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

John David Cummins
University of Pennsylvania

Greg P. Nini
University of Pennsylvania

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Abstract

Capitalization levels in the property-liability insurance industry have increased dramatically in recent years—the capital-to-assets ratio rose from 25% in 1989 to 35% 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.

Keywords

data envelopment analysis, capital structure, efficiency property-liability insurance, organizational form

Disciplines

Business | Economics | Public Affairs, Public Policy and Public Administration

Optimal Capital Utilization By Financial Firms:
Evidence From the Property-Liability Insurance Industry

By

J. David Cummins and Gregory 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 Nini
The Wharton School
3641 Locust Walk
Philadelphia, PA 19104
Phone: 215-898-3589
Fax: 215-898-0310
Email: greg30@wharton.upenn.edu

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Abstract

This paper investigates the use of equity capital in the property-liability insurance industry. The objective is to determine whether the sharp decline in leverage over the past fifteen years represents the over-utilization of capital or a rational response to changing market conditions. Using best practice technical, cost, and revenue frontiers, estimated using data envelopment analysis (DEA), we estimate each insurer's optimal capital utilization, which we compare with actual capital utilization. We conclude that measured capital over-utilization represents a true inefficiency which adversely affects firm financial performance. We also find that the decline in leverage was primarily attributable to capital gains on investments and provide evidence that insurers are reluctant to pay out capital accumulations as dividends, even if it means over-utilizing capital.

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1. Introduction

Financial firms such as insurers and banks differ from most other types of firms in the economy in that their debt-holders are also their principal customers. The debt-holder/customers rely on these financial institutions to protect their assets in the case of banks and life insurers and to pay contingent claims in the case of property-liability insurers. These debt-holder/customers thus are more concerned about insolvency risk than the debt-holders of other types of firms, who are willing to accept a higher rate of investment return in return for higher default risk. There is a market penalty for being a risky bank or insurer both in terms of product pricing and in terms of the potential loss of risk-averse customers if insolvency risk is perceived as excessive. To maintain insolvency risk at acceptable levels, financial institutions hold equity capital. However, holding capital in a financial institution is costly because of factors such as regulatory costs, agency costs, informational asymmetries, and corporate income taxation. Hence, institutions do not hold sufficient capital to eliminate insolvency risk. Rather, market-driven ”safe” or ”adequate” levels of capital are held by most financial firms.[1]

The puzzle in the property-liability insurance industry is why 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 an average level of approximately 2.0. Beginning in the mid-1980s, however, the ratio began a precipitous decline and was less than 1.0 at the end of 1999. Likewise, the equity capital-to-asset ratio, traditionally around 25 percent, increased to 35 percent by 1999. These developments have raised questions about whether the industry is over-capitalized or whether structural changes in the insurance and/or capital markets have driven the industry to higher capitalization.

The objective of this paper is to analyze capitalization in the industry to provide new information on whether the industry is over-utilizing capital. We employ a frontier efficiency approach to analyze capital utilization of property-liability insurers over the period 1993-1998.[2] Using data envelopment analysis (DEA), a non-parametric technique, we estimate ”best 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 the issue of 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 to the costs actually incurred by the firm. Thus, fully efficient firms have cost efficiency of 1, and inefficient firms have cost efficiency between 0 and 1. 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. Allocatively 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, and is defined as the firm's actual revenues divided by the revenues of a fully efficient firm with the same quantity of inputs. Like cost efficiency, technical, allocative, and revenue efficiency equal 1 for fully efficient firms and are between 0 and 1 for inefficient firms.

The concept of allocative efficiency provides a natural way to analyze whether insurers are over or under-utilizing capital because this efficiency concept specifically measures whether firms are choosing the correct quantities of inputs to produce their outputs and produces 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 under or over-optimal utilization of capital represents a rational response to market factors or firm organizational 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 which degrades firm performance. To provide information on which explanation is correct, we regress revenue efficiency scores and book-value returns on equity against a set of explanatory variables, including the ratio of the firms' optimal capital-to-assets and the ratio of its actual minus optimal capital-to-assets. The latter ratio, which we call the *sub-optimal capital-to-assets ratio,* represents the amount of capital under or over-utilization relative to assets.

The ratio of optimal capital-to-assets is expected to be positively related to revenue efficiency, i.e., firms are predicted to be rewarded with additional revenues for holding the optimal amount of capital. If measured capital under or over-utilization represents legitimate usage of capital, the sub-optimal capital-to-assets ratio will be positively related to revenue efficiency. However, if measured under or over-utilization captures true inefficiencies, the sub-optimal capital-to-assets ratio is expected to be unrelated or negatively related to revenue efficiency, providing evidence that firms are penalized by the insurance market for holding sub-optimal levels of capital.

With respect to return on equity, financial theory predicts that firms with relatively more equity (lower leverage) are less risky and thus should have lower costs of capital. Consequently, we expect the ratio of optimal capital-to-assets to have a negative coefficient in the return on equity regressions. If holding additional capital 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 additional capital represents inefficiency, the marginal safety benefits of holding the additional capital will be partially or fully offset by a market penalty for 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 insignificant or positively related to return on equity. An insignificant or smaller negative effect would imply that firms are not rewarded commensurately for holding sub-optimal capital as they are for holding the optimal amount of capital, and a positive coefficient would suggest that inefficient firms have higher costs of capital than relatively more efficient firms.

In addition to measuring the effects of optimal and 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. The tests are conducted by regressing the ratio of the firm's actual-to-optimal capital against a vector of explanatory variables representing the 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 dividends, preferring to maintain internal funds to cushion the next loss or investment shock. Finally, we find that insurers are substantially over-utilizing equity capital and that the over-utilization represents inefficiency and leads to significant revenue and cost of capital penalties and 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. Section 4 describes our sample and specifies the inputs and outputs used in the DEA analysis. In section 4, we discuss our hypotheses about revenue efficiency and return on equity. Section 6 discusses our estimation methodology, and the results are presented in section 7. Section 8 summarizes our findings and conclusions.

2. Capitalization Trends in Property-Liability Insurance

The 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 and the equity capital-to-asset ratio. The former is the traditional leverage ratio used in the industry, while the latter is used more commonly in the financial literature. Both leverage ratios show that 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-asset 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 possibly 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 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 an alternative to 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 to change capital structure by increasing 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 1995, 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 $78.9 billion in stockholder dividends and $29.7 billion in miscellaneous outflows. These capital disbursements are added back to the net change in capital to give the gross change in capital in section B of the table, and the percentages of the gross change from each source of capital are shown.

Capital gains provided the most important source of new capital during the ten-year period 1989-1998 and the five-year period 1994-1998 – accounting for 51.7 percent during the former period and 52.9 percent during the latter. The second most important source of gross new capital is retained earnings other than capital gains (net underwriting income plus investment income), and the third most important source is new capital paid-in, either 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. About two-thirds of the total gross change in capital is retained by insurers, about one-fourth paid out as dividends, and the remainder devoted to miscellaneous uses.

Table 1 also 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 actually 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.

As a second look at the over-capitalization issue, we consider the annual market returns and volatilities on a portfolio of property-liability insurance stocks and compare these statistics with the returns and volatilities on the Standard & Poor's (S&P) 500 stock index. If insurers have been inefficiently utilizing capital, it might be expected that their equity returns would suffer as a result. The portfolio of insurance stocks used in our analysis consists of all firms in standard industrial classification (SIC) category 6330, property-liability insurers, appearing in the CRSP database of New York Stock Exchange and NASDAQ stocks. The returns and volatilities are based on an unweighted average of the SIC 6330 firms.

The results of the return and volatility comparisons are shown in Table 2. The table shows the fifteen year period 1985-1999. The year 1985 was abnormal for property-liability insurers because it followed the 1984-1985 commercial liability insurance crisis, which caused a major adverse shock to equity capital for many insurers. As the second year of the crisis, 1985 was in many respects a rebound year when the effects of shock-induced insurance price increases first began to be realized. Accordingly, we show averages of returns and volatilities over two sample periods: 1985-1999 and 1986-1999. Averages are also presented for the last ten years and last five years of the sample period. The results indicate that insurance equity returns were higher than the S&P 500 return in all sample periods except 1995-1999, while insurer volatilities are generally lower than S&P 500 volatilities. The lower returns over the 1995-1999 period are primarily attributable to low returns in 1998 and 1999. Thus, if insurers are over-capitalized, it does not show up in the stock return data for traded firms, except possibly for the last two years of the sample period.[3]

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 over and under–capitalization.

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, regulatory costs, and corporate income taxation (Merton and Perold 1993). Consequently, 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 and relationship 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 (Cummins and Danzon 1998).

All else equal, as the expected costs of insolvency increase, the marginal benefit to capital increases, and the optimal leverage ratio decreases. For an insurance company, the probability of insolvency is related to an insurer's ability to diversify the risk to their capital. As proxies for insolvency risk, three measures of liability risk and one measure of asset risk are used.

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.[4] The second measure of liability risk is the insurer's

Herfindahl index across lines of insurance based on premium volume. 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 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.[5] 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. Risk levels also are expected to differ cross-sectionally among firms in the industry as a function of both underwriting and investment portfolio choices. To control for temporal and cross-sectional differences in insurer income volatility, we use the standard deviation of each insurer's book-value return on equity 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 return on equity, 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 capitalizaation 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. This suggests the following hypothesis:

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

Following the recent insurance efficiency literature (e.g., Cummins and Weiss 2000), we use the natural log of assets to represent firm size.

Agency Costs

Two significant sources of agency costs exist in the insurance industry. Conflicts between owners and managers arise because managers do not share fully in the residual claim held by owners and thus 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 other actions that increase the value of equity and decrease 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 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 perquisite consumption. Finally, additional leverage increases the probability of bankruptcy (a particularly costly event for managers), making private pursuits more costly for managers. Mitigating the conflict between managers and owners 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 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 the insurance industry is characterized by more than one ownership form, organizational form provides an excellent proxy for the degree of agency costs inherent in an insurance firm. Compared with stock companies, mutuals remove 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. To the extent that the costs of unresolved owner-manager conflicts are greater than the benefits from removing the policyholder-owner conflict, mutuals are likely to face a higher effective cost of capital and will appear under-capitalized in the efficiency analysis. Similarly, because the owner-policyholder conflict is eliminated in the mutual ownership form, there is reduced marginal benefit to additional capital, providing an additional reason why mutuals may be less capitalized than stocks. The prediction is summarized in the following hypothesis:

H6 *Mutuals will utilize capital 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. This can be accomplished by reducing capital and increasing leverage. 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. Therefore, we hypothesize that:

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

Asymmetric Information and Growth Opportunities

If corporate managers possess superior information about the nature of investment opportunities than do owners, Myers and Majluf (1984) demonstrate that this information asymmetry may cause equity mis-pricing. This results in a "pecking order" theory of financing where managers prefer internal funds and debt to financing through equity. As the degree of asymmetry between managers and investors increases, the mis-pricing problem worsens and raising equity capital becomes more costly. For an insurer, there are two immediate consequences. First, firms with more severe information asymmetries will become more leveraged over time, because raising equity capital is more costly for such firms. Second, for any given degree of informational asymmetry, insurance firms with more growth opportunities are expected to hold additional capital to avoid the need for raising costly capital in the future. Faster growth also increases uncertainty about future performance, so decreasing leverage provides additional security to customers and investors that the new business will not change the default probability. This suggests the following hypotheses:

H8 *Firms with higher information asymmetries between managers and owners will utilize relatively less equity capital.*

H9 *Firms with more growth opportunities will consume relatively more equity capital.*

As a proxy for the degree of information asymmetries between managers and investors, the standard deviation of return on equity (ROE) over time is used to capture the public information that is available to 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 therefor have more severe information asymmetries than less risky insurers. Such firms will find it more costly to generate equity capital and will accumulate less over time. Based on this rationale, the coefficient of variation of ROE is predicted to be inversely related to capitalization. Recall, however, that hypothesis H4 predicts a positive relationship between ROE and capital, based on reduction of financial distress costs. Thus, the actual sign of this variable will depend upon the extent to which it measures firm opacity versus aversion to financial distress costs.

As a 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.

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 1985, D'Arcy and

Doherty 1989). This informational advantage augments the insurer's franchise value, which is placed in jeopardy if the probability of financial distress increases. Consequently, firms with more franchise value at stake are expected to have lower leverage than firms with less at stake (Titman 1984).

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 (A or better) financial ratings. Moreover, commercial lines buyers and their brokers are more proficient than individual buyers in assessing insurer financial quality. This suggests the following hypothesis:

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

To test this hypothesis, 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.

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. Insurers are assessed RBC charges for asset risk, credit risk, underwriting risk, and other miscellaneous risks. The sum of the charges, after a covariance adjustment, constitutes the insurer's risk-based capital. 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. The introduction of risk-based capital thus 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 equation. If capital levels were adjusted during or after 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, then the primary 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. Most of the variables discussed in the preceding section are also relevant as hypothesis testing and control variables in the revenue efficiency and return on equity regressions. In this section, we discuss hypotheses and expected signs for the firm performance regressions.

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 which 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 frictions and market imperfections such as regulatory costs, corporate income taxation, and unresolved agency conflicts. Thus, at some point, the marginal benefit of adding capital to reduce insolvency risk falls below the marginal cost of the added capital.

The costly capital argument predicts that firms will be rewarded for holding the optimal amount of capital. Firms will be rewarded or penalized for measured capital under or over-utilization depending upon whether holding capital that deviates from the measured optimum represents a legitimate response to market forces or a true inefficiency. Under or over-utilization does not represent a true inefficiency if capital utilization patterns reflect legitimate differences in capital requirements across firms because of heterogeneity in underwriting or investment portfolios, organizational form, or other factors. On the other hand, if deviations from optimal represent a true inefficiency, insurers holding sub-optimal amounts of capital are likely to be penalized by the market in terms of lower revenues, 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 cover the dead-weight costs of the excess capital by charging prices that are viewed by buyers as too high.

To test the relationship between revenue efficiency and capital utilization, we specify two explanatory variables – the ratio of optimal capital-to-assets and the ratio of actual minus optimal capital-to-assets. We refer to the former variable as the *optimal capital-to-asset ratio* and to the latter as the *sub-optimal capital-to-asset ratio*. The costly capital hypothesis unambiguously predicts a positive relationship between revenue efficiency and the optimal capital-to-asset ratio, i.e., insurers that attain the optimal level of insolvency risk will be rewarded with additional revenues. 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.

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 exposure 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 insolvency risk and/or are able to earn higher revenues because size conveys market power. The standard deviation of return on equity could be negatively related to revenue efficiency, if it captures insolvency risk, or could be positively related based on the financial theory argument that higher risk activities earn higher returns. The mutual dummy variable is predicted to have a negative coefficient if mutuals are less efficient than stocks due to unresolved agency conflicts. The premium growth rate is expected to have a positive sign if firms with more growth opportunities tend to be more profitable. 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 have higher value-added because of higher service intensity in the commercial lines.

Return on Equity

The return on equity (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 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 return on equity 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 additional capital represents an inefficiency, the safety benefits of holding the 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 insignificant or positively related to return on equity. An insignificant or smaller negative effect would imply that firms are not rewarded commensurately for holding sub-optimal capital as they are for holding the optimal amount of capital, and a positive coefficient would suggest that inefficient firms have higher costs of capital than relatively more efficient firms.

Also included in an ROE regression is an indicator variable set equal to 1 if an insurer has a Best's rating of A or higher and equal to zero otherwise and the firm's revenue efficiency score. 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 and ROE. 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 ROEs, other things equal. The Best's rating variable and revenue efficiency are clearly jointly determined with ROE. Consequently, they are treated as endogenous variables, using an instrumental variables approach discussed below.

The set of explanatory variables included in the actual-to-optimal capital and revenue efficiency regressions also are included in the return on equity 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 default risk, the coefficients on the geographical and line of business Herfindahl indices are predicted to be positive in the return on equity regressions because higher Herfindahl indices imply less diversification and a higher cost of capital. The ratio of stocks and real estate to total assets and the standard deviation of return on equity also have predicted positive coefficients 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 return on equity. Firms with more growth opportunities are likely to be viewed favorably by capital markets, predicting a negative sign on the premium growth variable. Also, 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 is ambiguous a prior. 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 to the extent that ROE is correlated with the ex ante cost of capital. 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 because they do not have access to capital markets in the event of a loss shock, 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, including pure technical, scale, allocative, and cost efficiency. Next, we discuss the estimation of efficiency utilizing data envelopment analysis (DEA). The section concludes with a discussion of the regression methodology that we use to analyze capital structure and effects of under and over-capitalization on firm performance.

Efficiency

To analyze production frontiers, we utilize input-oriented distance functions as originally introduced by Farrell (1957). Suppose producers use input vector $x = (x_1, x_2, \ldots, x_K)' \in \Re_+^K$ to produce output vector $y = (y_1, y_2, \ldots, y_M)' \in \Re_+^M$. The production technology that transforms the K inputs into M outputs is represented by the input correspondence $V(y) = \left\{x : (y,x) \text{ is feasible}\right\}$. The input-oriented distance function for a specific decision making unit (DMU) is $D(y,x) = \sup\left\{\theta : \frac{x}{\theta} \in V(y)\right\}$, which is the reciprocal of the minimum equi-proportional contraction of the input vector x that can still produce y. Obviously, $D(y,x) \geq 1$.

The Farrell measure of input technical efficiency reflects the ability of a DMU to minimize required inputs to produce a given 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-porportional 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 is calculated with respect to a production frontier characterized by constant returns to scale (CRS) and variable returns to scale (VRS). From an economic perspective, firms should operate in a region of 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 technical efficiency is given by the remaining total inefficiency not explained by pure technical efficiency, $SE(y,x) = \frac{TE_{CRS}(y,x)}{TE_{VRS}(y,x)}$, where $SE(y,x)$ = scale efficiency.

By explicitly modeling the economic objective of cost minimization, we can estimate the cost efficiency of each DMU. 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 $w = (w_1, w_2, \ldots, w_K)' \in \Re^K_{++}$, 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 the ability of a DMU to use inputs in 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 DMU. Assuming output prices $p = (p_1, p_2, \ldots, p_M)' \in \Re^M_{++}$, 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: $RE(y,x) = \frac{p'y}{p'y^*}$.

Data Envelopment Analysis

Data envelopment analysis (DEA) is a non-parametric mathematical programming approach to estimating distance functions. Assuming the availability of input, output, and price data for each of *N* DMUs, DEA can be used to construct a frontier such that all observed points lie on or below the frontier. For the *i*th DMU, 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, W as the $K \times N$, $M \times N$, and $K \times N$ matrices of inputs, outputs, and input prices for all DMUs, i = 1, 2, . . . , N.

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

$$\min_{\theta_i, \lambda_i} \theta_i$$

$$\textit{subject to}: \quad y_i \leq Y\lambda_i$$

$$\theta_i x_i \geq X\lambda_i$$

$$\lambda_i \geq 0$$

where λ_i is an $N \times 1$ intensity vector for firm i representing the combination of DMUs 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_i if it operated on the production frontier. A value of $\theta_i^* = 1$, thus 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, 2, . . ., N. Constraining the λ_i only to be non-negative results in a constant returns to scale (CRS) frontier.

Following Banker, Charnes, and Cooper (1984), the above program is modified to account for variable returns to scale (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 $PTE_i = TE_{VRS}(y,x) = \theta_i^{**}$. Scale efficiency is given by the ratio of the two solutions, $SE_i = \frac{\theta_i^*}{\theta_i^{**}}$. To determine whether firm i is operating with increasing or decreasing returns to scale, it is necessary to conduct the estimation again with the constraint $\iota_N' \lambda_i \leq 1$, giving a non-increasing returns to scale (NIRS) frontier and NIRS estimates of technical efficiency, $TE_{NIRS}(y,x)$. If $SE_i = 1$, the firm has achieved CRS. If $SE_i \neq 1$ and $TE_{VRS}(y,x) = TE_{NIRS}(y,x)$, then DRS is indicated; and if $SE_i \neq 1$ and $TE_{VRS}(y,x) \neq TE_{NIRS}(y,x)$, IRS is indicated.

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

$$\min_{\lambda_i, x_i} \; w_i' x_i$$

$$\textit{subject to}: \quad y_i \leq Y\lambda_i$$

$$x_i \geq X\lambda_i$$

$$\lambda_i \geq 0.$$

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 overutilizing input k.

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

$$\max_{\lambda_i, y_i} \; p_i' y_i$$

$$\text{subject to : to} \quad y_i \leq Y\lambda_i$$
$$x_i \geq X\lambda_i$$
$$\lambda_i \geq 0.$$

Letting y_i^* be the cost minimizing vector of inputs for firm *i*, revenue efficiency is given by $RE_i = \frac{p_i' y_i}{p_i' y_i^*}$.

Ex-Post Analysis

After estimating efficiency scores and optimal inputs, we estimate regression models with the ratio of actual-to-optimal capital, revenue efficiency, and return on equity as dependent variables. The primary objective of the actual-to-optimal capital equation is to test the hypotheses about capital structure in the industry that were specified in section 3 above. The primary objective of the revenue efficiency and return on equity equations is to provide information on whether measured capital under or over-utilization is value-creating or value-destroying in the insurance industry. Ordinary least squares (OLS) is used to estimate the revenue efficiency equation and a version of the revenue efficiency and ROE regressions including the variables discussed in section 3.

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 included 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 ratio approach and instrumental variables estimation.

The inverse Mill's ratio (IM) approach involves adding two inverse Mill's ratios to the equation as additional regressors and then estimating the resulting augmented equation by ordinary least squares. The inverse Mill's ratios correct for the possibility that the expected value of the error term, conditional on the firm having an A rating or better, is likely to be different from the expected value of the regression error term, conditional on the firm being rated below A. The inverse Mill's terms are in fact functions of the conditional means of the error term for firms having Best's indicator function values of 0 and 1, respectively. The ratios are estimated using a probit equation with the Best's rating indicator variable as the dependent variable.

The second approach to correcting for the potential endogeneity of the Best's rating variable is instrumental variables (IV) estimation. The approach is similar to conventional two-stage least squares except that the instrumental variable for the Best's rating is equal to the predicted value of each firm's probability of having an A rating or above based on a reduced-form probit model with the Best's indicator variable as the dependent variable. Further discussion of the IM and IV estimation techniques are provided in the Appendix.

In the ROE equation we include both the Best's indicator variable and the firm's revenue efficiency score as addtional 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 varaible 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.

6. The Sample, Outputs, and Inputs

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 decision making units (DMUs) 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.[7] The number of DMUs declined from 972 in 1993 to 778 in 1998, primarily due to consolidation in the insurance industry. To apply DEA, it is necessary to specify inputs, outputs, and prices. The following sections define these variables.

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 intermediation output. All monetary valued variables are deflated to real 1989 values based on the consumer price index (CPI).

In keeping with the value-added approach to output measurement, the prices of the insurance outputs are defined as follows: $p_i = \frac{P_i - PV(L_i)}{PV(L_i)}$, where p_i = 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. This is a generalization of the insurance unit price concept that has been used extensively in the insurance economics literature (e.g., Pauly, Kleindorfer, and Kunreuther 1989). The conventional unit price measures the cost of delivering $1 of benefits as the ratio of premiums to incurred losses. However, because premiums reflect implicit discounting to account for the insurer's use of policyholder funds between the premium payment and loss payment dates, it would be incorrect to compare premiums to the nominal (undiscounted) value of losses. By using the present value of losses to represent the quantity of insurance, consistency is maintained in recognizing the time value of money both in the premium and loss components of the price.

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 (approximately 25 percent of invested assets in 1999). 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.

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 function differs across insurers because of variation both in the return on debt instruments and in the debt/equity portfolio proportions.

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 must be 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 determined 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 is obtained from the annual statement as total expenses incurred less all labor costs. This captures expenditures on advertising, board and bureau fees, equipment, printing, communications, auditing, and other business expenses.[9] The price of materials and business services input is given by a national average 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). The primary reserves in this category are the ”provision for reinsurance” and the ”excess of statutory over statement reserves.” 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. We adopt two alternative approaches to measuring the cost of equity capital: (1) The cost of equity is assumed to be constant for all firms in the industry and 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). (2) Following Cummins, Tennyson, and Weiss (1998), we alternatively adopt a three-tier approach to measuring the cost of capital, based on financial ratings assigned by the A.M. Best Company. Best's uses a fifteen tier letter-coded rating system ranging from A++ for the strongest insurers to F for insurers in liquidation. The three tiers we adopt consist of the four ratings in the "A" range, the four ratings in the "B" range, and all other rating categories. Based on an examination of the equity cost of capital for traded insurers, we assign a cost of capital of 12 percent to the top tier, 15 percent for the middle tier, and 18 percent for insurers in the lowest quality-tier. We rely primarily on the first measure of the cost of equity in reporting the results and briefly discuss the second measure as a robustness check. As a further adjustment for the variation in the cost of capital across insurers, we include variables known to be related to the cost of capital such as ROE volatility in our regression analysis.

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 prices of the four insurance outputs are the difference between premiums and the loss present values, a measure of value-added, divided by the present value of losses. The price of the intermediation output is the expected rate of return on the insurer's investment portfolio. 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, with an emphasis on changes in input usage over the sample period. We then turn to a discussion of the efficiency results, including comparisons of actual and optimal input usage. The section concludes by presenting the regression results used to test our hypotheses and provide information on whether measured sub-optimal input usage represents a true inefficiency or a rational response to market forces.

Summary Statistics

The inputs, input prices, and expenses of the property-liability insurance industry for the period 1993-1998 are shown in Table 3. 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 3). 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 4. 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, primarily due to favorable investment returns. When the average intermediation price is used rather than the year-by-year prices, the increase in revenues from the intermediation output is not as steep.

Additional summary statistics are presented in Table 5, 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. The proportion of mutuals increased during the sample period, primarily because stock insurers are more likely to be involved in mergers and acquisitions.

Efficiency Results

The results of the DEA analysis are presented in Table 6. Average scores are shown for pure technical, scale, technical, allocative, cost, and revenue efficiency.[10] The average efficiency scores are comparable to the scores reported in earlier research on property-liability insurers (Cummins and Weiss 1993, Cummins, Weiss, and Zi 1999). Cost efficiency in the industry tends to be around 40 percent, with pure technical inefficiency being the primary drag on cost efficiency – pure technical efficiency averages around 62 percent, whereas scale and allocative efficiency average 90 and 73 percent, respectively. 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 about 30 percent, indicating a fairly high degree of revenue inefficiency in the industry, at least on average.

The sources of allocative inefficiency in our sample of insurers are further analyzed in Table 7. Part A of the table shows percentage departure from optimal utilization ratios defined as follows: $U_i = 100 * (\frac{X_i}{X_i^{opt}} - 1)$, where U_i = under or over-utilization of input i, X_i = actual quantity of input i, and X_i^{opt} = 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 7 reveals that insurers on average over-utilize all three inputs. The average over-utilization of labor is 159.7 percent, indicating that insurers could reduce labor input by about 60 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, only 57.2 percent, implying that insurers could reduce materials inputs by 36 percent if they operated with full efficiency.

The over-utilization of capital is 85 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 overcapitalization has increased over time. On average, insurers could reduce capital by about 46 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 .20 for the capital-to-asset 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 7. Over-utilization increased by nearly 90 percent over the sample period, from 66.6 billion in 1993 to 124.2 billion in 1998.

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 return on equity (ROE), respectively. The actual-to-optimal capital equation is designed to identify covariates related to the utilization of capital, based on the theoretical discussion presented above. The implication of the capital over-utilization equation is either: (1) The more intensive use of capital by some firms represents a legitimate response to market conditions, so that the measured "over-utilization" is not really an inefficiency but is actually valued by the market. Or (2) the independent variables help to explain patterns of capital utilization in the industry, but measured capital over-utilization primarily constitutes inefficiency rather than legitimate optimization behavior. The revenue efficiency regression provides information on which of these interpretations is correct by including both the firm's optimal capital-to-asset ratio and the ratio of capital under or over-utilization to assets (the sub-optimal capital-to-asset ratio) among the independent variables. If over-utilization represents an inefficiency, the sub-optimal capital-to-asset ratio will have a negative coefficient; and if the measured over-utilization is valued by the market, the over-utilization variable will have a positive coefficient.

The actual-to-optimal capital regression equations are presented in Table 8. Three equations are shown in the table. The first equation, which is estimated by ordinary least squares (OLS), omits the Best's rating indicator variable. 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 variables is omitted from the OLS equation because it is jointly determined with capital and hence would likely result in biased coefficient estimates under OLS. The two additional equations in Table 8, which include the Best's rating indicator variable, are estimated using methodologies designed to control for the endogeneity of the Best's rating variable. Specifically, one equation uses the inverse Mill's (IM) approach and the other uses the instrumental variables (IV) approach.

The regressions presented in Table 8 provide support for most of our hypotheses regarding differences in capital utilization among insurers. The Best's A rating indicator variable is positive and significant in the IM and IV regressions, as expected if firms hold more capital in order to reduce the probability of a ratings downgrade. The reinsurance variable has a negative coefficient, as expected if use of reinsurance is a substitute for holding capital in terms of minimizing the expected costs of financial distress. However, this variable is statistically significant only in the OLS model. 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 risk in the asset portfolio. The natural log of assets is negative and significant, consistent with the argument that risk is inversely related to the size of the risk pool. The square of the size variable has a positive coefficient, suggesting diminishing returns in the effect of size on capital requirements. The mutual dummy variable is negative and significant, providing support for the view that the cost of capital is higher for mutuals because of unresolved agency conflicts.

The standard deviation of book return on equity is negative and significant in the OLS equation but is positive and significant in the IM and IV regressions. We consider the latter two equations to be more reliable because they include the Best's rating variable and thus are less likely than the OLS equation to suffer from omitted variable bias. Thus, we believe that the results support the hypothesis that firms with more volatile income streams utilize more capital.

The one-year premium growth rate is positive as expected but is significant only in the IM regression, providing weak evidence that firms with growth opportunities hold more internal 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. The ratio of insurance reserves to losses 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.

The line of business Herfindahl index is positive and significant in the inverse Mill's and instrumental variables regressions, as expected if less diversified firms need more capital. This variable is negative and significant in the OLS regression. Because we consider the IM and IV regressions more reliable than the OLS regression, we believe that the evidence with regard to this variable supports the diversification hypothesis. Contrary to expectations, the geographical Herfindahl index is negative and significant in all three equations. A possible explanation for these results is that operating over wider geographical areas exposes insurers to more risk 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. Finally, an F test reveals that there are no significant differences among the intercept terms for the six years of the sample period. This either suggests 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 return on equity equations presented in Table 9 are primarily designed to provide information on whether measured "sub-optimal" capital utilization represents a legitimate arket conditions or a true inefficiency which degrades firm performance.

The revenue efficiency equation provides evidence consistent with the view that firms are rewarded for achieving the optimal capital-to-asset ratio but that sub-optimal capital utilization represents a true inefficiency. The optimal capital-to-asset ratio has a significant positive coefficient indicating that firms are rewarded with additional revenues for holding the optimal amount of capital, consistent with the argument that insurers hold capital to satisfy market demands for safe insurance. However, the firm's sub-optimal capital-to-asset ratio has a negative coefficient in the revenue efficiency equation. This provides strong evidence that firm's holding more or less capital than the measured optimum are penalized by the insurance market in the form of lower revenues 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 cover the dead-weight costs of the excess capital by charging prices that drive away customers.

The results with the other explanatory variables in the revenue efficiency equation are mostly consistent with expectations. Both the geographical and line of business Herfindahl indices are positive and significant, suggesting that more diversified firms are rewarded with higher revenues. The size variable also 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 variable is negative and significant, suggesting that firms with riskier assets are less revenue efficient. However, the more global risk measure, the coefficient of variation of ROE, is positive and significant, consistent with the general capital-markets argument that firms taking more risk are rewarded with higher returns, other things equal. Mutuals are less revenue efficient than stocks, supporting the argument that mutuals have higher default risk. This result could also be consistent with the expense preference hypothesis, i.e., that mutuals are less efficient than stocks because of unresolved agency conflicts. The ratio of personal insurance output to total insurance output is negative and significant and the ratio of insurance reserves to losses incurred is positive and significant, reflecting higher prices received by commercial lines and long-tail lines (see Table 4).[11]

The return on equity (ROE) equations also are shown in Table 9. 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 item, policyholder dividends, and government mandated tax payments.[12] Two versions of the regression are included in Table 9, an OLS version that omits the Best's A rating indicator variable and revenue efficiency and an instrumental variables version that includes these potentially endogenous variables.

The ROE regressions provide additional evidence that measured sub-optimal capital utilization is a true inefficiency. 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-asset ratio also has a significant negative coefficient in the regressions. However, the coefficient of this variable is substantially smaller in absolute value than the coefficient of the optimal capital-to-asset 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. Both the Best's indicator variable and revenue efficiency have significant positive coefficients, providing evidence that efficient firms with good financial ratings earn higher returns.

The signs of the other variables in the ROE models are generally consistent with our theoretical predictions. 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 and the standard deviation of return on equity also have significant positive coefficients, consistent with the hypothesized positive relationship between risk and the cost of capital. Likewise, the reinsurance utilization variable has a significant negative coefficient, consistent with the argument 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, but is significant only in the OLS equation, providing 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 long tail lines variable (loss reserves divided by losses incurred) has is significant and negative consistent with the view that premiums in the long-tail lines have a higher discount for the time value of money than premiums in the short-tail lines. Finally, the mutual dummy variable is negative, but significant only in the IV regression, providing some support for the hypothesis that mutual firms write lower risk business than stock firms.

The overall conclusions to be drawn from the regression analysis are the following: (1) Measured sub-optimal capital utilization primarily reflects inefficiency, for which insurers incur a 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. (2) Revenue efficient firms and firms with A or better financial ratings earn higher returns than inefficient firms and firms with lower financial ratings. (3) Nearly all of the hypotheses about the relationships between firm characteristics and capital over-utilization are supported by the actual-to-optimal capital equation.

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 are reluctant to pay dividends when capital increases because it is difficult and costly for these firms to raise external capital following a loss or investment shock. Thus, 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 1994-1998 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 equal to 1, while inefficient firms have scores between 0 and 1.

The efficiency scores in our analysis are consistent with prior research on the property-liability insurance industry. Cost efficiency averages about 40 percent, implying that insurers could reduce costs by about 60 percent if they could operate with full efficiency. Average technical efficiency in our sample is 55 percent and average allocative efficiency is 73 percent. 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, defined as the failure to choose the optimal combination of inputs, is also a driver of cost inefficiency. Revenue efficiency in the industry averages only 30 percent during our sample period, indicative of a significant loss of potential revenues..

The efficiency analysis enables us to estimate the optimal utilization of inputs for each firm in the sample, i.e., the optimal quantities of labor, materials and business services, and equity capital, conditional on the firm's output vector and input prices. By comparing a firm's actual capital utilization with its optimal capital, we are able to provide direct evidence on the capital utilization issue.

The results indicate that firms on average over-utilize all three inputs, with the labor input subject to the most severe over-utilization. Based on a weighted average across the industry, insurers could reduce labor by 62 percent, materials by 36 percent, and capital by 46 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 capital 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 – the recalculated premiums to surplus ratio is 1.6, compared to an actual ratio of 1.0, and the recalculated capital-to-asset ratio is 0.2, compared to an actual ratio of 0.36. This provides further evidence of capital "stickiness" in the industry, i.e., a reluctance by insurers to distribute equity capital accumulations as dividends.

The final part of our analysis involves estimating regression equations. Three dependent variables are investigated – the ratio of actual capital to optimal capital, revenue efficiency, and return on equity. The explanatory variables in the models are designed to proxy for several economic hypotheses regarding insurer motivations for holding capital. The actual-to-optimal capital regression supports most of our economic hypotheses, and a substantial part (about 80 percent) of the variability of the dependent variable can be explained by our models. We find evidence supporting the hypothesis that insurers hold equity capital to reduce the expected costs of financial distress, to take advantage of growth opportunities without raising external capital, to deal with various informational asymmetries and agency costs, and to achieve higher financial ratings.

There are two opposing interpretations that can be given to the actual-to-optimal capital regression: (1) Because firms hold capital in response to hypothesized organizational and market characteristics, the measured ”over-utilization” could represent a rational response to market conditions that is rewarded with higher revenues; or (2) the measured over-utilization is a true inefficiency, degrading the performance of inefficient firms. The revenue efficiency and return on equity regressions are designed to help distinguish between these two possibilities.

The results support the second interpretation of measured capital over-utilization. The optimal capital-to-asset ratio is positively related to revenue efficiency, suggesting that optimally capitalized firms are rewarded with higher revenues. However, the sub-optimal capital-to-assets ratio (the ratio of actual capital minus optimal capital to assets) is inversely related to revenue efficiency, suggesting that measured capital over-utilization primarily reflects inefficiency. The optimal capital-to- assets ratio is inversely related to return on equity, consistent with the argument that better capitalized firms have lower costs of capital. The sub-optimal capital-to-asset ratio also has a negative coefficient, but it is much smaller in absolute value than the coefficient of the optimal capital-to-asset ratio. This provides evidence that the safety benefits of holding capital in excess of the optimum are at least partially offset by a market penalty for inefficiency.

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 next loss or investment shock. Finally, we find that insurers are substantially over-utilizing equity capital and that the over-utilization primarily represents an inefficiency that leads to financial performance penalties that are directly related to the degree of over-utilization.

Figure 1: Leverage Ratios 1970-1999

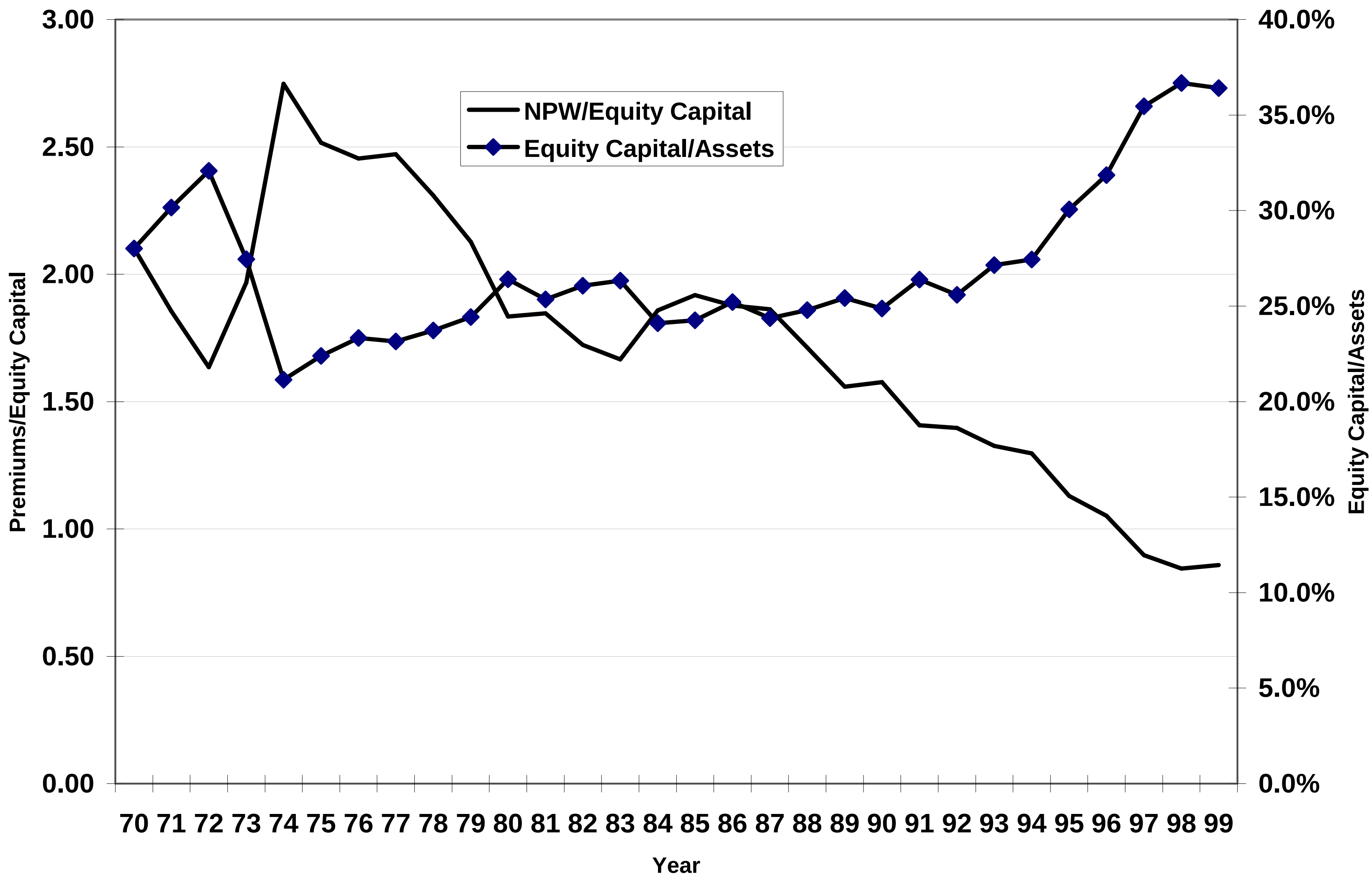

Figure 2: Growth Rates Of Premiums and Equity - 6 Year Moving Averages

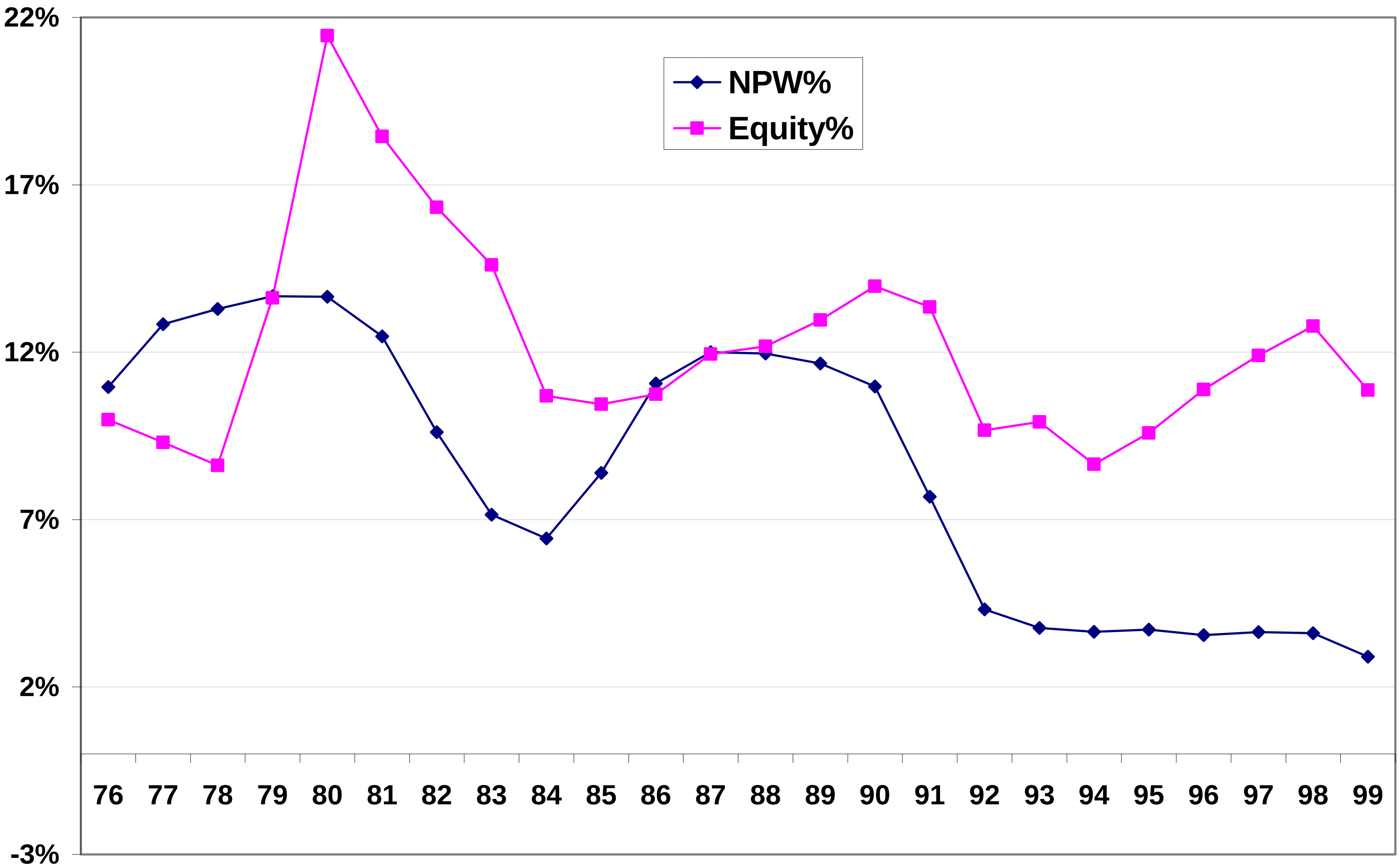

Table 1
Sources of Equity Capital Growth

Section A:	Total Change in Surplus	Retained Earnings (non-CG)	Realized Capital Gains	Unrealized Capital Gains	Capital Paid-In	Stockholder 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	63.10	30.34	32.05	17.33	20.76	-30.69	-6.69	30.5%
1994-1998	152.64	77.73	45.73	72.43	27.53	-48.10	-22.68	21.5%

		- Percent by Source -			
Section B:	Total Funds	Retained Earnings	Realized Gains	Unrealized Gains	Capital Paid-In
1989-1998	323.90	33.4%	24.0%	27.7%	14.9%
1989-1994	100.48	30.2%	31.9%	17.2%	20.7%
1994-1998	223.43	34.8%	20.5%	32.4%	12.3%

		- Percent by Use -			
Section C:	Total Funds	Stockholder Dividends	Misc. Uses	Retained Earnings	Total
1989-1998	323.90	24.3%	9.1%	66.6%	100.0%
1989-1994	100.48	30.5%	6.7%	62.8%	100.0%
1994-1998	223.43	21.5%	10.2%	68.3%	100.0%

Table 2
Yearly Returns and Volatilities:
Insurance Stocks and S&P 500 Index

	Actual Yearly Return		Implied Yearly StdDev	
Year	Insurance	S&P	Insurance	S&P
1985	62.4%	26.3%	13.7%	10.0%
1986	12.7%	14.6%	18.3%	16.4%
1987	-5.3%	2.0%	23.4%	24.0%
1988	27.1%	12.4%	7.9%	15.2%
1989	38.7%	27.2%	7.6%	13.5%
1990	-12.8%	-6.6%	14.4%	15.9%
1991	50.2%	26.3%	12.0%	13.5%
1992	42.6%	4.5%	9.3%	8.9%
1993	32.4%	7.1%	10.5%	7.7%
1994	1.3%	-1.5%	8.0%	10.0%
1995	49.4%	34.1%	6.5%	6.9%
1996	22.2%	20.3%	7.3%	12.9%
1997	39.0%	31.0%	9.2%	15.5%
1998	1.1%	26.7%	15.4%	18.6%
1999	-15.5%	19.5%	12.1%	18.7%
Averages:				
1985-1999	23.0%	16.3%	11.7%	13.8%
1986-1999	20.2%	15.5%	11.6%	14.1%
1990-1999	21.0%	16.1%	10.5%	12.9%
1995-1999	19.2%	26.3%	10.1%	14.5%

Table 3: Inputs and Expenses

	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							
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%
Financial Capital: Average Price	23.1%	24.1%	25.0%	26.7%	29.4%	31.1%	27.1%

Table 4: Outputs and Revenues

	1993	1994	1995	1996	1997	1998	Average
Output Quantities							
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							
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: Average 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: Average Price	35.1%	35.0%	34.0%	37.0%	36.0%	37.5%	36.0%

Table 5
Summary Statistics: Regression Explanatory Variables

	1993	1994	1995	1996	1997	1998	Average
(Actual Capital - Optimal Capital)/Assets	0.133	0.134	0.134	0.146	0.145	0.154	0.141
Optimal Capital/Assets	0.135	0.134	0.133	0.119	0.134	0.130	0.131
Geographical Herfindahl Index	0.571	0.571	0.574	0.559	0.600	0.598	0.579
Line of Business Herfindahl Index	0.459	0.466	0.468	0.476	0.499	0.505	0.479
Reins Reserves Ceded/(Direct+Assumed)	0.317	0.321	0.319	0.321	0.302	0.304	0.314
(Stocks+Real Estate)/Assets	0.181	0.173	0.181	0.184	0.200	0.215	0.189
Ln(Assets)	18.23	18.27	18.30	18.38	18.20	18.32	18.28
Mutual Dummy Variable	0.455	0.437	0.448	0.452	0.466	0.475	0.455
Insurance Reserves/Losses Incurred	0.871	0.867	0.861	0.861	0.855	0.852	0.861
Standard Deviation of Book Return on Equity	0.079	0.072	0.071	0.072	0.075	0.081	0.075
One-year Premium Growth Rate	0.123	0.150	0.096	0.105	0.125	0.109	0.118
Personal Insurance Output/Total Ins. Output	0.391	0.382	0.390	0.404	0.368	0.363	0.383
Bests "A" Rating Indicator	0.645	0.628	0.644	0.633	0.578	0.597	0.621
Return on Equity After PH Dividends and Taxes	0.076	0.033	0.116	0.074	0.116	0.078	0.082
Return on Equity Before PH Dividends and Taxes	0.115	0.064	0.150	0.104	0.149	0.109	0.115

Note: Reported values are unweighted sample means. PH = policyholder.

Table 6
Sample Mean Efficiency Results: All DMUs

Year	Number of DMUs		Pure Technical	Scale	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	0.412	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 7

A. Input Over/Under-Utilization: All DMUs

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%

Note: Over/under-utilization is the weighted average of actual input usage divided by optimal input usage minus 1 times 100%.

B. Financial Capital Utilization: All DMUs

Year	Actual Capital	Optimal Capital	Amount Overutilized
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

Note: Entries in section B are in billions of dollars.

Table 8
Regression Models: Actual Capital / Optimal Capital

	OLS	Inverse Mills	Instr. Vars
Geography Herfindahl	-0.184 **	-0.152 **	-0.150 *
	0.057	0.059	0.060
Line of Business Herfindahl	-0.388 **	-0.190 *	-0.220 **
	0.072	0.084	0.085
% of Reserves Reinsured	-0.309 **	-0.187 *	-0.176
	0.080	0.093	0.094
% of Assets in Stocks and Real Estate	1.745 **	1.558 **	1.597 **
	0.109	0.119	0.120
Ln(Assets)	-0.196 **	-0.287 **	-0.281 **
	0.010	0.018	0.017
Mutual Dummy	-0.071	-0.167 **	-0.158 **
	0.037	0.038	0.038
Insurance Reserves/Losses Incurred	-1.261 **	-1.318 **	-1.390 **
	0.138	0.181	0.182
Standard Deviation of Book Return on Equity	-0.672 **	-0.440	-0.412
	0.107	0.345	0.337
Percentage Change in Earned Premiums	0.033	0.040 **	0.039 *
	0.021	0.015	0.015
Percentage of Business in Personal Lines	-1.678 **	-1.592 **	-1.598 **
	0.054	0.051	0.052
Bests "A" Rating Indicator		1.162 **	0.842 **
		0.159	0.148
1993 Intercept	7.774 **	9.072 **	8.762 **
	0.242	0.444	0.309
1994 Intercept	7.838 **	9.156 **	8.842 **
	0.242	0.449	0.314
1995 Intercept	7.810 **	9.121 **	8.804 **
	0.242	0.449	0.313
1996 Intercept	8.018 **	9.339 **	9.027 **
	0.243	0.448	0.312
1997 Intercept	7.722 **	9.073 **	8.763 **
	0.242	0.452	0.317
1998 Intercept	7.821 **	9.166 **	8.856 **
	0.243	0.451	0.315
R-Squared	0.846	0.851	0.846

Note: Standard errors are presented below the estimated coefficients.
** Significant at 1 percent level, * Significant at 5 percent level.
Regression models include 4,049 observations.

Table 9
Regression Models: Revenue Efficiency and Return on Equity

	Revenue Efficiency OLS	ROEBDT OLS	ROEBDT IV
(Actual Capital - Optimal Capital)/Assets	-0.286 **	-0.087 **	-0.155 **
	0.025	0.023	0.028
Optimal Capital/Assets	0.139 *	-0.678 **	-0.750 **
	0.060	0.057	0.071
Geography Herfindahl	0.043 **	0.033 **	0.030 **
	0.007	0.007	0.007
Line of Business Herfindahl	0.088 **	0.091 **	0.095 **
	0.009	0.009	0.009
% of Reserves Reinsured	-0.012	-0.073 **	-0.063 **
	0.010	0.010	0.010
% of Assets in Stocks and Real Estate	-0.044 **	0.058 **	0.071 **
	0.015	0.014	0.016
Ln(Assets)	0.026 **	0.019 **	0.006 *
	0.001	0.001	0.003
Mutual Dummy	-0.011 *	-0.003	-0.009 *
	0.005	0.004	0.004
Insurance Reserves/Losses Incurred	0.012	-0.097 **	-0.123 **
	0.018	0.017	0.019
Standard Deviation of Book Return on Equity	0.032 *	0.023	0.036 **
	0.014	0.013	0.010
% Change in Earned Premiums	0.003	-0.005	-0.004
	0.003	0.003	0.004
% of Business in Personal Lines	-0.095 **	0.020 *	0.032 **
	0.008	0.008	0.009
Bests "A" Rating Indicator			0.078 **
			0.015
Revenue Efficiency			0.094 **
			0.036
1993 Intercept	-0.203 **	-0.092 *	0.096
	0.038	0.036	0.051
1994 Intercept	-0.171 **	-0.144 **	0.043
	0.039	0.036	0.051
1995 Intercept	-0.175 **	-0.062	0.124 *
	0.038	0.036	0.050
1996 Intercept	-0.206 **	-0.118 **	0.072
	0.038	0.036	0.051
1997 Intercept	-0.214 **	-0.065	0.129 *
	0.039	0.036	0.052
1998 Intercept	-0.181 **	-0.110 **	0.081
	0.039	0.037	0.051
R-Squared	0.827	0.519	0.536

Note: Standard errors are presented below the estimated coefficients. ROEBDT = return on equity before policyholder dividends and taxes.

** Significant at 1 percent level, * Significant at 5 percent level.

Regression models include 4,049 observations.

Appendix

Controlling for the Endogeneity of the Best's Rating Variable

As mentioned above, the Best's rating variable used in our analysis is likely to be endogenously determined with the dependent variables in our regression analysis – the ratio of actual to optimal capital, revenue efficiency, and return on equity (ROE). Thus, the coefficient of this variable will be biased if the endogeneity problem is not controlled. We use two alternative approaches to control for endogeneity – instrumental variables (IV) estimation and the use of inverse Mill's ratios (IM).

To explain our approaches for adjusting for endogeneity, we specify the following model:

$$b_{it} = J'X_{it}^{b} + P_{it} \qquad (A.1)$$

$$Y_{it} = K'X_{it}^{Y} + Lb_{it} + b_{it}g_{it}^{5A} + (1 - b_{it})g_{it}^{6A} + c_{it} \qquad (A.2)$$

where

b_{it} = 1 if firm i's Best's rating in period t is A or better and zero otherwise,

X_{it}^{b} = vector of explanatory variables in the Best's rating equation,

X_{it}^{Y} = vector of explanatory variables in the equation for Y_{it} ,

J and K = parameter vectors,

L = coefficient of the Best's rating dummy variable,

P_{it} and c_{it} = random error terms for equations (A.1) and (A.2), and g_{it}^{0A} and g_{it}^{6A} = random error terms for firms with A ratings or better and firms with lower ratings, respectively.

The specification allows different error terms for firms with A ratings or better and firms with lower ratings. In our analysis, there are three equations specified as (A.2), one each for the ratio of actual capital to optimal capital, revenue efficiency, and return on equity.

The equation for the dichotomous Best's rating variable (equation A.1), is estimated using maximum likelihood probit analysis. Equation (A.2) contains explanatory variables as well as the Best's rating variable. Because the Best's rating is likely to be endogenously determined along with Y_{it}, the coefficient L in (A.2) will be biased if the equation is estimated by ordinary least squares. Technically, the problem occurs if g_{it}^{0A} and g_{it}^{6A} are correlated with P_{it}, which is likely to occur if b_{it} and Y_{it} are jointly determined, i.e., if the Best's rating determines Y_{it} and Y_{it} simultaneously determines the Best's rating. We use two methods to control for the endogeneity of b_{it}: instrumental variables (IV) and inverse Mill's ratios.

The instrumental variables approach is to use as an instrument in estimating (A.2), the predicted probability of having an A rating or better from equation (A.1). Denoting the standard normal distribution function as F(6Þ, the predicted probability of having an A rating or better is $\mathrm{F}(J'X_{it}^{b})$, i.e., equation (A.1) is viewed as a reduced form probit model and only exogenous variables are included in the vector X_{it}^{b} , i.e., Y_{it} is excluded from X_{it}^{b}.

The inverse Mill's approach accounts for the presence of g_{it}^{0A} and g_{it}^{6A} in equation (A.2). If g_{it}^{0A} and g_{it}^{6A} are correlated with P_{it}, the conditional means $\mathrm{E}(g_{it}^{0A}|b_{it} = 1)$ and $\mathrm{E}(g_{it}^{6A}|b_{it} = 0)$ will not be equal to zero, creating an estimation bias. To correct the problem, the conditional means are included as independent variables in an augmented version of equation (A.2), yielding the following model:

$$\mathrm{Y}_{it} = K'X_{it}^{Y} + Lb_{it} + b_{it}a_{w}^{0A}\left[\frac{?f(J'X_{it}^{b})}{F(J'X_{it}^{b})}\right] + (1 ? b_{it})a_{it}^{6A}\left[\frac{f(J'X_{it}^{b})}{1?F(J'X_{it}^{b})}\right] + c_{it} \qquad (A.2)'$$

where f(6Þ is the standard normal density function.

Estimating equation (A.2)' using ordinary least squares produces consistent parameter estimates.

Endnotes

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

[2]Industry-wide capital grew at an average rate of 11 percent per year during our sample period.

[3]A caveat in considering the market return and volatility data is that only a fraction of property-liability insurers are publicly traded, so that results based on the traded firms may not generalize to the overall sample.

[4]The index is the sum of the squares of the percentages of premiums written by state.

[5]Ceded reserves are reserves 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.

[6]For further discussion of the conglomeration and strategic focus hypotheses see Berger, Cummins, Weiss, and Zi (2000).

[7]DMUs were eliminated from the sample if they had zero or negative assets, premiums, or net worth.

[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.

[9]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.

[10]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 DMU level and only as an approximation for the averages.

[11]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. \ Rather, it is more likely that the financial rating is determined by efficiency or by strong correlates of efficiency. \ Consequently, including the Best's rating variable here would not be appropriate. \ When the equation was reestimated with the Best's indicator variable included, the optimal capital to asset variable remained significant and positive and the sub-optimal capital to asset ratio remained significant and negative and most of the other explanatory variables retained the same signs and significances. Consequently, the conclusions of the analysis, most importantly with respect to the capital to asset ratios, are robust to the inclusion of the Best's indicator variable.

[12]Robustness checks using return on equity after dividends but before taxes and return on equity after dividends and taxes support the same conclusions regarding the effects of the optimal and sub-optimal capital to asset ratios on firm performance.

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