The Impact of RBC Requirements in Property-Liability Insurance

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Abstract

This research investigates the relationship between capital and risk in property-liability insurers for 1992 and for 1994 to 2007. The periods selected allow for comparisons in insurer behavior for the period prior to RBC implementation and after. Three-stage-least-squares is used to investigate the relationship between capital and two types of risk: underwriting and asset risk. Overall the results suggest that risk and capital are positively related, so that capital increases are associated with increases in investment and underwriting risk. This positive relationship was not significant in 1992, prior to the implementation of RBC requirements. Under-capitalized insurers decreased relative capital and increased relative underwriting risk in the post RBC period. However, marginally adequately capitalized insurers decreased asset risk in the post RBC period relative to capital and underwriting risk. Thus, to the extent that RBC requirements were designed to enhance solvency, the results of this study suggest that the impact of RBC requirements is consistent with this goal for marginally adequately capitalized insurers.

Keywords: Risk-Based Capital; Regulatory Effect; Capital; Risk

Introduction

Maintaining insurer solvency has always been a focal point of insurance regulation. U.S. regulators use various methods to promote insurers' financial strength and protect policyholders from losses due to insolvency. One important tool is embodied in Risk Based Capital (RBC) requirements which went into effect in the U.S. property-liability insurance industry in 1994. An important feature of the RBC system is that it mandates intervention by the regulator when risk-based capital levels are deemed deficient. The degree of intervention varies with the degree of deficiency, and ranges from regulatory approval of an insurer action plan to correct the deficiency to mandatory take-over of the insurer. Because it contains mandatory requirements, the RBC system is at least partly designed to eliminate regulatory forbearance in the industry.

Research by Cummins and Nini [1] suggests that the imposition of RBC requirements may have been partly responsible for increased capital levels in the property-liability insurance industry in the 1990s, enhancing solvency. But considerable research criticizes the RBC system. For example, Cummins *et al.*[2] hypothesize that imperfections in the existing RBC system will likely distort insurer's behavior in undesirable and unintended ways so as to avoid being incorrectly identified as needing regulatory attention.[3] Another possibility that exists is that insurers (especially weak insurers) will exploit anomalies in the RBC formula so as to make their financial position appear to be more favorable than it really is.

[1] Cummins and Nini (2002).
[2] Cummins, Harrington, and Niehaus (1994).
[3] Most studies of RBC have focused on the effectiveness of RBC requirements in predicting property-liability insurer insolvencies. This research suggests that RBC results are not good predictors of insolvency (e.g., Cummins, Grace and Phillips, 1999; Cummins, Harrington and Klein, 1995). Cheng and Weiss (2012) find that the accuracy of the RBC ratio in predicting insolvencies is inconsistent over time.

To understand the true effect of RBC requirements on insurers' behavior, the relationship between capital *and* risk in insurers must be determined. For example, capital and insurer risk may be positively related so that increasing capital requirements leads to offsetting increases in risk. In this case, increases in risk corresponding to the increased capital requirements associated with RBC may have offset RBC's intended effect of improving solvency. On the other hand, capital and risk may be unrelated or negatively related so that increases in capital requirements are accompanied by no change in insurer risk or decreases in insurer risk. Then, RBC requirements may have led to a net improvement in capital levels and enhanced solvency in the industry.

In spite of these possibilities associated with the use of RBC in practice, little research is aimed at addressing how insurers may have changed their capital decisions and risk taking behavior before and after adoption of RBC.[4] Cummins and Sommer [5] determine the empirical relationship between capital and risk in property-liability insurers using a sample period of 1979 to 1990. They find the relationship between capital and risk to be positive in property-liability insurers. This result suggests that any increases in capital that may be attributable to RBC requirements would be offset by increases in risk. However the period preceded implementation of RBC, and insurer behavior might be different as a result.

Thus the purpose of this study is to determine changes in insurers' capital positions and risk-taking behavior in 1992 (prior to the implementation of RBC) and

[4] Petroni and Shackelford (1995) study changes in stock life insurer's investment portfolios occurring after implementation of RBC to determine if RBC had an effect. The research concludes that there was little change in stock life insurer's investment portfolios during their sample period (1989-1993), suggesting that perhaps insurers may have chosen a mechanism to manage RBC reported results other than investment restructuring.

[5] Cummins and Sommer (1996).

from 1994 to 2007 (after RBC was adopted). The period 1992 in addition to 1994 to 2007 is examined because insurers may have been readjusting their capital and risk portfolio in anticipation of RBC. Further, this research estimates the impact of RBC requirements on marginally adequately capitalized insurers and under-capitalized insurers in particular.[6]

The sample of insurers studied consists of pooled, cross-sectional U.S. property-liability insurers included in the NAIC's data base for the period 1991 to 2007. Thus this research also updates the analysis of Cummins and Sommer.[5] Following a long line of literature, the model used allows for capital and risk positions to be determined simultaneously, so that three-stage least squares (3SLS) estimation is used to estimate the capital and risk equations.[7] The 3SLS model incorporates the possibility that insurers may be unable to adjust to their target risk or capital levels over the course of a year. That is, the capital and risk equations estimated allow for partial adjustment of capital and risk. The capital measures rely on surplus, while measures of insurer risk are based on asset and underwriting risk.

To measure the effect of RBC implementation on under- and marginally adequately capitalized insurers, indicator variables that reflect relative capitalization of insurers (using the RBC system) are included in the models. And the inclusion of these variables represents an innovation from Cummins and Sommer.[5] The results with respect to these variables can be interpreted as the impact of regulatory pressure on these insurers from RBC implementation. Ceteris paribus, we posit that weaker insurers may have had

[6] Under- and marginally adequate capitalization is determined relative to thresholds in the RBC system.
[7] Cummins and Sommer (1996); Shrieves and Dahl (1992); Jacques and Nigro (1997); and Aggarwal and Jacques(2001), among others.

a larger response to the imposition of RBC requirements in order to avoid regulatory sanctions.

By way of preview, the results overall suggest that risk and capital are positively related, so that capital increases are associated with increases in asset and underwriting risk. This positive relationship was not significant in 1992, prior to the implementation of RBC requirements. Further, marginally adequately capitalized insurers decreased asset risk in the post RBC period relative to capital and underwriting risk. For under-capitalized insurers, on the other hand, capital decreased while underwriting risk increased relatively in the 1994 to 2007 period.

This research is important because the RBC system is currently under review by the NAIC. Therefore it is desirable to understand how insurers respond to capital requirements such as those imposed by RBC. Of particular interest is whether RBC requirements have likely led to better capitalization in the insurance industry. This research suggests that to the extent that RBC requirements increased capitalization in the insurance industry an offsetting increase in risk occurred, contrary to the goals of RBC. However, this research also suggests that despite all of its criticisms, the RBC system has had a beneficial impact on the industry in terms of reducing relative risk for marginally adequately capitalized insurers.

The remainder of this research is organized as follows. In the next section the RBC requirements for insurers are briefly described. Following this, the hypotheses are presented. The next sections focus on the methodology and the data description. The results are contained in the subsequent section, and the last section concludes.

The RBC System

Capital adequacy is assessed with the RBC ratio, defined as the ratio of total adjusted capital (TAC) to RBC. TAC is composed primarily of surplus (or equity) of an insurer. RBC itself is determined from a formula that attaches weights (or factors) to detailed, risk-related items in the insurer's financial statements. The risks encompassed by RBC requirements are primarily underwriting and asset risk[8]; and these risks account for 87 percent of total risk based capital.[9]

Based on their RBC ratios, insurers are classified into one of five ranked categories depending on the degree of any capital deficiency. The RBC categories (and required regulatory/insurer action) are C1 (no action needed), C2 (insurer required to file a plan with commissioner detailing its financial condition and how it proposes to correct deficiency), C3 (regulator examines the insurer and institutes corrective action if necessary), C4 (regulator has legal grounds to rehabilitate the company) and C5 (regulator required to seize the insurer).[10] Table 1 specifies the thresholds corresponding to each of these categories. For example, Table 1 indicates that insurers with an RBC ratio greater than or equal to 2 are associated with no regulatory action.

Several features of the RBC requirements are noteworthy for purposes of this study. The lack of granularity in the risk loadings for invested assets has been criticized. For example, there is no variation in the RBC factors for assets with different durations, and no distinction is made in risk factors for assets rated from AAA to A-, although

[8]More specifically, six main types of risk are analyzed in the RBC system: off balance sheet risks, investments in insurance company affiliates, investment in bonds, investment in stocks, credit risk, and pricing risk. Pricing risk is estimated via underwriting loss and expense reserves and net premiums written by line.
[9] Cummins and Sommer (1996, p. 1081).
[10] Cummins, Harrington, and Klein (1995).

clearly there is a difference in risk. Also, charges do not differ for different types of bonds (e.g., RMBS, CMBS, etc.) Most likely the reason that at least some of these distinctions are not made in the RBC formula is that these issues were not as important when RBC was formulated as they are today.[11] Unfortunately, there is no way to determine the extent to which, if at all, these criticisms affect the ability of RBC to distinguish effectively among insurers of varying risk.

Hypotheses Development

A priori, it is difficult to determine the relationship between changes in risk and capital for insurers. Several reasons exist to suggest that changes in capital and risk are positively related.[12] That is, capital and risk may be considered as substitutes by an insurer. In this case, constraints on capital levels, such as those imposed by RBC, may induce insurers to take on more risk. If insurers are concerned with bankruptcy costs, then increases in risk may lead to higher capital and a positive relationship between risk and capital. Finally, agency costs may lead to a positive relationship between risk and capital if managers, because of their substantial human investment in the insurer, offset increases in insurer risk by holding higher capital amounts.

On the other hand, moral hazard is posited to exist in the insurance industry because of guaranty funds. More specifically, insurers are not charged a risk-based default premium to cover costs in the event of their insolvency. Instead, when an insurer becomes insolvent, solvent insurers are assessed a flat rate to cover insolvency costs.

[11] Finally, RBC may be subject to some manipulation as it relies on insurers' estimates of losses incurred for each year and reserves. Prior research has found evidence that insurers do manipulate reserves, at least in the short term. See, for example, Weiss (1985).
[12] Shrieves and Dahl (1992); Cummins and Sommer (1996).

Thus, maximizing shareholders wealth for insurers could entail increasing risk relative to capital to take advantage of the moral hazard posed by the guaranty fund system.[13]

However, guaranty fund coverage is much less complete than deposit insurance in the U.S. banking industry, so that the excessive risk-taking incentive is weaker in property-liability insurance. For example, some lines of insurance are excluded from coverage such as commercial insurance, and maximum guaranty fund payment limits exist where coverage does apply.[14] Thus policyholders have an incentive to monitor insurers for excessive risk-taking.

Even if incentives were not weaker for excessive risk-taking in property-liability insurance, however, insurers could not increase risk relative to capital in an unchecked fashion. Besides regulatory surveillance (other than RBC), rating agencies provide policyholders with information on the credit-worthiness of the insurer.

Another explanation for a negative relationship between capital and risk may be due to flaws in the RBC formula. Specifically, some factor loadings may result in overweighting of some types of risk and underweighting of other risks. In this case, insurers can re-arrange their underwriting and asset portfolios to "seemingly" less risky types of assets or lines of business that have factor loadings that are too low (given actual risk). Then actual insurer risk would have increased while capital requirements would have decreased, resulting in a negative relationship. This type of behavior would most likely be used by insurers for whom the RBC requirements are binding or close to binding for regulatory or rating agency purposes.

[13] Similar reasoning is used in the banking industry when discussing the deposit insurance subsidy (Shrieves and Dahl, 1992, for example).
[14] The commercial line workers compensation is covered by guaranty funds, however.

The discussion above suggests that the relationship between risk and capital in an insurer is largely an empirical matter. Thus, Hypothesis 1 states,

Hypothesis 1: Insurers' risk and capital are significantly related to each other.

The response of insurers' capital and risk levels after imposition of RBC may depend on whether insurers were holding an amount of capital above the RBC requirements prior to RBC implementation. Insurers with capital levels significantly above the required level may not have responded to the imposition of RBC at all or may even have increased risk (relatively). Insurers with relatively low capital buffers may have tried to build an appropriate buffer by raising capital and/or lowering risk. That is, insurers' results are exposed to exogenous shocks related to developments in the overall economy or the property-liability insurance industry, hence insurers may wish to insulate their capital from such shocks with a buffer. In addition, reducing risk or raising capital for these insurers may have served as a signal that they were in regulatory compliance leading to a reduction in regulatory costs.[15] Insurers with RBC deficiencies may have had a stronger response to RBC requirements as these insurers likely experienced regulatory pressure to improve capital positions (or decrease risk). Thus Hypothesis 2 states,

Hypothesis 2: Capital and risk were more responsive in weaker insurers with the implementation of RBC.

Imposition of RBC requirements may have changed the cost-return tradeoff between risk and capital in the insurance industry. In this case, one would expect that capital levels for insurers in different RBC categories responded differently prior to the time RBC became effective than afterwards. Hypothesis 3 states,

[15] Jacques and Nigro (1997).

Hypothesis 3: Changes in capital and risk for insurers in varying financial condition were different prior to the imposition of RBC requirements than afterwards.

Methodology

The hypotheses' discussion indicates that a simultaneous relationship between risk and capital may exist such that capital may depend on risk and vice-versa. Further, the imposition of risk based capital standards may have had an impact on both capital and risk.

In this section, the partial adjustment models used in the simultaneous equations are specified. Following this, the measures of capital and risk are discussed. Next the control variables used in the analysis are explained.

Model Specification

The models used in Cummins and Sommer and Shrieves and Dahl with the modification of Aggarwal and Jacques is used in this research.[7] More specifically, change in relative capital is modeled in a single equation, and two equations are used to specify relative changes in risk. Insurers' risk decisions are assumed to entail underwriting risk and asset risk.[16] Underwriting risk reflects the amount and types of business that the insurer underwrites each year, while asset risk reflects the asset quality of the insurer's investments.

Given this, observed change in an insurer's capital and risk are modeled as

$$(Cap_{it}\text{-}Cap_{i,t-1}) = \Delta Cap_{it} = \Delta^{END} Cap_{it} + \varepsilon_{it} \quad (1)$$

$$(UndRisk_{it}\text{-}UndRisk_{i,t-1}) = \Delta UndRisk_{it} = \Delta^{END} UndRisk_{it} + \omega_{it} \quad (2)$$

[16] The RBC formula identifies additional risks. However, some of these risks are likely to be more sticky in nature than asset and underwriting risk (e.g., investment in affiliates) or reflect past underwriting or reinsurance decisions (e.g., reserves' accuracy and reinsurance ceded).

$$(AssetRisk_{it}\text{-}AssetRisk_{i,t-1}) = \Delta AssetRisk_{it} = \Delta^{END}AssetRisk_{it} + \upsilon_{it} \quad (3)$$

where $\Delta^{END}Cap_{it}$, $\Delta^{END}Risk_{it}$ and $\Delta^{END}AssetRisk_{it}$ are assumed to be endogenous adjustments in capital and risk, respectively, and ε_{it}, ω_{it} and υ_{it} are random, exogenous shocks to capital (perhaps caused by fluctuations in the macroeconomic environment). The subscript *i* refers to insurer *i*, and *t* refers to time.

But insurers may not be able to adjust their capital and risk positions to the desired, or target levels instantaneously. Instead, it may take time for a firm to reach its targets. In this case, the endogenous changes in capital and risk can be specified as a partial adjustment model:

$$\Delta^{END}Cap_{it} = \delta(Cap^{*}_{it} - Cap_{i,t-1}) \quad (4)$$

$$\Delta^{END}UndRisk_{it} = \lambda(UndRisk^{*}_{it} - UndRisk_{i,t-1}) \quad (5)$$

$$\Delta^{END}AssetRisk_{it} = \rho(AssetRisk^{*}_{it} - AssetRisk_{i,t-1}) \quad (6)$$

where Cap^{*}_{it} is target firm capital and $UndRisk^{*}_{it}$ and $AssetRisk^{*}_{it}$ are target underwriting and asset risk, respectively. The factors δ, λ and ρ are partial adjustment factors, usually assumed to vary from zero to one.

Equations (4), (5) and (6) can be substituted into equations (1), (2) and (3), respectively, to yield

$$\Delta Cap_{it} = \delta(Cap^{*}_{it} - Cap_{i,t-1}) + \varepsilon_{it} \quad (7)$$

$$\Delta UndRisk_{it} = \lambda(UndRisk^{*}_{it} - UndRisk_{i,t-1}) + \omega_{it} \quad (8)$$

$$\Delta AssetRisk_{it} = \rho(AssetRisk^{*}_{it} - AssetRisk_{i,t-1}) + \upsilon_{it} \quad (9)$$

Cap^*_{it}, $UndRisk^*_{it}$ and $AssetRisk^*_{it}$ are assumed to depend on exogenous, firm specific factors [17]; and regulatory pressure is assumed to affect the insurer's capital and underwriting and asset risk positions. Cap^*_{it}, $UndRisk^*_{it}$ and $AssetRisk^*_{it}$ are all assumed to depend on each other. Finally after adding $Cap_{i,t-1}$ $UndRisk_{i,t-1}$, and $AssetRisk_{i,t-1}$ to both sides of equations (7) to (9), respectively, the following system of equations result[18]:

$$Cap_{it} = \alpha_0 + \alpha_1 UndRisk_{it} + \alpha_2 AssetRisk_{it} + AX_{t-1} + \alpha_3 RBCA + \alpha_4 RBCU + (1-\delta)Cap_{i,t-1} + \tau_{it} \quad (10)$$

$$UndRisk_{it} = \beta_0 + \beta_1 Cap_{it} + \beta_2 AssetRisk_{it} + BX_{t-1} + \beta_3 RBCA + \beta_4 RBCU + (1-\lambda)UndRisk_{i,t-1} + \eta_{it} \quad (11)$$

$$AssetRisk_{it} = \gamma_0 + \gamma_1 Cap_{it} + \gamma_2 UndRisk_{it} + \Gamma X_{t-1} + \gamma_3 RBCA + \gamma_4 RBCU + (1-\rho)AssetRisk_{i,t-1} + \pi_{it}, \quad (12)$$

where α_j, β_k, and γ_m are parameters and A, B, and Γ are vectors of parameters. X_{t-1} is a vector of exogenous control variables assumed to determine target capital and risk. And τ_{it}, η_{it}, and π_{it}, are error terms.

Hypothesis 1 would be supported if the coefficients for the capital and risk variables are significant in equations (10) to (12). More specifically, significant coefficients for α_1, α_2, β_1, and γ_1 would support Hypothesis 1. In addition, the signs of the coefficients for α_1 and α_2 should agree with β_1 and γ_1, respectively.

The RBC categorization of insurers in Table 1 is used to distinguish among well-capitalized insurers and less well-capitalized/financially distressed insurers in this study for purposes of determining how insurers in varying financial condition responded to the

[17] For example, Cap^*_{it} is assumed to be determined by firm-specific variables X_{it-1} (i.e., $Cap^*_{it}=AX_{t-1}$, where A is a parameter vector and X_{t-1} is a vector of firm characteristics. $UndRisk^*_{it}$ and $AssetRisk^*_{it}$ are assumed to be determined in a similar fashion.

[18] That is, $(Cap_{it} - Cap_{i,t-1}) = \delta(Cap^*_{it} - Cap_{i,t-1})$ and Cap^*_{it} is δX_{t-1}, where X_{t-1} is a vector of variables assumed to be related to the capital structure. The parameter δ is subsumed within the parameter A.

imposition of RBC requirements. Insurers in category C1 with an RBC ratio greater than three are considered well-capitalized. Insurers that are in category 1 but close to the lower threshold for category 1 may have had an incentive to build up a buffer of capital (or reduce risk). Thus insurers with ($2 \leq RBC < 3$) are considered marginally adequately capitalized and are designated by the indicator variable RBCA in the models above. It is assumed that insurers in categories C2 to C4 are under some regulatory pressure to increase capital, reduce risk, or both to improve their RBC ratios.[19] Therefore, these insurers are classified as undercapitalized/financially distressed in this study.[20] These insurers are designated in the model by the indicator variable RBCU.[21,22] Significant coefficients for the RBCU and RBCA variables, with $|RBCU| > |RBCA|$, would support Hypothesis 2.

The system of equations (10) to (12) is estimated for 1992 (prior to the imposition of RBC) and for 1994 to 2007. Hypothesis 3 would be supported if the coefficients for the variables involving RBCU and RBCA are significantly different in the 1992 estimation results compared to the 1994 to 2007 results.

Estimation

Three-stage least squares is used because the joint dependency between insurer's leverage, investment, and underwriting decisions means that OLS estimation is inefficient. Further, three-stage least squares is a full-information estimation technique which

[19] Insurers in categories C2 to C4 should face increased regulatory costs varying with the degree of their capital deficiency under the design of the RBC system. However, it is difficult to know in practice what these costs are and whether they are severe.

[20] Essentially the same breakdown into categories is used in Aggarwal and Jacques (2001, p. 1146).

[21] Note that even if RBC is not a good indicator of insurer risk, insurers would still be under regulatory pressure to keep the RBC ratio within acceptable bounds.

[22] The omitted category for the RBC regulatory pressure variables are well capitalized insurers with RBC>3. Insurers in category 5 are omitted from the study since they should have been seized by the regulator and most likely are in runoff.

estimates all parameters simultaneously and is preferred to two-stage-least squares for this reason. That is, three-stage least squares incorporates the cross-equation correlations, making the parameter estimates asymptotically more efficient than two-stage least squares. Another advantage of three-stage-least squares is that it eliminates problems associated with serial correlation in the error terms. This is because the three-stage-least squares methodology can be interpreted as an extension of generalized least squares (GSLS) to a simultaneous equation system.[23] Year dummies are included in the models for the sample with years 1994 to 2007.

Dependent Variables

Capital Equation. The specification for capital is the same as used in prior insurance and banking research: the surplus to total assets ratio.[12] This measure is unaffected by (any anomalies in) the RBC formula.

Risk Equations. Asset risk is proxied by investment in equities and real estate divided by total invested assets in some specifications[24], while in others it is proxied for by the RBC risk weighted assets divided by invested assets.[25] The rationale for using equities and real estate divided by invested assets is that these investments are considered to be relatively risky (as evidenced, for example, by their high RBC risk factor loading), and this ratio is easy to compute and cannot be manipulated.[26] Risk-weighted assets have been used in prior banking research; and these are calculated by multiplying the invested asset risk factors from the RBC formula with the values for these assets for each insurer.

[23] Intrilligator (1978).
[24] Petroni and Shackelford (1995).
[25] Shrieves and Dahl (1992); Jacques and Nigro (1997); Aggarwal and Jacques (2001).
[26] The RBC factor for equities is 0.15, which is higher than for all other risk classes except for the lowest rated unaffiliated bonds and preferred stock. However, the latter two assets account for an insignificant fraction of assets.

The use of risk-weighted assets as a proxy for investment risk poses some interesting issues. Recall that if some RBC asset factor loadings are too high while others are too low (given actual risk), insurers may be able to re-arrange part of their asset portfolio to take advantage of this. The end result of this would be a negative relationship between *actual* insurer risk and capital requirements. But, this problem cannot be detected if measures of risk rely on RBC factor loadings. Instead, if insurers re-arrange their asset portfolio to exploit RBC anomalies, the RBC requirement would decline because asset risk appears to decline. Insurers would have the option of decreasing their capital base (perhaps by paying a dividend). Then there would be a positive association between capital and risk (both "apparent risk" and capital would decrease at the same time). Alternatively, insurers may decide to maintain their capital base, in which case changes in capital and risk would appear to be unrelated, but the RBC ratio would improve. As indicated earlier, exploitation of this type would be less likely for insurers with an RBC ratio well above the "no action" benchmark of 2.

The reason for using this asset risk proxy in this study is that results prior to the imposition of RBC and after imposition of RBC are analyzed. Prior to the implementation of RBC, insurers would not have had an incentive to exploit any anomalies in the RBC formula, hence the results between the two periods studied are interesting for comparison purposes.[27]

Underwriting risk is measured as RBC risk-weighted net premiums written (NPW) divided by total NPW. RBC risk-weighted NPW is calculated by multiplying the NPW risk factors for each line from the RBC formula with the values for premiums by line for

[27] However, it is also possible that insurers expected the implementation of RBC and adjusted their asset and underwriting portfolios accordingly.

each insurer. Use of this measure poses the same challenges as for risk weighted assets and the same analysis applies to observed results. As a robustness test, underwriting risk is proxied by the proportion of premiums written in risky lines (analogous to the asset risk specification based on real estate and mortgages).[28] Use of risk measures such as these assumes that the RBC formula can identify risky lines (or risky assets), even if the factor loadings associated with these lines (or assets) do not completely accurately incorporate the relevant inherent risk.

Control Variables

The control variables ($X_{i,t-1}$) in the equations estimated are for organizational form, size, group status, herfindahl index of lines of business written, geographical herfindahl index of business written and reinsurance utilization. The rationales for including these variables are explained below.

The capital and risk position of an insurer is likely to be affected by its degree of diversification. Insurers that are more diversified are expected to require less relative capital to operate and can take on relatively larger risk. Size is sometimes associated with diversification because larger insurers, in theory, should be able to achieve a better spread of risk than smaller insurers. Therefore, size, defined as the logarithm of assets, is included in the regression models, and its expected sign is negative in the capital equation and positive in the underwriting and asset risk equations.

Insurers might also diversify risk by writing across many different product lines and/or across different geographic areas. Therefore, herfindahl indices for product mix and geographic spread are included in the model. The expected signs for the herfindahl

[28] Risky lines are those that have the highest NPW risk factor loadings: commercial auto liability, allied lines, earthquake, surety, theft, inland marine, fire, international, boiler and machinery, reinsurance and medical malpractice (occurrence).

index variables are positive in the capital equation and negative in the underwriting and asset risk equations. That is, decreases in product mix and geographic spreads are associated with increases in the herfindahl index and less diversification. Less diversification would be associated with higher capital requirements and less underwriting and asset risk undertaken.

Reinsurance usage is associated with increased diversification, since through reinsurance insurers can obtain a better spread of risks.[29] Reinsurance usage is measured as the ratio of ceded loss reserves to the sum of direct loss reserves and assumed loss reserves. Reinsurance usage is expected to be negatively related to capital requirements and positively related to underwriting and asset risk.

An indicator variable equal to one if an insurer is a member of a group is included in the models because group insurers might have an advantage by being able to diversify risks within the group (through intra-group reinsurance) and operate with relatively lower capital levels and higher asset and underwriting risk. On the other hand, capital and risk for insurers within a group might be determined strategically at the group parent level, meaning capital and risk decisions are made differently than for insurers that are not part of a group. Thus, overall, the sign for this variable cannot be determined a priori.

Finally, an indicator variable equal to one for mutual insurers is included in the model. Agency costs and therefore capital structure may vary by organizational form. An inherent owner-policyholder conflict exists for stock insurers (but not mutual insurers) whereby owners have an incentive to increase the risk of the firm to the detriment of policyholders. But a manager-owner conflict may affect stock versus mutual insurers differently because the owners of a mutual (the policyholders) do not exert much

[29] See, for example, Cummins and Nini (2002).

effective control over managers.[30] Also, mutuals have less access to capital markets, making raising capital more difficult and costly for them.[31] In summary, inherent differences in the owner-policyholder conflict and owner-manager conflict in mutual versus stock insurers and the fact that mutuals may find it more difficult to raise capital may result in different capital structures for stock versus mutual insurers. Thus the sign of the indicator variable is difficult to predict a priori in the equations.

Data

The sample data consists of pooled, cross-sectional data of U.S. property-liability insurance companies included in the NAIC's database for the period 1990 to 2007.[32] After 1994, data for the RBC ratio were obtained from the NAIC database; unpublished RBC data obtained directly from the NAIC for 1992 were used in some models.[33] The samples used in estimation include all insurers with positive net admitted assets, surplus and net premiums written (NPW). Certain specialty insurers and insurers that did not file a statement with the NAIC are excluded from the RBC database and from this study. Finally, data for two consecutive years were required for each insurer sample, hence observations that did not meet this criterion were eliminated from the sample.

Results

Table 2 contains summary statistics for the 1992 sample and the sample for 1994 to 2007 along with the results of t-tests for differences in means for these samples. The results indicate that many significant differences exist between the two samples.[34]

[30] Mayers and Smith (1992 and 2005); Mayers, Shivdasani, and Smith (1997).
[31] Harrington and Niehaus (2002).
[32] The data used in the analysis were winsorized at the 5 and 95 percent level.
[33] Prior to 1994 an insurer's RBC ratio was not published, however data for 1992 were available from the NAIC. Unfortunately, the NAIC did not have RBC ratio data for 1991 and 1993.
[34] The results of the Wilcoxon test for the difference in medians are virtually the same as for the differences in means.

Notably, the proportion of the sample that was undercapitalized in 1992 is significantly larger than in the 1994 to 2007 period. Underwriting risk (proxied by the (RBC risk-weighted NPW/Premiums) in year *t* and *t-1* is greater in 1992 compared to the 1994 to 2007 period. Also, the geographic herfindahl, and the proportion of mutuals are significantly greater in the 1992 period compared to the 1994 to 2007 period. All other variables are significantly lower in the 1992 period, except for the adequate capitalization indicator, and (Risky Assets/Invested Assets) in years *t* and *t-1*, which are not significantly different between the two periods.

Tables 3 through 6 contain the three-stage least squares regression results. Table 3 uses (RBC risk-weighted Invested Assets/ Invested Assets) as the risk measure for asset risk, while Table 4 uses the alternative measure for asset risk, (Risky Invested Assets/ Invested Assets). Tables 5 and 6 are analogous to Tables 3 and 4 except that the analyses are carried out for insurers that are well above the "no action" threshold for RBC; that is only insurers with RBC greater than 3 are used in the analysis for Tables 5 and 6. The coefficients for the year dummies for the 1994 to 2007 samples have been suppressed in the results for space reasons.

Hypothesis 1 states that insurers' risk and capital should be significantly related to each other. The results for 1994 to 2007 clearly show that this is the case. In these regressions, $(\text{Surplus/Assets})_t$ and $(\text{RBC risk-weighted NPW/ Premiums})_t$ are positive and significantly related to each other in Tables 3 and 4. Further, Table 3 indicates that $(\text{Surplus/Assets})_t$ and $(\text{RBC risk-weighted Invested Assets/ Invested Assets})_t$ are positively and significantly related, while Table 4 indicates that $(\text{Surplus/ Assets})_t$ and $(\text{Risky Invested Assets/ Invested Assets})_t$ are positively and significantly related also. It

is interesting to note that both asset risk measures used in Tables 3 and 4 are associated with the same results, even though some of the RBC factor loadings for assets have been criticized.

For 1992, the relationships between risk and capital are positive in most cases in Tables 3 and 4, but the relationships do not appear to be simultaneous because almost all of the relevant coefficients are not significant. For example, in the $(\text{Surplus/Assets})_t$ equation for 1992 in Table 3, the coefficient for $(\text{RBC risk-weighted NPW/Premiums})_t$ is 0.05139 and insignificant; and the corresponding coefficient for $(\text{Surplus/Assets})_t$ is not significant either in the $(\text{RBC risk-weighted NPW/Premium})_t$ equation for 1992. (The coefficient is 0.005077.) The reason for the lack of simultaneity is not known, although exploitation of the RBC formula cannot be ruled out. On the other hand, the lack of simultaneity may be due to the lower degrees of freedom in these models. In any case, the inconclusive results for 1992 are similar to results found in prior studies for years before the imposition of new banking capital requirements.[35]

As indicated earlier, a positive or insignificant relationship between capital and risk can arise from exploitation of the RBC formula. This exploitation would most likely occur, if it occurred at all, for insurers close to the 'no action' threshold or in the action level categories. Therefore, the analyses are carried out also for insurers with RBC ratios well above the threshold, i.e., for insurers with RBC ratios greater than three. And these results are in tables 5 and 6.

The results in Tables 5 and 6 are the same with respect to the relationship between $(\text{Surplus/Assets})_t$ and underwriting risk and investment risk for 1992 and the period 1994-2007. That is, $(\text{Surplus/Assets})_t$ in the 1994 to 2007 results is significant and positively

[35] See, for example, Aggarwal and Jacques (2001).

related to underwriting and asset risk in Tables 5 and 6. Also, there is a lack of significant coefficients generally for $(Surplus/Assets)_t$ and asset and underwriting risk in the 1992 results, which is inconsistent with simultaneity. Thus the results in Tables 3 and 4 do not appear to be attributable to exploitation of the RBC formula in some fashion to improve results.

Robustness tests were carried out in which the proportion of premiums written in risky lines is substituted for (RBC risk-weighted NPW/Premiums); and the results are in Appendix Tables 1 through 4. The results support the significant and positive relationships between capital and underwriting and asset risk for the 1994 to 2007 period in Tables 3 through 6. Contrary to the results in Tables 3 through 6, however, a positive and significant relationship between underwriting risk and capital is present in the 1992 results. Similar to the results in Tables 3 through 6, no significant relationship is detected between capital and asset risk for 1992.

These results taken as a whole suggest that increases in capital are accompanied by increases in risk in the period after RBC implementation. These results are similar to those found by Cummins and Sommer.[5] Thus, it does not appear that the imposition of RBC standards affected the basic relationship between capital and risk in property-liability insurers – the relationship remains positive. For regulatory purposes, these results suggest that to the extent that RBC requirements led insurers to increase capital, an offsetting increase in risk took place.

The variables, adequate capitalization and under-capitalization, are used to test Hypothesis 2 which states that risk and capital vary for insurers in different financial shape. These variables correspond to RBCA and RBCU, respectively, in equations (10)

to (12). The results in the $(Surplus/Assets)_t$ equations in Tables 3 and 4 indicate that, in 1992, undercapitalized insurers experienced larger decreases in capital than insurers that were adequately capitalized. This is evidenced by the coefficients which are negative and significant at the 1 percent level for these variables; and the absolute value of the capital coefficient is larger for under-capitalized insurers than for adequately capitalized insurers (i.e., $|-0.10695| > |-0.04095|$ in Table 4). The differences in the coefficients in Tables 3 to 4 for under- and adequately capitalized insurers are significant at the 5% level. Thus these results support Hypothesis 2 for the 1992 period.

Hypothesis 2 is not supported in the results for 1994 to 2007 in Tables 3 and 4 with respect to capital and underwriting risk. That is, the coefficient for marginally adequately capitalized insurers is insignificant in the capital and underwriting risk equations, indicating no effect of RBC on these insurers. In conjunction with this, under-capitalized insurers were taking on more underwriting risk and decreasing capital. This is evidenced by the positive and significant coefficient for Under Capitalized insurers in the underwriting risk equation and the negative and significant coefficient for Under Capitalized insurers in the (Surplus/Asset) equation. Hence financially weaker insurers did not respond more aggressively then marginally adequately capitalized insurers to overcome RBC related deficiencies, as Hypothesis 2 posits. However, the asset risk equation results do support Hypothesis 2 in the 1994 to 2007 period, as the coefficient for marginally adequately capitalized insurers is less than that for under-capitalized insurers in Tables 3 and 4 for the asset risk equation. (However, the result is not significant in Table 4.) Thus the results are mixed with respect to Hypothesis 2 for the 1994 to 2007 period.

The results for undercapitalized insurers are similar in the 1994 to 2007 period as in the 1992 period in Tables 3 and 4 with respect to capital. That is, the coefficient for under-capitalization is negative and significant in the capital equations in Tables 3 and 4. But underwriting risk (asset risk) is positively (negatively) related to the undercapitalization variable for the 1994 to 2007 period in Tables 3 and 4. And the results are significant except in the asset risk equation in Table 4. Thus it appears that underwriting risk increased while asset risk decreased for under-capitalized insurers in the 1994 to 2007 period. This contrasts with the 1992 period. Thus overall, there does appear to be a difference for under-capitalized insurers in the 1994 to 2007 period. One explanation for this result is that undercapitalized insurers may have had difficulty in raising capital due to their financial condition. Instead, underwriting risk increased, perhaps reflecting a 'go for broke' type of behavior. These results, overall, support Hypothesis 3 for under-capitalized insurers.

The results are very different for marginally adequately capitalized insurers between 1992 and the 1994 to 2007 period. The coefficient for marginally adequate capitalization is insignificant in the capital equation in Table 3 for the 1994 to 2007 period, while the coefficient for this variable is negative and significant in the 1992 period. Further, Tables 3 and 4 indicate that marginally adequately capitalized insurers experienced a decline in asset risk in the 1994 to 2007 period, while the corresponding coefficient for marginally adequately capitalized insurers was insignificant for the 1992 period in Tables 3 and 4. Thus Hypothesis 3 is supported for marginally adequately capitalized insurers as well.

The results with respect to asset risk in the 1994 to 2007 period are noteworthy. Marginally adequately capitalized insurers experienced a net decrease in risk relative to capital levels. Thus, to the extent that imposing RBC requirements were designed to enhance solvency, the results for marginally adequately capitalized insurers are consistent with this goal.

The coefficients for $(\text{Surplus/Assets})_{t-1}$, $(\text{RBC risk-weighted NPW/Premiums})_{t-1}$, $(\text{RBC risk-weighted invested Assets/ Invested Assets})_{t-1}$, and $(\text{Risky Invested Assets/ Invested Assets})_{t-1}$ can be interpreted as the speed of adjustment towards a target for capital, net premiums written, and assets, respectively, according to the model specification. In Tables 3 and 6 all of the speeds of adjustment variables are significant, and they are all between zero and one. The speed of adjustment results in Tables 3 and 4 vary from approximately 0.03 to 0.10 in the asset risk equations to 0.03 to 0.14 in the underwriting and capital equations in the results in Tables 3 and 4. These speeds of adjustment are very low compared to nonfinancial firms.[36]

The remainder of this discussion focuses on the other control variables. The results in the 1994 to 2007 period in Tables 3 and 4 are emphasized in the discussion. Size (measured as the log of assets) is negative and significantly related to capital in most equations, as expected, and it is also positively related to asset risk in Tables 3 and 4 as expected for the 1994 to 2007 period. It is unexpectedly negatively related to underwriting risk. Reinsurance usage is positively related to capital and negatively related to asset risks in Tables 3, which is unexpected. Reinsurance usage is not significant in the 1992 period. The herfindahl indices are mostly insignificant in the 1992 results in Tables 3 and 4, and they are positively related to asset risk as expected but

[36] See, for example, Flannery and Rangan (2006); Huang and Ritter (2009); Ovtchinnikov, (2010).

negatively related to underwriting risk, which is unexpected in the 1994 to 2007 results. The coefficients for the group and mutual indicator variables are mostly positive or insignificant. Recall that there were no priors on the coefficients for these variables. The results in Tables 5 and 6 largely conform to the above results.

Conclusion

This research investigates the relationship between changes in capital and risk in property-liability insurers for 1992 and for 1994 to 2007. The periods selected allow for comparisons in insurer behavior for the period prior to RBC implementation and after. This research is important because the NAIC is currently undergoing a review of its solvency mechanisms, including risk based capital requirements. Therefore, it is important to know if increased capital requirements are accompanied by increased, offsetting increases in risk. In the latter case, RBC requirements may not meet their intended goal which is to enhance solvency.

Overall the results suggest that changes in risk and capital are positively related. That is, a positive relationship was detected between capital and asset and underwriting risk, so that capital increases are associated with increases in investment and underwriting risk. This significant and positive relationship was not significant in 1992, prior to the implementation of RBC requirements in 1994.

Further, marginally adequately capitalized insurers decreased asset risk in the post RBC period relative to capital and underwriting risk. Thus, to the extent that RBC requirements were designed to enhance solvency, the results of this study suggest that the impact of RBC requirements is consistent with this goal for marginally adequately capitalized insurers. However, under-capitalized insurers are associated with declines in

capital and increases in underwriting risk, but some evidence exists to suggest that these results were offset at least to some extent by a decrease in asset risk.

Finally, an important limitation exists for studies of this type. That is, the analysis cannot be used to determine whether insurers are operating at levels of risk that are too high or too low in any absolute sense. Nor do they guarantee that capital levels are adequate.

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Table 1. "Risk" Categories Based on the NAIC RBC Ratios (TAC/ACL RBC)

Insurer "H	RBC Ratio	NAIC Regulatory Action Level	Classifications in this Study
C1	RBC ratio >= 2	No action need	N/A
C2	1.5 <= RBC ratio < 2	Company action level	Moderately financially distressed/Under-capitalized insurers
C3	1 <= RBC ratio < 1.5	Regulatory action level	Moderately financially distressed/Under-capitalized insurers
C4	0.7 <= RBC ratio < 1	Authorized control level	Moderately financially distressed/Under-capitalized insurers
C5	RBC ratio < 0.7	Mandatory control level	Highly financially distressed/Under-capitalized insurers

Note: TAC is the Total Adjusted Capital, and ACL RBC is the Authorized Control Level RBC.

Table 2
Summary Statistics

Variable	1992 Sample	1994 to 2007 Sample	t-tests for differences in means
(Geographic Herfindahl)$_{t-1}$	0.6070	0.5673	***
(Lines of Business Herfindahl)$_{t-1}$	0.5114	0.5403	***
(Reinsurance Usage)$_{t-1}$	0.3450	0.3858	***
(Group Indicator (=1 if group))$_{t-1}$	0.5976	0.6588	***
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.2462	0.1889	***
(Adequate Capitalization (=1 if adequate capitalization))$_{t}$	0.0595	0.0634	
(Under Capitalized (=1 if under capitalized))$_{t}$	0.0531	0.0302	***
Log(Assets$_{t-1}$)	17.3570	17.9990	***
(Surplus/Assets)$_{t-1}$	0.4223	0.4435	***
(RBC risk weighted NPW/ Premiums)$_{t-1}$	0.1727	0.1568	***
(Risky Assets/Invested Assets)$_{t-1}$	0.1248	0.1280	
(RBC risk-weighted Invested Assets/Invested Assets)$_{t-1}$	0.0166	0.0182	***
(Surplus/Assets)$_{t}$	0.4155	0.4398	***
(RBC risk weighted NPW/ Premiums)$_{t}$	0.1743	0.1564	***
(Risky Assets/Invested Assets)$_{t}$	0.1281	0.1283	
(RBC risk-weighted Invested Assets/Invested Assets)$_{t}$	0.0166	0.0184	***
N	1864	26668	

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively.

Note: RBC risk-weighted NPW is the sum of RBC NPW risk factor for premium line* premiums in line. RBC risk-weighted Invested Assets is sum of RBC asset risk factor by type * asset type. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2. Risky Invested Assets are the sum of stock and real estate investments.

Table 3
Three Stage Least Squares Results
(RBC risk-weighted Invested Asset/Invested Assets)$_t$ used as Dependent Variable
All Insurers

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$
Independent Variables						
Intercept	0.085253 ***	-0.001420	-0.002020	0.069116 **	0.026986 ***	-0.002240 ***
	2.98	-0.19	-0.70	8.58	13.02	-5.10
(Geographic Herfindahl)$_{t-1}$	0.002735	0.000475	-0.000230	-0.002140	-0.002820 ***	0.000243 ***
	0.47	0.32	-0.40	-1.41	-7.27	2.97
(Lines of Business Herfindahl)$_{t-1}$	0.021266 ***	-0.000020	-0.000840	-0.002450	-0.010080 ***	0.000196 **
	2.80	-0.01	-1.12	-1.24	-20.13	1.83
(Reinsurance Usage)$_{t-1}$	-0.008650	-0.002860	-0.000980	0.002830 **	-0.000200	-0.000360 ***
	-1.24	-1.59	-1.43	2.17	-0.43	-3.75
(Group Indicator (=1 if group))$_{t-1}$	0.003278	-0.001700	0.000140	0.005433 ***	0.000039	-0.000120 *
	0.69	-1.39	0.30	3.82	0.12	-1.73
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.007776	-0.001870	0.001114 **	0.005433 ***	0.000374	0.000438 ***
	1.60	-1.49	2.34	3.82	1.03	5.72
(Adequate Capitalization (=1 if adequate capitalization))$_t$	-0.049550 ***	-0.000310	-0.000970	0.003119	0.000881	-0.000450 ***
	-5.97	-0.14	-1.16	1.40	1.55	-3.73
(Under Capitalized (=1 if under capitalized))$_t$	-0.107060 ***	0.002669	0.000752	-0.007950 **	0.009560 ***	-0.000780 ***
	-11.60	1.06	0.78	-2.43	11.48	-4.41
Log(Assets$_{t-1}$)	-0.002830 **	0.000474	0.000183	-0.001650 ***	-0.000570 ***	0.000189 ***
	-2.02	1.29	1.32	-4.39	-5.84	9.30
(Surplus/Assets)$_t$		0.005077	0.003127 **		0.008900 ***	0.000908 ***
		1.50	2.45		9.53	4.60
(RBC risk-weighted NPW/Surplus)$_t$	0.051390		0.000838	0.091552 ***		0.000908 ***
	1.48		0.24	7.82		4.60
(RBC risk-weighted Invested Assets/Invested Assets)$_t$	0.050847	0.039874		0.155580 ***	0.009304	
	0.41	1.24		6.65	1.54	
(Surplus/Assets)$_{t-1}$	0.863729 ***			0.877399 ***		
	76.45			272.53		
(RBC risk-weighted NPW/ Premiums)$_{t-1}$		0.965795 ***			0.887284 ***	
		111.17			330.82	
(RBC risk weighted Invested Assets/ Invested Assets)$_{t-1}$			0.877720 ***			0.967816 ***
			81.70			786.92
System weighted R-squared	0.8197			0.9276		
No. of obs.	1864			26668		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients.

Note: RBC risk-weighted NPW is sum of RBC NPW risk factor for premium line* premiums in line. RBC risk-weighted Invested Assets is sum of RBC asset risk factor by type * asset type. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2.

Table 4
Three Stage Least Squares Results
(Risky Invested Assets/Invested Assets)$_t$ used as Dependent Variable
All Insurers

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(Risky Invested Assets/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(Risky Invested Assets/ Invested Assets)$_t$
Independent Variables						
Intercept	0.083982 ***	-0.002320	0.017428	0.068297 ***	0.026783 ***	-0.019230 ***
	2.96	-0.31	0.82	8.51	12.97	-5.92
(Geographic Herfindahl)$_{t-1}$	0.002686	0.000436	0.000225	-0.002290	-0.002830 ***	0.001840 ***
	0.46	0.29	0.05	-1.51	-7.29	3.03
(Lines of Business Herfindahl)$_{t-1}$	0.021170 ***	-0.000070	-0.012940	-0.002240	-0.010070 ***	0.000765
	2.79	-0.04	-2.31	-1.13	-20.11	0.97
(Reinsurance Usage)$_{t-1}$	-0.008710	-0.002880	-0.011370	-0.009640 ***	-0.000210	-0.002620 ***
	-1.24	-1.59	-2.22	-5.36	-0.46	-3.64
(Group Indicator (=1 if group))$_{t-1}$	0.003325	-0.001660	-0.001100	0.002984 **	0.000044	-0.001050 **
	0.70	-1.35	-0.32	2.29	0.13	-2.00
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.007878	-0.001820	0.005719	0.005157 ***	0.000382	0.003428 ***
	1.62	-1.44	1.60	3.61	1.04	6.00
(Adequate Capitalization (=1 if adequate capitalization))$_t$	-0.049520 ***	-0.000280	-0.003800	0.003034	0.000887	-0.001670 **
	-5.96	-0.13	-0.61	1.36	1.56	-1.88
(Under Capitalized (=1 if under capitalized))$_t$	-0.106950 ***	0.002790	0.002177	-0.007990 **	0.009617 ***	-0.001810
	-11.59	1.11	0.30	-2.44	11.49	-1.38
Log(Assets$_{t-1}$)	-0.002750 ***	0.000530	-0.000140	-0.001610 ***	-0.000550 ***	0.001468 ***
	-1.99	1.47	-0.14	-4.31	-5.75	9.77
(Surplus/Assets)$_t$		0.005470	0.015746 *		0.008986 ***	0.009666 ***
		1.63	1.66		9.62	6.60
(RBC risk-weighted NPW/Surplus)$_t$	0.051055		0.016829	0.090713 ***		-0.004940
	1.47		0.66	7.75		-1.05
(Risky Invested Assets/Invested Assets)$_t$	0.004209	0.003723		0.022761 ***	0.001070	
	0.26	0.90		6.65	1.21	
(Surplus/Assets)$_{t-1}$	0.864262 ***			0.877430 ***		
	76.99			272.64		
(RBC risk-weighted NPW/ Premiums)$_{t-1}$		0.965547 ***			0.887260	
		111.19			330.77	
(Risky Invested Assets/ Invested Assets)$_{t-1}$			0.908678 ***			0.961226 ***
			85.53			724.67
System-weighted R Squared	0.8648			0.9192		
No. of obs.	1864			26668		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients.

Note: RBC risk-weighted NPW is sum of RBC NPW risk factor for premium line* premiums in line. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2. Risky Invested Assets are the sum of stock and real estate investments.

Table 5
Three Stage Least Squares Results
(RBC risk-weighted Invested Asset/Invested Assets)$_t$ used as Dependent Variable
Insurers with RBC Ratio greater than 3

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$
Independent Variables						
Intercept	0.114373 ***	-0.011200	0.000013	0.053722 ***	0.021138 ***	-0.001900 ***
	3.78	-1.60	0.00	6.29	11.63	-4.24
(Geographic Herfindahl)$_{t-1}$	-0.002440	0.001771	-0.000260	-0.001040	-0.001990 ***	0.000270 ***
	-0.41	1.34	-0.45	-0.67	-5.97	3.30
(Lines of Business Herfindahl)$_{t-1}$	0.015615 **	0.002515	-0.001550 **	-0.000130	-0.007270 ***	0.000227 **
	2.02	1.44	-2.01	-0.06	-16.84	2.12
(Reinsurance Usage)$_{t-1}$	-0.010640	-0.002090	-3.001000	-0.009760 ***	0.000002	-0.000280 ***
	-1.51	-1.32	-1.47	-5.22	0.01	-2.87
(Group Indicator (=1 if group))$_{t-1}$	0.004738	-0.000500	0.000288	0.002569 *	-0.000120	-0.000140 **
	0.98	-0.45	0.60	1.90	-0.42	-2.02
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.006384	-0.001680	0.001180 **	0.005947 ***	0.000311	0.000368 ***
	1.29	-1.50	2.40	4.09	1.01	4.85
Log(Assets$_{t-1}$)	-0.004080 ***	0.000805 **	0.000060	-0.001130 ***	-0.000470 ***	0.000169 ***
	-2.80	2.41	0.42	-2.85	-5.61	8.19
(Surplus/Assets)$_t$		0.004600	0.002036		0.006802 ***	0.000662 ***
		1.59	1.60		8.54	3.37
(RBC risk-weighted NPW/Surplus)$_t$	0.017317		0.004174	-0.123377 ***		-0.000340
	0.39		0.93	9.65		-0.51
(RBC risk-weighted Invested Assets/Invested Assets)$_t$	0.097031	0.017428		0.155566 ***	0.005434	
	0.78	0.62		6.51	1.06	
(Surplus/Assets)$_{t-1}$	0.871621 ***			0.876914 ***		
	77.83			255.30		
(RBC risk-weighted NPW/ Premiums)$_{t-1}$		0.975085 ***			0.914480 ***	
		99.19			364.54	
(RBC risk weighted Invested Assets/ Invested Assets)$_{t-1}$			0.893606 ***			0.973725 ***
			80.54			796.28
System weighted R-squared	0.8577			0.9363		
No. of obs.	1605			24170		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients.

Note: RBC risk-weighted NPW is sum of RBC NPW risk factor for premium line* premiums in line. RBC risk-weighted Invested Assets is sum of RBC asset risk factor by type * asset type. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2.

Table 6
Three Stage Least Squares Results
(Risky Invested Assets/Invested Assets)$_t$ used as Dependent Variable
Insurers with RBC Ratio greater than 3

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(Risky Invested Assets/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(RBC risk-weighted NPW/Premium)$_t$	(Risky Invested Assets/ Invested Assets)$_t$
Independent Variables						
Intercept	0.112471 ***	-0.011620 *	0.043051 *	0.052164 ***	0.021086 ***	-0.018610 ***
	3.76	-1.68	1.91	6.13	11.64	-5.61
(Geographic Herfindahl)$_{t-1}$	-0.002520	0.001758	-0.001260	-0.001180	-0.001990 ***	0.001858 ***
	-0.43	1.33	-0.29	-0.75	-5.98	3.06
(Lines of Business Herfindahl)$_{t-1}$	0.015581 **	0.002499	-0.017480 ***	0.000024	-0.007260 ***	0.001309
	2.01	1.43	-3.08	0.01	-16.81	1.64
(Reinsurance Usage)$_{t-1}$	-0.010640	-0.002090	-0.011920 **	-0.009820 ***	0.000001	-0.001990 ***
	-1.51	-1.32	-2.32	-5.26	0.00	-2.75
(Group Indicator (=1 if group))$_{t-1}$	0.004846	-0.000480	-0.000250	0.002704 **	-0.000110	-7.001000 **
	1.00	-0.45	-0.07	2.00	-0.40	-2.04
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.006433	-0.001660	0.005926	0.005782 ***	0.000305	0.003128 ***
	1.29	-1.48	1.63	3.95	0.98	5.53
Log(Assets$_{t-1}$)	-0.003970 ***	0.000829 **	-0.001490	-0.001050 ***	-0.000470 ***	0.001406 ***
	-2.77	2.53	-1.39	-2.66	5.60	9.20
(Surplus/Assets)$_t$		0.004754 *	0.006967		0.006818 ***	0.007747 ***
		1.66	0.75		8.56	5.32
(RBC risk-weighted NPW/Surplus)$_t$	0.017223		0.029560	0.122641 ***		-0.002980
	0.38		0.90	9.59		-0.60
(Risky Invested Assets/Invested Assets)$_t$	0.104650	0.001728		0.021220 ***	0.000748	
	0.66	0.48		6.05	1.00	
(Surplus/Assets)$_{t-1}$	0.872224 ***			0.877356 ***		
	78.49			265.46		
(RBC risk-weighted NPW/ Premiums)$_{t-1}$		0.975065 ***			0.914454 ***	
		99.17			364.46	
(Risky Invested Assets/ Invested Assets)$_{t-1}$			0.926495 ***			0.966181 ***
			85.89			730.83
System-weighted R Squared	0.8610			0.9289		
No. of obs.	1605			24170		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients

Note: RBC risk-weighted NPW is sum of RBC NPW risk factor for premium line* premiums in line. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2. Risky Invested Assets are the sum of stock and real estate investments.

Appendix Table 1
Three Stage Least Squares Results
(RBC risk-weighted Invested Asset/Invested Assets)$_t$ used as Dependent Variable
All Insurers

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$
Independent Variables						
Intercept	0.091251 ***	-0.048900	-0.001680	0.086175 **	-0.005140	-0.002210 ***
	3.23	-1.63	-0.94	11.09	-0.60	-5.19
(Geographic Herfindahl)$_{t-1}$	0.004049	-0.009530	-0.000290	-0.002990 **	-0.005080 ***	0.000232 ***
	0.69	-1.57	-0.81	-1.98	-3.10	2.84
(Lines of Business Herfindahl)$_{t-1}$	0.018051 ***	0.007997	0.000078	-0.007800 ***	0.007502 ***	0.000167
	2.38	1.01	0.17	-3.95	3.52	1.58
(Reinsurance Usage)$_{t-1}$	-0.008500	-0.014230 **	-0.000300	-0.010050 ***	-0.000600	-0.000380 ***
	-1.22	-1.97	-0.70	-5.58	-0.31	-3.95
(Group Indicator (=1 if group))$_{t-1}$	0.004221	-0.007590	-0.000100	0.003080 **	-0.002190	-0.000140 *
	0.89	-1.55	-0.35	2.35	-1.55	-1.96
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.006769	-0.004080	0.000619 **	0.005463 ***	-0.000930	0.000495 ***
	1.40	-0.81	2.07	3.81	-0.60	6.42
(Adequate Capitalization (=1 if adequate capitalization))$_t$	-0.049940 ***	0.011013	-0.001000 *	0.004757 **	0.005123 **	-0.000480 ***
	-6.04	1.25	-1.91	2.15	2.15	-3.99
(Under Capitalized (=1 if under capitalized))$_t$	-0.107130 ***	0.031746 ***	0.000042	-0.004130	0.024572 ***	-0.000870 ***
	-11.88	3.20	0.07	-1.28	7.03	-5.00
Log(Assets$_{t-1}$)	-0.002750 **	0.002805 *	0.000121	-0.001840 ***	0.000518	0.000195 ***
	-1.97	1.92	1.39	-4.87	1.26	9.51
(Surplus/Assets)$_t$		0.053655 ***	0.002206 ***		0.009384 **	0.000730 ***
		3.87	2.67		2.44	3.80
(Risky Lines NPW/Premiums)$_t$	0.020470 ***		0.000085	0.007128 ***		-0.000001
	3.14		0.21	4.13		-0.01
(RBC risk-weighted Invested Assets/Invested Assets)$_t$	0.064183	-0.023820		0.191670 ***	-0.041480	
	0.55	-0.20		6.51	-1.30	
(Surplus/Assets)$_{t-1}$	0.856946 ***			0.882250 ***		
	74.50			280.32		
(Risky Lines NPW/Premiums)$_{t-1}$		0.957679 ***			0.956948 ***	
		146.27			535.26	
(RBC risk weighted Invested Assets/ Invested Assets)$_{t-1}$			0.937511 ***			0.961043 ***
			138.93			626.00
R-squared	0.9199			0.9228		
No. of obs.	1864			26668		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients.

Note: Risky Lines NPW is the sum of premiums written in risky lines that have the highest NPW risk factor loadings. RBC risk-weighted Invested Assets is sum of RBC asset risk factor by type * asset type. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2⩽RBC ratio<3 and under-capitalized if RBC ratio <2.

Appendix Table 2
Three Stage Least Squares Results
(Risky Invested Assets/Invested Assets)$_t$ used as Dependent Variable
All Insurers

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(Risky Invested Assets/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(Risky Invested Assets/ Invested Assets)$_t$
Independent Variables						
Intercept	0.089663 ***	-0.046840	0.018552	0.084601 ***	-0.006370	-0.018420 ***
	3.20	-1.57	1.31	10.97	-0.75	-5.86
(Geographic Herfindahl)$_{t-1}$	0.003988	-0.009470	-0.001840	-0.003170 **	-0.005050 ***	0.001823 ***
	0.68	-1.57	-0.64	-2.09	-3.08	3.01
(Lines of Business Herfindahl)$_{t-1}$	0.017966 **	0.008275	-0.004900	-0.007560 ***	0.007302 ***	0.000756
	2.36	1.04	-1.30	-3.82	3.43	0.96
(Reinsurance Usage)$_{t-1}$	-0.008550	-0.014080 *	-0.004300	-0.010050 ***	-0.000800	-0.002700 ***
	-1.23	-1.95	-1.25	-5.58	-0.41	-3.75
(Group Indicator (=1 if group))$_{t-1}$	0.004269	-0.007600	-0.001440	0.003231 **	-0.002290	-0.001190 **
	0.90	-1.55	-0.62	2.46	-1.61	-2.26
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.006862	-0.004370	0.002819	0.005267 ***	-0.000570	0.003758 ***
	1.41	-0.87	1.18	3.66	-0.36	6.53
(Adequate Capitalization (=1 if adequate capitalization))$_t$	-0.049900 ***	0.010821	-0.005490	0.004667 **	0.005255 **	-0.001980 **
	-6.03	1.23	-1.32	2.11	2.20	-2.23
(Under Capitalized (=1 if under capitalized))$_t$	-0.107020 ***	0.031472 ***	-0.001460	-0.004270	0.024760 ***	-0.002590 **
	-11.87	3.18	-0.31	-1.32	7.08	-2.00
Log(Assets$_{t-1}$)	-0.002650 *	0.002668 *	-0.000450	-0.001770 ***	0.000604	0.001457 ***
	-1.93	1.85	-0.66	-4.72	1.48	9.67
(Surplus/Assets)$_t$		0.052480 ***	0.007221		0.010197 ***	0.007781 ***
		3.82	1.10		2.65	5.48
(Risky Lines NPW/Premiums)$_t$	0.020357 ***		0.005972 *	0.007116 ***		-0.000370
	3.13		1.84	4.12		-0.54
(Risky Invested Assets/Invested Assets)$_t$	0.005830	0.001964		0.026509 ***	-0.009570 **	
	0.39	0.12		6.57	-2.18	
(Surplus/Assets)$_{t-1}$	0.857588 ***			0.882411 ***		
	75.06			281.09		
(Risky Lines NPW/Premiums)$_{t-1}$		0.957807 ***			0.956923	
		146.48			535.29	
(Risky Invested Assets/ Invested Assets)$_{t-1}$			0.954977 ***			0.955600 ***
			133.96			615.06
System-weighted R Squared	0.9168			0.9209		
No. of obs.	1864			26668		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients.

Note: Risky Lines NPW is the sum of premiums written in risky lines that have the highest NPW risk factor loadings. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2. Risky Invested Assets are the sum of stock and real estate investments.

Appendix Table 3
Three Stage Least Squares Results
(RBC risk-weighted Invested Asset/Invested Assets)$_t$ used as Dependent Variable
Insurers with RBC Ratio greater than 3

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(RBC risk-weighted Invested Asset/ Invested Assets)$_t$
Independent Variables						
Intercept	0.114366 ***	-0.064330 **	0.000594	0.078521 ***	-0.004430	-0.001900 ***
	3.90	-1.97	0.34	9.65	-0.52	-4.41
(Geographic Herfindahl)$_{t-1}$	-0.001160	-0.009400	-0.000310	-0.002370	-0.004480 ***	0.000261 ***
	-0.20	-1.47	-0.90	-1.51	-2.77	3.20
(Lines of Business Herfindahl)$_{t-1}$	0.011857	0.010148	-0.000430	-0.007380 ***	0.009826 ***	0.000214 **
	1.53	1.21	-0.95	-3.62	4.68	2.02
(Reinsurance Usage)$_{t-1}$	-0.010640	-0.014200 *	-0.000250	-0.010120 ***	-0.000080	-0.000300 ***
	-1.52	-1.87	-0.63	-5.40	-0.04	-3.06
(Group Indicator (=1 if group))$_{t-1}$	0.005807	-0.008270	0.000035	0.002721 **	-0.002430 *	-0.000160 **
	1.20	-1.58	0.13	2.00	-1.72	-2.24
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.005308	-0.003900	0.000618 **	0.006190 ***	-0.001070	0.000418 ***
	1.07	-0.73	2.16	4.22	-0.70	5.49
Log(Assets$_{t-1}$)	-0.003940 ***	0.003671 **	0.000002	-0.001460 ***	0.000436	0.000175 ***
	-2.72	2.30	0.02	-3.67	1.05	8.41
(Surplus/Assets)$_t$		0.055153 ***	0.001510 **		0.008124 **	0.000515 ***
		3.90	1.99		2.15	2.71
(Risky Lines NPW/Premiums)$_t$	0.017919 ***		-0.000002	0.008597 ***		-0.000030
	2.59		-0.01	4.72		-0.27
(RBC risk-weighted Invested Assets/Invested Assets)$_t$	0.104374	-0.027960		0.194789 ***	-0.040620	
	0.90	-0.22		6.49	-1.30	
(Surplus/Assets)$_{t-1}$	0.865356 ***			0.883265 ***		
	75.89			273.82		
(Risky Lines NPW/Premiums)$_{t-1}$		0.953292 ***			0.957983 ***	
		132.68			528.69	
(RBC risk weighted Invested Assets/ Invested Assets)$_{t-1}$			0.953528 ***			0.967922 ***
			147.81			635.33
R-squared	0.9252			0.929		
No. of obs.	1605			24170		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients.

Note: Risky Lines NPW is the sum of premiums written in risky lines that have the highest NPW risk factor loadings. RBC risk-weighted Invested Assets is sum of RBC sset risk factor by type * asset type. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2.

Appendix Table 4
Three Stage Least Squares Results
(Risky Invested Assets/Invested Assets)$_t$ used as Dependent Variable
Insurers with RBC Ratio greater than 3

Results for Year(s)	**1992**			**1994-2007 with year dummies**		
Dependent Variable	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(Risky Invested Assets/ Invested Assets)$_t$	(Surplus/ Assets)$_t$	(Risky Lines NPW/Premiums)$_t$	(Risky Invested Assets/ Invested Assets)$_t$
Independent Variables						
Intercept	0.112226 ***	-0.061700 *	0.044349 ***	0.076415 ***	-0.005670	-0.017550 ***
	3.87	-1.91	3.28	9.46	-0.67	-5.53
(Geographic Herfindahl)$_{t-1}$	-0.001240	-0.009360	-0.003080	-0.002540	-0.004450 ***	0.001845 ***
	-0.21	-1.47	-1.16	-1.62	-2.75	3.05
(Lines of Business Herfindahl)$_{t-1}$	0.011831	0.010381	-0.007500 **	-0.007190 ***	0.009639 ***	0.001201
	1.52	1.23	-2.13	-3.52	4.58	1.52
(Reinsurance Usage)$_{t-1}$	-0.010640	-0.014050 *	-0.005220 *	-0.010210 ***	-0.000250	-0.002080 ***
	-1.51	-1.85	-1.65	-5.45	-0.13	-2.87
(Group Indicator (=1 if group))$_{t-1}$	0.005911	-0.008270	-0.001260	0.002854 **	-0.002530	-0.001190 **
	1.23	-1.58	-0.58	2.09	-1.80	-2.26
(Mutual Indicator (=1 if mutual))$_{t-1}$	0.005352	-0.004250	0.001755	0.006083 ***	-0.000720	0.003435 ***
	1.08	-0.79	0.78	4.12	-0.47	6.04
Log(Assets$_{t-1}$)	-0.003820 ***	0.003503 **	-0.001740 ***	-0.001350 ***	0.000521	0.001389 ***
	-2.67	2.23	-2.64	-3.42	1.27	9.10
(Surplus/Assets)$_t$		0.053872 ***	0.001282		0.008887 **	0.006080 ***
		3.84	0.22		2.36	4.33
(Risky Lines NPW/Premiums)$_t$	0.017811		0.003567	0.008550 ***		-0.000130
	2.58		1.13	4.69		-0.19
(Risky Invested Assets/Invested Assets)$_t$	0.011424	0.001893		0.025555 ***	-0.009140 **	
	0.76	0.12		6.18	-2.12	
(Surplus/Assets)$_{t-1}$	0.866068 ***			0.883714 ***		
	76.57			274.59		
(Risky Lines NPW/Premiums)$_{t-1}$		0.953410 ***			0.957974 ***	
		132.79			528.76	
(Risky Invested Assets/ Invested Assets)$_{t-1}$			0.973070 ***			0.961154 ***
			146.20			621.84
System-weighted R Squared	0.9233			0.9271		
No. of obs.	1605			24170		

Note: *, **, *** significant at 10, 5 and 1 percent levels, respectively. T-statistics below coefficients

Note: Risky Lines NPW is the sum of premiums written in risky lines that have the highest NPW risk factor loadings. Reinsurance usage is ceded loss reserves/Total direct and assumed loss reserves. An insurer is considered to be adequately capitalized if 2≤RBC ratio<3 and under-capitalized if RBC ratio <2. Risky Invested Assets are the sum of stock and real estate investments.