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Insolvency Experience, Risk-Based Capital and Prompt Corrective Action in Property-Liability Insurance

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95-06

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The Working Paper Series is made possible by a generous grant from the Alfred P. Sloan Foundation

Insolvency Experience, Risk-Based Capital and Prompt Corrective Action in Property-Liability Insurance [1]

First Draft: March 1994
This Draft: February 1995

Abstract: In December 1992, the National Association of Insurance Commissioners (NAIC) adopted a life-health insurer risk-based capital (RBC) formula and model law that became effective with the 1993 annual statement filed in March 1994.

In principle, well-designed RBC requirements can help achieve an efficient reduction in the expected costs of insolvencies. They can provide incentives for insurers to operate safely in cases where market incentives are weak due to government mandated guarantees of insurer obligations or asymmetries regarding solvency between insurers and buyers. RBC requirements also may facilitate or encourage prompt corrective action by solvency regulators by helping regulators to identify weak insurers and giving regulators legal authority to intervene when capital falls below specified levels. RBC requirements may force regulators to act in a more timely manner when confronted with external pressure to delay action. However, RBC capital requirements have a number of potential limitations. Unavoidable imperfections in any meaningful RBC system will likely distort some insurer decisions in undesirable and unintended ways. RBC requirements by themselves will do little or nothing to help regulators determine when an insurer s reported capital (surplus) is overstated due to understatement of liabilities or overstatement of assets.

The authors make four main conclusions. First, less than half of the companies that later failed had RBC ratios within the proposed ranges for regulatory and company action. Second, total and component RBC ratios generally are significantly different for failed and surviving firms based on univariate tests. Third, estimation of multiple logistic regression models of insolvency risk indicated that allowing the weights of the RBC component to vary and including firm size and organizational form variables generally produce a material improvement in the tradeoff between sample Type I and Type II error rates. And, fourth, the RBC models are noticeably less successful in predicting large firm insolvencies than in predicting smaller insolvencies.

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INSOLVENCY EXPERIENCE, RISK-BASED CAPITAL AND PROMPT CORRECTIVE ACTION IN PROPERTY-LIABILITY INSURANCE

1. Introduction

Increases in the frequency and severity of property-liability and life-health insurer insolvencies beginning in the mid-1980s have led to allegations of insufficient regulatory monitoring and inefficient regulatory forbearance (see U.S. House of Representatives, 1990), proposals for federal insurance solvency regulation, and significant changes in state solvency regulation, including the development of risk-based capital (RBC) requirements. In December, 1992, the National Association of Insurance Commissioners (NAIC) adopted a life-health insurer RBC formula and model law that became effective with the 1993 annual statement filed in March 1994. A property-liability insurer RBC formula and model law adopted by the NAIC in December 1993 will become effective with the 1994 annual statement filed in March 1995. The development of the property-liability insurer RBC formula has been characterized by considerable controversy over the types of risk to be reflected, the magnitude of the risk charges, and the vulnerability of the formula to understatement of loss reserves (estimated liabilities for unpaid claims).

In principle, well-designed RBC requirements can help achieve an efficient reduction in the expected costs of insolvencies. They can provide incentives for insurers to operate safely in cases where market incentives are weak due to government mandated guarantees of insurer obligations and/or information asymmetries regarding solvency between insurers and buyers.[1] RBC requirements also may facilitate and/or encourage prompt corrective action by solvency regulators by helping regulators to identify weak insurers and giving regulators legal authority to intervene when capital falls below specified levels. This authority might be valuable in cases where intervention otherwise may have been blocked or delayed by the courts. RBC

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[1]See Cummins, Harrington, and Niehaus (1993a) for further discussion of this issue and the potential limitations and adverse effects of RBC.

requirements may force regulators to act in a more timely manner when confronted with external pressure to delay action. On the other hand, RBC capital requirements have a number of potential limitations. At a minimum, unavoidable imperfections in any meaningful RBC system will likely distort some insurer decisions in undesirable and unintended ways. Moreover, RBC requirements by themselves will do little or nothing to help regulators determine when an insurer's reported capital (surplus) is overstated due to understatement of liabilities or overstatement of assets.

A well-designed RBC system should minimize costs associated with misclassification of insurers. The system should be able to identify a high proportion of troubled companies early enough to permit regulators to take prompt corrective action and should identify as troubled only a minimal proportion of financially sound insurers. The accuracy of the NAIC property-liability RBC formula has been evaluated by Grace, Harrington, and Klein (1993). Their study provides evidence that (1) the ratio of actual capital to RBC was negatively and significantly related to the probability of subsequent failure, (2) relatively few companies that later failed had ratios of actual capital to RBC within the NAIC's ranges for regulatory and company action (see below), and (3) both the ratio of actual capital to RBC and a number of variables used in regulatory monitoring systems were statistically significant in multiple logistic regression models of insolvency risk.[2]

The fact that relatively few of the insurers that later failed had RBC ratios within the ranges for regulatory or company action raises concern that the requirements will be of limited effectiveness in facilitating prompt corrective action against troubled insurers. Whether relatively low RBC thresholds are a cause for serious concern depends on the extent to which market

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[2]The results also suggested that inclusion of the ratio of actual capital to RBC in the multiple logistic models produced only modest improvement, if any, in within sample predictive accuracy, even though the estimated coefficient for the RBC ratio was statistically significant.

incentives for safety are inadequate and the extent to which the RBC formula will facilitate market discipline for financially weak insurers with capital that exceeds the minimum threshold. Simply increasing the threshold ratio of required capital to RBC that triggers regulatory intervention will increase the number of false negatives (financially sound firms incorrectly identified as needing regulatory attention), distorting the decisions of safe insurers. Thus, the question arises as to whether the RBC formula can be improved without significantly increasing the number of false negatives.

In this study we analyze data on solvent and insolvent property-liability insurers to determine whether modifications in the NAIC's RBC formula can improve its ability to predict firms that subsequently fail without substantially increasing the proportion of surviving insurers that are incorrectly predicted to fail.[3] Using logistic regression models, we investigate whether changes in the weights for the major components in the RBC formula and incorporation of information on company size and organizational form (mutual vs. non-mutual) improve the tradeoff between Type I error rates (the percentage of insurers that later failed that are incorrectly predicted not to fail) and Type II error rates (the percentage of surviving insurers that are incorrectly predicted to fail). The results indicate that changes in the weights and inclusion of information on company size and organizational form generally lead to material improvements in the Type I - Type II error tradeoff.

Unavoidable limitations of our analysis include the relatively small number of insurers that failed during the time period analyzed, which leads us to focus on within-sample predictions, and the possibility that our estimates will be materially affected by idiosyncratic historical experience.

[3]A large empirical literature estimates models of insurance company insolvency risk. Willenborg (1992) provides a survey. Also see BarNiv and McDonald (1993). Examples of theoretical work on the determinants of insurer insolvency risk include Munch and Smallwood (1982) and Finsinger and Pauly (1984).

In addition, our study only considers the relationship between RBC ratios and ex post insolvency risk. A limitation of this approach is that regulatory forbearance will reduce the power of our tests and within-sample predictive accuracy, and it could lead to omitted variable bias. An alternative approach might be to classify firms as high risk using other indicators, such as assessments of rating agencies or publicly available results from regulatory monitoring systems.[4] Given that these assessments of insurer insolvency risk have been heavily criticized in recent years, it is not obvious that analysis of the ability of RBC ratios to predict these assessments would be worthwhile.[5]

Section II provides a brief overview of property-liability insurer insolvencies, insolvency risk, and the role of RBC requirements. Section III describes the NAIC RBC formula and thresholds for regulatory intervention. Section IV discusses our methodology and data. Empirical results are reported in Section V, and Section VI concludes.

[4]Jones and King (1993) use confidential results of detailed bank examinations to classify banks as high risk in their analysis of the relationship between insolvency risk and bank RBC requirements.

[5]We also note that the basic approach to RBC reflected in the NAIC formula has been criticized on a variety of grounds including its static nature, its alleged reliance on worst case scenarios to establish underwriting risk factors, its failure to include charges for interest rate risk, and its reliance on book values of fixed income securities. Other possible approaches to RBC include cash flow testing and options pricing models. (See Cummins, Harrington, and Niehaus, 1993b, for an overview.) While our study tests the relationship between the NAIC RBC formula and historical insolvency risk, we do not compare the performance of the NAIC approach to other broad approaches to establishing RBC. Nor do we comment on or attempt to evaluate whether the conceptual approach reflected in the NAIC formula is superior or inferior to these approaches.

II. Insolvency Experience and The Role of Risk-Based Capital

Insolvency Experience

Prior to the mid-1980s, both the number of property-liability insolvencies and the average size of insolvent companies were small. Beginning in 1984, the number and cost of insurer insolvencies increased dramatically (see Figure 1).[6] The number of insolvencies increased from an average of 10 per year from 1969-1983 to 32 per year after 1983, while average annual guaranty fund assessments increased from $22 million per year from 1969-1983 to nearly $500 million per year after 1983.[7] Moreover, larger firms began to fail; twenty-two of the twenty-five largest insolvencies have occurred since 1983. The top twenty-five insolvencies account for more than 80 percent of projected guaranty fund costs. Although the insolvency rate among insurers remains relatively low (less than 1 percent of insurers fail per year) and the annual assessment rate has never exceeded 0.5 percent of premium volume, the increased frequency and severity of insolvencies suggests that the financial stability of the industry has declined, raising concerns among regulators, claimants, and investors.

To provide a contextual background for discussion of the causes of insurer insolvencies and the potential effects of risk-based capital, we provide a brief overview of the financial theory of insurance firms. The economic role of property-liability insurers is to facilitate risk pooling and risk-transfer. Insurers charge premiums to all policyholders based on expected losses and redistribute the funds to those who suffer losses. Insurers generally collect premiums in advance

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[6]Insurance guaranty funds reimburse claimants of insolvent insurance companies for losses not covered by the remaining assets of the insurers. Guaranty funds operate at the state level and obtain funds to pay claims by assessing solvent insurers in proportion to their revenues in the state.

[7]These figures are in current dollars. In constant dollars (1979 = 1), assessments increased from about $20 million per year from 1969-1973 to almost $300 million per year (1984-1992).

of loss payments and assume the incidental role of financial intermediary.[8] Given limited liability, insurers hold equity capital to provide assurance to policyholders that losses have a high probability of being paid even if greater than expected. Insurers thus come to the market with equity capital and issue insurance policies, which are a form of debt capital. The funds raised by issuing both types of capital are invested, primarily in marketable securities, until needed to pay claims.

Assuming that insurance buyers care about insolvency risk and can effectively monitor solvency, the firms that succeed in a competitive insurance market will be those that diversify risk most effectively, i.e., those insurers (termed *efficient* insurers) that can provide a given level of risk diversification and assurance of claims payment at the lowest possible price. Insurers can achieve efficiency by diversifying across their asset and liability portfolios, taking into account the correlation between assets and liabilities as well as within the asset and liability portfolios. They also seek to take maximum advantage of the law of large numbers by insuring the largest possible number of independent exposure units, using reinsurance to pool risk with other insurers and across national boundaries. Reinsurance also helps to deal with catastrophic (large, non-independent) risks. Because insurers cannot completely eliminate risk through diversification and reinsurance, they hold equity capital to cushion the impact of larger-than-anticipated losses. Efficient insurers optimize over portfolio diversification, reinsurance transactions, and holdings of equity capital to offer insurance at the lowest possible price consistent with the desired level of insolvency risk (Berger, Cummins, and Tennyson, 1992).

The price of a property-liability insurance policy in a competitive market is the present value of expected loss, expense, and tax cash flows, discounted at appropriate risk-adjusted

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[8] This discussion focuses on property-liability insurers. Intermediation is not incidental to life insurers but is one of their primary functions.

discount rates reflecting the risk borne by the insurer as well as other factors such as insurer capital structure (Myers and Cohn, 1987). Parameter estimation risk is quite high in property-liability insurance, especially for long-tail policies such as general liability and workers' compensation, where loss payments extend over lengthy periods of time following policy issuance. Even if expected losses are estimated correctly and estimation risk is priced by the market, unanticipated shifts in loss distributions can adversely affect insurer net worth and threaten solvency. Covariability of losses resulting from factors such as property catastrophes and adverse court rulings in liability cases also represent a major source of risk.

Because the discounting process gives policyholders credit for the use of their funds at the time policies are issued, insurers also face investment income risk, i.e., the risk that investment earnings will fall short of the interest discount implicit in premium rates. Market equity values are affected by interest rate risk exacerbated by the long-term nature of liability and workers' compensation insurance and the unpredictability of loss payouts.

Premium rates declined during the early 1980s, influenced by high interest rates and allegedly cyclical price cutting. Falling interest rates and unanticipated increases in the frequency and severity of liability claims led to sharp declines in insurer profits in 1984 and 1985, resulting in a major crisis in liability insurance markets, characterized by large increases in premium rates and declines in coverage availability (Harrington, 1988, Cummins and Danzon, 1991). The increase in bond return volatility during the early to mid-1980s also adversely affected insurers, which hold about 60 percent of their assets in bonds.

Moral hazard may have contributed to the increase in insurance insolvency risk. Claimants against insolvent insurers are protected by state guaranty funds that assess solvent insurers to pay losses of insolvent companies. Guaranty fund coverage weakens the market incentive for buyers to monitor insurers solvency.[9] Because guaranty fund premiums are not risk-based, guaranty fund coverage gives insurers an opportunity to increase the value of owners equity by taking more risk without being fully penalized by the market (Cummins, 1988). There is anecdotal evidence that excessive risk-taking played a significant role in some of the largest insolvencies of the 1980s (U.S., House of Representatives, 1990). Harrington and Danzon (1993) present evidence consistent with the hypothesis that moral hazard contributed to ex ante price inadequacy in liability insurance during the early 1980s.

Insurers also have been affected adversely by more restrictive price regulation, in response to sharp price increases in important coverages such as general liability, workers' compensation, and private passenger automobile insurance. Although most analyses have concluded that cost inflation rather than insurer behavior were primarily responsible for the price increases (e.g., Cummins and Tennyson, 1992), populist sentiment has resulted in more stringent regulation and attempts to suppress rates in many states (Harrington, 1992).

Support for the foregoing interpretation of the insurance insolvency problem is provided by a study of insolvencies conducted by the A.M. Best Company (1991). Best's concluded that deficient loss reserves (inadequate pricing, either ex ante or ex post) were the primary contributing factor in 28 percent of the insolvencies examined, whereas rapid growth (also related to underpricing) was the most important factor in 21 percent of the insolvencies. Other important influences were fraud, overstated assets, the failure of key reinsurers, and catastrophic losses.

'Guaranty funds do not totally eliminate incentives for solvency monitoring by insurance buyers because coverage is subject to maximum per claim limits, payments by guaranty funds are usually delayed, and claimants are not compensated for the loss of "real services" (such as claims settlement and risk management services) provided by the insurer.

The Role of Risk-Based Capital

Traditional Solvency Regulation. The traditional rationale for insurance solvency regulation is that the complexity of the insurance transaction makes it difficult for buyers, especially individuals, to effectively monitor insurer solvency. The possibility that insurers could increase risk following policy issuance also provides a rationale for government monitoring, especially if the interests of new policyholders and existing policyholders do not fully coincide. As suggested above, the weakening of incentives for private monitoring due to non-risk- rated guaranty funds provides another rationale for government solvency regulation.

Traditionally, state regulators have monitored insurer solvency by conducting periodic audits and evaluating insurer financial statements. Financial statement evaluation initially consists of a series of ratio tests, followed by more detailed analyses of insurers that fail initial screens (see Klein, 1993). Insurers are also required to maintain minimum amounts of equity capital, although the minima are quite low and are therefore more appropriate for new entrants than for larger, established firms.

Advantages of Risk-Based Capital. Two primary factors motivated regulators to consider the adoption of risk-based capital in the late 1980s. First, it became apparent that regulatory audit ratios were not very effective in identifying problem companies early enough to permit prompt corrective action. And, secondly, it has been argued that some regulators failed to take corrective action even when it became apparent that insurers were financially unsound or were engaging in inappropriate business practices (U. S., General Accounting Office, 1989, 1991). The failure to act promptly could be due to political pressure (e.g., some state regulators may be reluctant to take action against prominent insurers headquartered in their states) and to inadequate statutory authority to intervene in the affairs of technically solvent insurers that regulators believed to be financially unsound.[10]

The underlying objective of a risk-based capital system is to minimize the direct and indirect costs of insurer insolvency. A well-designed risk-based capital system should help regulators identify financially weak companies while there is still time for rehabilitation and remove unsalvageable companies from the market before they incur significant deficits. Such a system should also motivate insurers that otherwise would have inadequate incentives for safety to hold more capital and to reduce their risk of insolvency.

The NAIC's risk-based capital system (described below) gives regulators legal authority to intervene if reported capital falls below risk-based capital requirements (or some percentage of risk-based capital). This authority will be valuable in cases where intervention previously may have been blocked or delayed by the courts. By mandating regulatory action when insurer capital reaches a specified proportion of risk-based capital, the system also provides some protection against political pressure for regulatory forbearance.

Limitations of Risk-Based Capital. It is infeasible for a risk-based capital system to duplicate precisely the capital levels and incentives for safety that would exist in a competitive environment in which both consumers and insurers have adequate information and incentives for safety. Insolvency risk depends on numerous factors that are difficult to quantify, and the insurance market is characterized by substantial diversity across insurers in types of business written, characteristics of customers, and methods of operation. It is impossible to specify the "right" amount of capital for most insurers through a formula.

As a result, the introduction of risk-based capital is likely to impose a one-time capital loss

[10]There have been a number of instances where insurers have been able to delay regulatory action by challenging regulatory authority in court. As noted earlier, it also might be difficult for regulators to prove that an insurer is economically insolvent.

on insurance company equity holders.[11] To the extent that risk-based capital charges are inaccurate or fail to recognize significant sources of risk (such as interest rate risk or the purchase of risky reinsurance) insurers may be able to neutralize the effects of risk-based capital on equity values by taking additional risk. Even if the initial capital loss is minimal for most insurers, inaccuracies in the risk-based capital charges provide risk-taking opportunities for insurers motivated by moral hazard.

An inaccurate risk-based capital formula may distort the investment, underwriting, and reinsurance decisions of well-managed insurers, leading to less effective diversification. This could actually reduce safety levels for financially sound insurers and lead to higher premium rates for any given level of safety. A poorly designed system also could lead to unjustified damage to the reputations of well-managed insurers, raising the costs of capital for these firms and impeding their ability to raise new equity capital. The result could be a reduction in the efficiency of insurance markets and an inefficient shift by buyers towards self-insurance and other risk-management alternatives.

III. The NAIC RBC Formula

The NAIC's property-liability RBC formula encompasses four major risk categories: (1) asset risk (default and market value declines); (2) credit risk (uncollectible reinsurance and other receivables); (3) underwriting risk (pricing and reserve inadequacy); and (4) growth and other forms of off-balance sheet risk (e.g., guarantees of parent obligations). The formulas apply factors to various amounts reported in (or related to) the statutory financial statement to determine RBC

[11]Imposition of a risk-based capital system is equivalent to the creation of a type of junior debt claim against the assets of the firm. Of course, regulators have always had a claim on the assets of insurers. Risk based capital will reduce market equity values to the extent that it is more stringent than the system previously in place.

charges for each type of risk. A covariance adjustment is made to the accumulated RBC charges to account for diversification between major risk categories.

A detailed discussion of the NAIC's RBC formula is beyond the scope of this paper but it is helpful to review some of its significant features.[12] The provision for underwriting risk is the most significant component of the property-liability RBC formula, representing approximately two-thirds of total charges for the industry. Separate risk factors are applied to reserves for unpaid losses and loss adjustment expenses and to net premiums written for each line of business. We refer to the resulting RBC charges as "loss reserve RBC" and "premium RBC," respectively. The loss reserve and premium risk factors are based on the industry's worst accident year development and worst accident year loss ratio over the previous ten years.[13] The risk factors are modified to lessen the severity of the charges for the lines with the most adverse historical experience and to increase the charges for the lines with the least adverse historical experience. The factors are also discounted to present value to reflect that insurers' reserves are generally reported on a non-discounted basis with the exception of workers' compensation.

For loss reserve RBC, the undiscounted risk factors range from a low of 17.5 percent for low-risk property lines, such as auto physical damage, to 83.8 percent for high-risk business liability reinsurance. For premium RBC, the effective undiscounted industry factors range from

[12]See NAIC (1993) for details.

[13]"Accident year development" refers to the ratio of developed (i.e., estimate of ultimate) incurred losses and allocated loss adjustment expenses evaluated at the current year to the sum of the initial evaluations of these incurred losses and allocated loss adjustment expenses. Positive development indicates that initial estimates of ultimate losses were too low. "Accident year loss ratio" refers to the ratio of developed incurred losses to net premiums earned. Under "accident year" reporting, all losses are assigned to the year in which the event occurred that triggered coverage (e.g., date of an accident).

15.8 percent for low-risk property lines to 74.2 percent for medical malpractice.[14] Fifty percent of an individual company's charges are based on industry factors; the remaining 50 percent reflects its own historical experience. Hence, if an insurer has worse than average loss development and loss ratios, its loss reserve and premium risk factors will be higher than the industry factors.

Two adjustments are made to an insurer's underwriting RBC charges for insurance contracts that are structured to reduce the insurer's risk. A 30 percent credit for direct business and a 15 percent credit for reinsurance business are applied to underwriting RBC (both premium and loss reserve charges) for loss sensitive contracts. A 20 percent credit is applied to loss reserve and premium RBC charges for medical malpractice business written on a "claims-made" basis.[15]

Asset charges account for about 20 percent of total property-liability insurer RBC. The asset (investment) RBC factors used in the property-liability formula are similar to the factors used in the life-health formula. The bond and preferred stock (for non-affiliates) factors are based on NAIC Securities Valuation Office categories, which generally parallel the rating categories of Moody's and Standard & Poor's. The bond factors range from 0 for federal government bonds to 30 percent for bonds in or near default. The factors used for the six categories of preferred stock range from 2.3 percent for the highest rated class to 30 percent for the lowest rated class. The bond factors are based on a Monte Carlo simulation study of bond default risk performed by an

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[14] This assumes a hypothetical 27 percent underwriting expense ratio. The effective premium factors for a given company will be higher (lower) if the expense ratio is higher (lower) than 27 percent.

[15] Loss sensitive contracts allow an insurer to collect additional premiums from the insured as a function of claims experience during the coverage period. On a claims-made policy, the insurer basically is only responsible for claims attributable to accidents that occurred and are reported during that policy period, as opposed to claims which stem from accidents that occurred during the policy period but were reported after the end of the policy period.

actuarial advisory committee to the NAIC's Life/Health Risk-Based Capital Working Group. An insurer's bond factors are adjusted upward (downward) if the number of issuers reflected in its bond portfolio are less (more) than the 1,300 issuers assumed in the study. There is a 15 percent charge for common stocks of non-affiliated corporations.

The RBC charges for bonds and stock of affiliates are based on the RBC of the affiliates (where it can be determined) and the percentage of ownership. Bonds or stock in affiliated non-U.S. insurers receive a 50 percent charge and investments in non-insurance/non-investment affiliates receive a 22.5 percent charge. Mortgage loans incur a 5 percent charge and real estate (including encumbrances) incurs a 10 percent charge. Other asset charges range from 0.3 percent for cash to 20 percent for "other" long-term invested assets (e.g., mineral rights and joint ventures). An asset concentration factor doubles the RBC charges (up to a 30 percent maximum) for the 10 largest asset exposures grouped by issuer. We subsequently refer to the sum of asset charges as "investment RBC."

The credit component of the formula applies a 10 percent charge to reinsurance recoverable from non-affiliates and affiliated alien insurers (minus a penalty for unauthorized or overdue reinsurance), a 1 percent charge to interest, dividend, and real estate income due and accrued, and a 5 percent charge to other miscellaneous receivables. We refer to this component of RBC as "credit RBC." An additional RBC charge is given to insurers with three-year average growth in gross premiums written (direct premiums plus reinsurance assumed from non-affiliates written on a group basis) in excess of 10 percent and to reflect other potential liabilities not shown on the balance sheet. Non-controlled assets, guarantees for affiliates, and contingent liabilities receive a 1 percent charge. We refer to this component of RBC as "growth RBC." Credit and growth RBC each account for about 5 percent of total industry RBC.

Finally, the sum of the RBC charges is reduced through a covariance adjustment that is designed to reflect the effects of diversification. The RBC charges are divided into five components: (1) equity investments; (2) fixed income investments; (3) 50 percent of credit RBC; (4) loss reserve RBC, a charge for reserve growth, and 50 percent of credit RBC; and (5) premium and premium growth RBC. The resulting RBC value equals the square root of the sum of the squares of each category, plus the RBC for affiliated investments and the remaining charges for off-balance sheet items, neither of which are subject to the square root adjustment.[16] Insurers also receive a credit on premium and loss reserve RBC for greater diversification among lines of business. For 1994, the RBC charge obtained from application of the covariance adjustment formula is multiplied by 0.4 to calculate the benchmark RBC level (the final formula result) that will be reported in an insurer's annual statement. This scale factor increases to 0.45 in 1995 and to 0.5 in 1996 and subsequent years.

Several aspects of the RBC formula have generated considerable controversy. Some insurers have criticized the underwriting RBC factors for long-tail liability lines for being too high relative to short-tail property lines. The industry also has argued that the factor for reinsurance recoverable should be reduced from 10 percent to 5 percent and that all credit RBC charges should be grouped separately in the covariance adjustment (which would produce a lower effective charge for reinsurance) to encourage greater risk spreading through reinsurance. The formula also has been criticized for ignoring interest rate risk, and an NAIC committee is studying the possibility of introducing an interest rate risk charge.

In addition, the charge for excessive growth has received some criticism. There is a concern that, due to the cyclical nature of the industry, the formula will inappropriately charge companies for excessive growth when markets tighten and prices increase. After considerable

[16] The square root adjustment is roughly equivalent to assuming that the five factors subject to the square root adjustment are statistically independent and that the sum of these factors is perfectly correlated with the sources of risk not subject to the square root adjustment.

debate, the NAIC rejected a proposal to require higher RBC for smaller companies to reflect the greater expected volatility in their results. This proposal was strongly opposed by small insurers who argued that the proposed "size charge" failed to discriminate between well-established small companies with historically stable returns and less established small companies in new and risky lines of business. Size and growth charges also might have the effect of reducing competition in the industry by constraining entry and reducing the effectiveness of new firms. Other debate has focused on the relative weights of the major RBC components and possible vulnerability of the formula to understatement of loss reserves. Finally, some insurers and analysts have criticized the NAIC for focusing on a ratio-based system rather than more dynamic alternatives such as cash flow simulation.

Under the model RBC law, certain company and regulatory actions are required if a company's capital falls below specified percentages of its RBC. Four levels of company and regulatory action are established with more severe action required at lower levels. The "authorized control level," which is equal to the final RBC formula result, is used as the primary point of reference. Other levels are calculated as percentages of the authorized control level:

(1) Company Action Level. An insurer with capital below the company action level RBC, which is 200 percent of the authorized control level RBC, must file a plan with the insurance commissioner that explains its financial condition and how it proposes to correct its deficiency.

(2) Regulatory Action Level. When an insurer's capital falls below the regulatory action level, equal to 150 percent of its authorized control level RBC, the commissioner is required to examine the insurer and institute corrective action, if necessary.

(3) Authorized Control Level. If an insurer's capital falls below 100 percent of its authorized control level, the commissioner has the legal grounds to rehabilitate or liquidate the company.

(4) Mandatory Control Level. If capital is less than the mandatory control level RBC, which is 70 percent of its authorized control level RBC, the insurance commissioner is required to seize the company.

IV. Methodology and Data

We analyze the relationship between recent industry insolvency experience and the ratio of actual capital to RBC (and the inverse of this ratio) for property-liability insurers with available RBC data from 1989 through 1991.[17] We compare RBC ratios each year for insurers that subsequently failed and insurers that survived through the first nine months of 1993. We analyze within-sample Type 1 error rates (proportions of failed insurers that are not predicted to fail) for specified Type II error rates (proportions of surviving insurers that are incorrectly predicted to fail) for the NAIC RBC ratio. We compare these error rates to RBC ratios based on (a) the sum of the NAIC RBC charges without any covariance adjustment and (b) the NAIC sum of these charges less a modified covariance adjustment. We also compare Type I - Type II error rates for the RBC ratios to those for the premiums-to-surplus ratio, a simple but commonly used measure of underwriting risk and leverage. In addition, we compare the distributions of the NAIC RBC ratios and each major component of the NAIC RBC formula for failed and surviving insurers.

Multiple logistic regression models of the relation between insolvency risk and RBC ratios are then estimated to provide evidence of whether within sample Type 1- Type II error rate tradeoffs can be improved by (a) relaxing the equal weighting constraint for the major components in the NAIC formula and by (b) incorporating information about firm size and organizational form. Previous univariate analysis of property-liability insurer failures provides evidence of higher insolvency rates for small firms and lower failure rates for mutual firms than for non-mutual firms. Other things being equal, claim costs tend to be more volatile for small firms. Small firms also might have relatively lower franchise values and thus less incentive to reduce insolvency risk than large firms.[18] Mutual insurers may be less prone to moral hazard in the

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[17]The NAIC formula utilizes some non-statement information that was not available for this study but the annual statement result is a good approximation for most companies.

[18]Like the theoretical literature on bank insolvency risk, the basic theory of insurer insolvency risk emphasizes the role of franchise value that arises from investments in reputation and building a book of business in providing insurers with incentives for safety even if demand by

presence of guaranty funds (see Hansmann, 1985; Garven, 1987; and Harrington and Danzon, 1993). They also may specialize in the sale of less risky coverage in a given line of business than non-mutuals (see Lamm-Tennant and Starks, 1992).

The logit model takes the following general form:

$$y_{jt} = \alpha_0 + \alpha_1(RBC^*_{jt} / S_{jt}) + \alpha_2 Log(Assets_{jt}) + \alpha_3 Mutual_{jt} + \epsilon_{jt}$$

where for insurer j and data year t: y_{jt} is the unobservable propensity for the insurer to fail subsequent to year t, RBC^*_{jt} is a measure of RBC, S_{jt} is adjusted surplus,[19] Log $(Assets_{jt})$ is the log of total assets, Mutual equals one if insurer j is a mutual and zero otherwise, and ϵ_{jt} is a mean-zero random error. The use of the ratio of RBC to adjusted surplus rather than the inverse of this ratio facilitates the analysis of the weights used in the NAIC formula with a model of y that is linear in the parameters. Assuming that insurer j fails subsequent to year t if $y > 0$ and that ϵ has the logistic distribution produces the standard logit model.[20]

We estimate eight versions of this model. The first two equations only include formula

policyholders is inelastic with respect to insolvency risk (e.g., Munch and Smallwood, 1982, and Finsinger and Pauly, 1984). Moral hazard resulting from non-risk-based guaranty fund coverage is also important (Cummins, 1988). Any tendency by regulators to practice “too big to fail” policies also could make the failure rate higher for small firms.

[19]The NAIC requires insurers to deduct any discounting of loss reserves from reported surplus to obtain an “adjusted surplus” measure for comparison with formula RBC. “Surplus” is insurance terminology for net worth or equity.

[20] Experimentation with ordered logit models that reflected the number of years until failure for the 1989 sample produced similar results. An alternative approach would be to analyze models in “event” time using matched samples of failed firms and surviving firms. An advantage of our approach is that we use data for all firms in a given year. Another possibility would be to pool data over time and estimate a hazard rate model, but the relatively small number of failures each year would likely lead to low power.

RBC and RBC without the NAIC covariance adjustment, respectively.[21] Equations (3) and (4) add the size and organizational form variables. Equation (5) defines RBC* as a weighted sum of the investment, credit, loss reserve, premium, growth, and covariance adjustment components of RBC with unknown weights. Estimates of the parameters for the RBC components in this equation provide estimates of $\alpha_1\beta_i$, where β_i is the unknown weight for the ith component of RBC. The NAIC formula imposes the constraint that the β_is are jointly equal to one (thus, $\alpha_1\beta_i = \alpha_1$ for each of the i components). We test this constraint and provide evidence of whether relaxing this constraint improves the tradeoff between Type I and Type II errors. Equation (6) is equivalent to equation (5) except that the covariance adjustment component of RBC is omitted. Equations (7) and (8) add the size and organizational form variables to equations (5) and (6).

The samples for 1989, 1990, and 1991 include all stock, mutual, reciprocal, and Lloyds property-liability insurers with admitted assets and net written premiums of at least $1 million in 1990 dollars. Companies also had to be included in the NAIC's RBC data base. The NAIC data base excluded Blue Cross - Blue Shield plans, financial guaranty insurers, title insurers, residual market mechanisms, and insurers that did not file statements with the NAIC. We also excluded professional reinsurers as classified by the NAIC.[22] We analyze data for individual companies, as opposed to groups of affiliated insurers. The RBC standards presently apply to individual insurers, and the primary focus of state solvency regulation is on individual insurers rather than groups.

These criteria produced samples of 1567, 1606, 1616 companies in 1989, 1990, and 1991, respectively. We identified insurers that became insolvent in 1990, 1991, 1992, or 1993 using

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[21]The covariance adjustment is defined as the difference between formula RBC and the sum of investment, credit, loss reserve, premium, and growth RBC.

[22]The NAIC RBC formula for professional reinsurer differs from the formula for primary insurers. A company is designated a professional reinsurer if it has premiums assumed from non-affiliates in excess of 75 percent of the sum of direct premiums written plus premiums assumed from non-affiliates.

NAIC and A.M. Best lists of single and multistate insurer insolvencies.[23] Seventy-four insurers with available data in 1989 subsequently failed (9 in 1990, 20 in 1991, 34 in 1992, and 12 in 1993). Fifty-one insurers with available data in 1990 subsequently failed (4 in 1991, 34 in 1992, and 13 in 1993), and thirty-seven insurers with available data in 1991 subsequently failed (23 insurers in 1992 and 14 in 1993).

The multiple logistic regression models are estimated using truncated values of all variables to reduce the effects of extreme outliers in the database. The values of each variable were truncated at the 1st and 99th percentile values of the variable in the sample.

V. Results

RBC Ratios and Univariate Tests

Table 1 shows cumulative percentages of insurers with ratios of adjusted surplus to RBC within specified ranges from 1989 through 1991. Results are shown for insurers that survived and for insurers that failed subsequent to data year t. The RBC formula used here employs the scale factor of 0.5 that will apply in 1996 and subsequent years. The 200 percent cutoff shown for the ratios calculated with a scale factor of 0.5 corresponds to a cutoff of 250 percent using the 1994 factor of 0.4.

Fewer than 10 percent of surviving firms had RBC ratios less than or equal to 200 percent (company action level) from 1989 through 1991. Twenty-eight percent of firms that subsequently failed had RBC ratios less than or equal to 200 percent in 1989 and 1990; 49 percent of firms that subsequently failed had ratios less than or equal to 200 percent in 1991. For 1991, 70 percent of failed firms had ratios less than or equal to 300 percent compared to 18 percent of surviving firms. While the cumulative percentages of failed firms with ratios less than or equal to the cutoffs for mandatory and authorized control or regulatory action are generally two to three

[23] We classify any insurer as insolvent if it was subject to formal regulatory proceedings for conservation of assets, rehabilitation, receivership, or liquidation.

times as large as those for surviving firms, only 15-20 percent of failed firms had ratios less than or equal to the 150 percent regulatory action level.

Since the survival horizon is approximately four years for the 1989 data, three years for the 1990 data, and two years for the 1991 data, the ability of the RBC ratio to predict failure might be expected to increase over the sample period. The results shown in Table 1 indicate that the cumulative percentages of failed firms generally increase while the percentages of surviving firms do not. However, most of the improvement between 1989 and 1990 occurs for cutoffs above 200 percent.

The relatively small number of failed firms with RBC ratios below the minimum action thresholds might suggest that the thresholds are too low to achieve the goals of RBC. However, increasing the thresholds for the current formula would increase the number of surviving firms with ratios less than the minimum thresholds. As noted, a result would be some increase in the number of false negatives and greater risk that RBC would lead to significant and undesirable market dislocations. While these data help illustrate the tradeoffs involved in increasing the thresholds based on recent insolvency experience, the optimal threshold depends on the relative costs of misclassifying sound and risky companies.

Table 2 illustrates the tradeoff between Type I and Type II error rates for Type II error rates from 5 to 30 percent for (a) the ratio of RBC to adjusted surplus, (b) the ratio of RBC without covariance adjustment to surplus, and (c) the ratio of RBC with a modified covariance adjustment to adjusted surplus.[24] The numerator of the ratio of RBC with modified covariance adjustment to adjusted surplus is calculated by: (1) summing credit, loss, premium, and growth RBC, (2) adding the square of this sum and the square of investment RBC, and (3) taking the square root of the resulting value. This modification basically employs the assumption that credit, loss,

[24]Note that we use ratios of RBC to adjusted surplus in Table 2 (and Tables 3-6). These ratios will produce the same Type I and Type II error rates as the ratios of adjusted surplus to RBC. As noted above, analysis of the ratio of RBC to adjusted surplus, rather than its inverse, facilitated tests of the constraints in the RBC formula.

premium, and growth risk are highly correlated but uncorrelated with investment risk. For comparison to the RBC ratios, Table 2 also shows Type I and Type II error rates for the ratio of premiums to adjusted surplus, which can be viewed as a simple RBC ratio.

The Type I error rate gives the percentage of failed firms with ratios less than the value, c*, which produces the specified Type II error rate (percentage of surviving firms with ratios greater than c*). The Type II error rate of 7.5 percent is roughly equal to the percentage of surviving firms that had ratios of adjusted surplus to RBC less than or equal to 200 percent from 1989 through 1991 (see Table 1).

Consistent with the results in Table 1, the Type I error rates in Table 2 are considerably lower for 1991 than for 1989 and 1990. Comparing the ratio of RBC to adjusted surplus with and without the NAIC covariance adjustment, it can be seen that the Type I error rates are generally quite similar. Thus, the covariance adjustment does not substantively improve within-sample classification accuracy. The ratio without the covariance adjustment produces slightly lower Type I error rates for 1990, but produces slightly higher Type I error rates for Type II error rates above 10 percent in 1991. The modified covariance adjustment generally produces slightly lower Type I error rates than the NAIC formula in 1989 and 1990, but it generally produces higher Type I error rates for 1991.

For 1989 and 1990, the ratio of premiums to adjusted surplus produces Type 1 error rates that are comparable to and in some cases lower than those for the RBC ratios. For 1991, the Type I error rates for the premiums-to-surplus ratio are much larger than those for the RBC ratios for Type II error rates above 5 percent. The relative deterioration in 1991 might reflect reduction in premium volume for insurers for which failure was imminent due to managerial retrenchment, regulatory pressure, and/or market discipline from agents and policyholders concerned with insolvency risk. The favorable performance of this simple measure during 1989 and to a lesser extent 1990 raises the question of whether the complexity of the NAIC RBC formula is warranted. However, this conclusion does not necessarily follow given the “dog that didn’t bark” problem.

I.e., the additional complexity might produce appropriate charges for risk that did not contribute to insolvencies during this time period.

Table 3 shows failed and surviving firm sample medians and Wilcoxon Z-statistics for testing the null hypothesis of identical failed and surviving firm distributions for the variables used in the logistic regression analysis. The median RBC ratios, with and without the NAIC covariance adjustment, and the component RBC ratios are generally greater for the failed firm samples in each year, and the Wilcoxon tests strongly reject the null hypothesis of identical distributions. There are two exceptions. First, the median Investment RBC / S for the failed firms is lower than for the surviving firms in 1989, and the Wilcoxon test does not reject the null hypothesis of equal distributions. The difference between the failed and surviving firm median for this variable becomes positive in 1990 and increases in magnitude in 1991. The null hypothesis of equal distributions is rejected in both 1990 and 1991. Second, the median value of Loss Reserve RBC / S for the failed firms in 1989 is only slightly larger than that for surviving firms in 1989, and the null hypothesis of equal distributions is not rejected. The difference between the failed and surviving firm median increases in 1990 and again in 1991, and the null hypothesis of equal distributions is rejected in both years. Given that the survival horizon declines over time, the results for Loss Reserve RBC / S possibly reflect understatement of reserves and/or increases in loss reserves due to unfavorable claims experience immediately prior to failure.

The results shown in Table 3 also indicate that the median failed firm had lower assets than the median surviving firm. The null hypothesis of equal distributions of Log (Assets) is rejected each year. The proportion of failed firms that were mutuals is much lower than the proportion of mutuals in the surviving firm samples.

Logistic Regressions

Logistic regression results for equations (1) - (8) are shown in Tables 4, 5, and 6 for 1989, 1990, and 1991, respectively. In addition to estimated coefficients and t-values, the tables show

Pseudo-R^2 values and within-sample Type I error rates for Type II error rates from 5 to 30 percent using fitted values from the regressions.[25] Note that the Type I errors for equation (1) and (2) are identical to those shown in Table 2 for RBC / S and RBC w/o Covariance Adj. / S, given that the fitted values are positive, monotonic functions of these variables.

Consistent with the nonparametric tests in Table 3, the estimated coefficients for the RBC ratio in equations (1) and (2) for the 1989 data (Table 4) are positive and significant. The Pseudo-R^2s only equal 0.01 for these equations. When Log (Assets) and Mutual are added in equations (3) and (4), the estimated coefficients for both variables are significant with the expected sign, and the Pseudo-R^2s increase to 0.12. The Type I error rates decline, especially for Type II error rates above 15 percent. Type I error rates for equation (4) (RBC w/o Cov. Adj. / S) are generally slightly lower than those for equation (3) (RBC / S).

The 1989 results for equations (5) and (6), which include the separate RBC components but exclude Log (Assets) and Mutual have Pseudo-R^2s equal to 0.11. The Type 1 error rates are materially lower than those for equations (1) and (2). For example, for a Type II error rate of 7.5 percent, the Type I error rate for equation (5) is 57 percent compared to 72 percent for equation (1). The differences are less pronounced for Type II error rates above 10 percent (e.g., 46 percent vs. 51 percent for Type II error rate of 15 percent). Inclusion of Log (Assets) and Mutual in equations (7) and (8) increase the Pseudo-R^2 to 0.21 and lead to further reductions in Type I error rates. The reductions are especially pronounced for Type II error rates above 10 percent.

Based on a likelihood ratio test, the null hypothesis of equal coefficients for the RBC components in equations (5) - (8) for 1989 is soundly rejected. Interpretation of the estimated coefficients for the individual RBC components requires a certain degree of caution, given the relatively small number of failed firms and possible multicollinearity. This is particularly true for

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[25] Pseudo-R^2 equals one minus the ratio of the log-likelihood for the model shown to the log-likelihood when the slopes are constrained to equal zero. Note that Type I error rates based on fitted value are identical to those based on predicted probabilities of insolvencies. Estimated intercepts are not shown for simplicity.

the equations that include Covariance Adj. /S, which is highly correlated with Credit RBC / S, Loss Reserve RBC / S, and Premium RBC / S (see the Appendix). The estimated coefficient on Loss Reserve RBC / S for 1989 is not significant in any equation and has the wrong sign in equations (5) and (6). The estimated coefficients for Growth RBC / S are generally much larger than those for the other components. The estimated coefficients for Investment RBC / S increase substantially and become significant when Log (Assets) and Mutual are included in the model. Overall, these results suggest that lower weights for Loss Reserve RBC / S, higher weights for Growth RBC /S, and inclusion of Log (Assets) and Mutual improve the within sample tradeoff between Type I and Type II errors using 1989 data.

The logistic regression results for 1990 shown in Table 5 are generally qualitatively similar to those for 1989 in that Type I error rates decline when the weights on the RBC components are allowed to vary and Log (Assets) and Mutual are included in the model. Notable differences are that the inclusion of Log (Assets) and Mutual in equations (3) and (4) produce higher Type 1 error rates than equations (1) and (2) for low Type II error rates. However, when the weights on the RBC components are allowed to vary, inclusion of Log (Assets) and Mutual reduces Type I error rates, especially when Covariance Adj. / S is omitted from the model.

The estimated coefficient for Loss Reserve RBC / S for 1990 has the wrong sign and is statistically significant in equations (5) - (8). The estimated coefficients and t-values for Credit RBC / S and Premium RBC / S are substantially lower when Covariance Adj. / S is included in the model. This result probably reflects the high correlation between these variables and Covariance Adj. / S (see the Appendix). The estimated coefficient for Investment RBC / S is consistently larger than those for the other components.

For 1991, in which case only 37 insurers in the sample subsequently failed, the results in Table 6 indicate that inclusion of Log (Assets) and Mutual in equations (3) and (4) reduce the Type I error rate compared to equations (1) and (2) for low Type II error rates, in contrast to the results for equations (3) and (4) in 1990. Type I error rates for equations (5) and (6) are lower than those for equations (1) and (2) when the Type II error rate is 5 percent. The Type I error rates for equation (5) for the remaining Type II error rates shown are generally higher than for equation (1), and those for equation (6) are similar to those for equation (2). Adding Log (Assets) and Mutual in equations (7) and (8) generally produces Type I error rates that are comparable to those for equations (3) and (4). Thus, allowing the weights on the RBC components to vary does not produce substantive reductions in Type I error rates for 1991.[26] The estimates and t-values for Credit RBC / S and Premium RBC / S again decline substantially when Covariance Adj. / S is included, presumably due to the high correlation between Covariance Adj. / S and these variables. The estimated coefficient for Loss Reserve RBC / S in 1991 is again negative for each equation but insignificant.

While the overall results display some instability over time, the results for 1989, 1990, and 1991 generally indicate that including information on firm size and organizational form improves the Type I - Type II error tradeoff. The equations for 1990 that do not allow the weights on the RBC components to vary represent an exception. The results for 1989 and 1990 suggest that allowing the weights of the different RBC components to vary improves the error rate tradeoff. There is little evidence that the covariance adjustment in the RBC formula materially improves the error rate tradeoff in any year.

The poor performance of the loss reserve component of the NAIC risk-based capital formula in all three years included in our study probably reflects the ambiguity of the underlying data used to calculate loss reserve RBC. Insurers that receive relatively high RBC charges for loss reserves are those firms for which loss reserves exhibited positive “loss development,” i.e., where the initial estimate of loss reserves was revised upward as time elapsed (initial underreserving). An upward revision of reserves is interpreted in the NAIC formula as an adverse event. However, loss development can be an indication that an insurer initially underreported

[26]A likelihood ratio test only rejects the constraint of equal weights at the 0.05 level in 1991. Significance levels for 1989 and 1990 were less than 0.01.

reserves to hide financial problems or it can represent a prudent management response to larger-than-anticipated losses. The poor performance of the loss reserve component of RBC may be attributable to the failure to discriminate between “good” and “bad” loss development.

On the other hand, the generally strong performance of the investment, premium, and growth components of the NAIC formula indicates that these charges are better able to discriminate between strong and weak insurers. Asset and growth RBC are likely to be relatively accurate indicators of risk exposure because they are more closely linked to the company’s financial profile during the near-term future. For example, rapid growth in the recent past increases an insurer’s exposure to pricing error and exogenous loss fluctuations. Because asset portfolios tend to change gradually, the current portfolio configuration should give a reasonably accurate indication of a firm’s asset portfolio risk during the projection period. The loss reserve charges, on the other hand, are purely retrospective. For well-managed companies, there is no reason to believe that adverse development over the past few years necessarily contains information that is predictive of future reserve adequacy or development patterns. The NAIC formula implicitly assumes that reserve development primarily reflects maintained factors that are endogenous to the individual insurer rather than transitory, exogenous factors which are likely to be more important for well-managed, financially sound firms. Although premium RBC would seem to be subject to the same criticism, the past loss ratio experience that determines premium RBC may be more reflective of the potential statistical bounds of loss experience rather than the evolution of losses over a specific historical period.

VI. Conclusions

This study has provided an empirical analysis of the relationship between property-liability insurer insolvency risk and capital adequacy relative to the recently adopted NAIC RBC formula. Analysis of data for 1989-1991 for firms that subsequently failed and for firms that survived through the first nine months of 1993 supports three main conclusions. First, less than half of the companies that later failed had RBC ratios within the proposed ranges for regulatory and company action. Second, total and component RBC ratios generally are significantly different for failed and surviving firms based on univariate tests. Third, estimation of multiple logistic regression models of insolvency risk indicates that allowing the weights of the RBC components to vary and including firm size and organizational form variables generally produces a material improvement in the tradeoff between within sample Type I and Type II error rates.

Regarding the estimated weights in the logistic regression models, the fact that the estimated coefficient for the ratio of loss reserve RBC to adjusted surplus generally has the wrong sign is particularly noteworthy given concern over the vulnerability of this ratio to understatement of loss reserves. The results for firm size and organizational form suggest that failure to include a size-related RBC charge is likely to produce a less favorable Type I - Type II error tradeoff. As noted, the NAIC has justified omission of a size charge based on the potential for harmful effects on small, stable firms. This argument essentially implies relatively higher costs for Type II errors than for Type I errors for small firms. While this argument may well be valid, it also seems likely that higher RBC charges for readily identifiable and highly organized subgroups of insurers, such as small firms and mutuals, would be difficult to achieve given substantial political pressure that can be exerted against such charges. Furthermore, considering the potential effects of size charges on industry competitiveness as well as the predominant role of large insolvencies in generating guaranty fund assessments, it is not clear that a size charge is necessary or desirable unless minimal Type II error is achieved for small firms.

Risk-based capital is likely to improve solvency regulation in property-liability insurance by helping regulators to detect troubled or high risk insurers and strengthening their authority to take prompt corrective action. Risk-based capital also may encourage some insurers to reduce risk or add capital to avoid falling below the risk-based capital thresholds. Further research is needed to provide guidance for improvements in the risk-based capital formula and to offer regulators additional analytical tools to assist in the financial evaluation of insurers.

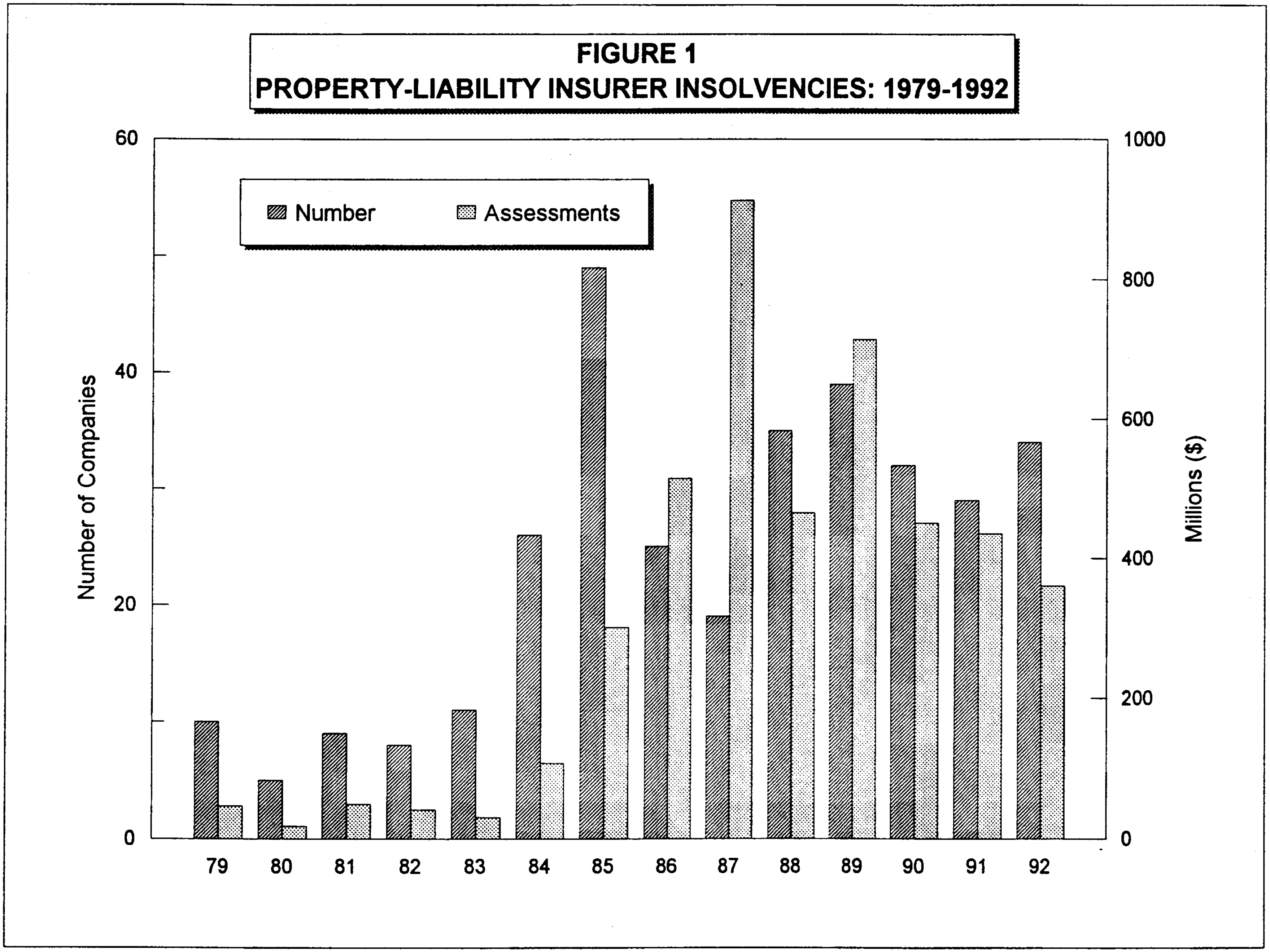

FIGURE 1
PROPERTY-LIABILITY INSURER INSOLVENCIES: 1979-1992
Number
Assessments
Number of Companies
Millions ($)
0
20
40
60
0
200
400
600
800
1000
79
80
81
82
83
84
85
86
87
88
89
90
91
92

Table 1

Cumulative Percentages of Insurers with Ratio of Adjusted Surplus to RBC within Specified Ranges from 1989 through 1991 for Insurers that Survived and for Insurers that Subsequently Failed through 1993

S / RBC Less Than or Equal to:	1989 Data		1990 Data		1991 Data	
	Failed	Solvent	Failed	Solvent	Failed	Solvent
70% (Mandatory Control)	4.1%	1.5%	3.9%	1.9%	8.1%	1.3%
100% (Authorized Control)	5.4	2.3	5.9	2.5	10.8	2.1
150% (Regulatory Action)	16.2	4.4	15.7	4.2	18.9	3.6
200% (Company Action)	28.4	7.4	27.5	8.1	48.6	6.9
250%	43.2	12.1	45.1	14.3	54.1	12.0
300%	52.7	18.8	60.8	21.0	70.3	18.0
400%	63.5	33.1	78.4	35.1	78.4	32.3
500%	73.0	45.6	88.3	47.2	91.9	47.1
Sample Size	74	1493	51	1565	37	1569

Note: RBC ratio is calculated with scale factor of 0.5, which will take effect in 1996. The scale factors for 1994 and 1995 are 0.4 and 0.45, respectively.

Table 2

Type I and Type II Error Rates for Alternative Ratios of RBC to Adjusted Surplus and for the Premiums-to-Surplus Ratio

Type II Error Rate (%)	RBC / S	Without Covariance Adj.	With Modified Covariance Adj.	Premiums / S
Panel A: 1989 Data				
5	80	78	81	80
7.5	72	74	66	66
10	66	65	62	59
15	51	54	57	49
20	47	51	46	43
25	46	46	45	39
30	39	42	42	36
Panel B: 1990 Data				
5	82	80	82	78
7.5	78	71	73	75
10	63	63	61	65
15	55	51	53	51
20	45	43	43	47
25	37	37	37	39
30	29	27	27	33
Panel C: 1991 Data				
5	70	70	68	73
7.5	46	46	51	73
10	46	41	49	73
15	30	35	35	68
20	27	35	35	57
25	24	27	27	49
30	22	24	22	38

Note: Type I error rate is the percentage of insolvent firms with value of specified variable less than value that produces the specified Type II error rate for surviving firms.

Table 3

Sample Medians and Wilcoxon Z-statistics for Ratios of RBC to Surplus, Components of RBC to Surplus, Log (Assets), and Mutual* from 1989 through 1991

Variable	1989 Data			1990 Data			1991 Data		
	Failed Median	Solvent Median	Z-Stat.	Failed Median	Solvent Median	Z-Stat.	Failed Median	Solvent Median	Z-Stat.
RBC / S	0.344	0.186	5.25	0.380	0.192	6.57	0.490	0.191	6.95
RBC w/o Cov. Adj. / S	1.036	0.607	5.11	1.223	0.630	6.54	1.556	0.639	6.77
Investment RBC / S	0.045	0.052	-0.76	0.070	0.044	2.54	0.096	0.045	2.74
Credit RBC / S	0.097	0.023	6.01	0.146	0.023	6.33	0.227	0.024	6.46
Loss Reserve RBC / S	0.190	0.158	0.60	0.279	0.177	2.40	0.366	0.177	4.40
Premium RBC / S	0.438	0.233	3.74	0.487	0.232	4.72	0.478	0.239	4.21
Growth RBC / S	0.042	0.000	7.21	0.043	0.000	5.28	0.001	0.000	3.55
Covariance Adj. / S	0.352	0.233	4.44	0.463	0.231	6.28	0.543	0.241	6.07
Log(Assets)	16.313	17.563	-6.65	16.530	17.540	-4.07	16.565	17.638	-3.88
Mutual*	0.068	0.242	-7.98	0.098	0.241	-6.51	0.108	0.232	-6.10

*Proportion of mutuals shown in median column.

Note: S = Adjusted Surplus. RBC / S and RBC w/o Covariance Adj. / S are calculated with scale factor of 0.5.

Table 4

Logistic Regression Results for Insolvency Risk Models: 1989 Data

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RBC / S	0.274 (2.78)		0.239 (2.20)					
RBC w/o Cov Adj. / S		0.094 (2.92)		0.085 (2.42)				
Investment RBC / S					1.345 (1.05)	0.455 (0.41)	3.688 (2.96)	3.192 (2.80)
Credit RBC / S					1.690 (1.78)	0.797 (1.13)	1.016 (1.09)	0.447 (0.61)
Loss Reserve RBC / S					-0.077 (0.23)	-0.293 (0.99)	0.321 (0.93)	0.093 (0.35)
Premium RBC / S					1.391 (3.33)	1.106 (3.17)	0.931 (2.37)	0.766 (2.19)
Growth RBC / S					4.463 (5.98)	4.133 (5.97)	3.624 (4.59)	3.374 (4.55)
Covariance Adj. / S					-0.859 (1.28)		-0.586 (0.95)	
Log (Assets)			-0.611 (6.28)	-0.611 (6.29)			-0.650 (5.90)	-0.644 (5.90)
Mutual			-1.773 (3.73)	-1.785 (3.75)			-1.809 (3.56)	-1.897 (3.67)
Pseudo-R^2	0.01	0.01	0.12	0.12	0.11	0.11	0.21	0.21
Type II Error Rate (%):	Type I Error Rate (%):							
5	80	78	80	78	68	66	59	59
7.5	72	74	69	69	57	54	55	53
10	66	65	64	62	51	50	43	45
15	51	54	49	49	46	42	28	30
20	47	51	38	36	39	38	26	26
25	46	46	30	28	38	35	22	22
30	39	42	23	23	34	31	16	15

Note: Dependent variable equals 1 if insurer failed subsequent to data year and 0 otherwise. Values of independent variables are truncated at 1 and 99 percentiles. Absolute t-values in parentheses. S = Adjusted Surplus. Type I error rate is the percentage of insolvent firms with with predicted values less than value that produces specified Type II error rate for surviving firms.

Table 5

Logistic Regression Results for Insolvency Risk Models: 1990 Data

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RBC / S	0.496 (2.70)		0.521 (2.78)					
RBC w/o Cov Adj. / S		0.259 (3.69)		0.279 (3.89)				
Investment RBC / S					4.287 (3.09)	4.564 (3.64)	5.411 (3.63)	6.264 (4.58)
Credit RBC / S					1.869 (1.56)	2.298 (3.06)	0.826 (0.65)	2.216 (2.81)
Loss Reserve RBC / S					-0.954 (2.38)	-0.863 (2.57)	-0.984 (2.63)	-0.699 (2.39)
Premium RBC / S					0.371 (0.77)	0.526 (1.57)	0.125 (0.26)	0.576 (1.75)
Growth RBC / S					2.686 (3.43)	2.721 (3.47)	1.401 (1.67)	1.704 (2.09)
Covariance Adj. / S					0.471 (0.46)		1.536 (1.41)	
Log (Assets)			-0.407 (4.01)	-0.416 (4.09)			-0.457 (4.09)	-0.440 (3.97)
Mutual			-1.313 (2.72)	-1.360 (2.78)			-1.730 (3.07)	-1.575 (3.01)
Pseudo-R^2	0.01	0.02	0.07	0.08	0.11	0.11	0.18	0.17
Type II Error Rate (%):	Type I Error Rate (%):							
5	82	80	94	84	69	69	61	57
7.5	78	71	82	75	65	65	55	47
10	63	63	69	67	51	55	45	41
15	55	51	57	49	41	41	33	39
20	45	43	43	35	35	35	27	25
25	37	37	37	33	29	31	25	22
30	29	27	27	24	25	25	22	22

Note: Dependent variable equals 1 if insurer failed subsequent to data year and 0 otherwise. Values of independent variables are truncated at 1 and 99 percentiles. Absolute t-values in parentheses. S = Adjusted Surplus. Type I error rate is the percentage of insolvent firms with with predicted values less than value that produces specified Type II error rate for surviving firms.

Table 6

Logistic Regression Results for Insolvency Risk Models: 1991 Data

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RBC / S	2.205 (6.53)		2.286 (6.32)					
RBC w/o Cov Adj. / S		0.793 (6.93)		0.831 (6.79)				
Investment RBC / S					3.388 (2.08)	3.811 (2.56)	4.476 (2.66)	5.215 (3.37)
Credit RBC / S					0.805 (0.69)	1.333 (1.70)	0.480 (0.38)	1.494 (1.76)
Loss Reserve RBC / S					-0.440 (0.83)	-0.232 (0.57)	-0.525 (0.90)	-0.086 (0.21)
Premium RBC / S					1.236 (1.83)	1.536 (3.46)	0.864 (1.34)	1.372 (3.25)
Growth RBC / S					2.078 (1.89)	2.369 (2.37)	0.903 (0.80)	1.393 (1.35)
Covariance Adj. / S					0.768 (0.61)		1.429 (1.10)	
Log (Assets)			-0.470 (3.79)	-0.495 (3.90)			-0.496 (3.72)	-.0482 (3.67)
Mutual			-1.115 (2.02)	-1.136 (2.05)			-1.385 (2.38)	-1.359 (2.33)
Pseudo-R^2	0.09	0.10	0.15	0.16	0.14	0.14	0.20	0.20
Type II Error Rate (%):	Type I Error Rate (%):							
5	70	70	65	51	59	57	51	59
7.5	46	46	41	38	46	43	41	41
10	46	41	32	30	43	43	35	32
15	30	35	27	30	38	35	27	22
20	27	35	22	24	35	35	22	19
25	24	27	22	22	30	27	22	19
30	22	24	22	22	27	24	19	19

Note: Dependent variable equals 1 if insurer failed subsequent to data year and 0 otherwise. Values of independent variables are truncated at 1 and 99 percentiles. Absolute t-values in parentheses. S = Adjusted Surplus. Type I error rate is the percentage of insolvent firms with with predicted values less than value that produces specified Type II error rate for surviving firms..

Appendix

Correlation Matrices for RBC Components

1989 DATA

	1-TINV/S	2-TCRED/S	3-TLOSS/S	4-TPREM/S	5-TGROW/S	6-TCOV/S
1-TINV/S	1.0000					
2-TCRED/S	0.16332	1.0000				
3-TLOSS/S	0.12178	0.24405	1.0000			
4-TPREM/S	0.12727	0.28837	0.31931	1.0000		
5-TGROW/S	-0.00933	0.17924	0.11438	0.23391	1.0000	
6-TCOV/S	0.35844	0.58354	0.64373	0.62510	0.28619	1.0000

1990 DATA

	1-TINV/S	2-TCRED/S	3-TLOSS/S	4-TPREM/S	5-TGROW/S	6-TCOV/S
1-TINV/S	1.0000					
2-TCRED/S	0.18455	1.0000				
3-TLOSS/S	0.23477	0.31385	1.0000			
4-TPREM/S	0.16081	0.37638	0.37577	1.0000		
5-TGROW/S	0.01613	0.23329	0.18926	0.29113	1.0000	
6-TCOV/S	0.42656	0.66228	0.63270	0.74254	0.34957	1.0000

1991 DATA

	1-TINV/S	2-TCRED/S	3-TLOSS/S	4-TPREM/S	5-TGROW/S	6-TCOV/S
1-TINV/S	1.0000					
2-TCRED/S	0.17222	1.0000				
3-TLOSS/S	0.22767	0.42405	1.0000			
4-TPREM/S	0.12882	0.30631	0.38825	1.0000		
5-TGROW/S	-0.02625	0.17044	0.13252	0.22975	1.0000	
6-TCOV/S	0.40912	0.66791	0.71905	0.71620	0.30108	1.0000

Note: TINV/S = Investment RBC / S, TCRED/S = Credit RBC / S, TLOSS = Loss Reserve RBC / S, TPREM/S = Premium RBC / S, TGROW/S = Growth RBC / S, and TCOV/S = Covariance Adjustment / S, where S = Adjusted Surplus. Variables are truncated at 1 and 99 percentile values.

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