Capital Ratios and Property-Liability Insurer Insolvencies

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Abstract

This paper analyzes the ability of two different risk-based capital ratios to predict property-liability insurer insolvencies. The first ratio is the National Association of Insurance Commissioners (NAIC) risk-based capital (RBC) ratio and the second ratio is Best's Capital Adequacy (BCA) ratio, produced by the private rating agency, A.M. Best Company. While the regulatory capital ratio is completely formula-based, the BCA ratio incorporates qualitative adjustments based on the expert judgment of the rating agency. We find that the BCA ratio produces a more powerful insolvency detection model. A simple rank transformation greatly improves the performance of the NAIC RBC ratio, but not enough to surpass the performance of the BCA ratio. We also examine the predictive ability of Best's ratings and find that Best's ratings and BCA are jointly more powerful than either measure alone.

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Introduction

Both the public and private sectors are actively involved in assessing the financial strength of insurance companies. Insurance regulators are interested in the detection and prevention of insurer insolvencies with the goal of minimizing losses to consumers and guaranty funds. Private rating organizations are also vitally interested in the financial condition of insurers. The focus of their business is the provision of information relating to the financial soundness of insurance companies.

In their desire to improve the methods by which the financial condition of insurers is assessed, both regulators (through the National Association of Insurance Commissioners (NAIC)) and the primary private insurer rating organization (A.M. Best) have in recent years developed separate risk-based capital (RBC) models. A risk-based capital ratio is a measure of an insurer's actual level of capital and surplus relative to the level of capital that the risk-based capital model determines is adequate to maintain a particular probability of solvency given the specific risks faced by the insurer. As such, a risk-based capital ratio is a summary measure of financial strength.

The accuracy of the NAIC RBC system is of great interest, especially given the mandatory regulatory interventions built into the system for various RBC thresholds. An inaccurate system has the potential to create significant costs. These costs arise both from misclassifying a distressed firm as financially sound as well as misclassifying a sound firm as distressed. When regulators fail to identify an insurer as weak and that firm later becomes insolvent, costs are imposed on guaranty funds, and thus eventually on policyholders and taxpayers (Lamm-Tennant, Starks and Stokes, 1996). On the other hand, when a financially strong firm is identified as weak, this creates numerous costs. First, regulators must expend their limited resources to examine the firm more closely. Second, the misclassified insurer incurs costs in working with the regulators, providing them with information, making suboptimal decisions based on regulatory pressure, or perhaps losing business if consumers discover the firm has been identified by regulators as weak (Grace, Harrington and Klein, 1998).[1]

RBC for insurers has been the focus of significant research in the academic literature. Cummins, Harrington and Klein (1995) were the first to test the ability of the NAIC's RBC ratios to predict insurer insolvencies. Additional papers have followed that compare the predictive ability of the NAIC RBC versus other solvency monitoring tools, including the NAIC FAST audit ratio system and a cash flow simulation model (Grace, Harrington and Klein, 1998; Cummins, Grace and Phillips, 1997). These previous papers have only compared NAIC RBC either to other regulatory measures (e.g., FAST ratios/scores) or to models not yet used in practice (e.g., a cash flow simulation model). The primary contribution of this paper is that it

[1] For a more complete analysis of the rationale behind risk-based capital and its potential economic consequences, see Cummins, Harrington and Niehaus (1993).

compares the predictive ability of two measures of financial strength currently in use, one produced by regulators and one produced by a private sector rating organization. In addition, both of these measures are of the same genre, risk-based capital ratios. Thus, it provides a unique opportunity to compare the effectiveness of the public and private sectors in assessing the financial strength of insurance companies with the same basic type of tool.

In addition to the primary analysis, comparing the predictive abilities of the NAIC risk-based capital ratio and Best's risk-based capital ratio, we will also present some other interesting comparisons. For example, we will compare the predictive abilities of risk-based capital ratios with non-risk-based capital ratios, as well as Best's risk-based capital ratios versus Best's ratings. The motivations for these comparisons will be explained later in the article.

Cummins, Harrington and Klein (1995), hereafter referred to as CHK, were the first to analyze the ability of NAIC RBC ratios to predict insurer insolvencies. They conclude that the RBC ratio alone provides poor predictive accuracy. Accuracy improves when size and organizational form are added to the prediction model, as well as when RBC is broken down into its components. Grace, Harrington and Klein (1998), hereafter referred to as GHK, followed up on CHK by comparing the predictive abilities of NAIC RBC and the NAIC FAST audit ratio system. They find that FAST scores provide superior predictive power compared to RBC, and that a model containing FAST scores alone is just as good at predicting insolvencies as a model with both FAST and RBC together. Finally, Cummins, Grace and Phillips (1997) compare the predictive abilities of RBC, FAST, and a cash flow simulation model. They find that their cash flow simulation model dominates both RBC and FAST in predicting insolvencies.

GHK conclude their article by noting the inherent limitations of any solvency screening method based solely on accounting data and a formula. They state that it may be "that any formula-based assessment of financial strength will need to be supplemented by additional qualitative and quantitative information and expert judgment to achieve meaningful increases in power" (GKH, p. 241). Best's Capital Adequacy (BCA) Ratio is an attempt to improve upon the NAIC RBC with just such an approach. The present paper will assess the extent to which Best has been able to use this approach to achieve greater predictive accuracy than the NAIC RBC.[2]

The paper will proceed as follows. The next section discusses and compares the NAIC RBC and Best's Capital Adequacy Ratio. The following section presents hypotheses regarding predictive abilities. Next is a section describing the data and methodology to be used. Empirical results are then presented. The final section contains a summary and conclusions.

Comparison of NAIC RBC Ratio and Best's Capital Adequacy Ratio

The NAIC and Best each have their own method of calculating risk-based capital measures. The calculation methods have much in common, but also exhibit significant differences. Both the NAIC and Best define their respective capital ratios as the ratio of available capital to risk-based (required) capital. The NAIC system is entirely formula-based, aggregating risk charges for an insurer's various assets, liabilities and other risks into a single number meant to represent the level of capital required to support the insurer's operating, financial and business risks. Specifically, the NAIC formula incorporates four categories of risk: asset risk, credit risk, underwriting risk, and off-balance sheet risks. Asset risk includes the risk of default for bond

[2] Our measure of NAIC RBC is calculated using "total adjusted capital" and "authorized control level," both of which are available directly from the NAIC statements. We do not attempt to break down RBC into its components. First, this breakdown is not reported in the statements, and thus must be calculated using the NAIC formula. Second, it would be impossible to similarly break down BCAR into its components, since Best's formula is not entirely public and BCAR is not solely formula-based. Finally, our goal is to compare single, summary risk measures. We also do not include any analysis of FAST scores. Although the list of ratios used in the FAST system

investments, as well as the risk of loss in market value of all assets. Credit risk is the risk of not being able to collect on receivables, such as reinsurance recoverables and agents balances. Underwriting risk involves the risk of mispricing insurance and improperly setting reserves. Finally, off-balance sheet risk includes a variety of things such as guarantees for affiliates and premium and reserve growth risk. The formula attempts to recognize diversification across the various risk categories through a covariance adjustment.

Best refers to its risk-based capital measure as Best's Capital Adequacy Ratio, or BCAR. In addition to the four risk categories in the NAIC RBC ratio, BCAR includes an interest rate risk component that considers the potential market value decline in a company's fixed-income portfolio as a result of rising interest rates. The factors applied to determine risk charges are different in many cases, sometimes higher with BCAR and sometimes higher with RBC. In addition to using different factors, and perhaps more important, methodological differences exist between the NAIC RBC and the BCAR. Unlike the NAIC measure, Best's measure reflects qualitative considerations, such as financial flexibility, reinsurance quality and catastrophic loss exposures, in addition to purely quantitative factors. Best's analysts may adjust risk components and risk charges based on qualitative factors. For example, an insurer's BCAR may be adjusted to reflect conservative reserving practices or the support of a financially strong parent organization (Best, 1994). Best has claimed that its risk-based capital system is superior to the NAIC's (Best, 1994), but no published study has documented whether or not this is true. The primary purpose of this paper is to test whether either NAIC RBC or BCAR is superior to the other in predicting property-liability insurer insolvencies.

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is publicly available, the actual scoring system and results are not. GHK were able to calculate FAST scores based on information obtained as part of contract research for the NAIC.

Hypotheses Regarding Predictive Abilities

In this section, we present hypotheses regarding the relative abilities of various summary risk measures to predict insolvencies. Before moving to the central comparison of the relative predictable abilities of the NAIC RBC ratio versus BCAR, we begin at a more fundamental level:

Hypothesis 1: Both the NAIC RBC ratio and BCAR are superior to the non-risk-adjusted capital-to-assets ratio in predicting insolvencies.

It seems logical to first establish that a risk-based capital ratio is superior to a non-risk-based capital ratio in predicting insolvencies before beginning to compare different risk-based capital measures. As a non-risk-based capital ratio, CAP, we will simply use the capital-to-assets ratio of the insurer (Cummins and Sommer, 1996; Sommer, 1996). Obviously, it would be quite surprising if this hypothesis was not supported by the data. However, it is still interesting to test, if only to get an idea of how much of an improvement risk-based capital ratios provide in insolvency prediction relative to non-risk-based capital ratios.

Hypothesis 2: BCAR is superior to the NAIC RBC ratio in predicting insolvencies.

Assuming both the NAIC RBC ratio and BCAR are superior to simple non-risk-adjusted capital ratios, the next, more interesting question is which of the two risk-based measures is better at predicting insolvencies. Unlike Hypothesis 1, it is not obvious that Hypothesis 2 will hold true. RBC and BCAR are two versions of the same tool: risk-adjusted capital ratios. It is quite possible that these two versions of the same tool perform quite similarly, or even that RBC performs better than BCAR. However, there are reasons to expect that BCAR may dominate RBC in predictive ability. Most importantly, the NAIC RBC ratio is entirely formula-based. Adjustments cannot be made even when it may be clear that the unique circumstances of a particular insurer make its RBC ratio a poor measure of capital strength. By contrast, Best's analysts can make adjustments to their formula-produced ratio in arriving at the final BCAR if their analysis determines that it is warranted. For example, adjustments are sometimes made to reflect factors such as reinsurance quality and exposure to catastrophe losses. As noted by GHK, the application of expert judgment in supplementing formula-based output may be the best way to meaningfully improve the predictive accuracy of the NAIC RBC. Thus, our hypothesis is that BCAR is superior to RBC.

Another potential reason to expect that BCAR may be a more accurate predictor of insolvencies than RBC is political pressure. As pointed out by GHK, because the RBC system is designed by regulators it is likely to be influenced by political pressure from insurers. The effect of this political pressure would in all likelihood be a reduction in the accuracy of the system, as weaker insurers attempt to influence the system so that it does not identify them as weak. The extent of political opposition by weak insurers to increased accuracy would be expected to be particularly high due to the fact that the RBC system actually requires various levels of regulatory intervention based on certain RBC thresholds. BCAR, on the other hand, is produced by a private-sector rating agency and triggers no mandatory regulatory action. As such, it may be free of these political influences and thus superior in accuracy.

Hypothesis 3: The NAIC RBC ratio and BCAR jointly provide better predictive ability than either one alone.

Regardless of which risk-based capital ratio is superior in predicting insolvencies, it is possible that using RBC and BCAR together produces better predictions than using either one by itself since the ratios use different risk charges and different methodologies. In other words, the inferior measure may still contain some information not incorporated in the superior measure, such that adding the inferior measure to a model already including the superior measure will add incremental information and thus improve the predictive accuracy of the model.

Hypothesis 4: Best's ratings have greater predictive ability than BCAR.

This hypothesis addresses an issue related exclusively to A.M. Best. In addition to producing the BCAR discussed throughout this article, Best is of course best known for assigning financial strength ratings to insurers. Like BCAR, the letter ratings are summary measures of financial strength. However, BCAR only measures capital strength. Best states that capital adequacy is only one aspect of the rating process, along with such things as profitability, liquidity, competitive position, and reserve adequacy. Therefore, ratings presumably incorporate additional information beyond BCAR and should thus be superior to BCAR in predicting insolvencies.

Hypothesis 5: BCAR and Best's ratings jointly provide better predictive ability than either one alone.

Because BCAR is one of the elements used to determine an insurer's rating, it might be expected that BCAR provides no incremental information beyond that already reflected in the rating. However, ratings are a categorical variable with only thirteen different categories. BCAR, on the other hand, is a continuous variable. Within a given rating category, a range of BCARs would exist. Thus, some information contained in BCAR may be lost when incorporating BCAR into a rating. Therefore, we predict that a model including both ratings and BCAR will perform better than a model containing either one separately.

Data and Methodology

Our data consists of two samples, one for insurers with available data for 1994 and one for insurers with available data for 1995.[3] The samples include all property-liability insurers on the NAIC annual statement data tapes that had admitted assets and net premiums written greater than zero and had available BCARs in Best's Key Rating Guide, Property-Casualty Edition (Best, 1995 and 1996). As in CHK and GHK, we use data for individual insurers rather than groups of affiliated insurers, because RBC standards only apply to individual insurers and the primary focus of solvency regulation is on individual insurers. Our final samples consist of 1542 firms for 1994 and 1787 firms for 1995.

We identified insurers that became insolvent during the period from 1996 to 1998[4] using A.M. Best's list of property-liability insurer insolvencies.[5] Nineteen insurers with available data for 1994 failed in the years 1996 to 1998 (4 in 1996, 11 in 1997 and 4 in 1998). Twenty-six insurers with available data for 1995 failed during this period (4 in 1996, 18 in 1997 and 4 in 1998).

Before moving to multiple regression analysis, we perform some univariate tests. We compare the distributions of the CAP ratios, RBC ratios and BCA ratios for insurers that subsequently failed and insurers that survived through 1998 at various Type I error rates (proportion of insolvent insurers that are classified as solvent) for specified Type II error rates (proportion of solvent insurers that are classified as insolvent). We also conduct statistical tests of the differences in the distributions of capital ratios, log of total assets and organizational form.

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[3] The NAIC and Best each introduced risk-based capital measures starting with the 1994 annual statement year.
[4] BCAR was not available for any 1995 insolvencies for either data year.
[5] A.M. Best classifies an insurer as insolvent if it was subject to regulatory action such as rehabilitation, receivership, conservatorship, involuntary liquidation, or some other type of state supervision.

For our primary analysis, we estimate four logistic regression models. The four models differ with respect to which capital ratios are included. The first model includes the CAP ratio, which does not adjust for a company's risk. The second model includes the NAIC RBC ratio.[6] The third model includes the BCA ratio. The fourth model includes both the RBC ratio and the BCA ratio in order to test the incremental information hypothesis (i.e., hypothesis 3). For comparability with prior studies on risk-based capital and insolvency (Cummins, Harrington and Klein, 1995; Grace, Harrington and Klein, 1998), we include firm size and organizational form in each of these four regressions. The log of total assets is used as a measure of insurer size, and the organizational form variable is a binary variable equal to one if the insurer is a mutual and zero otherwise.[7] Previous insolvency studies provide evidence that small firms have higher insolvency frequency rates and that mutuals have lower insolvency frequency rates. Small firms might underprice insurance to gain market share and tend to have more volatile claim costs than large firms. Mutual insurers might have less incentive to increase risk after policies are issued (Garven and Pottier, 1995). They might also specialize in less risky lines of business than non-mutuals (Lamm-Tennant and Starks, 1993). For each regression, the values of each variable are truncated at their 1st and 99th percentile values to reduce the possible effects of outliers. In an additional analysis, the values of the CAP ratios, RBC ratios and BCA ratios were ranked and these ranked values are used in the logistic regressions. Because the sample was not large enough to use a separate holdout sample, we use the approximate jackknife method described by Pregibon (1981) to calculate predicted probabilities of insolvency to reduce the upward bias that occurs when the same sample is used for estimation and prediction (classification) purposes.

[6] We define the RBC ratio as 50 percent of the ratio of total adjusted capital to the authorized control level. Thus, a ratio of 1 (i.e., 100 percent) would trigger the first level of regulatory intervention (i.e., company action level) rather than a ratio of 2. This "normalization" makes a RBC ratio of 1 comparable to a BCA ratio of 1 in that a BCA ratio of 1 is "adequate" according to A.M. Best standards.

Empirical Results

Univariate tests

While only 15 percent (4 out of 26) of insurers that subsequently became insolvent had RBC ratios in 1995 that would have required regulatory or company action, over 96 percent (25 out of 26) of these insurers had BCA ratios below the adequate level based on A.M. Best standards.[8] While this contrast may appear striking, it does not necessarily imply that BCAR is a vastly superior system to the NAIC RBC. Regulators might have an incentive to have a less stringent standard of capital adequacy than private rating agencies because regulatory intervention is required when the RBC ratio indicates it is warranted, while neither Best nor regulators are required to take any action if the BCA ratio is below the adequate level. In addition, limited regulatory resources might also reduce regulator's incentive to design a stringent RBC system. However, regulators still have an incentive to provide an accurate RBC system in regards to the relative ranking of insurers' capital strength.

Table 1 illustrates the tradeoff between Type I and Type II errors for a specified Type II error rate for each data year and all three capital ratios. The Type I error rate gives the percentage of failed firms with ratios greater than the value, *z*, which produces the specified Type II error rate (percentage of surviving firms with ratios less than *z*). Type II error rates of 5, 10, 15, 20, 25 and 30 percent are shown, as in Grace, Harrington and Klein (1998).[9] For all specified Type II error rates, the BCA ratio produces a lower Type I error rate than the RBC ratio for both samples, providing evidence that BCA is a superior method of identifying financially distressed insurers. The difference in Type I error rates reaches a maximum of 32 percentage points for a

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[7] This definition of the mutual variable follows Grace, Harrington and Klein (1998) and Cummins, Harrington and Klein (1995).
[8] According to A.M. Best a company with a BCA ratio of at least 1 (i.e., 100 percent) is adequately capitalized.

Type II error rate of 30 percent for 1994. BCAR dramatically outperforms CAP. For most Type II error rates, the RBC ratio also produces a lower Type I error than the CAP ratio, implying that even the weaker risk-adjusted capital measure more accurately identifies insolvent insurers than a non-risk-adjusted measure.

Table 2 shows sample means for the variables used in the logistic regression analysis and selected percentile values of the capital ratios for both data years for both solvent and insolvent insurers. For each data year, the RBC, BCA, and capital-to-assets ratios are smaller on average for the failed insurers than the solvent insurers. In addition, insolvent insurers are smaller on average than solvent insurers. These differences between the solvent and insolvent samples of insurers are statistically significant based on Wilcoxon *Z* statistics, except for the CAP ratio and log of assets in 1994. Unlike GHK (1998) and CHK (1995), we do not find any statistically significant difference in the proportions of insolvent and solvent insurers that are mutuals.

The bivariate Spearman rank correlations between the CAP ratio, RBC ratio, BCA ratio and the log of assets are shown in Table 3. While the capital ratios are all significantly positively correlated, the level of these correlations suggests that the capital ratios could differ significantly in their ability to identify financially distressed insurers. Interestingly, RBC is more highly correlated with the non-risk-adjusted capital ratio, CAP, than with BCAR. Consistent with the findings of Pottier and Sommer (1997) for life insurers, risk-based capital ratios and size are negatively correlated. This might imply that larger insurers can attain the same level of insolvency risk as a smaller insurer with a lower level of relative capital.

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[9] The Grace, Harrington and Klein definition of a Type I (Type II) error is the same as our definition of a Type II (Type I) error. We follow the definition used by Cummins, Harrington and Klein (1995).

Logistic regressions

Logistic regression results for the 1994 and 1995 data years are shown in Tables 4 and 5, respectively. For each data year, eight sets of regression results are shown. The main difference among the eight regressions is the capital ratio used in the analysis. Tables 4 and 5 show estimated coefficients and *t*-values, pseudo-R^2 values, and within-sample Type I error rates for Type II error rates from 5 to 30 percent using jackknife predicted probability (of insolvency) values.

As expected, all capital ratios are negatively related to the probability of insolvency, although only the BCA and CAP ratios are statistically significant in both data years. Hypothesis 1, that both RBC and BCAR are superior to CAP in predicting insolvencies, is only partially supported. BCAR performs much better than CAP, but RBC did not perform well compared to CAP for 1995. Surprisingly, the simple non-risk-adjusted CAP ratio produces a lower level of Type I errors than the RBC ratio in 1995 for Type II errors from 5 to 30 percent.

Hypothesis 2 is strongly supported. BCAR consistently outperforms the NAIC risk-based capital ratio by more than ten percentage points. For instance, for the 1995 data year and a Type II error of 30 percent, BCAR correctly classifies 92 percent of insolvent insurers while RBC correctly classifies only 58 percent of insolvent insurers. This result suggests that a better formula and/or the qualitative adjustments made by Best significantly improve the ability of the BCA ratio to identify financially weak insurers compared to RBC.

The RBC ratio also did not perform well when combined with BCAR. Contrary to hypothesis 3, combining RBC and BCAR in a model never improves the accuracy of the model compared to using BCAR alone. In one instance (in 1995 for a Type II error of 10 percent), adding the RBC ratio to BCAR actually reduces classification power compared to BCAR alone.

The coefficient on BCAR continues to be highly significant when the RBC ratio is also included, but the RBC ratio is not ever significant in the presence of BCAR. These results suggest that the inclusion of RBC does not contain any incremental information beyond that incorporated into BCAR.

While the exact reason for the disappointing performance of the RBC ratio is not clear, univariate statistics demonstrate that the distribution of the RBC ratio is more dispersed than the distribution of the BCA ratio.[10] The greater frequency of outliers among the RBC ratio values compared to the BCA ratio might partly explain the weaker performance of the RBC ratio. GHK, CHK and Pottier and Sommer (1997) note that the RBC ratio might be used for ranking insurers' financial strength, despite the NAIC's warnings against using the RBC ratio for such purposes. Consequently, we perform the previous four logistic regressions again using ranked values of the capital ratios (columns 5 to 8, Tables 4 and 5) rather than the actual values to determine if such a transformation will improve the performance of the RBC ratio vis-a-vis the other two capital ratios.

Using ranked values of the capital ratios (RNKCAP, RNKRBC, and RNKBCA), Type I errors for the RBC ratio model are the same or lower for all levels of Type II errors compared to regressions based on actual values (not ranks) of the RBC ratio. In several instances, the improvement is quite dramatic, with a decrease in Type I errors of 20-35 percentage points. The performance of the CAP and BCA ratios is about the same as that based on actual values, but improves or declines slightly in a few instances. Hypothesis 1 is now supported, with both ranked RBC and BCAR outperforming CAP. However, BCAR continues to greatly outperform the other two capital ratios even after the rank transformation.

[10] The RBC ratio has a coefficient of variation (i.e., ratio of standard deviation to mean) of over 2 while the other two capital ratios have coefficients of variation of under one.

The improved performance achieved by using ranked RBC is important. Because RBC is easily available for all insurers on the NAIC data tapes, it is natural for researchers to want to use it in empirical analyses as a measure of insurer financial strength. Our results, along with those of previous researchers, indicate that the RBC ratio itself does not provide a very good proxy for financial strength. However, our findings indicate that using the rank of RBC rather than the actual ratio might well provide a better measure of relative financial strength, though not as good as BCAR.

Another interesting aspect of the regressions reported in Tables 4 and 5 is the results for the size variable in the RBC ratio model and the BCA ratio model. The coefficient on the variable for the log of total assets is negative and significant in the RBC ratio model for both 1994 and 1995, but is not significant for either year in the BCA ratio model. This is also true when the ranked values of the RBC ratios and BCA ratios are used. The NAIC risk-based capital model does not make any adjustment for insurer size nor does it make any qualitative adjustments that might correlate with insurer size even though smaller insurers historically have experienced higher rates of insolvency than larger insurers. The RBC ratio has been criticized for not explicitly adjusting for size-related risk.[11] Several of Best's qualitative adjustments would tend to be correlated with an insurer's size, such as competitive position. The results here reflect this.

Although our main focus is on capital ratios, we also present some results using Best's ratings to investigate hypotheses 4 and 5. Just as the RBC ratio is one of several tools used by regulators to monitor insurer insolvency, the BCA ratio is one, albeit major, component of the insurer rating process. Since capital strength is only one dimension of financial strength and

[11] GHK point out that the NAIC rejected a recommendation of the actuarial advisory group on RBC to include a size factor, fearing a negative effect on small insurers.

Best's ratings are another readily available summary measure of insurer insolvency risk, we provide evidence on the ability of Best's ratings to identify insolvent insurers. These results are shown in Table 6.[12] As expected, the coefficient on the Best's rating variable is negative and significant in all models, implying that property-liability insurers with higher Best ratings have a lower probability of insolvency. The rating variable produces lower Type I error rates than the BCA ratio alone (except for a Type II error rate of 10 percent in 1995), consistent with hypothesis 4. As a test of hypothesis 5, Best's ratings and BCAR are both included in the same regression. Here, the rating variable is significant in both years, while BCAR is significant only in 1995. Most importantly, a model that includes both ratings and BCAR performs better than a model with ratings alone for most Type II error levels, suggesting that BCAR provides incremental information not already fully reflected in the insurer's rating. The additional information in BCAR might be due to its continuous nature compared to the categorical rating variable and variations in financial and capital strength within a given rating category.

Conclusion

In recent years, both a regulatory body, the NAIC, as well as a private sector rating agency, A.M. Best, have developed risk-based capital systems. The NAIC system is entirely formula-based, whereas Best's system incorporates qualitative factors and the expert judgment of analysts. The focus of this article has been on analyzing the effectiveness of each of these systems in predicting insolvencies. The key finding of the empirical analysis is that Best's Capital Adequacy Ratio significantly outperforms the NAIC's RBC ratio. In addition, the inclusion of

[12] The rating variable is an integer value ranging from 0 (D rating, very vulnerable) to 12 (A++ rating, superior). Since a rating is not assigned to all insurers with a Best's capital adequacy ratio, the total sample is reduced to 1464 and 1688, of which 13 and 19 are insolvent insurers, for 1994 and 1995, respectively.

both BCAR and RBC together in a model provides no better predictive ability than using BCAR alone.

Because of the importance of solvency regulation, as well as the key role played in that regulation by RBC, the accuracy of the RBC system is of great interest. Our results demonstrate both that the current NAIC RBC system is a poor predictor of insolvencies and that a more accurate risk-based capital system is possible. If the NAIC wishes to improve the accuracy of its RBC system, it may want to make the system more like Best's. On the other hand, the key to BCARs greater accuracy may lay in the qualitative adjustments made by expert analysts. For political reasons, the NAIC might be compelled to use a system that is completely formula-driven. Thus, it may never be able to improve its system to the point where it compares favorably to BCAR.

One empirical finding of potential importance to regulators and researchers alike is that the predictive ability of NAIC RBC improves dramatically when ranks of the RBC ratios are used rather than the ratios themselves. Therefore, researchers who include RBC in an empirical model as a summary measure of financial strength might be much better off using ranks than actual RBC ratios. Regulators, too, may want to focus more on the ranks of RBC ratios than on absolute levels. It should be noted, however, that even when ranks are used, RBC does not perform as well as BCAR.

Another interesting finding of the article is that despite the fact that Best uses BCAR as part of its rating process, BCAR still provides incremental information not fully reflected in the rating. This is likely due to the fact that BCAR is a continuous measure, whereas ratings are categorical.

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Table 1
Type I and Type II Error Rates for Various Capital Ratios

	1994 data			1995 data		
	CAP	RBC	BCA	CAP	RBC	BCA
Type II error rate (%)	Type I error rate (%)					
5	89	79	63	85	62	42
10	74	68	42	62	46	15
15	68	68	42	50	38	15
20	63	63	37	50	35	12
25	53	58	32	46	27	8
30	53	53	21	38	19	4

Note: Type I error is the percentage of insolvent firms with a value for capital ratio (CAP, RBC or BCA) above the value that produces the specified Type II error rate for solvent firms. CAP=capital-to-assets ratio; RBC=NAIC risk-based capital ratio; BCA=Best's Capital Adequacy ratio.

Table 2
Selected Summary Statistics

		1994 data		1995 data	
Variable	Statistic	Insolvent	Solvent	Insolvent	Solvent
CAP ratio	Mean	0.37	0.42	0.31	0.43
	10%	0.18	0.21	0.15	0.22
	25%	0.20	0.27	0.21	0.28
	50%	0.32	0.36	0.26	0.38
	75%	0.50	0.51	0.33	0.53
	90%	0.69	0.74	0.59	0.77
RBC ratio	Mean	4.39	8.97	3.70	7.52
	10%	1.00	1.72	0.81	1.69
	25%	1.52	2.45	1.18	2.39
	50%	2.97	3.88	1.56	3.59
	75%	4.62	6.80	2.43	5.83
	90%	13.06	15.19	5.60	12.14
BCA ratio	Mean	0.70	1.44	0.50	1.64
	10%	0.23	0.72	0.15	0.73
	25%	0.45	0.88	0.32	0.94
	50%	0.69	1.09	0.50	1.16
	75%	0.90	1.43	0.71	1.59
	90%	0.99	2.29	0.93	2.80
Size	Mean	17.50	17.92	17.32	17.91
Mutual	Mean	0.11	0.20	0.15	0.19
Sample size		19	1522	26	1761

Note: CAP=capital-to-assets ratio; RBC=NAIC risk-based capital ratio; BCA=Best's Capital Adequacy ratio; Size=natural log of assets; Mutual=1 if insurer is a mutual, 0 otherwise.

Table 3
Spearman Correlations

Panel A: data year 1995, 1787 firms				
	CAP	RBC	BCAR	Size
CAP	1	0.73	0.56	-0.46
RBC		1	0.60	-0.28
BCAR			1	-0.11
Size				1

Panel B: data year 1994, 1541 firms				
	CAP	RBC	BCAR	Size
CAP	1	0.74	0.56	-0.48
RBC		1	0.57	-0.32
BCAR			1	-0.14
Size				1

Note: CAP=capital-to-assets ratio; RBC=NAIC risk-based capital ratio; BCAR=Best's Capital Adequacy Ratio; Size=natural log of assets.

Table 4
Multivariate Logistic Regression Results for 1994

Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	1.67	0.32	1.13	1.26	1.48	0.69	-0.01	-0.55
	(0.29)	(0.02)	(0.18)	(0.22)	(0.24)	(0.07)	(0.00)	(0.04)
Size	-0.28	-0.23	-0.13	-0.13	-0.28	-0.23	-0.14	-0.12
	(3.05)	(2.68)	(0.66)	(0.71)	(3.07)	(2.80)	(0.87)	(0.58)
Mutual	-0.82	-0.83	-0.76	-0.78	-0.81	-0.79	-0.85	-0.83
	(1.17)	(1.20)	(1.00)	(1.03)	(1.15)	(1.09)	(1.26)	(1.19)
CAP ratio	-2.48							
	(2.65)							
RBC ratio		-0.08		-0.01				
		(1.73)		(0.05)				
BCA ratio			-3.42	-3.37				
			(19.94)	(18.49)				
RNKCAP					-0.10			
					(3.07)			
RNKRBC						-0.13		0.04
						(5.31)		(0.44)
RNKBCA							-0.36	-0.39
							(16.17)	(14.92)
Pseudo-R^2	0.03	0.03	0.15	0.15	0.03	0.04	0.15	0.15
Type II error rate (%)	Type I error rate (%)							
5	100	100	68	68	95	95	68	74
10	90	79	53	53	90	79	53	53
15	79	68	53	53	74	68	53	53
20	74	63	47	47	68	63	42	42
25	68	58	37	37	68	53	42	42
30	63	58	26	26	68	47	32	32

Note: t-statistics in parentheses. CAP=capital-to-assets ratio; RBC=NAIC risk-based capital ratio; BCA=Best's Capital Adequacy ratio; RNKCAP=rank of CAP; RNKRBC=rank of RBC; RNKBCA=rank of BCA; Size=natural log of assets; Mutual=1 if insurer is a mutual, 0 otherwise.

Table 5
Multivariate Logistic Regression Results for 1995

Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	6.80	1.34	0.75	0.74	6.36	2.66	-0.35	0.05
	(-6.09)	(0.37)	(0.09)	(0.09)	(5.77)	(1.54)	(0.02)	(0.00)
Size	-0.49	-0.28	-0.07	-0.07	-0.51	-0.30	-0.08	-0.10
	(11.23)	(5.20)	(0.25)	(0.24)	(12.16)	(6.12)	(0.31)	(0.45)
Mutual	-0.35	-0.35	-0.23	-0.23	-0.35	-0.16	-0.16	-0.17
	(0.40)	(0.41)	(0.13)	(0.13)	(0.38)	(0.08)	(0.08)	(0.09)
CAP ratio	-6.62							
	(14.81)							
RBC ratio		-0.13		0.00				
		(3.08)		(0.00)				
BCA ratio			-4.14	-4.15				
			(39.22)	(37.06)				
RNKCAP					-0.23			
					(21.87)			
RNKRBC						-0.25		-0.03
						(21.77)		(0.30)
RNKBCA							-0.62	-0.58
							(23.67)	(18.09)
Pseudo-R^2	0.09	0.04	0.27	0.27	0.11	0.13	0.27	0.27
Type II error rate (%)	Type I error rate (%)							
5	77	100	50	50	77	73	50	50
10	73	89	23	27	69	50	23	31
15	50	65	19	19	46	31	15	15
20	35	50	15	15	39	27	12	12
25	35	42	12	12	35	23	8	12
30	31	42	8	8	35	23	8	8

Note: t-statistics in parentheses. CAP=capital-to-assets ratio; RBC=NAIC risk-based capital ratio; BCA=Best’s Capital Adequacy ratio; RNKCAP=rank of CAP; RNKRBC=rank of RBC; RNKBCA=rank of BCA; Size=natural log of assets; Mutual=1 if insurer is a mutual, 0 otherwise.

Table 6
Multivariate Regression Results Including Best's Ratings

	1994 data year			1995 data year		
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-3.85	0.37	-1.61	-2.85	1.02	-0.98
	(1.72)	(0.01)	(0.25)	(1.17)	(0.14)	(0.12)
Size	0.17	-0.12	0.06	0.16	-0.13	0.07
	(0.94)	(0.43)	(0.09)	(0.98)	(0.60)	(0.15)
Mutual	-0.39	-0.42	-0.44	-0.11	-0.01	-0.18
	(0.24)	(0.29)	(0.31)	(0.03)	(0.01)	(0.08)
Rating	-0.49		-0.33	-0.59		-0.39
	(19.29)		(5.20)	(45.56)		(12.92)
BCA ratio		-3.04	-1.40		-3.42	-1.75
		(10.92)	(1.85)		(21.53)	(6.45)
Pseudo-R^2	0.12	0.11	0.14	0.22	0.21	0.26
Type II error rate (%)	Type I error rate (%)					
5	92	92	92	58	63	58
10	77	77	69	37	32	26
15	39	69	31	26	32	5
20	23	69	31	11	21	5
25	8	62	0	0	11	5
30	8	39	0	0	5	5

Note: t-statistics in parentheses. BCA=Best's Capital Adequacy ratio; Rating=Best's rating, an integer from 0 to 12 for rating categories D to A++; Size=natural log of assets; Mutual=1 if insurer is a mutual, 0 otherwise.