FORMULAS, MODELS, METHODS AND TECHNIQUES

MR. MARK LITOW: This session focuses on formulas, methods and corresponding considerations that are currently being used, to our knowledge, in analyzing various risks of concern to the health valuation actuary. Because the valuation actuary concept is in its infancy, especially in regard to health insurance, we will concentrate primarily on the basics rather than excessive detail. To start with, we'll talk briefly about concepts and type of risks the health insurance actuary is concerned with to provide a framework. Next, we'll review the considerations and influences affecting the actuary. Third, we'll look at formulas and methods for evaluating risk. And finally, we'll summarize the present status of health insurance valuation actuary concepts and practices and where they appear headed.

I. Concept of Valuation Actuary

The valuation actuary concept was developed in that the traditional balance sheet and supporting statement of opinion provided by the actuary does not necessarily tell the regulators and public whether a company is properly protected against various contingencies. In other words, the actuary currently provides an opinion on solvency at the valuation date, but not on the likelihood of future solvency and/or company strength given

certain scenarios. Under the valuation actuary concept, a responsibility is assigned to the actuary to study in more detail than ever before the health of a company or its:

A. Solvency - Comparison of whether assets exceed liabilities at valuation date.

B. Solidity - Comparison of whether assets exceed liabilities in a multitude of situations.

C. Vitality - Availability of excess surplus for a company to grow. Surplus is the excess of assets over liabilities.

Thus, the actuary now must be a doctor, economist, and soothsayer, all rolled into one, which increases liability concerns. In fact, the additional liability imposed upon the actuary relative to the expanded opinion has been a real concern in fully developing this concept. Attorneys may therefore be its strongest advocate.

In preparing the opinion, the actuarial profession has identified various contingencies that the actuary must study.

C-1 - Asset Default

All asset backing reserves are of concern in regard to the C-1 risk. This does not relate to maturity or call dates of assets, only whether they become worthless or not. This risk would be analyzed similarly for life or health insurance.

C-2 - Premium Inadequacy (Pricing Assumption)

For health insurance, C-2 is generally the primary risk. Items included would be health insurance C-2 risks, like morbidity, expenses, persistency, interest earnings, and miscellaneous.

Other major risks affecting health insurance are generally recognized in C-4, or external risks.

C-3 - Interest Rate Risk

For intrasensitive interest products -- single premium deferred annuities (SPDAs) and guaranteed investment products -- the C-3 risk is important. In health policies, it is generally insignificant. The concerns here come with matching of assets and liabilities and how they interact with interest rates. Interest earnings in health pricing are particularly important on long-term-care and disability products, but they do not seem to interact significantly with matching concerns; thus, it is a C-2 risk.

C-4 - External, Other (Inflation, etc.)

The C-4 risk includes regulatory, inflation, cost shifting and other forces beyond the control of a company. These features are often very important to health insurance and become a part of any analysis of C-2 risk. In fact, I have great difficulty in studying C-2 and C-4 separately in health insurance, if they can indeed be studied distinctly.

In examining these risks, many considerations and situations must be assessed.

II. Formulas and Methods for Analyzing C-Risk

This section addresses the C-risk independently and in conjunction with component parts as they relate to health insurance.

In life insurance, the reserves are not generally a material issue, and cash-flow methods can be used without serious problems. For health insurance, use of cash-flow models is certainly a plausible approach, but adjustments to an accrual accounting base are important. This concern should be kept in mind throughout our discussion of possible methods.

One other note worth mentioning is that the development of formulas and methods for analyzing C-risk is very much in its infancy and most people feel ignorant on this subject.

To start with, three general methods exist of studying C-risks. These are cash flow or accrual modeling, stochastic processes, and ruin theory. What is meant by each of these terms?

In the following slides, we briefly illustrate what is meant.

SLIDE 1

Cash Flow and Accrual Illustration (in 000s)

	1989	1990	1991	1992
Revenue*	1,000	1,000	1,000	1,000
Claims	400	500	600	700
Expenses**	400	400	400	400
Cash Profit	200	100	---	(100)
Reserve Change	100	50	---	(50)
Accrual Profit	100	50	---	(50)

* Includes interest
** Includes federal income taxes

What this illustration shows is a year-by-year projection of revenue and disbursements. Therefore, the sensitivity of various assumptions can be studied as shown in Slide 2.

SLIDE 2

Scenarios for Percentage Change in Cash Flow and Accrual Illustration

	1	2	3	4
Revenue	+5%	-10%	0%	-10%
Claims and Reserves	+25%	+25%	-15%	-10%
Expenses	+5%	0%	+5%	+10%
Adjusted Cash Profit	$130	$(125)	$+70	$(170)
Adjusted Accrual Profit	$5	$(187.5)	$+70	$(125)

A second method is to use stochastic processes. This generally means multivariate probability distribution in the following form:

SLIDE 3

Illustration of Stochastic Processes through Multivariate Distribution

Amount*			Frequency	
X_1	=	0	P_1	.50
X_2	=	100	P_2	.10
•		•	•	•
•		•	•	•
•		•	•	•
X_n	=	50,000	P_n	.01

* Can be more than one variable X and a dependent Y. Practical problems result when using more than one-dimensional distributions.

In this case, X_1 represents no claim ($0) in a calendar year, and P_1 represents the probability that no claim will occur. X_2 represents the probability of a claim of $100, which is the average in a cell of say $0 to $200; the corresponding probability of a claim in that amount range is P_2. Subsequently, amounts of $200 and above and corresponding probabilities make up expected costs. X_n, P_n is the last cell in the distribution.

In aggregate, the mean (u) or $\Sigma X_1 P_1$ is the mean of the distribution, and the variance (V) is $\Sigma X^2 P_1 - U_2$. Note that for independent events with N insureds, the mean is NxU and the variance is NxV. In the everyday world, the mean of a group is N • U, but the variance is greater than NxU. We will discuss this more later.

The third method is ruin theory. This theory basically defines a surplus line which identifies the point at which insolvency occurs under various scenarios. In other words, a two-dimensional distribution is derived showing the surplus needed to exactly cover losses under a certain scenario Xi, at the corresponding probability Pi. The standard nomenclature for the ruin theory formula is:

SLIDE 4

Ruin Theory

Formula: $P(U \leq u) = \Sigma f(X_1, X_2, ..., X_n) = 1\text{-}P$

- U is amount of surplus needed.
- u is amount of surplus available.
- 1-P is probability of ruin.
- $X_1, ..., X_n$ are random variables.

Possible distribution types available for use in ruin theory are many. A few types are:

- Log normal (major medical)
- Poisson (number of claims)
- Pareto (severely skewed - long-term care)

  Chi-Square, etc.
- Claim experience providing the probability model.

For example, if you wish to study the surplus needed to cover probable major medical claim fluctuations, you could use a log normal distribution in conjunction with a starting point probability distribution per adult and child. Further, you would need a distribution to recognize additional variances due to dependent events found in the health care environment today. A case study documenting the methodology is discussed later.

In studying health insurance in a vacuum, C-1 and C-3 are not generally important risks. However, in conjunction with other types of business, or in analyzing a company as a whole, such risks may need to be seriously addressed. Thus, I will briefly cover these risks at this time. Analyzing the C-1 risk requires a review of type, quality, and distribution.

For example, higher risk bonds should generate a higher yield, but these assets may at times pose a high probability of default. The actuary will need to assess this type of risk, and determine its impact on company solvency, solidity and vitality by reviewing the distribution of various assets. Simulation is usually done to evaluate the importance of this risk.

C-3

The C-3 risk represents the interest rate risk. The considerations in assessing this risk are yield curve possibilities, asset mix, call rates and maturity dates, and cash flows. When reviewing this risk, more specifically, two concerns are usually paramount:

1. Disintermediation Risk - Assets are longer than liabilities and interest rates rise. For instance, given that monies from an SPDA are invested in long-term bonds (and/or mortgage loans); rising interest rates can mean that the credited rate on SPDAs of competitors may exceed rates earned on assets minus costs. In other words, assume an SPDA is purchased at an initial rate crediting 10% interest minus expense and

the money is transferred to a bond earning 12%. Further, if subsequent interest rates reach 15%, the company will face these options:

a. Credit SPDAs with a higher return than is earned on the bonds.

b. Incur substantial lapsations or loss of business if credited rates on the SPDAs are not increased.

2. Reinvestment Risk - Liabilities are longer than assets and interest rates decrease. For instance, SPDAs are invested in high yielding Treasury notes of short duration. In this case, assets would mature and have to be reinvested at a low rate, thus reducing yields to the company.

Models studying this risk are often quite complex. Because C-3 is of minor significance relative to health insurance risks, I will not address such models here.

Turning to the C-2 and C-4 risks, we have already noted the influences to be concerned. Turning to morbidity, generally the most serious concern, the following are considerations.

1. Random variation (C-2) - Statistical aberrations only. For instance, a convolution of two coin tosses produces four equally likely possibilities and reflects only statistical

aberrations. Of course, if the coin is modified in any way or outcomes are not equally likely, the independence of events no longer exists.

2. Non-random variations (C-2), which include:
   a. The initial mean value assumed may be incorrect due to lack of data, inability to properly interpret information, or agency, underwriting or claim administration problems.
   b. Independence of events may not be a correct assumption.
   c. Catastrophes.
3. External Influences (C-4)
   a. Trends in utilization, charge levels, public attitudes, available facilities.
   b. Regulatory influences including mandated benefits, cost shifting, policy provisions.
   c. Antiselection against rate increases.

As an example, an analysis of the C-2 and C-4 risks on a long-term-care policy (with respect to claims only) could be performed as follows:

Slide 5

Method of Analyzing C-2 and C-4 Combined

Step 1: Develop a probability distribution representing the costs per individual insured.

Step 2: Develop a probability distribution representing the costs for the total number of insureds in any period, assuming independence of costs between these individuals.

Step 3: Add variance to represent nonrandom and external risks based on possible variations of actual to expected experience for these risks only.

A sample calculation of our long-term-care policy is shown below:

SLIDE 6

Step 1:

Expected Probability Distribution Per Individual Insured

Claim Amount	Frequency
$ 0	.9800
2,500	.0040
5,000	.0035
10,000	.0030
20,000	.0025
40,000	.0022
70,000	.0018
100,000	.0015
150,000	.0010
250,000	.0005

Step 2: Calculate aggregate distribution reflecting random variation only for 10,000 policies.

Claim Amount (Million)	Cumulative Probability
$5471	.01
6541	.16
7027	.33
7430	.50
8326	.84
8973	.95
9643	.99

Step 3: **Addition of NonRandom Variation on LTC Policy**

Ratio of Actual-to-Expected Result	Probability
.40	.065
.60	.110
.75	.140
.90	.160
1.00	.165
1.10	.140
1.25	.090
1.50	.055
1.75	.040
2.00	.025
2.50	.010

In other words, the probability that the true underlying claim level is 150% of expected or greater is .13, or .055 + .040 + .025 + .010.

SLIDE 7

Amount	Cumulative Probability
$2,609	.01
4,714	.16
6,054	.33
7,089	.50
9,728	.84
13,256	.95
17,209	.99

Given that the mean of this distribution is $7,465,000, one can see the large variation in results possible; especially when compared to the result in Step 3 which excludes nonrandom variation and external influences. The actuary must consider this variation as part of his/her opinion as to the solidity and vitality of the company.

Now these types of claims distributions can be set up for any type of business. Further, reserves and expenses can be added to develop a simulation cash flow or accrual model. In doing so, one must review potential major variations by type of business. These are listed in Slide 8, followed by a discussion of each.

SLIDE 8

Major Considerations by Type of Health Business

1. Low frequency, high severity (long-term care, disability insurance, major medical)
   High frequency, low severity (medicare supplement)
2. Large reserves and interest + earnings (long-term care, disability insurance)
3. Persistency (all types)
4. Area (all types), occupation (disability insurance)
5. Regulatory (all types)
6. Integration with home health, other benefits (long-term care)

Frequency, Severity. Quite often these two have an inverse relationship such that high frequency occurs with low severity and vice versa. Examples of high frequency, low severity are Medicare supplement and dental. Examples of low frequency high severity are major medical and long-term care.

Reserve and Interest. Large reserves usually mean a product is significantly affected by interest earnings, such as for long-term care and disability.

Persistency. Poor persistency in early years makes it difficult to recover acquisition costs. Good persistency in later years on products with steep age cost curves can mean heavy losses in those years.

Area. Subsidization of high cost areas and an increasing concentration of business there can mean severe losses.

Regulatory. Cost shifting is a serious problem. This is particularly true in major medical. Shifting can be a direct result of government action such as with Diagnosis Related Groups (DRGs) causing changed treatment patterns.

Integration. Coverage provided by other policies may reduce costs for a policy, i.e., coordination of benefits, long-term care overlapping utilization (nursing home and home health), etc.

Once all risks have been separately modeled, a very difficult task is that of combining them. Methods that currently exist include:

1. Sensitivity Testing - Testing of various scenarios to reach a conclusion.

2. Use of a Probability Model - Follow-up to test of C-2 and C-4 risks such that C-1 and C-3 tests are incorporated into the probability model; the model can take the form of an accrual model, cash-flow model or combination of the two.

3. Ruin Formula $U^2 = \underset{(1)}{\Sigma} U^2 + \underset{(2)}{\Sigma} [U^2 + 2 \times R_{J,K} \times U_J \times U_K]$

   (1) All independent variables.

   (2) All dependent variables (for example, $_J$ and $_K$)

As an example combining various risks, consider the following case study of a company:

SLIDE 9

Case Study Balance Sheet
(in millions)

	Assets	Liabilities - Surplus	
Bonds	$ 60	Major Medical (MM)	30
Mortgages	35	Long Term Care (LTC)	30
Cash	5	Single Premium Deferred Annuity (SPDA)	20
Total	$100	Surplus, Mandatory Securities Valuation Reserve (MSVR)	20
		Total	$100

Slide 10

Income Statement - Past Year and Anticipated for New Year
(in millions)

	Major Medical	Long-Term Care	SPDA
Cash Premium	$60	$30	$20
Investment Income	1	3	2
Cash Claims	30	5	2
Change in Reserves	10	10	16
Expenses	15	15	2
Profit	$ 6	$ 3	$ 2

Further, let's assume the following scenario:

SLIDE 11

Summary of Assumptions Corresponding to Case Study Scenario

1. Interest rate = 15%.
2. Inflation rate in medical costs = 15%.
3. Probability that scenario produces bottom line result at or worse than case study = 5%.
4. Assets defaults = $1 million loss.
5. Disintermediation risk = $5 million loss.
6. Long-term care experience is higher than expected by 67%.
7. Major medical premium volume decreases by 25%, but claim levels remain unchanged.

Under this scenario, the following occurs:

SLIDE 12

High Interest, High Inflation Scenario
(i.e., 1981, 1982) (in millions)

	Major Medical	Long-Term Care	SPDA	Total
Cash Premiums	$45	$30	$20	$95
Investment Income	1	3	1	5
Cash Claims	40	10	32	82
Change in Reserve	0	15	(14)	1
Expenses	15	15	2	32
Profit	$(9)	$(7)	$ 1	$(15)*

* Cash-flow shortage is $14 million, or 95 + 5 - 82 - 32.

Default of Assets - $1 million loss
Disintermediation - $5 million loss

SLIDE 13

Balance Sheet Reconciliation for Case Study Scenario*

Assets			Liabilities-Surplus	
Bonds	$60-9-5-1 =	$45	Major Medical	$30
Mortgages		35	Long Term Care	45
Cash		0	SPDA	6
			Surplus	(1)
		$80		$80

*Bonds - $60 million in previous year's total, negative $9 million represents liquidation of bonds due to cash flow shortages or $5 million cash at end of prior year minus $14 million shortage this year, negative $5 million represents disintermediation loss; and negative $1 million represents asset default loss.

Mortgages - No change.

Cash - $5 million surplus of previous year is used up in funding $14 million cash shortage.

Major Medical - No change from prior year end reserve level.

Long-term care - Reserves increase from $30 to $45 million.

SPDA - Reserves decrease from $20 to $6 million.

Surplus - Decreases from $20 million to negative $1 million due to accrual profit loss of $15 million, disintermediation loss of $5 million and asset default loss of $1 million.

Since the company is insolvent under the scenario chosen at the end of the following year (as noted above), the solidity of the company as currently defined is at slightly less than a 95% confidence level. Further, the vitality of the company is weak or nonexistent under the set of assumptions used. Clearly, sensitivity testing has more limitations than a probability model or ruin formula, but the result here would normally cause management to reassess strategy due to the risks indicated.

In conclusion, the value of performing proper methodology and testing in accordance with the valuation actuary concept is to achieve a balance of proper investment strategies and risk undertakings, as well as producing the appropriate liability level. If a valuation at least as extensive as shown in the case study is performed, the result should be improved performance of management due to better information.

III. Summary

The profession is currently headed toward passage of new standards for requiring an expanded opinion from an actuary as of year-end 1991 or 1992. This requirement, however, could still run into roadblocks and the implementation date delayed. Nevertheless, every reason exists to believe this concept will eventually be put into practice. As such, health actuaries need to get serious about the implications of the valuation actuary. Without

substantial advancement of the valuation actuary concept in health insurance, objectives will not be achieved and compliance will not be good.