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**RESEARCH REPORT
ON SELECTED DYNAMIC SOLVENCY TESTING TOPICS**

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I. EXECUTIVE SUMMARY

A. Purpose of Research

In response to the research recommendation of the Dynamic Solvency Task Force, the Society of Actuaries commissioned Allan Brender of William M. Mercer Limited and Donna Claire of Claire Thinking, Inc. to prepare papers to define certain topics and provide information on techniques currently available in support of the development of dynamic solvency testing (DST).

Topics covered in this paper are:

- Time frame for analysis
- Scenario interpretations
- Credibility and reliability
- Confidence standards
- Reliance guidance.

The report also comments on what additional research may be needed.

The primary audience for the Dynamic Solvency Testing Report is company management. However, regulators currently receive reports based on a form of DST and will be interested in the more general reports. Both audiences are considered in this report.

B. Situation Analysis

The main purpose of DST is to obtain insight into a company's sensitivity to changes in experience and to discover situations that could cause financial difficulties for the company. It is a type of early warning test for management and the board of directors.

The use of models and cash-flow projections is increasing rapidly within the actuarial, insurance, and financial communities. This is a worldwide phenomenon. Actuaries and others must begin developing a science of cash-flow modeling. Research will have to be undertaken on a wide front, in

many countries, and by many individual researchers. We expect that forums to stimulate and report on this research, such as international conferences and journals, will emerge soon. The Society should consider participation in and sponsorship of this international effort.

C. Observations and Recommendations for Research

1. Time Frame for Analysis

DST reports should be consistent with management and board of directors' internal planning cycle, which in many companies is three to five years. However, risks beyond the reporting period should not be ignored. Test projections, particularly for long-term business, should be done mainly for the actuary's own information and reported when qualitative information indicates that trends emerging over a longer projection period are significant for the company's future stability. Year-by-year results should be examined through the projection period.

We recommend the Society of Actuaries begin research on new techniques to interpret the large amount of numerical data resulting from multiple-scenario projections, especially using graphics.

2. Scenario Interpretation

Although solvency is a matter of the company as a whole, management and the board of directors usually will want to track results by line of business or by divisions. The actuary's DST report and the modeling software used should accommodate the level of projection analysis at whatever level is most helpful to the user.

3. Credibility and Reliability

Readers of the actuary's report must be confident that the results accurately represent the company's behavior. The value of the DST study depends on the nature, variety and number of scenarios tested.

The choice of scenarios should include "outliers," or rare events. We recommend the Society of Actuaries compile "unlikely" scenarios that actually happened to help actuaries generate ideas for DST scenarios and show others the need to consider extreme scenarios.

Appropriate scenarios are usually selected deterministically, with the actuary choosing scenarios thought to be relevant. Guidance for doing this can be found in the Society's *Dynamic Financial Condition Analysis Handbook*,

which we recommend be updated periodically. Stochastic interest generators now in use probably are not appropriate for DST. We recommend the Society research and educate actuaries on the development and proper use of various generators. A new paradigm for the development of interest scenarios is needed for use in DST.

More research is needed into what key quantities most strongly influence the company's financial condition.

4. Confidence Standards

Some may expect that the result of a DST study is a statement about a company's future solvency, indicating the level of confidence with which the actuary holds that opinion. Given the current legal environment and the profession's current lack of technical tools in this area, actuaries should not offer an opinion on a company's continuing solvency if it is likely this opinion will be interpreted as a type of expert guarantee. It also is not consistent with current actuarial practice to express an opinion on the likelihood that the assumptions used to project future experience will be realized.

In Canada, the Canadian Institute of Actuaries (CIA) developed a standard of practice in which the Appointed Actuary making a favorable opinion states that the financial condition is "satisfactory." This makes a minimal statement without offering a guarantee of continuing solvency.

We recommend the Society carry out an active research program to discover as much as possible about assigning likelihood or probability densities to various scenarios. We also recommend a call for papers on relating certain assumptions used in DST to economic conditions.

5. Reliance Guidance

In conducting the DST study, the actuary must rely on information gained through specialists during consultations. He or she should not accept that work without question, however, and should evaluate the quality of that input and be prepared to test alternative situations. The actuary must accept full professional responsibility for the DST report.

II. TIME FRAME FOR ANALYSIS

A. Projection Period

The fundamental issue discussed in this section is the appropriate number of years for a projection model for sensitivity testing purposes. The two aspects to this issue are:

- o The number of years for which a company model should be projected to obtain adequate information
- o The number of years for which projections should be reported in the actuary's report.

The first number will always be at least as large as the second. However, sound reasons may exist for these values not to be equal.

1. The Case for a Shorter Projection Period

In Canada, the standard of practice on DST of the CIA calls for a five-year projection period for life insurers. Actuaries carry out projections for this period and report on results obtained for the entire period.

The CIA chose a five-year period for several reasons:

- (1) Management and other users of the actuary's reports are comfortable with a period of this length, because it is consistent with many companies' planning horizons. Using a very long period such as 25 years, coupled with inflationary assumptions, could lead to financial statements containing significantly larger numbers toward the end of the projection period than current values. Readers may have difficulty accepting these numbers and will give less credibility to the report, even if they ultimately prove correct.
- (2) If a company could be shown to be relatively secure during this period, it would have enough time to adapt to changing circumstances as they evolve.
- (3) It allows the actuary to model trends in experience and in company reactions to these trends.

The actuary often needs input from others in choosing projection assumptions and constructing models. For example, input may be needed from marketing specialists on new business assumptions and from investment managers on the economic environment and investment policy. These individuals may not be comfortable in choosing assumptions covering longer than five years.

A five-year period can also be justified in that the length of a product cycle (the period before major changes are made to a product) has shortened in the past few years.

Some companies have a very short planning horizon, such as three years. This is particularly true for companies that are dynamic (for example, that very actively trade blocks of business). Also, some U.S. regulators have requested three-year plans from companies that are in rehabilitation or under supervision.

The argument is that major problems should be recognizable in a three-year study, and corrections for these problems should take less than three years. It is questionable whether the effects of a developing problem and the results of a company correction can be adequately modeled over only three years. For some changes, such as a deterioration in mortality, it could easily take two or three years for the trend to be recognized as something other than randomly unfavorable experience. Calculating and implementing a new premium scale could take another year. More time is then needed to see the effects of this repricing on the company. A five-year period seems a better choice from this point of view.

Certain products may become unprofitable in years beyond the projection period. This can be taken into consideration by setting the reserves at the end of the DST report's projection period at a level that provides for these negatives. This topic is explored further in this report's section on valuation assumptions.

2. The Case for a Longer Projection Period

Life insurance and annuity products usually are long term, and profitability patterns can vary over the product lifetime. A full understanding of these products and the possible risks they present to insurers might require projections to be carried out for 25 or 30 years.

Examples of products with variable patterns are:

- Lapse supported products that are priced on the assumption of significant lapses over the first 20 years
- Products that pay persistency bonuses after some period, such as 20 years
- Products with enhanced settlement options after a number of years
- Products with high dividend scales at later durations
- Annuities containing long-term interest rate guarantees that are sensitive to earnings on the company's investment portfolio.

It is important for the actuary to be aware of these long-term risks and to communicate their significance to management and the board of directors. It may not be necessary to provide detailed numerical projections; a descriptive and qualitative report may be enough. Numerical projection results may not in themselves be seen by the layperson as believable. However, the actuary should be able to spot the trends in the data and to interpret them for management.

Therefore, it seems advisable that, at least for certain crucial scenarios, projections be carried out over a longer projection period of 20–30 years. This period needs to be long enough to test whether the products are unprofitable at any future time.

An example of the joint use of a five-year reporting period with a longer projection period is provided by Singapore, where DST is being implemented in 1994. The memorandum on DST issued by the Monetary Authority of Singapore, the local regulator, suggests that the actuary carry out projections for 30 years but only report on the first five-year projection period.

3. The Role of Valuation Assumptions

An important feature of the Canadian approach to DST is that the valuation assumptions used in the projection are expected to change over time to be consistent with projected experience emerging in the scenario. Policy reserves at the end of the five-year period effectively “lock in” the deterioration in experience beyond the projection period for the remaining lifetime of the policies in force. Because some provision is made in this way for unfavorable experience beyond the five-year projection period, the Canadian DST process does not usually involve projections over the long term. The results of five-year projections that incorporate appropriate reserve changes are fairly easy to interpret and communicate. Although computer time is saved because of the shorter projection period, the revaluation process itself requires additional programming and can consume significant computer resources.

The essence of a cash-flow projection is to determine all the various future cash flows that affect the company in a particular scenario. Once these cash flows are available, they can be used to prepare financial reports according to various sets of accounting rules, including statutory and GAAP.

In the U.S., valuation assumptions tend to be fixed over time. If results of the DST study are reported by the actuary in terms of statutory or GAAP

financial reporting, it will not be feasible to account for long-term trends by changing valuation assumptions at the end of five years, as is done in Canada. In this case, it is advisable to make use of a longer projection period to more fully appreciate the effects of unfavorable long-term trends. Alternatively, the actuary can report long-term projection results over a shorter three- to five-year reporting period by using Value Added Accounting (a source of information on Value Added Accounting is SOA *Study Note 443-23-89*, "Value Based Financial Management") with appropriate changes in valuation assumptions. It also would be desirable to provide an analysis of the change in reserves, showing what part of the change is due to a change in assumptions.

4. Computing Considerations

The amount of computer time required to carry out projections is a practical issue. This assumes greater importance when multiple scenarios are projected. Increasing the length of the projection period clearly increases computing time. However, in a well-designed program, this increase is usually proportionally less than the increase in the length of the projection period. In many projection programs, the length of the projection period depends on the choice of a single parameter. Virtually no additional work is required of the user to run a longer projection.

Computing time, in our experience, is not a very significant factor in choosing the projection period. With the increasing speeds of computer processors, computing time becomes less of a concern.

Long projections will generate large amounts of output data. This increases data storage requirements (disk space). This may be an important practical consideration for some companies, particularly when many scenarios are tested.

Actuaries carrying out growing numbers of projections will be faced with interpretation of the large amount of numerical data, which can be time-consuming and difficult. New techniques in the interpretation of this sort of data are needed. We suggest the Society of Actuaries initiate research on this topic and investigate graphical techniques in particular.

5. Projection Period Conclusions

The management of many companies focus on an internal three- to five-year planning cycle. Since the primary focus of DST is on management and

the board of directors, reports prepared by actuaries should be consistent with the planning cycle.

However, the actuary should not ignore risks beyond the reporting period. Test projections, particularly for long-term business, should be done mainly for the actuary's own information. It is appropriate for the actuary to report qualitative information on trends that emerge over a longer projection period and are significant for the company's future stability.

B. Interim Solvency Requirements

The focus of reserve adequacy testing has been to concentrate on end-of-period results. For solvency, interim results are also important. Year-by-year results should be examined throughout the projection period. At first glance, the actuary will most likely examine trends in a few important quantities such as:

- Net surplus
- Risk-based capital (RBC) ratios
- Net income
- Policy reserves
- Total assets.

If many scenarios are projected, the actuary will examine many intermediate results. This will be difficult, and it is likely the few quantities listed previously will be tracked first. Detailed examination of results for particular lines of business will lead to examination of many other time series relating to profitability.

Since DST is a "what if" process, it is not necessary for the company to always "pass" each scenario. One of the purposes of DST is to discover situations that can cause difficulty for the company. For most companies, scenarios can be found for which the projected results are unfavorable. These scenarios should be tested, and the resulting difficulty should be analyzed and understood, providing valuable information to management.

In this context, difficulty may be defined in many ways, for example, falling below the 200% RBC ratio, insolvency of the company, and certain lines becoming unprofitable.

The model should be dynamic and reflect actions likely to be taken if the company does experience difficulty. Actions may include such things as an infusion of capital from a parent, issue of new debt or equity, or reduction in the volume of future new business, among others.

III. SCENARIO INTERPRETATION

A. Measures and Results Most Important in Analyzing Scenarios

When considering its financial condition, a company's principal consideration is maintaining its license to do business. Therefore, statutory surplus and the RBC ratio will be of most interest. Net income is a leading indicator of patterns of changes in surplus and will also be of great interest.

Management also will be interested in tracking the company's GAAP results, particularly net earnings. As mentioned previously, the results of cash-flow testing can be presented according to various accounting formats. The actuary should be prepared to present GAAP figures with market values. However, it is important to also present statutory figures, since company solvency usually is judged according to the state of the statutory balance sheet.

If the DST study is carried out using sophisticated cash-flow modeling software, any figure contained in the annual financial statements will be available for examination. These can be used to pinpoint particular sources of difficulty that emerge in the various projections. It is desirable to use such software and to have this facility to examine projection results on as detailed a level as possible.

In examining multiple scenarios involving changes in the same factor, such as variations in interest rates or in mortality, the actuary should concentrate more on the variability of results than on the mean values. The main purpose of DST is to obtain insight into a company's sensitivity to changes in experience. Sensitivity is best measured by variability of the projected results. A projection of the company's business plan is probably the best basis against which results of other scenarios can be compared.

If an appropriate stochastic generator is available for use in choosing multiple scenarios of variations in a single factor, such as interest rates, a very large number of numerical results will be generated. It will be very difficult to examine these individually. A graphical presentation of a single time series, say net surplus, for all scenarios tested may be of great help in understanding the results. This technique is very well illustrated in the recent book *Practical Risk Theory for Actuaries* by C.D. Daykin, T. Pentikainen, and M. Pesonen, published by Chapman & Hall in 1994.

B. Level of Aggregation

In analyzing results of projections, it is natural to ask whether the emphasis should be placed on the results of the entire company or of divisions of the company. Solvency is a matter for the company as a whole, since a company cannot fail in parts. Therefore, the corporate view will be the primary focus of interest.

Management and the board of directors, however, will want to track results by line of business or by divisions as specified in an internal financial reporting system. The form this system takes will vary from company to company. Therefore, no general rule can be given, other than to perform the analysis of projections at whatever level is most helpful to the ultimate user of the DST study results.

This suggests that modeling software used for projections should be flexible enough to analyze various levels of the company and according to various financial reporting structures, including statutory, GAAP, and internal.

One consideration that arises when the company is divided in divisions is the matter of negative cash flows in certain lines of business. In periods when a line of business has negative cash flow, the model should allow the line to borrow (at current interest rates) internally from corporate surplus or other lines of business or externally from the bank, or to sell assets to raise the necessary cash. Similar provision must be made when the company as a whole has negative cash flows.

If an insurer has subsidiary companies within its lines of business, DST should be done separately for each company. Each subsidiary, as a legal entity, must stand on its own and meet its own solvency requirements. This applies to subsidiaries that are insurance companies and those that are other types of financial institutions.

Similarly, if the company in question is a subsidiary of a larger corporation, it usually is necessary to consider the company on a stand-alone basis for purposes of DST, because usually there is no automatic recourse to the parent if the company fails. The parent may intend to support the subsidiary under most or all circumstances. Considering the subsidiary as a stand alone will provide the parent with information on the size of future capital infusions into the subsidiary that could be required.

C. Sources of Outside Capital

Management may have contingent plans to raise additional capital if the company's fortunes deteriorate. If the actuary has confidence in these plans, it would be appropriate to incorporate them into the projections. However, the actuary also should recognize the possible delays in implementing this strategy. The expected source of this capital, be it a private investor or the capital markets, may be unwilling or unable to provide some or all the capital when it is needed. For example, it may be easier to raise more capital to support a large volume of new business than if the company is perceived by the financial markets as being in serious financial difficulty because of a deterioration in asset values. These possibilities should be tested as alternative scenarios.

If the additional capital is in the form of debt, the cost of supporting that debt should be taken into account. Note that this cost can be expected to increase as the company's financial situation worsens.

In the case of a mutual company, it may not be possible to raise additional capital. The acceptability of surplus notes or other forms of subordinated debt as capital will vary by jurisdiction. The only recourse may be to demutualize in order to raise equity capital. If the actuary chooses to model this possibility, it is important to take into consideration the complexity of this process, the long period before it can be effected, and the expense of the process.

A contingent plan may involve the sale of assets, or of blocks of in-force business, if financial difficulty occurs. If the actuary wishes to incorporate this strategy in the projections, it is important to account for these assets' degree of marketability and liquidity and to be realistic about their value in what might be a fire-sale situation. Moreover, projections should extend several years beyond the point of sale to understand the effects of the sale itself.

IV. CREDIBILITY AND RELIABILITY

A. Confidence in the Model

If readers of the actuary's report are to accept the results of the DST study, they must be confident that the results presented are truly representative of the company's behavior. Although readers know that the study is

based on projections using a simulation model of the company, they must believe the model used accurately reflects the company.

Three aspects enter into the question of accuracy of the model: the beginning position, the dynamic behavior of the model, and assumptions made for expected future experience, as described below.

The Beginning Position

Projections will begin from the company's position at a particular time, usually the end of a business year. Comparisons should be made between initial summary data in the model and the company's financial position as indicated in its financial statements prepared at the beginning projection date.

Some measure of acceptance or a tolerance for error must be used, much as one chooses a standard of materiality when doing financial reporting. It is rare that a model will agree completely with the actual figures; some deviation is to be expected. One can reduce this modeling error by enlarging and refining the model, adding more data points or cells. The effort to improve accuracy in major figures from, for example, a 1% error to a ¼% error may be considerable. A trade-off between accuracy and cost clearly exists. Because the purpose of DST is to test the company's sensitivities, it may be acceptable for the model to not fully agree with the company's financial statements if the model reacts to changing situations in the same way as the actual company would.

The Dynamic Behavior of the Model

The actuary should understand how the software operates, what the assumptions for timing of events are, and the order in which events are processed. Probably the best test of the projection capabilities is to construct the model based on an earlier year's position and to project from that point to the end of the most recent, completed fiscal year. Projected results can then be compared to the latest annual statement to measure the model's accuracy. Usually, results will be compared at detailed product or line-of-business levels. These comparisons may indicate where adjustments are needed in the model.

Assumptions Made for Expected Future Experience

The company should have recent experience studies of all important factors, including mortality, morbidity, lapse, expense, credit risk, mortgage

prepayment, and bond call risk. It should base assumptions for the base scenario on these factors, unless a valid reason exists to expect change in experience levels. If the company does not have highly credible experience on which to base assumptions, intercompany experience studies published by the Society of Actuaries and other organizations usually will be used. Because of increased uncertainty about future experience levels, testing must include a wider variety of scenarios reflecting possible variations in that experience.

B. Selection of Scenarios

The value to be derived from a DST study of an insurance company will depend on the nature, variety, and number of scenarios tested. The choice of scenarios is clearly one of the most important components of a study's design. However, this choice can be complicated and requires a great deal of consideration.

When considering the choice of scenarios, the actuary should keep in mind that DST is more of a "stress test" than an exercise in prediction. Its primary purpose is to examine the company's financial resiliency.

Some of the scenarios to be tested will be quite different from the actuary's expectations of future experience. In a statistical sense, these scenarios will be "outliers." Because these scenarios seem to be extreme and unlikely to occur, the temptation exists to dismiss them or the results generated from them. They may lack credibility. Still, the actuary should understand the role played by these scenarios and should be prepared to explain their importance as part of the DST report.

In the language of probability theory, rare events or outliers are not likely to occur or do not occur often. However, they do occur occasionally. For example, in 1975, a scenario projecting interest rates rising to 20% or higher and then receding over the next 10 years would have been regarded as most unlikely. Many today would dismiss this scenario as not credible, but this scenario actually was realized.

Actuaries would benefit from a compilation of "unlikely" scenarios that actually happened. This would stimulate their imaginations, help them generate DST scenarios, and would show others the need for consideration of extreme scenarios. We suggest the Society of Actuaries undertake this project.

Scenarios can be selected in several ways.

A deterministic approach is the most obvious method. The actuary chooses those scenarios thought to be relevant. Because the important “outlier” scenarios are not likely to emerge from a stochastic scenario-generating process, a strong case for using some deterministic scenarios can be made. The actuary may also be aware of certain sensitivities in the company that should be examined, so appropriate scenarios would be selected deterministically.

Deterministic methods are emphasized in the selection of scenarios in the Canadian DST process. Besides those considerations mentioned previously, a perception exists that appropriate alternative methods for scenario selection are not developed well enough yet.

Actuaries need some guidance in selecting scenarios on a deterministic basis. Some will be provided in the Society’s *Dynamic Financial Condition Analysis Handbook*. We suggest the handbook be updated periodically as new insights develop and as the profession develops more experience in this field.

Many in the actuarial community believe that some scenarios, particularly those dealing with variations in interest rates, should be generated stochastically. In the U.S., stochastic interest generators have been used for reserve testing; it is natural to think they could be used in the same way for DST. We urge caution.

Most stochastic interest generators found in the actuarial and financial economics literature have been developed for pricing financial instruments. This has two consequences for DST:

- *Too little emphasis on future volatility.* In many models, it is up to the modeler to select volatility parameters. This may be appropriate for pricing and reserve testing but may not extend to DST. Since, as has been noted before, the emphasis in DST is on a wide range of scenarios, generators should have high volatility. We believe many generators now used may not be appropriate for this purpose.
- *Does not produce a full yield curve for each future time interval.* Many of these models generate spot rates for each future time period; they can then produce yield curves in effect at time zero. However, few of these generators produce a complete yield curve at each future time; a complete DST study usually would require a full yield curve for each future time interval. Generators that produce full yield curves at future times require much skill in fitting the appropriate parameters. If actuaries are

to use these generators, they will have to exercise great care in selecting the appropriate model and great skill in fitting the parameters, so a proper variety of scenarios that sufficiently test the insurance company's condition is produced. We see a need for research on the development and proper use of various generators and an extensive educational effort in this area by the Society of Actuaries.

A change in interest rates usually is accompanied by changes in other economic variables and in other variables affecting life insurance company operations. For example, much of the cash-flow testing done on interest-sensitive products has used lapse rates that depend on the level of interest rates. The scenarios tested mostly have involved rather ad hoc relationships between interest rates and lapses. For a scenario to be coherent, variables related to interest rates should change when interest rates vary.

We are not aware of any systematic study of these relationships. We recognize that the strength of these relationships will vary over time and from company to company. Still, we believe there is room for research in this area. The Society now has a project of this type, Actuarial Modeling I, under way.

We also suggest the Wilkie model be reviewed (a copy is available from the SOA library), and other models in use in the United Kingdom or elsewhere, for possible application to the U.S. and Canadian situations. The Wilkie model generates a number of economic variables in a coherent manner.

While the stochastic approach is attractive, it does not explain fully the movement of interest rates and other important economic variables. Nonstochastic changes in these variables often result from political events, actions by governments, and actions by central banks.

A new paradigm for the development of interest scenarios for use in DST is needed, and much research needs to be done here. A possible approach is through chaos theory. Many others may exist. The SOA Actuarial Modeling II research project will study this question. We support this move but caution that this is a very large research area. This project is likely to be only the first step in this direction.

Much work remains to be done on the selection of appropriate scenarios involving important insurance variables other than interest rates. For example, in gross premium valuations of traditional life insurance products as well as interest-sensitive products, a provision for adverse deviations in the

policy lapse assumption will be positive at times and negative at others. At which durations the changes in sign should occur often is not clear.

The real risks in policy lapses are not obvious. There is not much professional literature on this question. We suggest the Society of Actuaries conduct research that would guide actuaries on the appropriate testing of policy lapse experience in DST studies. Some work is under way. For example, the Interest-Sensitive Cash-Flow Research project studied lapse rates for single-premium deferred annuities (SPDAs) and has started a similar study for universal life. One problem with these studies is that they cover only the years 1985–1990, during which interest rates gradually tended down. So the relationship between lapses and credited versus actual interest rates could not be established. We believe the same consideration should be given to all other important policy variables.

Regardless of how a set of scenarios is selected, the set of scenarios should consider all significant sources of risk, individually and in combination as appropriate. Scenarios incorporating the impact of a combination of risks should be included, because the impact implied by such scenarios may be much different than the combined impact implied by the use of scenarios treating each risk separately.

C. Key Measures

The volume of data produced by cash-flow testing under a variety of scenarios can be very large. This makes interpreting results difficult. Actuaries and others in these cases often focus on a few key values such as:

- Net income
- Total surplus
- The RBC ratio of available to required surplus
- Other ratios used by regulators (for example, the NAIC's IRIS system) or the rating agencies.

Much analysis of companies is based on studies of trends over time in these key values.

Confronted with large volumes of data, actuaries could benefit from guidance on which key quantities are most sensitive to the company's financial condition and deserve their greatest attention. Little information seems to be published in this area.

The Society has sponsored some research directed to determining leading indicators of insurance company financial difficulty and on methods of

company analysis based on the results of cash-flow projections. This was in the Ph.D. thesis completed by SOA Ph.D. grant recipient, James Carson, titled "Identifying Life Insurance Financial Distress: Parametric and Nonparametric Classification Models and Empirical Evidence." However, more work can be done in this area.

V. CONFIDENCE STANDARDS

A. *The Relevance of Confidence Standards in DST*

DST is more a matter of probing for a company's possible weaknesses (and strengths) than a procedure for assigning a probability of ruin. It is best viewed as a type of early warning test directed primarily to company management and the board of directors. Regulators also will be interested in the actuary's DST report. In Canada, DST is a major component of the actuary's financial condition report.

Any opinions expressed by the actuary are, at best, qualitative and do not offer numerical levels of confidence. It is, however, appropriate for the actuary to describe the extent of the testing upon which any conclusions offered in the report are based.

It has been suggested that the development of DST involves the choice of a confidence standard. The notion of a confidence standard usually arises in connection with the making of an estimate. Since an estimate is, by its very nature, not an exact but an approximate value, it is appropriate to indicate the degree of confidence the estimator has that the estimate is close to the true value. Confidence is usually expressed as a number between zero and one or as a percentage. Often, the situation may be too imprecise to specify an exact numerical confidence level. The estimator will then express his or her degree of confidence in qualitative terms.

Actuarial groups have discussed the proper confidence standard to apply to various actuarial models. For example, the Actuarial Standards Board defines "reserve adequacy" as a level of reserves "...adequate to cover obligations under moderately adverse conditions. ..." Society of Actuary meeting transcripts published in the *Record* and proceedings of Valuation Actuary Symposia indicate many actuaries would prefer a numerical confidence standard. Often, it is asserted that reserves should hold up at least x (for example, 80) percent of the time. Presumably, what is meant is that the probability that the present value of benefits less premiums exceeds the

calculated reserve is no more than $1 - 0.01x$ (for example, 0.20). The probability in question would be drawn, in the case of net level reserves, from the joint probability distribution of the valuation interest rate and the insured's remaining future lifetime. If gross premium reserves were used, the distribution would be a joint distribution of these variables together with, for example, lapse rates, expense rates, tax rates, and morbidity rates.

However, the relationships between these variables are complex and not completely understood. The distributions in question are not generally known, and some may be unknowable.

Much research needs to be done in this area. Some research, such as the Society of Actuaries Actuarial Modeling I and II projects, is under way or about to begin. Actuarial Modeling I will develop sets of econometric series that are relevant to the financial solidity of insurance companies. Actuarial Modeling II is more conceptual. This project will attempt to develop key factors to be used in constructing models of insurance companies to project financial results. It is not yet known which variables will be able to be quantified, which may be reduced to a formula based on economic conditions, and which may not be able to be defined within a confidence standard. The Actuarial Modeling II project has just begun, and it is not expected to provide useful information for several years.

Actuaries are not yet in a position to make quantitative confidence statements. To the layperson, an expert, such as an actuary, offering a numerical confidence statement often implies a high degree of technical precision and exactness. Given the current state of the profession's knowledge, it is not appropriate for actuaries to make such statements.

Some actuaries, some members of insurance company management, boards of directors, and insurance regulatory agencies might expect the result of a DST study to be a statement about a company's future solvency. An opinion that a company is likely to remain solvent should indicate the confidence with which that opinion is held. However, the purpose of the DST exercise is not necessarily to give such an opinion.

Should an actuary offer an opinion on an insurer's continuing solvency if it is likely this opinion will be interpreted as a type of expert guarantee? The actuary can never be sure, in doing a DST study, that all possible scenarios of future experience have been investigated and all possible future outcomes for the company have been considered. In general, for any company, scenarios could be constructed that would drive the company into

insolvency. Even with a qualification that the actuary's confidence level in making that statement was less than 100%, those who choose to rely on that statement may not properly recognize the qualification. Given the legal environment in professional liability in the U.S., it may not be advisable for actuaries to offer this type of opinion, even for the strongest companies.

Another way in which the notion of confidence levels can be associated with DST is with the assumptions used by the actuary in projecting the company's future experience. The actuary might express an opinion on the likelihood that the assumptions will be realized. This would not be consistent with current actuarial practice, for the following reasons.

Most actuaries would regard a "best guess" set of assumptions as being an estimate of the mean or expected value drawn from the distribution of all possible sets of rates that might be experienced in the future. They also would recognize that the actual rates to be experienced, being one sample point or realization of the general situation, will not exactly match the expected value; actual experience will be the expected value plus a random deviation. Therefore, it makes little sense to offer an opinion on whether the "best guess" will be realized.

Logically, if a likelihood or probability density could be assigned to each set of assumptions, we would know the distribution of all possible future outcomes for the company. Assigning such densities to various scenarios implies knowledge that is not now available, and we should not suggest it is. However, as a profession we should carry out an active research program to discover as much of this knowledge as possible. Some of this work is being undertaken by the Actuarial Modeling I and II projects.

This work also may benefit from a call for papers on relating certain assumptions used in DST to economic conditions. Such variables could include lapse, mortality, morbidity, retirement, and premium continuance rates; mortgage prepayments, bond calls; real estate valuations; and commercial mortgage defaults.

Most importantly, DST involves sensitivity testing of a "what if" nature. The actuary will carry out projections based on scenarios or sets of assumptions that he or she may not believe are likely to occur. It is the nature of DST to use assumptions that are not likely but should be tested. It would be misleading to weigh the results of a particular scenario by the likelihood the scenario will be realized. The objective of DST is to test a company's ability to survive adversity, not to calculate its expected loss.

It is interesting to speculate on how an opinion based on a DST study could be formulated if the distribution of future experience were known. It might then be appropriate for the actuary to state, for example, that the company is likely to remain solvent if experience differs from the mean by no more than one standard deviation. Unfortunately, we believe that research and development will take a long time, and actuaries will not have the tools necessary to make such a statement for many years. It is possible the full distribution of future experience is unknowable and that the profession will never be in a position to make a probability statement of this sort.

B. Caveats

A DST study will involve many and varied sets of assumptions. The variety of scenarios tested can be confusing to the reader of the actuary's report.

It is important that the report clearly state the purpose of the study and describe the manner in which it is carried out. The report should clearly identify its intended audience, usually management, directors, and regulators. Because the scenarios are speculative, it is important to stress the confidential nature of the report.

The report must be carefully worded and contain the proper caveats so the reader will not be misled. The reader should understand that the scenarios tested are not intended to be predictions. The emphasis is on variability of the company's results and not on their expected values. The dependence of the results on the many assumptions involved should be made clear. It should be emphasized that the assumptions made in the various scenarios are not intended as predictions of the company's future experience, but are used to test the company's sensitivities.

C. Confidence Standards in Other Professions

We were asked to consider whether other professions use confidence standards in similar situations. We could not find any examples of the significant use of confidence levels by members of other professions when offering professional opinions.

Physicians often are asked to give opinions on survival or on the effectiveness of a course of treatment. In general, they will respond by citing experience in clinical trials, but always stressing the unpredictability of individual cases. Guarantees or confidence statements usually are not offered and often are not expected by their patients.

Auditors usually do not offer an opinion on the financial condition of a company. Rather, they certify that the financial statements prepared by management are in accordance with professional accounting standards. Estimates of the financial condition are not made, and so the issue of confidence standards does not arise.

We recognize that some professionals are required at times to offer numerical estimates. For example, petroleum engineers often are asked to estimate oil reserves. These numerical estimates may carry with them confidence statements based on standard professional techniques.

We are not aware of any situation in another profession similar to DST, involving future financial condition or chance of survival, which would involve a numerical estimate with an associated confidence statement. Our profession's situation is different from that of the physician. We do not have a collection of repeatable independent clinical trials on which we can base a statistical inference. Our situation is also different from the petroleum engineer whose estimates are based on experience of a physical phenomenon not subject to change because of human decisions and economic factors, as are insurance companies. We believe the actuarial profession has no valid precedents to follow that would oblige it to include confidence statements in DST reports, given the current state of our art.

D. Qualitative Statements

Qualitative descriptions relating to confidence levels arise in several situations with DST. Most common is the notion of the "best guess" scenario, or the business plan scenario. This scenario, or set of assumptions, often serves as the base scenario against which all others are measured. The use of the "best guess" terminology conveys the notion of a mean or expected value. As long as this is understood to include the possibility of deviation from the best guess, the term is common within the insurance industry and quite acceptable. The general usage of this term does not seem to require a numerical quantification of likelihood or confidence.

A more interesting and difficult situation arises when the requirement to carry out periodic DST studies is imposed by means external to the profession, for example, by legislation or regulation. If the requirement is public, though it is understood that the report itself is confidential, the actuary may have to state publicly that the requirement has been met. This is the position taken by the CIA.

In Canada, DST was originally developed by the CIA, and members were required by a CIA standard of practice to carry out annual DST studies. Subsequently, legislation gave the Superintendent of Financial Institutions the power to require Appointed Actuaries to prepare financial condition reports. The Superintendent has now required these reports, based on the annual DST studies. The CIA has taken the position that because financial condition reports are now required by legislation and regulation, the actuary must publicly recognize this obligation.

According to the CIA's standard of practice "The Appointed Actuary's Report for Insurance Company Published Financial Statements," beginning with 1995 statements the opinion of the Appointed Actuary in the published financial statements of an insurance company in Canada will, in the case of a favorable opinion, contain the following wording: "... and I have examined the company's financial condition . . . and the financial condition is satisfactory." In the case of qualified opinions, professional standards suggest possible alternative wording for the opinion, according to the circumstances.

The statement that the financial condition is "satisfactory" was believed to be a minimal statement that could be made without offering what could appear to the layperson to be a guarantee of continuing solvency. Because the requirement to deliver the report is spelled out in public government documents, the CIA believed the actuary must make some type of comment. With many actuaries having to sign this modified opinion in less than two years' time, parts of the Canadian profession became increasingly uncomfortable. So that actuaries, especially property and casualty actuaries, might have more time to prepare for this new role, the requirement to publicly opine on the company's financial condition has been deferred by the CIA for two years until 1997.

Although details of the DST report are confidential and the profession may not believe it is appropriate to make statements that embody level-of-confidence statements, situations exist in which some form of qualitative statement cannot be avoided, both in Canada and in the U.S. The difficult task is to find wording that meets the requirements but does not offer greater confidence or security than the actuary can actually deliver. It remains to be seen whether the current Canadian wording fully meets the need.

VI. RELIANCE GUIDANCE

DST requires the actuary* to examine all significant factors that might influence an insurer's future financial condition. This is usually done by means of a projection model that incorporates all material aspects of the company's operations. These include pricing, marketing and sales, investments, and administration. In most companies, each of these areas will be the responsibility of specialists. The actuary usually has general knowledge of most topics but is not an expert. Thus, the actuary will have to make use of the knowledge and experience of the specialists.

The actuary's preparation for a DST study will usually involve consultations with leading specialists in all parts of the company. In many companies, these consultations are helpful to the company's operations, as various areas become more aware of the effect of their actions on the company's fortunes. The need for consistency in operations between different areas often will be reinforced by the consultation process.

In conducting the DST study, the actuary will rely implicitly on the information gained from specialists during the consultations. The issue that must be decided is the extent to which this is formal reliance implying a certain sharing of professional responsibility.

Consider, as an example, the actuary's reliance on information system specialists to provide accurate data on current business in force and assets held by the company. The same issues arise in the traditional calculation of policy reserves. In valuation, the actuary often will rely on the basic policy files maintained by information systems specialists. However, professional actuarial standards require the actuary to be satisfied that systems are in place to verify the accuracy of the data. In some cases, the actuary may rely on the auditor to verify the accuracy of the data. This usually requires a formal agreement between the actuarial and accounting professions on the reliance on other professionals' work. Such an agreement is in effect in Canada now. Ultimately, the actuary has the responsibility, unless otherwise provided for in professional standards of practice, to be satisfied that the data used in the valuation of policy liabilities is accurate. We suggest a similar responsibility should exist in DST.

It was once common for the actuary to rely on the investment officer for assumptions about future interest rates and the company's investment policy. Now the profession expects actuaries, especially Valuation and Appointed

*The actuary responsible for valuation; one or more of the specialists could also be actuaries.

Actuaries, to be conversant with these subjects. This is because of recent developments within the actuarial profession, including the introduction of cash-flow testing, the formation of AFIR (the investment and finance section of the International Actuarial Association), and the expansion of actuarial education in financial economics and investments.

Certainly, the actuary will consult with the company's economic and investment officers when planning a DST study. It would be impossible for the actuary to fully understand the company's investment operations without these consultations. In developing alternative scenarios for testing, the actuary will usually ask investment officers how they would react to particular changes in the external environment or in the company's circumstances. Their answers usually will be incorporated in the scenarios to be tested. In this sense, the actuary is relying heavily on the investment specialists.

However, the actuary's task does not end with the use of scenarios, or components of scenarios, suggested by the investment specialists. DST is "what if" testing. The actuary should test the effects if investment strategies and assumptions suggested by the specialists are not as expected. The actuary will be aware of the past performance of the company's investment specialists and should be able to judge whether this performance is consistent with the changes assumed in the alternative scenarios. If the actuary has concerns about how the company's investment department might react, or fail to react, in a particular situation, then what the actuary fears might actually take place also should be modeled. The actuary also should be aware of special circumstances, such as the structure of the current investment portfolio or forward financial commitments, which may inhibit the company from implementing changes in the portfolio as required by circumstances. These inhibitions should be reflected in alternative scenarios.

In short, the actuary should test not only the investment strategies and assumptions suggested by the specialists but also other plausible deviations. In doing this, the actuary is not "second-guessing" the investment specialists, but is studying the possible effects on the company if the assumptions of the specialists are not realized. This is important information for those charged with safeguarding the insurer's financial condition.

It is the actuary's responsibility to look beyond the assistance obtained from the specialists. The ultimate professional responsibility rests with the actuary. Although the input of the investment specialists is crucial to the success of the DST study, the actuary must evaluate the quality of that input and be prepared to test alternative situations. Though the actuary makes use

of and depends upon the work of other specialists, he or she should not accept that work without question.

We suggest this position should be the same for information supplied by all other specialists within the company, including the input of senior management on strategic corporate plans. This input is crucial for the construction of scenarios to be tested by the actuary. However, it is possible much of this input, assumptions really, will not be realized. This is particularly important if the assumptions differ greatly from recent company experience; special attention should be given to this situation. It is the actuary's ultimate responsibility to assess the risks to the company if future experience should deviate from that assumed by the specialists. The "what if" nature of DST requires the actuary to examine alternatives and to accept full professional responsibility for the DST report.

In Canada, for purposes of signing an Appointed Actuary's report, there is an important distinction made between "reliance" and "use." "Reliance" relates to the situation in which the actuary may have some expertise in the area but is using someone else's work. "Use" relates to the situation in which the actuary is not a specialist in the area to which the information relates and accepts the information that is given by such a specialist, subject to the actuary's general satisfaction that the information is reasonable.

The question of reliance on others is more a matter of professional standards of practice than an objective scientific question susceptible to research. We do not believe it is appropriate to suggest areas of research on this question.

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