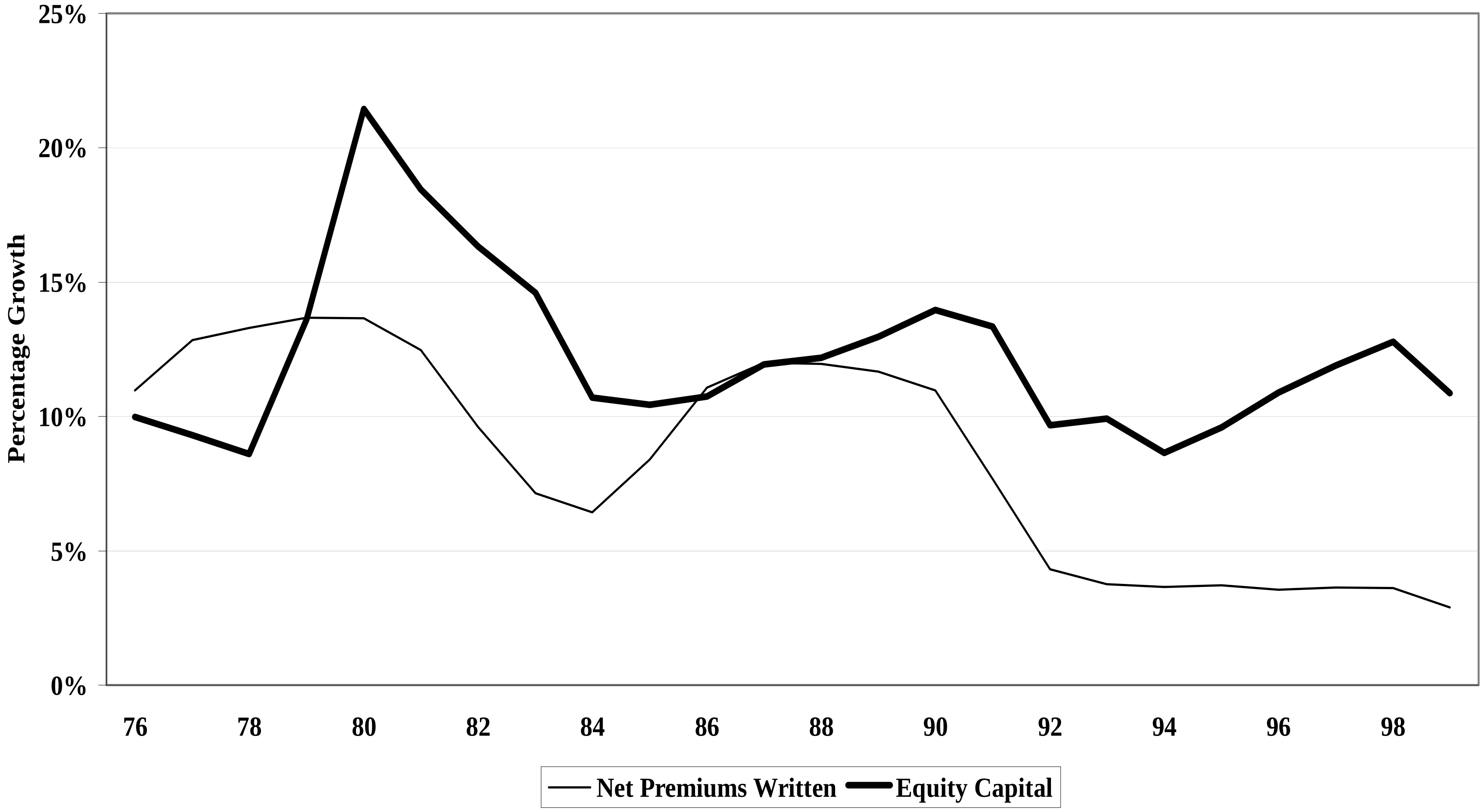

TABLE 1

Sources of Equity Capital Growth

The source of the data is Best's Aggregates and Averages: Property-Casualty Edition (Oldwick, NJ: A.M. Best Co., various years). All values are in billions of U.S. dollars. Total change in surplus is industry-wide change in policyholder surplus during the calendar year. Percent Paid as Dividends is the ratio of Stockholder Dividends to the Total Change in Surplus. In Section B and Section C, Total Funds is the sum of Retained Earnings (non-CG), Realized Capital Gains, Unrealized Capital Gains, and Capital Paid-In.

Section A

	Total Change in Surplus	Retained Earnings (non-CG)	Realized Capital Gains	Unrealized Capital Gains	Capital Paid-In	Stock-holder Dividends	Misc. Surplus Changes	Percent Paid as Dividends
1989	16.04	7.57	4.65	8.03	2.39	-5.52	-1.08	24.4%
1990	3.49	7.95	2.88	-5.12	3.43	-5.66	0.00	61.9%
1991	20.12	9.37	4.81	13.43	2.00	-5.76	-3.73	19.5%
1992	4.21	-4.05	9.89	-0.06	5.51	-6.49	-0.59	57.5%
1993	19.25	9.50	9.82	1.05	7.43	-7.26	-1.29	26.1%
1994	8.12	9.21	1.66	-1.81	6.82	-6.29	-1.47	39.6%
1995	37.54	14.60	6.00	21.72	7.11	-8.23	-3.65	16.7%
1996	30.60	15.16	9.24	13.31	4.50	-8.96	-2.64	21.2%
1997	52.87	26.01	10.81	28.98	3.91	-11.31	-5.53	16.2%
1998	23.51	12.75	18.02	10.24	5.19	-13.31	-9.38	28.8%
1989-1998	215.74	108.07	77.78	89.76	48.30	-78.80	-29.37	24.3%
1989-1994	71.22	39.54	33.71	15.51	27.59	-36.98	-8.16	31.8%
1995-1998	144.52	68.53	44.07	74.24	20.71	-41.82	-21.21	20.1%

		Section B - Percent by Source -				Section C - Percent by Use -		
	Total Funds	Retained Earnings	Realized Capital Gains	Unrealized Capital Gains	Capital Paid-In	Stock-holder Dividends	Misc. Uses	Retained Capital
1989-1998	323.90	33.4%	24.0%	27.7%	14.9%	24.3%	9.1%	66.6%
1989-1994	116.36	34.0%	29.0%	13.3%	23.7%	31.8%	7.0%	61.2%
1995-1998	207.55	33.0%	21.2%	35.8%	10.0%	20.1%	10.2%	69.6%

Total capital gains (realized plus unrealized) are 42.3% for the 1989-1994 period and 57.0% for the 1995 - 1998 period. Assuming equal variances across the time periods, the estimated standard deviation of the difference in weighted averages is 0.4% so the difference is statistically significant at better than the 1% level.

The 11.6% decrease in stockholder dividends between the 1989-1994 and 1995-1998 time periods also is statistically different from 0 at better than the 1% level. Assuming equal variances across the time periods, the estimated standard deviation of the difference in weighted averages is 0.6%.

TABLE 2
Inputs and Expenses

Table 2 provides summary statistics for the input quantities and prices used in the data envelopment analysis. Quantities and prices are unweighted sample means. The average column reports averages across years. Expenses are the product of input quantities and prices. The Percent of Total Expenses reports the ratio of expense by input to total expenses. The financial capital percentages are computed in two ways - using the yearly input prices and using the average input price for the sample period. The latter calculation was conducted in order to isolate the effect of the increase in the quantity of capital consumed from the change in price over the period.

	1993	1994	1995	1996	1997	1998	Average
Input Quantities (000s)							
Administrative Labor	3,542	3,614	3,589	3,675	4,116	4,468	3,834
Agent Labor	4,586	4,740	4,818	4,810	5,321	5,952	5,038
Materials & Bus Services	9,462	9,821	9,606	9,281	9,766	11,383	9,886
Financial Capital	146,475	159,684	170,738	191,860	247,040	301,936	202,956
Input Prices							
Administrative Labor	5.087	5.184	5.330	5.485	5.633	5.753	5.412
Agent Labor	4.373	4.401	4.455	4.551	4.677	4.637	4.516
Materials & Bus Services	2.907	2.874	2.979	3.110	3.271	3.221	3.060
Financial Capital	11.5%	12.3%	14.4%	14.1%	14.4%	14.2%	13.5%
Expenses (000s)							
Administrative Labor	18,015	18,732	19,131	20,158	23,184	25,708	20,749
Agent Labor	20,055	20,863	21,468	21,890	24,886	27,597	22,750
Materials & Bus Services	27,501	28,229	28,615	28,866	31,945	36,663	30,256
Financial Capital	16,815	19,673	24,518	27,033	35,599	42,905	27,355
Percent of Total Expenses							
Administrative Labor	21.9%	21.4%	20.4%	20.6%	20.1%	19.3%	20.5%
Agent Labor	24.3%	23.8%	22.9%	22.3%	21.5%	20.8%	22.5%
Materials & Bus Services	33.4%	32.3%	30.5%	29.5%	27.6%	27.6%	29.9%
Financial Capital	20.4%	22.5%	26.2%	27.6%	30.8%	32.3%	27.1%
Fin Capital: Avg Price	23.1%	24.1%	25.0%	26.7%	29.4%	31.1%	27.1%

TABLE 3
Outputs and Revenues

Table 3 provides summary statistics for the input quantities and prices used in the data envelopment analysis. Quantities and prices are unweighted sample means. The average column reports averages across years. Revenues are the product of output quantities and prices. For the Intermediation output, revenues are calculated in two ways: first by using the yearly prices and second by using the average price across years. The Revenues: Percentage of Insurance Output reports the ratio of revenues by output to total revenues. The Revenues: Intermediation as Percentages of Total Output reports the ratio of Intermediation revenues to total revenues using the two methods of computing Intermediation revenues.

	1993	1994	1995	1996	1997	1998	Average
Output Quantities (000s)							
Personal Short-Tail	14,699	16,218	17,628	20,186	21,667	24,958	19,226
Personal Long-Tail	43,701	45,001	44,523	47,020	47,491	54,852	47,098
Commercial Short-Tail	27,136	31,921	15,010	15,633	18,244	20,736	21,447
Commercial Long-Tail	40,486	36,332	47,310	45,755	45,521	50,769	44,362
Intermediation	415,508	438,402	450,330	483,926	569,515	653,153	501,806
Output Prices							
Personal Short-Tail	0.370	0.323	0.259	0.198	0.245	0.246	0.274
Personal Long-Tail	0.251	0.236	0.308	0.240	0.334	0.337	0.284
Commercial Short-Tail	0.863	0.850	0.986	0.874	0.989	0.887	0.908
Commercial Long-Tail	0.450	0.524	0.642	0.685	0.727	0.690	0.620
Intermediation	7.0%	6.8%	7.5%	7.4%	7.7%	7.7%	7.3%
Revenues (000s)							
Personal Short-Tail	5,442	5,241	4,574	4,005	5,300	6,133	5,260
Personal Long-Tail	10,987	10,627	13,726	11,282	15,866	18,477	13,397
Commercial Short-Tail	23,412	27,139	14,804	13,670	18,041	18,395	19,480
Commercial Long-Tail	18,213	19,046	30,374	31,358	33,115	35,012	27,494
Intermediation	28,976	29,909	33,805	35,880	43,918	50,027	36,873
Intermediation: Avg Price	30,531	32,214	33,090	35,559	41,848	47,993	36,873
Revenues: Percentages of Insurance Output							
Personal Short-Tail	9.4%	8.4%	7.2%	6.6%	7.3%	7.9%	8.0%
Personal Long-Tail	18.9%	17.1%	21.6%	18.7%	21.9%	23.7%	20.4%
Commercial Short-Tail	40.3%	43.7%	23.3%	22.7%	24.9%	23.6%	29.7%
Commercial Long-Tail	31.4%	30.7%	47.8%	52.0%	45.8%	44.9%	41.9%
Revenues: Intermediation as Percentages of Total Output							
Intermediation	33.3%	32.5%	34.7%	37.3%	37.8%	39.1%	36.0%
Intermediation: Avg Price	35.1%	35.0%	34.0%	37.0%	36.0%	37.5%	36.0%

TABLE 4

Summary Statistics: Regression Variables

Table 4 provides summary statistics for the variables input quantities and prices used in the data envelopment analysis. All reported values are unweighted sample means, except for number of observations, which is a sum. Sub-Optimal Capital-to-Assets is the ratio of the firms' actual less optimal capital to assets. Capital Over-Utilization / Assets is the positive portion of Sub-Optimal Capital-to-Assets, and Capital Under-Utilization / Assets is the negative portion. Optimal Capital-to-Assets is the ratio of optimal capital to assets.

	1993	1994	1995	1996	1997	1998	Total
Sub-Optimal Capital-to-Assets	0.137	0.136	0.135	0.147	0.144	0.155	0.142
Capital Over-Utilization / Assets	0.139	0.139	0.138	0.148	0.147	0.156	0.144
Capital Under-Utilization / Assets	-0.002	-0.003	-0.003	-0.001	-0.003	-0.001	-0.002
Optimal Capital-to-Assets	0.133	0.134	0.133	0.119	0.136	0.131	0.131
Geographical Herfindahl Index	0.561	0.563	0.573	0.562	0.603	0.589	0.575
Line of Business Herfindahl Index	0.448	0.456	0.455	0.462	0.486	0.484	0.465
(Ceded / Gross) Loss Reserves	0.325	0.319	0.322	0.326	0.307	0.309	0.318
(Stock + Real Estate) / Invested Assets	0.184	0.174	0.182	0.189	0.202	0.218	0.191
Natural Log of Assets	18.279	18.299	18.309	18.394	18.195	18.304	18.296
Mutual Dummy Variable	0.451	0.435	0.452	0.448	0.477	0.484	0.458
Insurance Reserves / Losses Incurred	1.388	1.357	1.402	1.363	1.405	1.404	1.387
One-Year Change in Premiums	0.135	0.148	0.100	0.108	0.131	0.114	0.123
Personal Lines Output / Total Output	0.396	0.388	0.401	0.412	0.379	0.379	0.392
Best "A" Rating Indicator	0.664	0.636	0.649	0.642	0.589	0.602	0.630
Number of Observations	643	657	646	634	660	628	3,868

TABLE 5
Data Envelopment Analysis Efficiency Results

Table 5 provides summary statistics for the efficiency scores for DEA analysis. Sample means and standard deviations are reported by year. The DMU count is the number of decision-making units utilized in the analysis.

Year	DMU Count		Pure Technical	Scale	Total Technical	Allocative	Cost	Revenue
1993	971	Mean:	0.550	0.934	0.510	0.775	0.393	0.263
		Std Dev:	0.228	0.105	0.216	0.152	0.180	0.187
1994	956	Mean:	0.596	0.905	0.535	0.795	0.422	0.271
		Std Dev:	0.225	0.127	0.211	0.138	0.175	0.188
1995	949	Mean:	0.569	0.879	0.493	0.844	0.416	0.393
		Std Dev:	0.235	0.145	0.216	0.126	0.183	0.333
1996	920	Mean:	0.578	0.907	0.519	0.824	0.425	0.234
		Std Dev:	0.229	0.125	0.209	0.154	0.184	0.185
1997	826	Mean:	0.587	0.800	0.486	0.747	0.365	0.202
		Std Dev:	0.235	0.220	0.223	0.170	0.200	0.169
1998	770	Mean:	0.581	0.889	0.529	0.799	0.419	0.246
		Std Dev:	0.241	0.136	0.217	0.212	0.196	0.187
Total	5,392	Mean:	0.576	0.888	0.512	0.798	0.406	0.271
		Std Dev:	0.232	0.152	0.216	0.162	0.187	0.226

TABLE 6
Data Envelopment Analysis Efficiency Results

Table 6 provides additional summary statistics from the DEA analysis. Part A of the table shows percentage departures from optimal utilization ratios defined as follows: $U_i = 100 \cdot \left(\frac{X_i}{X_i^{opt}} - 1\right)$, where U_i is under- or over-utilization of input *i*, X_i is actual quantity of input *i*, and X_i^{opt} is the optimal quantity of input *i*. If $U_i > 0$, the implication is that inputs are over-utilized and if $U_i < 0$, inputs are under-utilized. Part B shows actual capital, optimal capital, and excess capital, which is actual less optimal capital.

A. Input Over/Under-Utilization

Year	Total Labor	Materials Services	Financial Capital
1993	204.5%	40.9%	88.1%
1994	183.6%	38.6%	74.0%
1995	145.9%	71.0%	68.7%
1996	123.3%	47.0%	97.9%
1997	207.3%	97.7%	71.5%
1998	123.0%	67.2%	114.7%
Total	159.7%	57.2%	85.8%

B. Financial Capital Utilization

Year	Actual Capital	Optimal Capital	Excess Capital
1993	142.2	75.6	66.6
1994	152.6	87.7	64.9
1995	161.9	96.0	65.9
1996	176.5	89.2	87.3
1997	204.3	119.1	85.2
1998	232.5	108.3	124.2
Average	178.3	96.0	82.4

TABLE 7
Regression Models: Capital Utilization

The endogenous variable is the ratio of actual-to-optimal capital. Standard Errors are presented below the estimated coefficients. *** denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, and * denotes significance at the 10 percent level. Significance is based on a two-sided test with a t-distribution.

	Expected Sign	Ordinary Least Squares	Instrumental Variables	Inverse Mills Ratio
Geographical Herfindahl Index	+	-0.045	-0.042	-0.046
		0.058	0.058	0.057
Line of Business Herfindahl Index	+	-0.137 *	-0.090	-0.094
		0.073	0.077	0.077
(Ceded / Gross) Loss Reserves	-	-0.242 ***	-0.193 **	-0.228 ***
		0.083	0.087	0.087
(Stock + Real Estate) / Invested Assets	+	1.607 ***	1.587 ***	1.570 ***
		0.111	0.111	0.111
Natural Log of Assets	-	-0.160 ***	-0.186 ***	-0.183 ***
		0.011	0.019	0.019
Mutual Dummy Variable	Ambiguous	-0.084 **	-0.110 ***	-0.103 ***
		0.037	0.039	0.039
Insurance Reserves / Losses Incurred	-	-0.129 ***	-0.128 ***	-0.128 ***
		0.020	0.020	0.020
Standard Deviation of ROE	Ambiguous	-4.076 ***	-3.660 ***	-3.842 ***
		0.296	0.384	0.383
One-Year Percentage Change in Premiums	+	0.025	0.027	0.026
		0.021	0.021	0.021
Personal Lines Output / Total Output	-	-1.883 ***	-1.863 ***	-1.867 ***
		0.059	0.060	0.059
Best "A" Rating Indicator	+		0.259 *	0.840 ***
			0.154	0.152
1993 Intercept		6.388 ***	6.633 ***	6.122 ***
		0.225	0.266	0.424
1994 Intercept		6.398 ***	6.651 ***	6.140 ***
		0.225	0.270	0.428
1995 Intercept		6.393 ***	6.644 ***	6.134 ***
		0.225	0.269	0.427
1996 Intercept		6.551 ***	6.807 ***	6.294 ***
		0.226	0.271	0.430
1997 Intercept		6.270 ***	6.534 ***	6.015 ***
		0.226	0.274	0.434
1998 Intercept		6.356 ***	6.623 ***	6.105 ***
		0.227	0.275	0.435
Number of Observations		3,868	3,868	3,868
Adjusted R-Squared (centered)		0.359	0.369	0.372

TABLE 8
Regression Models: Revenue Efficiency and Return on Equity

The endogenous variable is either revenue efficiency or ROE. Standard Errors are presented below the estimated coefficients. *** denotes significance at the 1 percent level, ** denotes significance at the 5 percent level, and * denotes significance at the 10 percent level. Significance is based on a two-sided test with a t-distribution.

	Revenue Efficiency OLS	Revenue Efficiency OLS	ROE OLS (ROE1)	ROE OLS (ROE2)	ROE IV (ROE3)	ROE IV (ROE4)
Sub-Optimal Capital-to-Assets	-0.264 ***		-0.083 ***		-0.125 ***	
	0.024		0.022		0.031	
Capital Over-Utilization / Assets		-0.264 ***		-0.089 ***		-0.126 ***
		0.025		0.023		0.030
Capital Under-Utilization / Assets		-0.278		0.141		-0.108
		0.219		0.197		0.223
Optimal Capital-to-Assets	0.137 **	0.136 **	-0.542 ***	-0.523 ***	-0.579 ***	-0.578 ***
	0.061	0.064	0.055	0.058	0.057	0.062
Geographical Herfindahl Index	0.039 ***	0.039 ***	0.027 ***	0.027 ***	0.027 ***	0.027 ***
	0.007	0.007	0.007	0.007	0.007	0.007
Line of Business Herfindahl Index	0.072 ***	0.072 ***	0.074 ***	0.074 ***	0.079 ***	0.079 ***
	0.009	0.009	0.008	0.008	0.009	0.009
(Ceded / Gross) Loss Reserves	-0.021 **	-0.021 **	-0.068 ***	-0.068 ***	-0.061 ***	-0.061 ***
	0.011	0.011	0.010	0.010	0.010	0.010
(Stock + Real Estate) / Invested Assets	-0.059 ***	-0.059 ***	0.066 ***	0.066 ***	0.074 ***	0.074 ***
	0.015	0.015	0.014	0.014	0.014	0.014
Natural Log of Assets	0.026 ***	0.026 ***	0.015 ***	0.015 ***	0.008 ***	0.008 ***
	0.001	0.002	0.001	0.001	0.003	0.003
Mutual Dummy Variable	-0.013 ***	-0.013 ***	-0.013 ***	-0.013 ***	-0.017 ***	-0.017 ***
	0.005	0.005	0.004	0.004	0.004	0.004
Insurance Reserves / Losses Incurred	-0.004 *	-0.004 *	0.005 *	0.005 *	0.004 *	0.004 *
	0.003	0.003	0.002	0.002	0.002	0.002
One-Year Change in Premiums	0.003	0.003	-0.004	-0.004	-0.003	-0.003
	0.003	0.003	0.002	0.002	0.002	0.002
Personal Lines Output / Total Output	-0.092 ***	-0.092 ***	0.021 ***	0.020 **	0.024 ***	0.024 ***
	0.009	0.009	0.008	0.008	0.009	0.009
Best "A" Rating Indicator					0.042 **	0.042 **
					0.018	0.018
Revenue Efficiency					0.033	0.033
					0.041	0.041
1993 Intercept	-0.174 ***	-0.174 ***	-0.114 ***	-0.114 ***	-0.032	-0.032
	0.034	0.034	0.030	0.030	0.046	0.046
1994 Intercept	-0.142 ***	-0.142 ***	-0.163 ***	-0.162 ***	-0.080 *	-0.080 *
	0.034	0.034	0.030	0.030	0.046	0.046
1995 Intercept	-0.148 ***	-0.148 ***	-0.088 ***	-0.087 ***	-0.005	-0.005
	0.034	0.034	0.030	0.030	0.046	0.046
1996 Intercept	-0.178 ***	-0.178 ***	-0.139 ***	-0.138 ***	-0.055	-0.055
	0.034	0.034	0.030	0.030	0.047	0.047
1997 Intercept	-0.186 ***	-0.186 ***	-0.085 ***	-0.084 ***	0.001	0.001
	0.034	0.034	0.031	0.031	0.048	0.048
1998 Intercept	-0.158 ***	-0.158 ***	-0.136 ***	-0.135 ***	-0.051	-0.051
	0.034	0.034	0.031	0.031	0.047	0.048
Number of Observations	3,868	3,868	3,868	3,868	3,868	3,868
Adjusted R-Squared (centered)	0.239	0.239	0.186	0.186	0.210	0.210