A NON-PARAMETRIC APPROACH TO EVALUATING REINSURERS' RELATIVE FINANCIAL STRENGTH

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ABSTRACT

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There have been a number of past attempts aimed at taking financial data on individual companies, and using this data to produce a predictive model of insurance company solvency. These models have come in two forms: parametric and non-parametric. For example, the NAIC, with its eleven Early Warning Tests, is taking a non-parametric approach to this problem, while the AIA has used a parametric approach in producing its formula for assessing an insurer's financial strength. In trying to evaluate a reinsurer's financial strength, however, these two systems have several shortcomings. The first is that all past models were developed by analyzing a primary company data base, and it is not clear that a model created for primary companies will be effective when applied to reinsurance companies. The second is that even when applied to primary companies, the predictive power of these models is questionable.

Our model for assessing a reinsurer's financial strength is non-parametric. By using five years of data (1980-84) and two sets of ten companies (financially strong vs. financially weak), we identified those financial ratios which have historically discriminated between the strong and weak companies. These historically consistent discriminators have been used to produce a current ranking of reinsurers based on relative financial strength. Based on this model, most of the companies which currently have poor Best's ratings are identified as financially weak using 1981 data, which is a far better performance than any of the existing solvency-tracking models. Going forward, we feel that given similar economic/insurance industry conditions as existed during the early 1980's, this model will do a good job of predicting future problem reinsurers.

I. INTRODUCTION

Evaluating the solvency of an individual insurance market is at best a difficult task. Due to the underwriting practices prevalent during the industry's recent past, many companies are still feeling the aftereffects on their bottom line. The reinsurance market has been especially hard hit, with numerous companies either withdrawing from the market voluntarily or by state order, thus causing a capacity shortage in certain areas of reinsurance. At the same time, as both direct and reinsurance rates have rebounded, new untested capacity has started to enter into the reinsurance arena. While solvency-tracking models have been in place for many years, there have been no models developed specifically for the reinsurance industry. In this paper we present a non-parametric model for ranking reinsurance companies according to their relative financial strength, and compare its results to the NAIC model which has been used in the past, but which was not specifically developed for reinsurers. It should be noted here that in formulating this model, our goal was not to produce something which would replace all existing solvency-tracking systems. Rather, our intent, much like the NAIC's, was to produce a straightforward method for quickly developing a ranking based on relative financial strength, with the results being used to highlight those companies where a more extensive review of the financials is most urgently needed.

II. HISTORY

As mentioned, a number of models have been produced in the past, none of which specifically address reinsurers. These models can generally be split

into two broad categories: (1) Non-parametric, and (2)Parametric. A brief review of three of these models follows:

1. NAIC Early Warning Tests - Non-Parametric

Established over a decade ago, the IRIS (Insurance Regulatory Information System) tests consist of the following eleven ratios which provide a quick overview of a company's operations:

		Acceptable Range
1.	Net Written Premium to Surplus	$\leq$ 3.0
2.	Change in Net Written Premium	-33% to +33%
3.	Surplus Aid to Surplus	$<$25%
4.	Two-Year Adjusted Underwriting Ratio	$<$110%
5.	Investment Yield	$\geq$ 6%
6.	Change in Surplus	-10% to +50%
7.	Liabilities to Liquid Assets	$<$ 105%
8.	Agents' Balances to Surplus	$<$40%
9.	One-Year Reserve Development to Surplus	$<$ 25%
10.	Two-Year Reserve Development to Surplus	$<$ 25%
11.	Estimated Current Reserve Deficiency to Surplus	$<$ 25%

Acceptable ranges have been established for each ratio, and any company which fails four or more of these tests is classified as a "priority" company.

In applying these Early Warning Tests to reinsurance companies, several shortcomings in this model become apparent. First, since only one set of

acceptable ranges has been established for the entire insurance industry, they may not be stringent enough to identify "priority" reinsurance companies. For example, while a Premium to Surplus ratio of 3.0 may be fine for a direct company, it may not be proper for a reinsurance company. More importantly, nowhere has it been shown that any of these eleven ratios even possess any predictive power in identifying "priority" reinsurers.

In order to assess the adequacy of the NAIC system, a database was established for eighty-four domestic companies which predominantly wrote a reinsurance book and also had annual net written premiums of at least $1 million over the 1980-84 period. For these eighty-four companies which comprise our domestic reinsurance "industry", the distribution by number of test failures is shown below:

Number of Failures:		1980	1981	1982	1983	1984	1985
	0	33	41	31	19	5	1
	1	29	23	28	22	11	10
	2	12	11	17	18	16	13
	3	7	4	5	15	13	14
	4	0	1	3	8	14	19
	5+	3	4	0	2	25	27

As is shown, the first point at which a significant number of "priority" companies are identified is when year-end 1983 data is available, which would be early 1984. This can hardly be described as an "early warning". It is safe to say that a reinsurance buyer, relying solely on NAIC Early Warning Test results as an authoritative statement regarding the financial strength of its reinsurers, could have easily made a number of costly mistakes in its choice of

reinsurers. Moreover, unlike individual policyholders who have the state guaranty funds to fall back on in case of a bad insurance-buying decision, an insurance company which makes a mistake in its choice of reinsurance markets has no such safety net.

2. A. M. Best Ratings

A. M. Best Inc. founded in 1899, annually assigns ratings to some several thousand domestic insurers. These ratings range from a high of A+ (Excellent) to a low of C (Fair). There are also a number of conditions under which Best will not assign a letter rating, for example: NA-3 (Insufficient Experience), NA-6 (Reinsured by Unrated Reinsurer), NA-7 (Below Minimum Standards), and NA-10 (Under State Supervision).

As described in their literature, Best reviews a number of financial ratios as a part of its analysis, with these ratios coming from the following general areas:

1. Profitability Tests
2. Leverage Tests
3. Liquidity Tests
4. Loss Reserve Tests
5. Cash Flow Tests

A listing of the individual tests is given in Exhibit 1.

While details of their rating assignment methodology are not known, there is no question that A. M. Best ratings have historically been

heavily relied upon as an aid in making both insurance and reinsurance buying decisions. However, as with the NAIC Early Warning System, the question which must be addressed is whether or not the Best ratings are appropriate for the reinsurance industry in general, and whether or not they provided an early warning against some of the "weak" reinsurers. Shown below is the historical distribution of companies by Best rating for the eighty-four companies in our domestic reinsurance industry data base:

		1980	1981	1982	1983	1984	1985
Best Rating:	A+	37	37	32	26	7	4
	A	12	18	31	37	37	28
	B+	7	5	2	5	14	19
	B	2	2	3	3	1	2
	C+	1	-	-	1	-	1
	C	-	-	-	-	-	-
	NA-3	25	22	16	9	7	4
	NA-6	-	-	-	-	-	6
	NA-7	-	-	-	1	10	6
	NA-10	-	-	-	-	-	1
	Other	-	-	-	2	8	13
	Total	84	84	84	84	84	84

Similar to the NAIC Early Warning Tests, the A. M. Best Ratings do not show a significant downward movement until 1984.

3. AIA Formula - Parametric

The AIA model, developed by Aetna Life and Casualty and completed in 1978, applies a mathematical formula, designed to differentiate between solvent and insolvent companies, to a set of five ratios. This formula is shown below:

Company Score = 19.00916 minus (.11305) x (Two-year Operating Ratio)
minus (.04106) x (Liabilities to Liquid Assets)
minus (.06742) x (Change in Surplus)
minus (.00335) x (Net Written Premium to Loss and Loss Adjustment Expense Reserves)
minus (.07314) x (Change in Liability Mix)

A company's score produced by this formula is then compared to the following index of financial strength:

Score (S)	Index of Financial Strength
$2.2 \leq S$	10 Very Strong
$1.4 \leq S < 2.2$	9
$1.0 \leq S < 1.4$	8
$.5 \leq S < 1.0$	7
$0 \leq S < .5$	6
$-.5 \leq S < 0$	5
$-1.0 \leq S < -.5$	4
$-1.4 \leq S < -1.0$	3
$-2.2 \leq S < -1.4$	2
$S < -2.2$	1 Very Weak

Due to the unavailability of some of the necessary data, we did not test the AIA model's predictive power. However, it is reasonable to assume that since this model was derived from a general insurance industry base and not from a specific reinsurance industry base, its results, much like the NAIC model, would not provide the necessary "early warning".

III. CHOICE OF MODELS: PARAMETRIC VS. NON-PARAMETRIC

While not meant to be an exhaustive discussion of the pros and cons of either model, we have listed below a few points to be considered with each model.

Advantages of a Parametric Model

1. In a non-parametric model, such as the NAIC system, each of the eleven ratios receives an equal weight in determining whether or not a company

will be designated a "priority", while with a parametric approach, such as the AIA system, each ratio is assigned a weight (coefficient) which attempts to reflect that ratio's relative discriminative power.

2. Through use of a parametric model, all collinear variables (i.e. ratios that don't provide any additional explanatory power) can be removed, which is a step that can be easily overlooked in a non-parametric system.

3. There is probably some appeal to the idea that through a formula approach, such as the AIA model, all the information for an individual company can be consolidated into a single number (score), which is not only an immediate indicator of that company's financial strength (e.g., Positive Score = Strong, Negative Score = Weak), but also an item which can be computed on a pocket calculator.

Advantages of a Non-Parametric Model

1. In an attempt to produce an efficient, streamlined formula, the parametric models simply do not incorporate as much data as do the non-parametric models. For example, the NAIC model uses eleven ratios, while the AIA model uses only five. Thus, it is possible that the non-parametric models may pinpoint some of the "priority" companies sooner, since more data is being used to evaluate these companies.

2. Through the use of a non-parametric model, it is more readily apparent as to which areas are causing a company's problems. This can be done by simply tracking which NAIC tests a company is failing. In the formula approach, it is much more difficult to deduce what area is causing the company to receive its unfavorable final score.

3. Perhaps the greatest advantage of a non-parametric approach is that the ratios are treated as random variables, and in our model these random variables are combined in a theoretically consistent manner.

The theoretical basis for our model can therefore be formulated in terms of a hypothesis test; a description of the theoretical basis for our model is included in the Appendix.

IV. THE NON-PARAMETRIC MODEL

Data was collected for eighty-four companies which predominantly wrote a reinsurance book, and which had net written premiums of at least $1 million for each of the years 1980-84. For these companies, twenty-two ratios were tested in order to determine their discriminative power. These ratios, along with their median values by year, are shown in Exhibit 2.

1. Selection of Ratios

The first step in the process was to establish a set of ten financially strong and ten financially weak companies. Then, for each of the twenty-two ratios a non-parametric statistical test, the Wilcoxon Rank Sum test, was performed in order to identify those ratios which have historically segregated the strong and weak companies into two distinct groups.

Briefly, the Wilcoxon Rank Sum test works as follows:

For a given ratio (e.g., Gross Leverage) and a given year (e.g., 1980) the twenty companies were ranked in ascending order. Then, the ranks of the

ten "strong" companies and the ranks of the ten "weak" companies were summed. If the Gross Leverage ratio perfectly distinguished between the two groups back in 1980, the rank sums would be 55 and 155, respectively, for the "strong" and "weak" groups. For this particular example, the actual rank sums were 84 for the "strong" companies and 126 for the "weak" companies, which indicates that this ratio displayed substantial discriminative power as early on as 1980.

The Wilcoxon test was performed on each of the ratios for each of the five years of data, with the results being used to choose those ratios which consistently (1980-84) discriminated between the two groups of companies. The results of this Wilcoxon Rank Sum Test are shown in Exhibit 3; based on this procedure, the following ten ratios were chosen as being "good" discriminators:

Gross Leverage

Surplus Aid to Surplus

Operating Ratio

Net Operating Income to Net Earned Premium

Yield on Investments

Premium Balances to Surplus

Ceded Leverage

1-Year Loss Development to Surplus

2-Year Loss Development to Surplus

Gross Leverage/Net Leverage

For those ratios which were not identified as being "good", an additional technique was employed. By redefining the test ratio to be the absolute value of the difference between the company's actual ratio and that ratio's industry median value, an attempt was made to additionally highlight those ratios, such as Change in Net Written Premium, where the "strong" companies may be clustered around the median value, while the "weak" companies will show up at both extremes. By redefining these remaining ratios and then performing the Wilcoxon test, the following ratios were additionally identified as being "good" discriminators:

Change in Net Written Premium

Combined Ratio

Estimated Reserve Deficiency

(% Change in Gross Leverage)/(% Change in Net Leverage)

Exhibit 4 shows the results of the Wilcoxon test on the redefined ratios for each year.

Thus, of the initial twenty-two ratios, fourteen of these have historically shown an ability to discriminate between "strong" and "weak" reinsurance companies.

2. Ranking Methodology

Given the fourteen ratios, our method for ranking the companies works as follows:

A. For each year of data (1980-84), the companies were ranked (1 through 84), for each of the fourteen ratios individually.

B. For each company/year, that company's average rank for the fourteen ratios was computed.

C. For each individual year, a final ranking of the companies was prepared by ordering the companies based on their 14-ratio average ranks.

D. Our "best guess" at ranking the companies was made by then taking a weighted average of the 1982, 1983 and 1984 individual year rankings, with relative weights of 1:2:4 being judgmentally used to arrive at a final ranking.

V. RESULTS

How well would this ranking technique have worked historically? We have tried to evaluate our results in several different ways as a means to answering this question. First of all, has there been any consistency to the rankings we have developed? To address this question we have (1) used the 1982-84 weighted average ranking as our "best guess" of the correct ranking, (2) eliminated the ten "strong" and ten "weak" companies from our eighty-four company data base, and (3) split the remaining sixty-four companies into thirds (Top 21, Middle 22, Bottom 21). We have then looked back to see if these companies have historically fallen into the same categories based on the individual year rankings (1981-84). For example, Exhibit 5 shows us that

thirteen of the current Top 21 companies were also ranked in the Top 21 based on the 1981 data, while six were ranked in the Middle 22 and two were ranked in the Bottom 21. More importantly, it shows that only one of the current Bottom 21 was ranked in the Top 21 based on 1981 data. If we look at 1982 data, seventeen of the current Bottom 21 companies were already correctly identified.

A second, more important issue is that while the rankings may have exhibited reasonable consistency over the years, are they correct? To help answer this question, we looked at the average Best rating assigned to companies in our Top 21, Middle 22 and Bottom 21 historically. We have assigned the following point scheme to the Best ratings:

Rating	Points
A+	8
A	7
B+	6
B	5
C+	4
C	3
NA-7 (Below Minimum Standards)	2
NA-10 (Under State Supervision)	1
Liquidated	0

Using the 1982-84 weighted average ranks as a base, we have computed the average Best ratings historically assigned to the current Top 21, Middle 22, and Bottom 21 companies. As a point of comparison, we have also displayed the average Best ratings of the ten "strong" and ten "weak" companies which were used to develop this model.

AVERAGE BEST'S RATINGS

	1980	1981	1982	1983	1984'	1985
Top 21*	7.5	7.6	7.5	7.4	6.7	6.4
Middle 22*	7.5	7.6	7.5	7.4	6.8	6.3
Bottom 21*	7.1	7.2	7.1	6.4	3.9	3.7
"Strong" 10	7.8	7.6	7.6	7.7	7.6	7.3
"Weak" 10	7.1	7.2	6.9	6.0	3.6	2.5

*Based on 1982-84 weighted average ranking

Alternatively, if we rank the companies based solely on 1981 data, the same movement in the average Best ratings is again apparent:

	1980	1985
Top 21**	7.7	6.3
Middle 22**	7.4	5.6
Bottom 21**	7.1	4.3

**Based on 1981 Ranking

As can be seen, while the Bottom 21 companies clearly are carrying a much lower average Best rating today, that was not the case back in 1980. However, since our rankings have exhibited the necessary consistency over time, these companies had already been identified back in 1981, indicating that this model provides a much more accurate assessment of the relative financial strength of reinsurance companies than any of the existing solvency-tracking models.

VI. CONCLUSION

It is unreasonable to assume that any solvency-tracking system that is established for the entire insurance industry will work equally as well, or at all, for the reinsurance industry. Through the use of non-parametric techniques, however, we feel that it is possible to produce a separate model for the domestic reinsurance industry, with this model exhibiting a predictive power much greater than that of the existing NAIC Early Warning system.

APPENDIX

The assumptions of the null hypothesis are:

1) Each test ratio is a random variable, with the same unspecified distribution (and mean) applying to all companies.

2) The resulting test ratio for a particular company is a selection from the distribution.

3) The test ratios are independent.

The above assumptions imply that the distribution of the ranks for a particular test ratio has a discrete uniform distribution with mean $\mu = (n+1)/2$ and variance $\sigma^2 = (n^2 - 1)/12$, where n is the number of companies.

Excluding the twenty companies used to develop the model, the distribution of the ranks for an individual test is:

x	p.d.f.	c.d.f
1	1/64	1/64
2	1/64	2/64
3	1/64	3/64
.	.	.
.	.	.
.	.	.
.	.	.
63	1/64	63/64
64	1/64	1

Since the ranks of the companies' test ratios are summed to obtain our final financial indicator, this Rank Sum is also a random variable. Under the null hypothesis this variable has a distribution function that can be calculated by convoluting the discrete uniform distribution. The process consists of the (number of ranks minus one) convolutions, where the first convolution uses the p.d.f. and c.d.f. listed above, and subsequent convolutions use the results of the previous convolution and the uniform p.d.f. in the formula:

$$F_z(z) = \sum_{\text{all } x \leq z} F_y(z-x)\, f_x(x)$$

Since fourteen test ratios are ranked in this analysis, the random variable is the sum of 14 ranks and it requires 13 convolutions to calculate the distribution. The Central Limit Theorem implies that the resulting distribution function of the convolutions approaches a normal distribution as the number of tests increases. If m is the number of test ranks summed, then for this case the distribution that results from the m-1 convolutions will have mean equal to $m(n + 1)/2$ and variance $m(n^2 - 1)/12$.

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(a) Best's Trend Reports
(b) Best's Advance Rating Reports
(c) Best's Insurance Reports
(d) Best's Insurance Management Reports

EXHIBIT 1

BEST'S ADVANCE RATING REPORT TESTS

PROFITABILITY TESTS

1. Loss Ratio
2. Expense Ratio
3. Combined Ratio
4. Operating Ratio
5. Net Operating Income to Net Earned Premium
6. Yield on Investments
7. Change in Surplus
8. Return on Surplus

LEVERAGE TESTS

1. Change in Net Written Premium
2. Casualty % of Net Earned Premium
3. Direct Written Premium to Surplus
4. Net Written Premium to Surplus
5. Net Liabilities to Surplus
6. Net Leverage
7. Ceded Reinsurance Leverage
8. Gross Leverage
9. Surplus Aid to Surplus
10. Reinsurance Recoverable to Surplus

CASH FLOW TESTS

1. Net Cash Flow
2. Net Cash Flow to Quick Assets
3. Quick Liquidity

LIQUIDITY TESTS

1. Current Liquidity
2. Overall Liquidity
3. Agents' Balances to Surplus
4. Premium Balances to Surplus
5. Investment Leverage

LOSS RESERVE TESTS

1. Development to Surplus
2. Estimated Reserve Deficiency to Surplus
3. Loss Reserves to Surplus
4. Developed to Industry Average
5. Projected to Reported
6. Developed to Net Earned Premium
7. Change in Loss Reserves

EXHIBIT 2

MEDIAN TEST SCORES FOR REINSURERS

DESCRIPTION	1980	1981	1982	1983	1984	1985
Change in Net WP	7	8	4	5.5	14	32
Premium to Surplus	1.35	1.3	1.15	1.2	1.4	1.6
Net Leverage	3.8	3.9	3.3	3.5	3.85	4.2
Gross Leverage	4.5	5.1	4.6	4.4	5.25	5.5
Surplus Aid to Surplus	1	1	1	1	1	1
Combined Ratio	107	107	113.5	117	131.5	120
Operating Ratio	89	89	93	99	112.5	102
Net Operating Inc. to Net EP	8	9	6	2	-9	-5
Yield on Investments	7.85	8.6	8.65	8.3	8.5	8.8
Change in Surplus	15.5	7.5	9	5	-13	7
Return on Surplus	14.5	9	10	7	-14	-1
Quick Liquidity	40	41.5	33	48.5	43.5	N/A
Overall Liquidity	122.5	118.5	117	120.5	105	N/A
Agents Balances to Surplus	18	19	15	15	22	20
Prem. Balances to Surplus	22	21.5	21	16.5	18.5	16
Investment Leverage	26	25.5	23.5	25	24	25
Estimated Reserve Deficiency	-5	-5.5	-7.5	-2	8	14.5
Ceded Leverage	0.5	0.5	0.5	0.7	1.3	1.2
1-YR Reserve Dev. to Surplus	3	4	4	6	16	1.5
2-YR Reserve Dev. to Surplus	0	4	6	7	12.5	0
% Change in Gros Lev. ÷ % Change in Net Lev.	--	1.01	1.00	1.01	0.77	1.03
Gross Leverage ÷ Net Lev.	1.13	1.13	1.19	1.21	1.33	1.32

EXHIBIT 3

WILCOXON RANK SUM TEST RESULTS
(Sum of Ranks for Strong Companies)/(Sum of Ranks for Weak Companies)

	1980	1981	1982	1983
Change In Net Written Premium	103/107	97/113	120/90	118/92
Net Written Premium to Surplus	98/112	96/114	93/117	91/119
Net Leverage	106/104	104/106	102/108	98/112
Gross Leverage	84/126	83/127	77/133	78/132
Surplus Aid to Surplus	71/139	73/137	67/143	70/140
Combined Ratio	100/110	104/106	75/135	68/142
Operating Ratio	97/113	90/120	66/144	57/153
Net Operating Income to Net Earned Premium	116/94	122/88	142/68	144/66
Yield on Investments	116/94	120/90	124/86	117/93
Change in Surplus	122/88	104/106	120/90	127/83
Return on Surplus	120/90	102/108	144/66	131/79
Quick Liquidity	94/116	92/118	122/88	100/110
Overall Liquidity	90/120	89/121	111/99	123/87
Agents Balances to Surplus	116/94	117/93	113/97	123/87
Premium Balances to Surplus	132/78	128/82	127/83	121/89
Investment Leverage	100/110	103/107	111/99	109/101
Estimated Reserve Deficiency	89/121	80/130	98/112	96/114
Ceded Leverage	63/147	62/148	62/148	65/145
1-Year Reserve Development to Surplus	96/114	95/115	69/141	55/155
2-Year Reserve Development to Surplus	109/101	93/117	68/142	57/153
(% Change in Gross Leverage)/ (% Change in Net Leverage)	N/A	98/112	120/90	118/92
Gross Leverage/Net Leverage	60/150	59/151	63/147	64/146

EXHIBIT 4

WILCOXON RANK SUM TEST RESULTS
(Sum of Ranks for Strong Companies)/(Sum of Ranks for Weak Companies)
BASED ON COMPANY RATIO MINUS INDUSTRY MEDIAN

	1980	1981	1982	1983	1984
Change in Net Written Premium	83/127	113/97	78/132	80/130	91/119
Net Written Premium to Surplus	114/96	127/83	112/98	91/119	77/133
Net Leverage	102/108	124/86	98/112	108/102	70/140
Combined Ratio	90/120	78/132	75/135	90/120	88/122
Change in Surplus	94/116	85/125	101/109	92/118	59/151
Return on Surplus	109/101	93/117	88/122	84/126	101/109
Quick Liquidity	98/112	98/112	93/117	105/105	112/98
Overall Liquidity	104/106	121/89	124/86	118/92	103/107
Agents Balances to Surplus	119/91	111/99	105/105	121/89	115/95
Investment Leverage	102/108	113/97	102/108	94/116	84/126
Estimated Reserve Deficiency	88/122	98/112	86/124	81/129	75/135
(% Change in Gross Leverage)/ (% Change in Net Leverage)	N/A	87/123	81/129	80/130	91/119

EXHIBIT 5

COMPARISON OF RESULTS

Individual Year Rankings VS. 1982/83/84 Weighted Average Ranking

Individual Year Rankings		1982/83/84 Weighted Average Ranking Top 21	Middle 22	Bottom 21
1981	Top 21	13	7	1
	Middle 22	6	9	7
	Bottom 21	2	6	13
1982	Top 21	15	6	0
	Middle 22	4	14	4
	Bottom 21	2	2	17
1983	Top 21	15	6	0
	Middle 22	6	10	6
	Bottom 21	0	6	15
1984	Top 21	18	3	0
	Middle 22	3	16	3
	Bottom 21	0	3	18