

## **A Financial Approach for Determining Capital Adequacy and Allocating Capital for Insurance Companies**

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### **ABSTRACT**

There are several methods companies use to determine the appropriate amount of capital required to support their insurance operations. In general these models focus on the downside risk arising from the existing book of liabilities, such as the 1-in-100 or 1-in-500 underwriting loss. Unfortunately, many of the methods either ignore the risk arising from their investment portfolio or use a method that is disconnected from their liability risk analysis. Further complicating the issue is the question of how to allocate the company's capital back down to the separate profit centers or operating units.

In this paper we will explore the use of an economic approach to capital adequacy and capital allocation. We will utilize a dynamic financial analysis (DFA) model that incorporates asset, liability and capital market risk factors into both the capital adequacy and allocation formulae. The paper includes a case study to illustrate the DFA approach and the resulting outcomes.

### **Keywords**

Dynamic financial analysis (DFA), Risk-adjusted capital, Regulatory-required capital, Shapely values

## **A Financial Approach for Determining Capital Adequacy and Allocating Capital for Insurance Companies**

In general, there are three reasons that an insurance company allocates capital:

- To ensure their financial solidity;
- To use as a basis to establish an overall profitability target, including income from past and current operations; and
- To measure the performance of the profit centers on a current business basis.

The amounts of capital that are required for the first two purposes are identical. If we want to gauge the current performance of each line of business the required capital must be further allocated amongst new business, and business written and earned in the past. The current performance should only be measured against the capital required to support new business.

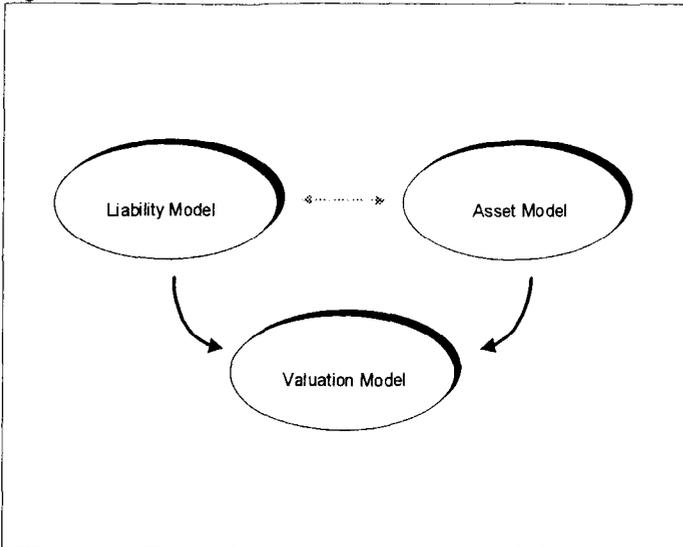
There are several methods companies use to determine the appropriate amount of capital required to support their insurance operations. In general these models focus on the downside risk arising from the existing book of liabilities, such as the 1-in-100 or 1-in-500 underwriting loss. Unfortunately, many of the methods either ignore the risk arising from their investment portfolio or use a method that is disconnected from their liability risk analysis. This can produce misleading results and may affect the way a company manages its business.

One method that would ensure a consistent approach to risk measurement is dynamic financial analysis (DFA). By utilizing a DFA model that incorporates asset, liability and capital market risk factors into both the capital adequacy and allocation formulae management will have the ability to obtain a realistic risk profile of their company, allowing them to make better decisions.

### **The DFA Model**

Before we begin the case study we will give a brief overview of the model employed. Many articles have been written on DFA and we refer the reader to the references at the end of this paper for more details. The underlying architecture of such models is shown in figure 1.

Figure 1 - Schematic on DFA



Since we are interested in insurance companies, a logical starting point is with the liability model. This module projects cash flows arising from the company's existing reserves as well as new business. Both inforce and new business liabilities are modeled on a line of business basis so that the unique characteristics of each line can be captured. Historical experience and expected future trends need to be reflected in the assumptions to capture how the insurance company's liability structure will develop in the future.

Projections of the runoff of the existing reserves are done stochastically by assuming an underlying distribution of the loss payouts as well as an expected payout pattern. The model should allow for normal, lognormal or other types of distributions. We use the expected ultimate undiscounted reserve amount as the mean of the underlying distribution, and sample from the assumed underlying distribution to create up to 10,00 different runoff patterns. Since we are interested in downside risk, it is critical that one runs a sufficient number of scenarios to capture the characteristics of the tail.

Modeling the existing liabilities alone would imply that the company is in a liquidation mode. Since we are interested in determining the amount of capital required at the beginning of the year to support the ongoing operations of the company, it is imperative to model the firm's new business plan in order to accurately reflect the company's expected liability structure.

In order to project the new business liability cash flows, assumptions regarding the premium cash flows, loss ratios, expected payout patterns and expenses are needed. The starting point is the company's budget, adjusted for any optimism or trends built into the company's projections. Expected future loss ratios are generated assuming a stochastic sampling of an underlying distribution. Once the projected loss ratios are determined, the liability cash flows are calculated by multiplying the loss ratio by the forecasted earned premium. Again it is important to recognize that since each line of business has its own characteristics, all of the above projections are done on a line by line basis before being aggregated up to the total company level.

A critical aspect of the model is to recognize how quickly a company will realize that existing reserves or budgeted loss ratios may be deficient or redundant. One needs to work closely with management to ensure that the projected cash flows and reserve levels reflect reality.

The second step in the process is to model the cash flows arising from the asset portfolio. This step is just as crucial to the DFA process as the liability cash flows and is often overlooked. There are several methods available, with the common goal being to simulate a wide range of realistic economic conditions (representing future states of the economy) and their effect on the investment portfolio. Capital market factors include interest rates, inflation, and returns for various asset classes, such as bonds and stocks. The goal of the simulation should be to produce a broad range of economic conditions spanning the entire universe of possible outcomes.

Typically, the core asset classes modeled include fixed income, equity, and cash. Fixed income categories are defined as a function of their anticipated yield (spread to relevant Treasury), duration, convexity, and default or volatility risk. More detailed asset classes, such as intermediate bonds, mortgage-backed securities, and high yield bonds are then modeled based on the derived results for the core asset classes. These more detailed classes serve as a proxy for the assets currently held and/or expected to be held by the company. The economic simulation model ensures that the resulting asset class returns are consistent with each of the economic conditions simulated.

The liability and asset cash flows generated above are projected over the economic scenarios and fed into a valuation model. This is, in simple terms, a financial calculator that determines the accounting values that management is interested in analyzing. For purposes of capital adequacy and allocation, we will be focused on the company's surplus at the end of the time horizon. Adjustments need to be made to the cash flows as necessary to account for the correlation between the assets, liabilities, and capital markets.

To summarize, the DFA model produces a set of 10,000 scenarios, each representing a possible underwriting and economic scenario and the resulting financial outcome.

### **Setting up the Case Study**

The remainder of this paper will show how a company (XYZ Insurance Company) can use an economic approach, such as DFA, to:

1. Determine the amount of capital required to support its business plan
2. Distinguish between risk-adjusted capital requirements versus the capital required by regulatory bodies or rating agencies
3. Allocate capital back to the profit centers to provide for a performance measurement benchmark.

XYZ Insurance Company currently writes three major lines of business: Homeowners, including catastrophic coverage, Auto and Workers' Compensation. Total net written premium for XYZ is expected to be \$300 million in 1999, \$100 million for each line of business. Table 1 gives a summary of XYZ's financial position at 12/31/98 and its 1999 business plan.

Table 1

<b>1999 Business Plan:</b>				
	<b>Homeowners</b>	<b>Auto</b>	<b>Workers' Comp</b>	<b>Total XYZ</b>
NEP	100	100	100	300
Inv Inc	2	7	19	28
Total	102	107	119	328
Loss Incurred	65	83	95	243
Expenses	33	23	18	74
Total	98	106	113	317
Op Income	4	2	6	11
Loss Ratio	65.0%	83.0%	95.0%	81.0%
Combined Ratio	98.0%	105.5%	113.0%	105.5%
Assets				436
Reserves	4	67	245	316
Capital				120

Note that although XYZ has 3 separate underwriting profit centers, it manages the assets as one-shared pool. Therefore, the model will generate operating cash flows and underwriting income at the profit center level and then aggregate these cash flows to the total company level in order to determine investment income, realized gains and unrealized gains. These results are then reallocated back to the profit center based on their starting reserves and cash flows. The starting capital position for the various profit centers have intentionally been omitted since one of the objectives of the case study is to determine an appropriate allocation amongst them.

One can observe that the three lines have different risk profiles. Homeowners' is the most volatile and pays out quickly. Workers' Comp is the least volatile and has the longest payout structure. Auto is somewhere in the middle.

The asset portfolio of \$436 million is invested in 80% fixed income securities and 20% equities. The expected return on the portfolio is approximately 6.40%, with a standard deviation of 5.35%. The capital at 12/31/98 was \$120 million.

### **Determining Capital Adequacy**

For any insurer, capital is necessary to ensure that its policyholder obligations will be honored. Because of the risks inherent in the insurance business, there will always be a chance of insurer default i.e. the insurer's liabilities exceed its assets. Thus required capital is generally defined as the capital necessary to reduce the probability of insurer default to some target level. XYZ Insurance Company has defined its required capital as the amount of surplus, assets in excess of liabilities, held by XYZ which will reduce its probability of default, during any one year of operation, to 0.2%. This is referred to as the *probability of ruin*.

To determine the required capital that corresponds to a probability of ruin of 0.2%, or ruin once every 500 years, we had to generate the probability distribution of XYZ Insurance’s net income, i.e. we had to determine the probability of having every possible net income or loss. Ruin occurs when the net loss exceeds surplus. Therefore, if we set surplus equal to an amount that is greater than the net loss 99.8% of the time, the probability of ruin would be equal to 0.2%. This amount would be, according to XYZ’s definition, the required surplus.

Historically, XYZ would run its simulation assuming a fixed rate of return for its investment portfolio. It would generate 10,000 different loss scenarios. Since losses varied by scenario, investment income would also fluctuate. But the investment yield was always set to a “conservative” rate determined by their investment managers.

Table 2 shows the simulated results for Operating Income simulation assuming fixed investment yields.

Table 2

<b>Risk-adjusted Capital results:</b>				
	<b>Homeowners</b>	<b>Auto</b>	<b>Workers' Comp</b>	<b>Total XYZ</b>
<b>Mean</b>	4.5	1.8	6.2	12.4
<b>Std Deviation</b>	10.3	6.2	12.7	17.5
<b>95th percentile</b>	21.3	11.8	26.7	40.9
<b>75th percentile</b>	11.4	6.1	14.9	24.3
<b>50th percentile</b>	4.5	1.9	6.4	12.8
<b>25th percentile</b>	-2.5	-2.4	-2.1	0.7
<b>5th percentile</b>	-12.5	-8.6	-15.2	-16.7
<b>0.2% percentile</b>	-25.3	-16.7	-31.7	-38.6
<b>Risk-adjusted Capital</b>	<b>25.3</b>	<b>16.7</b>	<b>31.7</b>	<b>38.6</b>

Using XYZ’s definition of required surplus, \$38.6 million would be needed to provide sufficient capital to sustain a 1-in-500 “worst case” operating result.

However, XYZ’s investment managers did not feel comfortable ignoring asset risk. Recall that the asset portfolio (\$436 million) had a portfolio standard deviation of 5.35%. Assuming a normal distribution, a 0.2%’ile loss implied a 2.878 standard deviation move, or a total loss on the portfolio of almost 9.0% (6.40% - (2.878 x 5.35%)). Therefore, the investment managers indicated that XYZ needed to set aside an additional \$40 million for asset risk.

The problem now is how much total capital for XYZ is required. One method is to add the two amounts (\$38.6 for liability risk, \$40.0 for asset risk) to get \$78.6 million. But this would be overly conservative since the likelihood of a 1-in-500 liability scenario combining with a 1-in-500 asset scenario is less than 1-in-500. The question now facing XYZ is “How

should one combine the outcomes from two different sets of distributions, each with different functional forms”?

One way to circumvent the problem is by using an economic approach, or DFA. DFA allows one to model the company holistically versus the segmented approach that XYZ was trying to employ. Volatility from asset returns are combined with the randomness of liability losses within the simulation, and the impact on the company’s bottom line would reflect the true risk inherent in XYZ’s business.

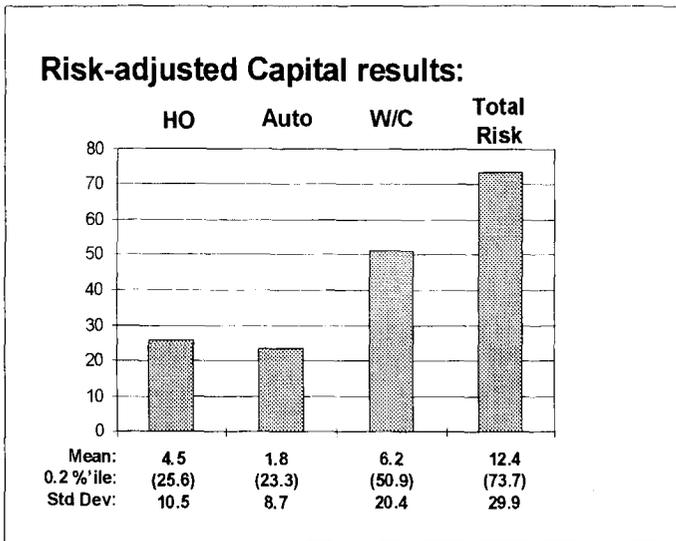
XYZ already had its liability model developed. To complete the DFA model, XYZ needed to incorporate the asset risk into its simulation model. XYZ’s investment managers’ produced a set of 10,000 economic scenarios and the corresponding asset returns for each of the core assets included in the model. Due to the longer duration of the loss payout for Workers’ Comp, XYZ realized that it must adjust the loss cash flows by the underlying inflation rate produced by the economic simulation model. This ensures that the simulated inflation would have the same impact on the asset cash flows as on the liability cash flows.

Using the above assumptions, the 10,000 simulations were run through the valuation model and the result corresponding to the 20<sup>th</sup> worst net income was the initial estimate of the required capital, which corresponds to 1-in-500 worse income. Results are shown in Table 2 and Figure 2 below.

Table 2:

<b>Risk-adjusted Capital results:</b>				
	<b>Homeowners</b>	<b>Auto</b>	<b>Workers’ Comp</b>	<b>Total XYZ</b>
<b>Mean</b>	4.5	1.8	6.2	12.4
<b>Std Deviation</b>	10.5	8.7	20.4	29.9
<b>95th percentile</b>	21.9	16.3	39.4	61.5
<b>75th percentile</b>	11.5	7.5	19.9	32.7
<b>50th percentile</b>	4.4	1.6	6.1	11.8
<b>25th percentile</b>	-2.6	-4.1	-7.6	-8.1
<b>5th percentile</b>	-12.9	-12.4	-27.1	-36.2
<b>0.2% percentile</b>	-25.6	-23.3	-50.9	-73.7
<b>Risk-adjusted Capital</b>	<b>25.6</b>	<b>23.3</b>	<b>50.9</b>	<b>73.7</b>

Figure 2:



XYZ would need to set aside \$74 million of capital to ensure that it has sufficient capital to sustain a “worst case” 1-in-500 outcome. One should also note that the sum of the risk-adjusted capital for the three lines of business is greater than the amount required in total. The issue of how to allocate capital is addressed later in the case study.

This capital, however, is not the actual amount required, for two reasons. First, additional asset risk is borne in investing this surplus. Therefore additional surplus would be required in the event of negative investment income. Secondly, this surplus will earn investment income, adding to the bottom line. This amount needs to be subtracted from the required surplus.

Recall that, given our asset assumptions, a 1-in-500 event corresponds to approximately 9.0% decline in asset value. Therefore, an additional 9.0% was added to the capital from our simulations to obtain the total risk-adjusted capital. According to our calculations the risk-adjusted capital is now \$80 million ( $\$73.7 + 9.0\% \times 73.7$ ). Note that the actual amount of capital held by XYZ at the beginning of the year was \$120 million.

**Risk-adjusted Capital versus Rating Agency Capital**

In order to maintain a targeted rating by a certain rating agency, XYZ is required to meet a minimum capital requirement calculated using an approach similar to the NAIC’s Risk Based Capital calculations. Based on this methodology, XYZ estimated the amount the rating agency would require to be approximately \$100 million, resulting in approximately \$20million ( $\$120 - \$100$ ) of excess capital. However, if XYZ were to release all of the excess, or free capital, the rating agency would likely reduce their rating. This is because the rating is a qualitative rating that considers other risk factors besides capital adequacy, such as earning fluctuation, growth assumptions, competitive forces, management skills, etc. Through discussions with the rating agency, it was decided that the true amount of excess

capital was approximately \$10 million. The problem, if one considers excess capital to be a problem, of how to utilize this excess capital is an interesting one. For purposes of this case study, we will assume that XYZ has some mechanism (dividend to parent, dividend to shareholders, etc.) that allows them to remove this amount from their balance sheet without a corresponding rating decline from the rating agency. Therefore, after the \$10 million dividend, XYZ would be left with \$110 million of capital, of which \$80 would be risk-adjusted capital and the remaining \$30 million classified as rating agency capital.

The rates of return before the proposed dividend would be:

ROE Prior To Dividend				(\$ Millions)
	Capital	Target Return	Budgeted Profit	Budgeted ROE
Risk-adj capital	80.3	15.0%	12.4	15.5%
Rating agency req cap	29.7	15.0%	1.9	6.4%
Free Capital	10.0	15.0%	0.6	6.4%
<b>Total Capital</b>	<b>120.0</b>	<b>15.0%</b>	<b>14.9</b>	<b>12.4%</b>

After the proposed dividend the return on equity would be as follows:

ROE After Dividend				(\$ Millions)
	Capital	Target Return	Budgeted Profit	Budgeted ROE
Risk-adj capital	80.3	15.0%	12.4	15.5%
Rating agency req cap	29.7	15.0%	1.9	6.4%
Free Capital	-	15.0%	-	0.0%
<b>Total Capital</b>	<b>110.0</b>	<b>15.0%</b>	<b>14.3</b>	<b>13.0%</b>

The reduction in free capital increased XYZ's ROE by over 0.5% because this capital was only generating a profit of 6.4%, the budgeted investment yield.

### **Allocation by Line of Business**

Surplus is allocated to lines of business according to the additional risk that the line of business contributes. The question is "how is the additional risk quantified"? One approach would be to construct models of mono-line companies with revenues and expenses exactly like each of XYZ's lines of business and test the capital requirements of these companies. The results from the analysis, when summed would exceed the risk capital required. This can be seen by summing the individual profit centers' risk-adjusted capital amounts in Table 2 ( $25.6 + 23.3 + 50.9 = \$99.8$ ) and comparing that to the total (\$73.7). The results, however, could be scaled back proportionally until the total from this analysis equals the risk capital. This approach is called the "First In" approach, since it allocates surplus as if each line was the first line of business written by the company. The capital calculated is equal to the amount needed for a mono-line company. Figure 3 shows the results using this allocation method:

Figure 3

<b>“First In” Allocation Method:</b>			
	<u>Simulated Required Capital</u>	<u>Contribution to Total Risk</u>	<u>Allocated Required Capital</u>
<b>Homeowners'</b>	25.6	25.6%	18.9
<b>Auto</b>	23.3	23.3%	17.2
<b>Workers' Comp</b>	<u>50.9</u>	51.1%	<u>37.6</u>
<b>Total</b>	99.8		73.7

These results do not produce the optimal capital allocation. In particular it ignores interaction amongst the lines of business. If two lines of business tend to move up and down together, then the effect of diversification is lessened for these two lines, and this should be reflected in the allocation.

An alternative to the above is called “Last In”, where each line is treated as if it were the newest line of business. The additional capital required for adding the line of business to a company writing all of the other lines are calculated. Then the amounts are grossed up proportionally so that the total equals the risk capital for the company. Figure 4 shows the results using the “Last In” method.

Figure 4

<b>"Last In" Allocation Method:</b>			
	<b>Simulated Required Capital</b>	<b>Contribution to Total Risk</b>	<b>Allocated Required Capital</b>
<b>Homeowners'</b>	9.1	15.2%	11.2
<b>Auto</b>	12.7	21.1%	15.6
<b>Workers' Comp</b>	<u>38.3</u>	63.7%	<u>46.9</u>
<b>Total</b>	60.1		73.7

However, there are several problems with the Last In method, including:

- The overly large proportions of the benefit of diversification are given to smaller or less volatile lines of business.
- The capital allocated to smaller lines of business is highly dependent on the business mix of the dominant lines.
- Lines that are highly correlated may be overly penalized, to the extent that their capital allocation is greater than the stand alone required capital.
- A line that is negatively correlated to other lines of business can receive a negative allocation. For example consider a limiting case where in a three-line book of business two of the lines are perfectly negatively correlated. The marginal capital needed write each of the two books will be negative. The total capital required will be the capital required to write only the uncorrelated line. However, this line would be allocated capital greater than its stand-alone required capital to offset the negative capital assigned to the other lines.
- Lines that are highly profitable can receive a negative allocation.

An alternative to both the First In and Last In methods is an application of Shapley's cost allocation method. The method takes a weighted average of the marginal capital required to write each line of business under all permutations of possible orders of entry. This method is founded in game theory and achieves an allocation that is symmetric i.e. the allocation to a line of business is the same regardless of order of entry.

For the case study, assume that Homeowners was a stand-alone company. Then, from Figure 3, it would require \$25.6 million of capital. Now if Homeowners was to add Auto as part of the company, the new risk-adjusted capital for the company would become \$35.4 million. Assuming Homeowners agrees to reward Auto the entire benefits of the diversification. Then Auto's risk-adjusted capital would be  $\$35.4 - \$25.6 = \$9.8$  million. Now assume that

Homeowners and Auto adds Workers' Comp to the coalition. The risk-adjusted company for the total company would be \$73.7 (see table 2), and Workers' Comp would be assigned capital of  $\$73.7 - \$35.4 = \$38.3$  million. But what if Homeowners added Workers' Comp first and then Auto? The resulting capital requirements would be \$25.6 for Homeowners stand-alone, \$61.0 for Homeowners and Workers' Com combined, and \$73.7 for the addition of Auto. Therefore Workers' Comp would be assigned capital of  $\$61.0 - \$25.6 = \$35.4$  million, and similarly, Auto would be assigned  $\$73.7 - \$61.0 = \$12.7$  million.

Figure 5 shows the results of the six possible permutations for forming XYZ:

Figure 5

<b>Possible combinations of forming XYZ:</b>						
First In	Second In	Last In	<u>Marginal Capital</u>			Total
			HO	Auto	WC	
HO	Auto	WC	25.6	9.8	38.3	73.7
HO	WC	Auto	25.6	12.7	35.4	73.7
Auto	HO	WC	12.1	23.3	38.3	73.7
Auto	WC	HO	9.1	23.3	41.3	73.7
WC	HO	Auto	10.0	12.7	50.9	73.7
WC	Auto	HO	9.1	13.6	50.9	73.7

To calculate the Shapley value for Homeowners, one must take the average of its "First In", "Second In" and "Last In" amounts. There is only one way Homeowners could be "First In", and that leads to a risk-adjusted capital amount of \$25.6. Similarly, there is only one way Homeowners could be "Last In" and the corresponding capital is \$9.1. There are two ways that Homeowners could be "Second In". One if it followed Auto, and the other if Workers' Comp was the "First In". The average of the two possibilities is  $0.5 \times (\$12.1 + \$10.0) = \$11.1$ . Therefore, the Shapley value is  $0.333 \times (\$25.6 + \$11.1 + \$9.1) = \$15.3$ . Similarly it can be shown that the Shapley values for Auto and Workers' Comp are \$15.9 and \$42.5 respectively. Note that the sum of the Shapley values equals \$73.7, and there is no need for scaling the results.

The following table summarizes the three methods of allocating capital amongst the different profit centers.

Table 3

**Comparing Capital Allocation Methods:**

	Homeowners	Auto	Workers' Comp	Total XYZ
First In	18.9 25.6%	17.2 23.3%	37.6 51.1%	73.7
Last In	11.2 15.2%	15.6 21.1%	46.9 63.7%	73.7
Shapley	15.3 20.7%	15.9 21.6%	42.5 57.7%	73.7

Using the Shapley method, XYZ Insurance arrived at the following allocation of risk-adjusted capital. Recall that the allocated risk capital amounts must be “grossed up” by 9% to account for the additional asset risk associated with investing that amount of capital.

Line of Business	Allocated Risk Capital	Risk-adj Capital	Total Budgeted Capital	Budgeted Profit	Budgeted Return on Total Capital
Homeowners	15.3	16.7	16.7	4.5	26.9%
Auto	15.9	17.3	17.3	1.8	10.4%
Workers' Comp	42.5	46.3	46.3	6.2	13.4%
Corporate	0.0	0.0	29.7	1.9	6.4%
<b>Total</b>	<b>73.7</b>	<b>80.3</b>	<b>110.0</b>	<b>14.3</b>	<b>13.0%</b>

Since controlling rating agency expectations is a management function, capital held by XYZ to support their rating is allocated as corporate overhead and does not impact the profit centers' results. As one can observe, the budgeted total return on total capital is 13%, varying significantly by line of business.

One last point on using Shapley's method for capital allocation is that it produces capital levels that are greater than or equal to zero regardless of the correlation of the lines of business. Recall that this is one of the shortfalls for the “Last In” method. Suppose you have a company that has three lines of business, and assume that lines 1 and 2 are perfectly negatively correlated. In addition, assume that stand-alone required capital is \$10 million for each line of business. The six possible orders of entry are Line 1 first, then Line 2 and then line 3, which we will denote as (1,2,3), (1,3,2) (2,1,3), (2,3,1), (3,1,2), and (3,2,1). With the (1,2,3) and (1,3,2) orders of entry Line 1's marginal capital would be \$10 million, since it is

first in. With orders of entry (2,1,3) the marginal capital would be minus -10 since Line 1 is perfectly negatively correlated with Line 2. The remaining scenarios are shown below:

Order of Entry Scenario	Allocation to Line 1
(1,2,3)	\$10 million
(1,3,2)	\$10 million
(2,1,3)	(\$10) million
(2,3,1)	(\$10) million
(3,1,2)	\$10 million
(3,2,1)	(\$10) million
<b>Shapley Value</b>	0

### **Performance Measurement**

The above capital allocation is suitable for measuring a profit center's contribution to the overall return on equity for XYZ. However, for measuring the performance of current underwriting activity, the return on equity as calculated above is inappropriate. For example, the risk capital needed for Workers' Comp (\$46.3) is primarily due to the large starting reserve amount. Capital is required to cover the investment risk as well as to protect against adverse claims development. Since the underwriter for Workers' Comp has no control of claims operations or investments, the performance measure will be influenced largely by factors beyond his or her control. Outside of positive claims development, which is not expected, the only return on reserves is investment income. With a budgeted yield of 6.4% the ROE on capital supporting reserves will be less than 10%. The difference between this and the target ROE would have to be made up by current operations will be difficult, if not impossible for the underwriter to achieve.

A more appropriate measure of underwriting performance would consider total income, less changes in reserves for prior year losses and investment income attributable to reserves from prior years. To arrive at a ROE for the current year risk capital would be further allocated to new and existing business. Again, one can use the Shapley approach to determine the appropriate allocation. Once XYZ has properly aligned the risk-adjusted capital with the source of risk, they can then determine ROE targets that can be used as performance benchmarks. This topic will be explored in more detail in a subsequent paper.

### **Conclusion**

Historically, insurance companies are faced with difficult issues when trying to determine the appropriate amount of capital needed to support its insurance and investing activities. Often models used to determine capital requirements either ignore asset risk completely or use a separate method for measuring asset risk. The question of how to combine the capital required for unlikely events is difficult to answer without making some simplifying assumptions. Using a financial approach, such as dynamic financial analysis, a company can integrate the risk arising from liabilities, assets and capital market factors into one risk measure and capture the company's true risk exposure.

Even once a company identifies the amount required to support its operating and rating agency objectives, it still must determine how to allocate capital amongst its various profit centers. The benefit of diversification is key to efficient capital utilization. The Shapley method, as demonstrated above, allows each unit to share in its proportion of the

diversification benefit, without penalizing other lines of business. One can use the Shapley method, in combination with DFA, to decompose the company's capital into appropriate categories, such as asset risk, existing reserve risk, new business risk, etc. Only then can the company develop benchmarks that are specific a manager's performance and truly represent the value that manager adds to the organization.

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