RECORD OF SOCIETY OF ACTUARIES
1981 VOL. 7 NO. 4

POSSIBLE VALUES VS. EXPECTED VALUES

Moderator: R. STEVEN RADCLIFFE. Panelists: JAMES C. HICKMAN, J. LYNN PEABODY, IRWIN T. VANDERHOOF, JOHN C. WOODDY

An increasing need exists for the actuary to provide ranges and frequency distributions of possible values instead of providing only mean values. Our discussion will cover:

1. Projections of asset experience under various economic scenarios.

2. A practical application of profit analysis using scenarios and a deterministic model.

3. Exploring possible values by means of stochastic modeling.

4. Description of the new life contingencies textbook's stochastic approach and application to some practical population and census problems.

MR. R. STEVEN RADCLIFFE: Much of our professional work is analysis of a multitude of random variables. In the past, actuaries have tended to concentrate on the mean value of those random variables. Today we would like to look at the distributions that surround the mean values. One of the mean values we work with is profit. As the mean value of that random variable tends toward zero, the distribution around it becomes a little more interesting. We would like to know how much of the tail of the distribution is negative. There seems to be more interest in this topic now because people need to know more than just the mean values when they are analyzing such random variables.

Today I hope we can give you a nice blend of the practical and the theoretical This topic tends to get bogged down quickly in very difficult formulas and complicated explanations. Hopefully, today we will give you something useful.

We will start with Irwin Vanderhoof. He is the Senior Vice President at Equitable Life. He will cover projections of asset experience under various economic scenarios.

MR. IRWIN T. VANDERHOOF: My talk is going to cover several different but related points:

1. Deterministic Planning vs. von Neuman Morgenstern Strategy

   The attractiveness of planning and the difficulties of strategies

2. Scenarios vs. Historical Records

3. Planning for the Changing Investment Climate

   How the investment opportunities and demands upon the industry will change depending upon the economic scenario that develops in the total economy.

4. Methods of Handling Variable Cash Flows

Tilley scenarios

Immunization with variable cash flows

The first point is the relationship between deterministic planning and a strategy in the von Neuman Morgenstern sense. Planning has come of age; senior executives have started espousing planning. The problem is that the planning they espouse allows no room for maneuvering if the plan does not work.

The problem is psychological. High-level executives are usually chosen because they can act and have high energy levels. They are not chosen on account of their ability to meditate on the complexities of the world and all of the different things that could happen. Consequently, top executives try to get their advisors to give them a detailed prediction of the future. The top executives will then develop a plan as to how the future can be best exploited for the benefit of the company.

The problem is the inadequacy of the advisors. They are rarely willing, or perhaps not even able, to provide the needed blueprint of the future. The top executive rarely has the patience to listen to dozens of qualifications and dozens of possible alternates. Top executives get to be top executives by finding out the state of the world and acting on it; they are top executives because they have been able to act and get desired results. They really should not be blamed for demanding that someone tell them the nature of the environment in the future so that they can do what they do well, that is, act.

Strategy in the von Neuman Morgenstern sense is a far more difficult and demanding concept. In Theory of Games, they defined a strategy as a series of actions that were keyed to every possible future state of the world. The distinction between a plan and a strategy may be illustrated in the case of a game of chess. The plan would call for deciding in advance what the opponent's moves would be and then developing the moves that would defeat him. A strategy would call for determination of every possible move of the opponent and the corresponding move on the part of the player.

This example reveals a defect in the development of strategies. To develop a complete strategy for chess requires that we have solved the entire game. We cannot legitimately postulate a computer doing so in a finite period. Maybe the top executives are right -- developing complete strategies takes too long to be worthwhile. The sum of the whole world that includes chess games cannot be simpler than a chess game, so complete strategies are impossible for any interesting situation. Maybe, however, we can get away with incomplete strategies.

When a chess-playing human being, as opposed to a chess-playing automaton, looks at a chessboard, he does not try to review every possible future progression of moves. Rather, he looks at the board and only investigates in detail those fewer situations that look "interesting". This is an immense advantage. Since the interesting situations are manageable in size, the human player is developing a strategy covering only that small number of situations. This is why the best human players can still beat the best computers. The human player can isolate the interesting situations and thereby deal with a far smaller number of possibilities. The computer must examine every possibility, because no one has determined what makes a possibility in chess look "interesting".

The argument, however, is not that humans will always be able to win over computers in chess. Rather, the argument is that it is possible to have an incomplete strategy that does the job. By investigating those possibilities that seem interesting in terms of their impact on a company, a series of plans can be developed which, taken together, will constitute a strategy that spans the space of the entire range of possibilities.

Substantial care must be taken in developing the set of strategies. To be effective, they must span the space rather than be minor modifications of a simple deterministic projection. The crucial part is like the problem of the chess player -- to find the interesting possibilities. This is not the same as examining the past to develop statistical measures of variability of the important parameters over the past twenty or fifty years.

I do not intend to disparage the uses of the past in determining our thinking. All our thinking must be conditioned by our experiences and the measures of the past movement of important variables. However, looking only at the past can be as grave an error as ignoring it. Let me give a few examples. At almost any point in the past fifty years, looking at fertility rates of the past could lead to serious errors about their future course. No one expected the baby boom of the 1940's, and in the late 1960's there was much discussion of the very difficult steps necessary to achieve zero population growth. The fertility rates now are about at the zero population growth level, and predictions of future fertility rates from historical evidence only are not attempted with the same frequency as in the past.

Another example of the inability to develop proper scenarios from the past alone is our current situation with inflation and, therefore, interest rates. If we look only at the past, and more specifically the last twenty years, we arrive at projections of the future that must allow no probability for a significant reduction in the rate of inflation. Statistical methods must assume that the future is drawn from the same urn as the past. But that assumes that the rules that govern macro society are constant. They are not; they are being changed right now.

Look at it another way. If we attempted to do statistical projections of the decade of the 1970's using the data of the previous twenty years, we could not get a reasonable probability of the society we actually experienced. On the other hand, a task force of the American Council of Life Insurance was able to produce economic forecast scenarios, one of which, the upward rachet, worked out reasonably close to what has actually occurred.

In summary, the argument so far is as follows:

1. It is highly desirable to develop a strategy for our progress into the future rather than a deterministic forecast.

2. A complete strategy involves a prohibitive amount of work.

3. An incomplete strategy which spans the space should be a reasonable solution -- both practical and effective.

4. Such a set of scenarios cannot be developed solely from statistical examination of the past but must also be based on judgments about changes in trends the statistical methods cannot pick up.

I have some charts showing historical records of yields on insurance industry assets and the AA utility rate. If purely historical records were examined, I do not know how you would extrapolate a curve. In any case, during the last couple of years we have had an interesting differential develop between the rate on new bonds (the environmental rate) and the rate we earn on our portfolios. If we make a few adjustments in the assets of our insurance industry, as reported in the Life Insurance Fact Book, we also get some interesting results. Since our portfolio rates are running about 8% and the environmental rate is 15%, our bonds are all below book value. If we adjust for this fact and also the reduction in the nominal dollar value of our bonds to the real value, that says that in 1980 about 1/3 of our assets are not real in CPI terms. Most of that is because of the drop in market value of our assets. That is an environment that deserves some looking into.

Let us look quickly at some other interesting economic scenarios. Look at nominal amounts of assets in the insurance industry under the assumption that Reagan fails. That means we will have a big recession and then we will have a renewal of inflation. This scenario says that we will have a big drop off in nominal assets in the insurance industry and then they will pop up like mad because of the new inflation.

Under the same economic scenario, we will look at the change in the real value of life insurance company assets. You can see we have an interesting possibility here. In 1983 we might have the real value of life insurance company assets going up by as much as 30%, and then no increase at all in 1984.

All I am trying to show with these scenarios is that not only the nominal value but the real value of our life insurance company assets is subject to great change over the next five to ten years depending on the economic scenario that develops. I am trying to show that it is possible to develop economic scenarios that span the possibilities of the economy over the next five to ten years. It is possible to relate the activities of the insurance industry and our own companies to those economic scenarios.

I said at the beginning of my talk that there are two methods that can be appropriately used for solving the problems created by this kind of instability in the economy. One is the Tilley strategies on which several papers have been written and which have been discussed rather widely. The second is the immunization of assets, which is more of an opportunistic approach. If it is known what our liabilities are and we have some idea of the scenarios that might exist in the future, we can essentially plan our investments to immunize them against the change in cash flow implied by our scenarios.

MR. RADCLIFFE: Thank you, Irwin. Our next speaker is Lynn Peabody. He is from the Milliman and Robertson office in Indianapolis. Lynn does what most practical actuaries do with this problem. He works with scenarios and models to develop an estimate of the distribution function. Could you tell us your approach, Lynn?

MR. J. LYNN PEABODY: The cover of the September 1981 edition of Best's Review splashed the headline, "REVOLUTION - Industry in Midst of Upheaval". This single edition included numerous articles related to various challenges the industry is facing today. Let me quote from just a few of the articles:

"In the short term at least, turmoil will continue to cause problems in the industry".

"Factors contributing to the development of new life insurance products include the uncertain and unstable economic conditions, reflected in double digit rates of inflation and interest".

"Disintermediation replacement, erosion of the purchasing power of death benefits and the confiscatory effect of the 1959 income tax law on life companies with high current earnings rates have all taken their toll".

After reading that magazine, I was about ready to look for a new profession. And although the picture is not as bleak as might be assumed from these statements, things just "ain't like they used to be".

One area of the insurance industry that I an continually exposed to is the pricing of new products. Let us look at how the approach to pricing has changed in recent years:

1. With regard to pricing procedures, the level of sophistication has greatly improved. This stems in part from modern computers and the ability to do more in the same amount of time, but another reason is that the pricing environment demands more sophistication. The risks in today's industry are such that management cannot afford the results of pricing in a way which ignores these risks.

2. Pricing assumptions have also changed. Margins are reduced more each time a new product is developed. And many of the new products are such that historical experience is of little value in developing pricing assumptions.

3. Profit objectives also reflect recent changes in the pricing environment. Lower premiums coupled with higher expenses create later breakeven periods. However, available investments with high yields serve as an alternative to companies investing surplus in new business, thus requiring a comparable return on invested surplus as a profit objective. Therefore, you have potentially conflicting profit criteria.

In light of these changes in pricing approach in recent years, what is the pricing actuary's responsibility to managment?

1. Today, more so than at any time in recent years, the pricing actuary must communicate the pricing approach and assumptions to management. The smaller margins in the assumptions being used require managers to "buy in" to these assumptions. In fact, a measure of management's success should be their ability to manage the operations to meet those assumptions.

2. Communicating the results of profit tests is equally important. This refers not only to providing numerical results, but also explaining these results in terms management understands. It is imperative to set forth the impact on a company's operations if the desired results are achieved or in fact not achieved.

3. Finally, it is the pricing actuary's responsibility to set tracks for management to follow. The old joke about actuaries directing an automobile's path by looking out the rear window does not apply anymore. Foresight has replaced hindsight. We know now that what has been certainty in the past will not be in the future. We are in the driver's seat now, not the back seat.

Where does scenario testing fit into all this? When it comes to pricing, I am considerably less confident today than I was in the past. I wonder if my pricing assumptions are conservative enough. If experience proves worse than expected, will some profit still result? Therefore, it is the pricing actuary's responsibility to plan the "what if" game with management.

Pricing using various scenarios allows management to evaluate the risks, and to choose which risks can better be minimized given current objectives. If it is necessary to alter objectives, the information is available to do so. To the extent scenario testing meets the requirements of today's pricing relative to approach, so too does it help the actuary fulfill his role to management.

In some cases, there is a definite reluctance on the part of management to enter into the scenario approach. This may be due to cost, or time pressures, or even reluctance to recognize problems. I recently had one executive tell me that his prior actuary always said, "These are the rates and these are the profits", and he took them. He did not care about all the alternative "what ifs", he just wanted a product to sell! Once I was able to show the man that if he wanted yesterday's profits he could not have today's premiums or vice versa, and we talked about some of the relevant risks, he began to see the value of the approach I was using.

Let me give you two elementary examples of scenario pricing using simple models. In real life, of course, you would be dealing with an expanded model with numerous ages and possibly numerous different products.

In my first example, Keep-Up Life Insurance Company (KULIC) is a medium-sized stock company. The parent of KULIC is an eastern-based holding company, with no involvement in insurance other than KULIC. The parent views KULIC as a cash flow producer and keeps close tabs on the upstream dividend picture. KULIC's products are marketed primarily by General Agents and Brokers, using a heaped commission scale. KULIC is developing a new portfolio of permanent products. Included are both participating and non-participating life policies including one very competitive indeterminate premium product. Premiums are to be banded, with minimum sizes of about $100,000 (a larger minimum than in the past). KULIC's underwriting standards have recently been relaxed at the urging of the marketing department to enhance sales potential.

What are some of the risks faced in this situation which call for a scenario pricing approach? Let me just list a few:

1. The high amounts and heaped commissions combined with a brokerage marketing force may make persistency questionable.

2. The easier underwriting standards may impact mortality and perhaps persistency somewhat.

3. Selling a large volume of permanent products can require new reserves of such volume as to create undersized surplus strain.

4. The fact that the new market creates minimum sizes expected to be considerably larger than in the past indicates that KULIC is in a new ball game ...one in which historical company experience may be of little value.

5. The impact of this new portfolio on KULIC's ability to meet its parent's expectations may also be great. Increased new business and the resulting in-pouring of cash funds to KULIC rather than as dividends to the parent certainly conflicts with the parent's desires.

The situation facing KULIC's pricing actuary is a classic scenario situation. The ramifications of the new portfolio are numerous, too numerous in fact to ask anyone to make a single "best estimate" of the results or assumptions.

What are the "expected values" in this situation? Is it even possible to step up and define such values? I would hate to do it. And, I would hate to have management or the parent company measure my future performance by comparing actual results to a single expected criteria.

What approach should be taken? As a minimum, you should define a number of "what if" scenarios for your price testing, attempting to incorporate as many of the various "unknowns" as possible. Testing all the possible combinations is not feasible and may muddle things further. But it is your responsibility to management to pinpoint the most critical assumptions and the impact of deviations of actual from expected for these items.

Probably the most useful pricing tool in this particular situation may be a projection which will allow the company to test various scenarios on a portfolio-wide or company-wide basis. We are finding more and more situations where our clients are using such projections as a practical management information tool, instead of guessing at best estimate assumptions that carry risks too great to accept. A good projection system will provide the tool for the "what if" type questions the KULIC's actuary has the responsibility to consider.

For the second example, Innovation Life is a medium-size traditional mutual company exploring the introduction of a Universal Life type insurance product. The company President has asked the legal department to research some of the taxation considerations and policy drafting and filing concerns. This includes the feasibility of establishing or purchasing a stock company to market the product.

As the Company's actuary, the President is looking to you for pricing the product, analyzing profitability, and generally coordinating the various functions involved in the product development process.

If any case for utilizing scenarios exists, Universal Life is it. Let us briefly look at some of the risks:

1. The nature of the product allows it to be used in several distinct markets, with minor modifications in the rates or structure of the policy. Because most markets will exhibit different experience in many of the major pricing variables, it is imperative that these differences be evaluated.

2. As a current interest type product, it puts the company directly into the asset/liability matching situation so prevalent in the industry today. Future fluctuations in the spread between earned and credited interest rates must also be explored.

3. Anticipated expenses may vary widely from the past depending on the administrative systems and procedures developed to handle this product.

These risks are not dissimilar from those faced by KULIC in our first example. But even broader questions exist which the actuary has the responsibility to evaluate:

1. What will be the impact on profits arising from existing business if replacements or rewriting of the current policyholders occurs?

2. How does the product impact levels of equity between various blocks of policyholders?

3. If the product is a marketing success, are traditional surplus objectives endangered?

These are just a few of the special risks. In fact, entire seminars have been held regarding this subject.

I do not intend to get into a critique of Universal Life and the problems involved. I do feel, however, that this is a classic example of the need for scenario testing, and perhaps more so for the need of a projection to evaluate the impact of alternative circumstances.

This is a case where even defining the "expected values" is a considerable project. However, consider the consequences to a company, literally "diving" into this product, without a proper evaluation of the risks involved.

Some persons feel that scenario testing is an "easy out" which allows the actuary to slide out from under the responsibility he should carry. On the contrary, this approach is not an escape, but rather an enlightenment. The actuary still must form an opinion to help management understand the variances in probability that certain scenarios will occur. He cannot sidestep that duty. However, he does owe it to himself and to management to confide that some variations from expected are going to occur, and to measure as best he can the impact of those variations.

Is management's confidence in the pricing structure of a new product or portfolio diminished when the actuary takes a scenario approach? No. Most insurance managers are well aware of the volatility in our industry today. In my experience, most clients have welcomed this approach because it helps them recognize the major risks and to measure the impact on the company if actual results do not meet expectations.

What is the major risk if the actuary utilizes other, more traditional, "mean value" pricing techniques? It is ignorance as to what alternatives are available to management if pricing assumptions are not met, ignorance as to the impact of any deviations on the operations of the company, and ignorance as to what expected standards the future actual results should be measured against.

Remember the headline on the Best's Review edition: "REVOLUTION - Industry In Midst of Upheaval". We, as actuaries, are in the middle of that upheaval. As professionals, we owe it to ourselves, our peers, and our public to provide accurate, reliable, and, most importantly, useful information in the development of our new products and their continuing evaluation.

I think that a scenario pricing approach is a means by which we can meet those responsibilities.

MR. RADCLIFFE: Irwin and Lynn have used deterministic models in their analysis. Our next speaker is John Wooddy, a consulting actuary in New York City. John has a stochastic model that he uses.

MR. JOHN C. WOODDY: As actuaries we are familiar with various methods of deriving mean or expected values of the random variables which are the subject matter of our professional practice. We are aware that the expected value does not tell us all we need to know about a particular random variable. It does not tell us what the next observed value will be or even what the mean of the next ten observed values will be.

An important part of an actuary's job is to be aware of deviations from the mean and to quantify this awareness in terms that are relevant to the problem at hand. Many people who are not actuaries are capable of adding up a series of numbers and dividing the sum to determine the mean. It is an actuarial task to evaluate the validity of estimates of the future derived from the experience of the past; it is up to the actuary to deal with risk.

One way to contrast expected and possible values is to take note of the fact that an estimate of an expected value is generally derived from an observed sample of possible values. Furthermore, a different sample would most likely yield a different estimate, so that the estimates themselves are also possible values.

Another contrast is between the expected value, however derived, projected into the future and the possible values which may actually emerge in the future. This is the point of view from which the two previous speakers have dealt with the subject, and I shall pursue a similar course.

The first heading listed for discussion is "Projections of asset experience under various economic scenarios". Obviously the panelists agree on the importance of future interest rates in any economic scenario.

The outstanding characteristic of present day interest rates which would impress anyone trying to estimate future interest rates is their variability. Of course, the magnitude of interest rates on the highest grade bonds is also a new experience in the modern (since 1800) Western World.

A quantitative view of our present situation is presented in the background data compiled by the Committee on Theory of Risk in the course of preparing the monograph "Adverse Deviation" recently issued by the Society of Actuaries. For information on interest rates we turned to the Durand Series, published in Sidney Homer's "A History of Interest Rates" and extended by Salomon Brothers. These are monthly average market interest rates for long term prime corporate bonds from 1899 to 1976. They are printed in an appendix in the monograph.

The amount of assets held in the future will also be affected by future mortality and future expenses. Mortality seems to take on less and less importance in the operations of a life insurance company, although we must always be wary of some event such as the 1918 flu epidemic. Expenses, on the other hand, seem increasingly important, always rising, but not a source of shock loss. Surrenders for cash or exercise of policy loan privileges can also vary substantially, unpredictably, and in some circumstances, might shock a company into insolvency. The interplay of these factors and the wide range of financial results arising from different patterns of variation in the factors suggest simulation as the way to get a handle on what the future may bring.

The word "simulation" is in these days. In developing the Society of Actuaries Simulation Model (SOFASIM), a model of a stock life insurance company to be used for the Generally Accepted Accounting Principles (GAAP) project, the Committee on Theory of Risk started out by specifying the financial operations of such a company and then translating those specifications, as nearly as possible, into a computer program. Thus the company being simulated collects premiums, pays claims, buys and sells bonds, collects interest, pays taxes, etc. Each simulated year's activities gives rise to four lines of computer printout. A run of 31 years, which was chosen for our purposes, has close to a thousand numbers displayed.

We have our simulation, which may show interesting and unforeseen developments, but how do we use it? It would be convenient to have a single number to represent each run of the model. Depending upon the objectives of the simulation this single number might be business in force at the end of the run, number of years to insolvency, accumulated profits, etc. For our purposes we calculated the discounted value of the model company at the beginning of the simulation. The variation of this value as input was varied and also its variation with application of the Monte Carlo procedure was taken as the index of variation due to the change in input or from one Monte Carlo run to another as the case might be. The point I want to emphasize is that the specific simulation results required to deal with the problem must be identified before the design of the simulation is programmed.

Deterministic simulations answer the question "what if?" What if mortality rates increase by 20%? What if market interest rates go to 25%? Or what if they go to 5%? Also, deterministic runs provide bench marks for stochastic runs. In preparing the monograph "Adverse Deviation" we ran a good many deterministic simulations as well as a hundred Monte Carlo simulations.

SOFASIM is owned by the Society and is presently installed on the National C S S time-sharing computer. It is available to any member of the Society who chooses to open an account with National C S S.

SOFASIM is a dynamic, integrated model. The overall view of a life insurance company originally conceived for the model was that of individual insureds taking out policies, paying premiums, dying and requiring death claims to be paid, surrendering and receiving cash values, with accompanying payment of commissions and other company expenses, and investment of company funds in bonds with specific coupon rates and terms to maturity. It was not possible to go all the way to individual policies, but SOFASIM does process each cohort separately. A cohort consists of all of the policies of a given type and size group issued at a given age in a given calendar year.

SOFASIM has an optional U.S. Federal Income Tax Section. When this is in operation, the user is constrained by the built-in definition of a calendar year. If the tax calculation is turned off by an appropriate input instruction, the nominal calendar year may be regarded as some shorter or longer period by suitable modification of such input factors as mortality rates, interest rates, expenses, etc.

SOFASIM provides for new policies to be issued and for old and new policies to be terminated by death and lapse. These three processes, issue, death and lapse, independently, can be on either a deterministic or random basis at the user's choice. Other types of occurrence (e.g., interest rate changes) may be generated outside the model, randomly or functionally as the user chooses, and fed to the model as input.

Valuation factors, cash value factors, a variety of interest rates on bonds of various types and maturity dates can be changed monthly (or less frequently, or not at all) by appropriate input specification.

SOFASIM was programmed in SIMSCRIPT by Dr. Harry Markowitz while he was acting as a consultant to the Society of Actuaries, which is how the Society came to own the rights to the model. A few words concerning the SIMSCRIPT view of a world to be simulated may be useful.

As of any moment in time, a simulated world has a status. In the SIMSCRIPT view this status is described in terms of how many of each type of entity exist, what are the values of the attributes of each entity, what are the sets to which each entity belongs, and what other entities are members of the sets it owns.

Status changes at points in time called events. Events may be caused from the outside, e.g., a line of input specifying a change in the rate at which new policies are sold for a particular cohort; or events may be caused by prior occurrences of events within the system, e.g., a change in a company's asset total resulting from payment of a death claim.

The principal entities in SOFASIM are COMPANY and COHORT. The program permits only one COMPANY but an unlimited number of COHORTS. The attributes of COMPANY include its cash balance, its total reserves, its death benefits paid thus far this year, and so on. COMPANY owns the set of all cohorts.

The attributes of COHORT include age at issue, policy type, policy size, etc. Some of the SOFASIM events are process policies, buy/sell (investments), calculate taxes, etc. Each type of event is described by an event routine.

SIMSCRIPT operates on an internal clock which triggers the several events determining the results of the simulation. Initialization takes place when general company information, initial company conditions, and initial status of investments held are read in and stored by the computer. The initialization process also sets the timing of various routines and causes the first occurrence of certain events. The input may specify that some of the initial information is to be changed in a specified way at designated times during the course of the simulation. SOFASIM's internal cycle includes monthly events, non-monthly events and external events. Monthly events include: process policies, pay operating expenses, process existing investments, and buy or sell investments.

Non-monthly events comprise stockholder dividend decisions and payments, quarterly tax estimates, final tax calculations, paying taxes or receiving refunds. On December 31, after all actions are completed for the year, information pertaining to the year's performance and year-end statistics are noted and certain "last year's" figures are reset in preparation for the next simulated year's transactions.

External events consist of those dealing with company parameters, interest rate structure, desired investment profile, mortality, valuation and lapse tables, commission tables, and policy parameters. All of these events must occur once at the beginning of the simulation. They may occur at other times during the course of the simulation if it is desired to make changes in any of the underlying specifications of these events or to change sales rates after the start of the simulation.

Output for SOFASIM is produced in two separate routines. The Trace routine is responsible for the first set of summary information and prints one line of output at the end of each simulated year. A "report-and-reset" routine stores each year's performance information and statistics and, after the printing of the final line of the Trace routine output, prints four tables of these annual results. If the SOFASIM run is aborted for any reason, the information provided by the Trace routine will be printed up to the year of interruption, while the final four tables will be lost. These four tables are: (1) balance sheet information of assets and liabilities; (2) profit and loss items detailing income and disbursements; (3) tax data, giving most of the figures necessary to the final tax calculation (this group is omitted from the output if the "no tax" option is exercised); and (4) miscellaneous headings.

At the end of the run a summary of gains after taxes and stockholder dividends for the entire period simulated is presented, showing their means and standard deviations, and the sums of their present values at the start of the simulation calculated at three different interest rates, six percent, nine percent, and twelve percent. The final random seeds generated for deaths, lapses, and sales complete the output.

The SOFASIM user, by appropriate choices of input specificiations, has broad latitude in defining the company he wishes to simulate and the kind of future he wants his company to experience. It may be a new company or one with an extensive inforce on a wide variety of plans, issue ages, issue years, and valuation bases. Plans are limited, however, to coterminous term and endowment policies and limited pay and whole life policies. Gross annual premiums are level unless the input specifies a change at some date during the simulation. Initial assets may be all cash or may include bonds with a wide variety of coupon rates and maturities. If the tax module is to be used for a company in existence before the start of the simulation, some tax information for prior years is required in the input.

The initial inforce will be updated to year one, and for each year thereafter during the period of time simulated, as to attained age, duration, statutory reserves and cash surrender values. Reserves are calculated by accumulation of the specified first-year and renewal-year valuation premiums with specified valuation mortality and interest. Any reserving method recognizing these constraints may be used. Cash surrender values are similarly updated, accumulating a specified initial expense and adjusted premium at the same valuation mortality and interest rates as for reserves. Note that a renewal valuation premium, adjusted premium, interest, and/or mortality may be changed at a point or points of simulated time, but this affects only the accumulation from the point of change into the future - not the past accumulation to that point.

Policies may be sold during the course of the simulation. These may be new issues on plans already in the initial inforce, and/or new issues on completely different types of plans. The user may sell a prescribed number of policies by entering a zero standard deviation of policies sold, or he may sell a random number (normally distributed) of policies with a specified mean and standard deviation. As stated above, the computer keeps track of the sales for each month of each year. Thus age, duration, and other factors change annually in the appropriate month, not at some common date in the calendar year.

SOFASIM maintains a five-year moving history of tax-related information in a set of returns. If the company being studied is not new, then tax data of the immediately preceding (up to) five years should be specified as input. The model updates returns at the end of each calendar year and takes any required action before destroying an outdated return. These returns are used primarily to recognize the three-year carryback and five-year carryforward provisions of the U.S. Life Insurance Company Income Tax Act of 1959. (The model has not been modified to allow for the seven-year carryforward or to permit the "option" of carryback as provided for in the Tax Reform Act of 1976.)

If the tax routine is eliminated, output items denoted as "after tax" are identical with those "before tax" and stockholder dividends are paid out of "Other" surplus rather than "Shareholders" surplus.

The reserves used in the balance sheet are also the reserves used in the tax calculation. Since SOFASIM is a model of a stock company which issues only non-participating life policies on an annual premium basis, there are no due and uncollected or deferred premiums to consider, no pension plan reserves to adjust and no special credit for health insurance or group life insurance contracts. Furthermore, our company has no deficiency reserves or policy loans and invests only in fully taxable bonds. The tax section was programmed in accordance with the Society of Actuaries Study Note No. 101E 2-1-71.

The investment module of SOFASIM is both simple and elaborate. It is simple because only cash and fully taxable bonds are held; in other respects the detail and flexibility are quite elaborate. The user, by appropriate choice of buy/sell parameters, may keep all company assets in cash-equivalent investments if he chooses. The user specifies the interest rate the company will earn on all such investments. This rate or another specified rate is also applied to any negative cash balance which may arise during the course of the simulation, creating an interest paid deduction from total investment income. The interest rate on cash-type investments may be changed as often as monthly during the course of the simulation.

Any bonds held by the company at the start of the simulation must be carried at par and categorized by callability, coupon rate, and number of years to maturity. An existing bond with one year to maturity on January 1 of the first year of the simulation will be redeemed during the first year. The portfolio may include callable bonds, non-callable bonds, or both.

Bonds are puchased at par and must have a duration to maturity of at least one year (all capital gains or losses are considered long term). The coupon rates for the newly purchased bonds are specified in yield curve tables; the table for callable bonds may differ from that for non-callable bonds. These tables may be changed as often as monthly.

When bonds are sold the price received is determined by an array of yield curve tables which may differ from those specifying the coupon rates on purchases. The tables may differ not only as between callable and non-callable bonds but also by coupon ranges, e.g., 5%-7.5%, 8%-10%, etc. These yield curve tables may also be altered as often as monthly.

The bond model is a market price model, giving the user the facility to specify different money market conditions as often as desired, simulating what a company actually faces in the real world.

Asset gains and losses without tax effects are permitted since the model has provision for credits and charges directly into the cash balance.

It will, by now, be clear why SOFASIM is referred to as an integrated model. Each transaction, receipt of premiums, payment of claims, collection of interest produces all of the required effects on the simulated company within the model. Reserve calculation and tax payment or refund have their sometimes diverse impacts (e.g., forced asset sale or even insolvency) with the need to collate results manually from disparate models to achieve a composite. Subject to the given constraints, the output of a SOFASIM run are the complete results of the given input.

SOFASIM represents a framework upon which further elaboration can be built. The provision for issuance of new policies and for termination of new and old policies by death and lapse can be viewed somewhat more abstractly. A new issue means that a flow of income (premiums) to the company begins and some payments (commissions) may be made. A termination by death or lapse stops a flow of income and calls for a single outgoing payment. In SOFASIM, all of the probabilities of payment and amounts thereof are under user control.

The inherent flexibility nominally characteristic of SOFASIM results in a second level of flexibility achievable by looking at the controlling elements of a particular routine and considering how, with ingenuity, they may be used to simulate occurrences other than those they were designed to simulate. For example, it is possible to simulate an epidemic by having all of the mortality rates or the rates at certain selected attained ages increase substantially for an appropriate period of time and then drop back, either immediately or by degrees, to a normal level; the call provision may be manipulated to simulate default on bonds in the manner of the Penn Central Railroad.

A third level of flexibility is available because SOFASIM is written in SIMSCRIPT, which has a more "English-like" syntax than some other programming languages. Thus, reading, understanding, and modifying (a copy of) the SOFASIM program are easier than if SOFASIM had not been written in SIMSCRIPT.

SOFASIM permits testing of a wide variety of hypothetical futures, either deterministically or by a series of Monte Carlo runs. Thus many questions are answerable by use of SOFASIM which could not be asked of any other model with which I am acquainted. Actuaries today are greatly concerned with the future of interest rates. The perhaps unique feature of SOFASIM as compared with other models, computerized or not, is that the user in specifying his future "state of the world" is required to give only the parameters of the bond market, i.e., the yield curve at each point of simulated time. He does not have to specify the company's earnings rate or capital-gain-and loss situation. This attribute is useful, for instance, in studying the effects of a combination of increasing market interest rates with increasing lapse rates. Such a study, of course, is possible because SOFASIM traces all of the complex interactions among various kinds of financial transactions carried out by a life insurance company. The use of the call device to simulate bond default requires that the user specify a very low call price and create the circumstances which will force the call provision to operate. Principal sum accident benefits may give rise to questions which may now be answered by simulation. This would be done by specifying mortality rates equal to the desired claim rates and providing for zero cash values and little or no reserve build up.

These few sketches of examples give only a hint of the potential for problem-solving inherent in SOFASIM. With some application, the actuary will find that it answers questions not even approachable by other means.

MR. RADCLIFFE: Thank you, John. For the theory of the stochastic approach, we have Professor Jim Hickman from the University of Wisconsin.

MR. JAMES C. HICKMAN: Much of the traditional practice of actuarial science has had as its objective the computation of actuarial present values for use in making business decisions. The goal has been the determination of sets of premiums, reserves, asset shares, normal costs and accrued liabilities that are the result of converting possible streams of future uncertain payments to present values and summarizing the distributions of the present values through expected value computations. The existence of this panel confirms that now there is interest in accompanying these actuarial present values with some indication of the range of possible outcomes and, if possible, with an index of the reliance to be attached to the interval estimates.

The motivation of this interest in interval estimates, after almost two centuries of concentration on point estimates of actuarial present values, is based on two facts:

(1) The technology for generating interval estimates have improved. High speed computation now makes it possible to solve explicitly, or to approximate the solution through simulation, very complex distribution problems.

(b) Business managers increasingly expect to have an indication of the range of possible outcomes when making a decision so that the risk aspect of the issue under consideration can enter the decision process in an explicit fashion. The everyday language of investment portfolio management, product development, and environmental protection now contains concepts relating to the measurement of possible outcomes as well as the expected outcome. The foundation for this development was laid during the past 50 years as a comprehensive theory of decision making was constructed based on the quantification of uncertainty in the form of probability distributions and of preferences as utility functions. The natural extension of this development is that in the future not only will a range of possible outcomes be reported, but the distribution of possible outcomes will be required. If this were done, all known aspects of future outcomes would be available to the decision maker. (These developments are summarized by Raiffa (1968).)

The case for interval estimates is clearly stated by Keyfitz (1972), well-known demographer, who has addressed the Society of Actuaries on several occasions.

> "When a forecast is in the form of a distribution, the user sees immediately how much he can trust its mean. He is entitled to the warning constituted by a wide distribution that the forecaster is unsure of his statement of the mean; the least that can be said for the subjective statement of the variance is that it is a compact way of expressing the forecaster's uncertainty. In fact it is much more than that; it permits observation of where the realization fell in relation to the forecast distribution. Evaluation after the event is no problem for forecasters that show variance as well as mean."

Types of Intervals

The vocabulary of interval estimates is somewhat confusing. For consistency within this essay, the following divisions and distinctions will be made:

(a) The quantity for which an interval estimate is sought

- (i) The mean value, a parameter, of a distribution.
- (ii) A future realization of a random process for which the investigator may or may not have precise estimates of the process parameters.

(b) The index of reliance

- (i) A confidence coefficient which is not interpreted as a probability.
- (ii) A probability is attached to the interval.
- (iii) No numerical index is attached to the interval but some sort of qualitative statement is made.

For example, although the computations in the Society of Actuaries Simulation Model (SOFASIM) (Wooddy (1981)) are complex, the final result is a statement about a future realization of a random process whose basic parameters have been fixed by the investigator. Simulation is used to produce an empirical distribution of possible results. On the other hand, the interval estimates reported in connection with OASDI are also about future realizations of a macroprocess, but there is no numerical index of reliance. (See 1981 OASDI Trustees Report and Myers (1945)).

The following table illustrates elements of this classification system with almost the simplest possible example. Consider a normal distribution with unknown mean μ and known variance σ^2. A random sample of size n is planned. The sample will be used to determine an interval estimate of μ and for the next outcome X_{n+1}.

		Interpretation	
		Sampling Theory	Bayesian
(a) (i)	For μ	$\bar{X} \pm 1.96\sigma/\sqrt{n}$	$\omega\bar{X} + (1-\omega)m' \pm 1.96\sigma''$
	Index	(b) (i) Confidence Coefficient .95	(b) (ii) Probability .95 (Credible Interval)
(a) (ii)	For X_{n+1}	$\bar{X} \pm 1.96\,\sigma\sqrt{(n+1)/n}$	$\omega\bar{x} + (1-\omega)m' \pm 1.96\sqrt{\sigma''^2 + \sigma^2}$
	Index	(b) (ii) Probability .95	(b) (ii) Probability .95

Notes on Table:

(1) The Bayesian interpretation requires the specification of a probability distribution that summarizes all available information about the parameter of interest. (See Jones (1965)).

(2) The symbols are defined as follows:

(a) The normal prior distribution, summarizing information available before the sample of size n is obtained, has mean m' and variance σ'^2.

(b) Parameters of the posterior normal distribution for M which combines information from the sample as well as the prior distribution depend on

$$w = (n\sigma''^2)/\sigma^2,$$

$$\sigma''^2 = [(\sigma'^2)^{-1} + (\sigma^2/n)^{-1}]^{-1}.$$

(c) The sample average is denoted by $\bar{x}$.

Ranges and classical actuarial models

By definition an actuarial present value incorporates an expected value calculation based on an assumed distribution of the random variable of interest. For example, in life contingencies a life table is selected to define the distribution of the random variable time until death. Actuarial present values, such as premiums and reserves, that are usually reported are only one aspect of the distribution of outcomes which can be determined on the basis of the original distribution assumption.

These ideas can be traced back to early developments in life contingencies and will be reflected in the Society of Actuaries new study materials (See Menge (1937)). We let

$$_kL = v^{j+1} - P_x \ddot{a}_{\overline{j+1|}}, \qquad j = 0, 1, 2, \ldots,$$

denote the present value of the loss to the insurer at the death of a life with a unit whole life policy, issued at age x, who is now age x + k and who dies at age last birthday x + k + j. The probability mass function of the random variable j is give by

$$_jp_{x+k}\, q_{x+k+j}$$

The mean and variance of $_kL$ can be shown to be

$$E[_kL] = {}_kV_x \qquad Var(_kL) = (A'_{x+k} - A^2_{x+k})/(d\ddot{a}_x)^2,$$

where A'_{x+k} is valued at $i' = (1+i)^2 - 1$. Then if the distributions of losses on n identical policies, each for amount one, are mutually independent, the present value of the future losses on the portfolio of policies will fall outside the interval

$$n\,{}_kV_x \pm 3\sqrt{n\,Var[_kL]}$$

with probability that is less than 1/9 by Chebyschev's inequality and with probability approximately .003 using the central limit theorem.

This approach has impressive pedagogical advantages, for it stresses the random nature of insurance losses. Nevertheless, many actuaries would consider the development interesting but impractical. The reasons for this legitimate criticism form an agenda for further work:

(a) The model ignores expense, loadings, dividends and nonforfeiture values.

(b) The possibility of a change in the distribution of the random variable time until death is not introduced into the model.

(c) Interest rate variation is not considered.

Criticism (a) can be answered within existing life contingencies models by defining the joint distribution of the two random variables time of decrement by specifying a double decrement table. The loss function can be augmented to include expenses, loadings, dividends and nonforfeiture values.

Criticism (b) can be alleviated if the possible life tables and a set of transition probabilities for the shift from one to another table are specified. As we complicate the model, the option of using simulation to estimate the distribution of outcomes becomes more inviting. The force of even the most telling criticism, that labeled (c), can be reduced. In so far as a stochastic model for interest rates is available, simulation can be used to generate realizations of the process for the purpose of valuing insurance losses. The steps outlined are not hypothetical possibilities, they have in fact been largely carried out in SOFASIM and other comprehensive simulation models.

The existing model for short term insurances also has at its foundation probability assumptions that are sufficient to build a rudimentary stochastic model for generating the distribution of future financial results. For example, the pure premium for a short term coverage is the product of expected number of claims and the average claim amount. Assumptions about the distributions of number of claims and claim amount are the key elements in our model. We have

$$U(t) = P(1+\theta)t - X(t) + U(0),$$

where $U(t)$ are the funds generated by the particular group of policies by time t, $U(0)$ is the amount of assets assigned to the group of policies, P is the pure premium rate for the group of policies and θ is the security loading factor. The random variable in this expression is $X(t)$, total claims generated by the group by time t. The distribution of $X(t)$ is determined by the distribution of the number of claims and the distribution of claim amounts; the two distributions required are also involved in fixing the pure premium. Much of the collective risk theory is concerned with computing or approximating the distribution of $X(t)$ and thereby also that of $U(t)$ for fixed values of t. Once again these ideas will be reflected in the Society of Actuaries new study materials (See Gerber (1979)).

This model also is subject to criticism, but once again the criticisms form an agenda:

(a) Investment income and loss are omitted from this model. However, if an acceptable model for interest rates exists, interest factors can be generated and used to augment the balance from insurance operations, $U(t)$.

(b) Although expenses and expense loads are not explicitly in the model, there are no barriers to their inclusion.

(c) Fundamental shifts in the two basic distributions are not allowed for within the model. However, insofar as alternative distributions exist and transition probabilities are specified, such interventions can be incorporated into a simulation.

Recent developments

Three fairly recent developments which have an impact on reporting interval estimates with actuarial present values deserve special mention. Two of these developments are technical in nature and one relates to the need for interval estimates.

The first of the technical developments has already received extensive comment. It is the creation of comprehensive models for insurance operations which permit the reporting of an interval estimate for financial results based on an empirical distribution of financial results. The empirical distribution in turn is constructed by simulation built on a number of specified distributions. Models such as SOFASIM answer most of the criticism of interval estimates derived from naive models that assume that only time until death is random.

The second technical development is the fairly recent publication of methods for combining time series models for interest rates and existing models for insurance or annuity losses that depend on time of death. This development permits the estimate of variance of future losses from an insurance or annuity contract to depend on the joint distribution of time until death and the set of future interest rates. (See Bellhouse and Panjer (1980)).

The third development is economic rather than technical in nature. It is the increased volatility of many aspects of the North American economy. This volatility has increased business risk and magnifies the need to convey a measure of the risk dimension of a proposed business venture to a decision maker.

Principles of Prediction

Brass (1974) has suggested that continuity, constraint and consistency should serve as guiding principles in prediction. Continuity requires that in looking into the future we must start from where we are. The requirement to recognize constraints compels the investigator to recognize that natural restrictions exist on many trends. For example, health care prices have advanced more rapidly than most other prices during many recent years. This trend is of considerable importance in making predictions about health insurance costs. However, it is clear that this trend is constrained; it is impossible for the standard market basket used to measure consumer prices to contain only health care. The consumer will always need food, shelter, clothing, etc. There is a bound on the portion of income that can go for health care. The principle of consistency may be illustrated by the observation that experience in the United States and other industrial nations, especially in the past 20 years, indicates that it would be inconsistent to assume a high fertility rate and high labor force participation by women.

The principle of continuity may be the most controversial of these principles for actuaries. The issue is how much useful information is contained in the record of past experience. It is appealing to short cut the analysis of past experience and to construct collections of assumptions, often called scenarios, for purposes of running a model forward under each of alternative sets of assumptions. The results are two plausible extreme results and perhaps several intermediate results. The disadvantage of this procedure is that without the discipline of data the principles of continuity and consistency may be inadvertently violated. Fitting stochastic models to past results leads to data-based intervals. Because of the existence of an estimate of the variance of the error term, interval estimates derived from these models by analytic or simulation methods will have a probability-based index of reliance. (See Miller and Hickman (1973)).

A case study with problems

The analysis of real data for the ultimate purpose of prediction can be a perplexing task. However, the effort is necessary if we are to use all available information. Some of the problems will be illustrated by an outline of a case study involving birth rates in the United States. Predicting birth rates is of considerable importance in Social Security cost estimation as well as for other planning operations. (The work is reported by Miller and Hickman (1981).)

Data: Birth rate by age of mother (15-19), (20-24), (25-29), (30-34), and (35-39) for each year from 1910 to and including 1979.

Preliminary Observation: The time series of birth rates before World War I and after World War II are different. We worked on the most recent data because prediction was the goal.

Transformation: To stabilize the variance and to creat stationary time series, the series of first differences of the square roots of birth rates across time within the same age group were analyzed. In addition, a linear transformation to eliminate contemporaneous linear relationships among the series was made before model fitting.

Model Fitting: A multivariate time series model was fitted to the transformed series. In this step the residuals were examined to ascertain if they contained useful information.

Prediction: The model was run forward and the transformations reversed to produce the predictions shown on Figure 1. Note that recent observed upturns in the birth rate among same ages of mother is reflected in predictions for other ages.

Intervals: Because of the complexity of reversing the transformations, technical problems in incorporating the uncertainty in parameter estimates as well as basic variability of the series into variance, and a desire to convey a sense of which sample paths are most probable, we have not solved the interval estimation problem to our satisfaction.

Moral: Computers and modern statistical techniques permit model builders to extract much more information from data than in the past. Better methods to convey information about the distribution of future sample paths to decision makers are needed. Paths rather than points are often the concern.

References

1. Bellhouse, D. R., and Panjer, H. H., "Conditional Stochastic Interest Rate Models in Life Contingencies", ARCH 1981.1, 1-20.

2. Brass, W. (1974), "Perspectives in Population Prediction, illustrated by the statistics of England and Wales", Journal of the Royal Statistical Society, Series A, 137, 532-583.

3. Gerber, H. U. (1979), "An Introduction to Mathematical Risk Theory", Homewood: Richard D. Irwin.

4. Jones, D. A. (1965), "Bayesian Statistics", TSA, 17, 33-57.

5. Keyfitz, N. (1972), "On Future Population", Journal of the American Statistical Association, 67, 347-363.

6. Menge, W. O. (1937), "A Statistical Treatment of Actuarial Functions", RAIA 26, 65-88.

7. Miller, R. B. and Hickman, J. C. (1973), "Time Series Analysis and Forecasting", TSA 25, 267-302.

8. Miller, R. B. and Hickman, J. C. (1981), Time Series Modeling of Births and Birth Rates", Working Paper 8-81-21, Graduate School of Business, University of Wisconsin, Madison.

9. Myers, R. J. (1945), "Some Considerations in Pension-Fund Valuations", TASA 46, 51-58.

10. Raiffa, H., Decision Analysis, Reading, Mass: Addison-Wesley Publishing Company

11. Trustees of OASDI, 1981 Annual Report, Washington: GPO.

12. Wooddy, J. C. (1981), Adverse Deviation, Chicago: SOA.

Figure 1: Plots of U.S. Birth Rates by Age of Mother, 1917-1977, plus Forecasts for 1978-1987 (vertical scale is number of births per 1000 women in age group)

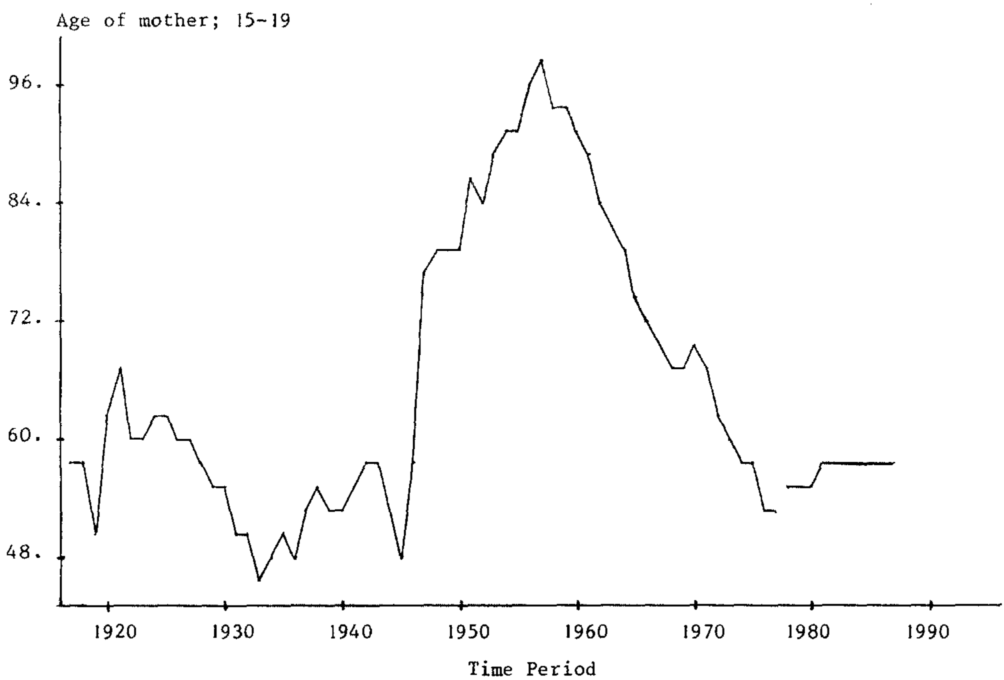


Figure 1 (continued)

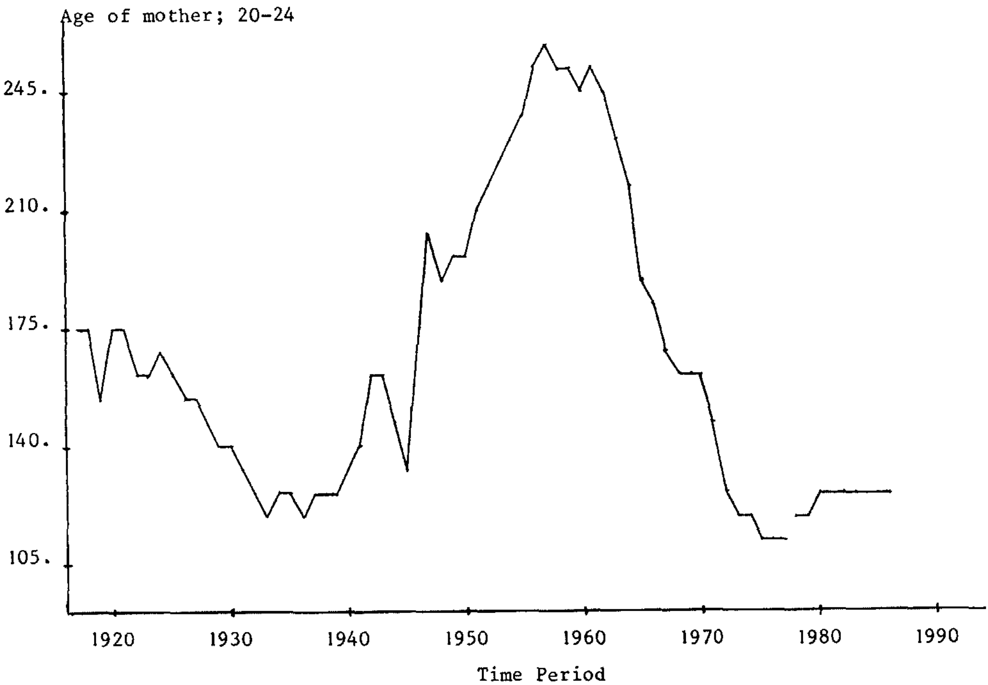


Figure 1 (continued)

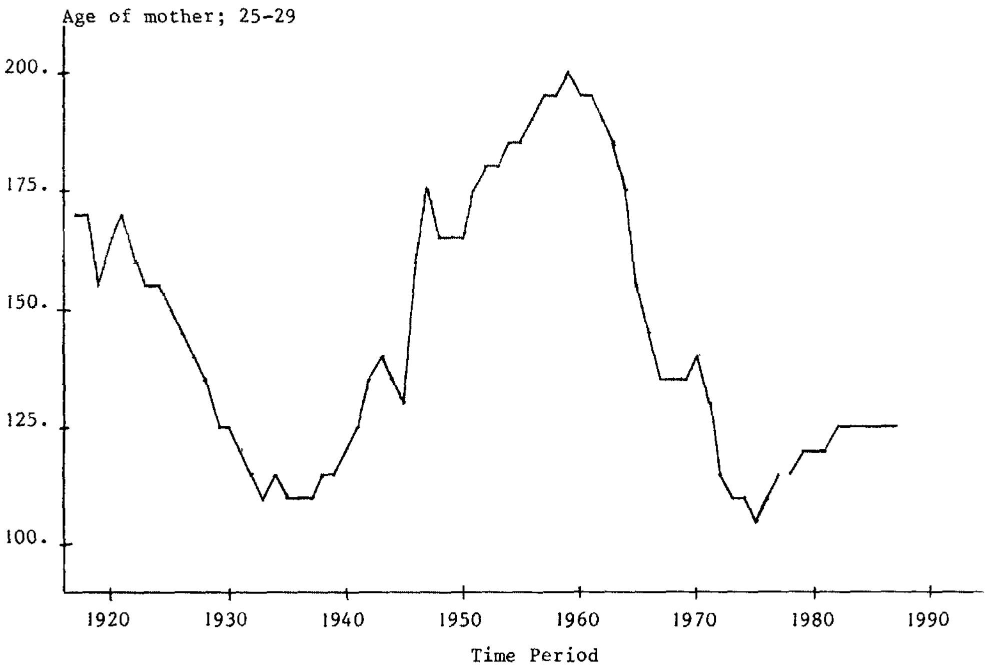


Figure 1 (continued)

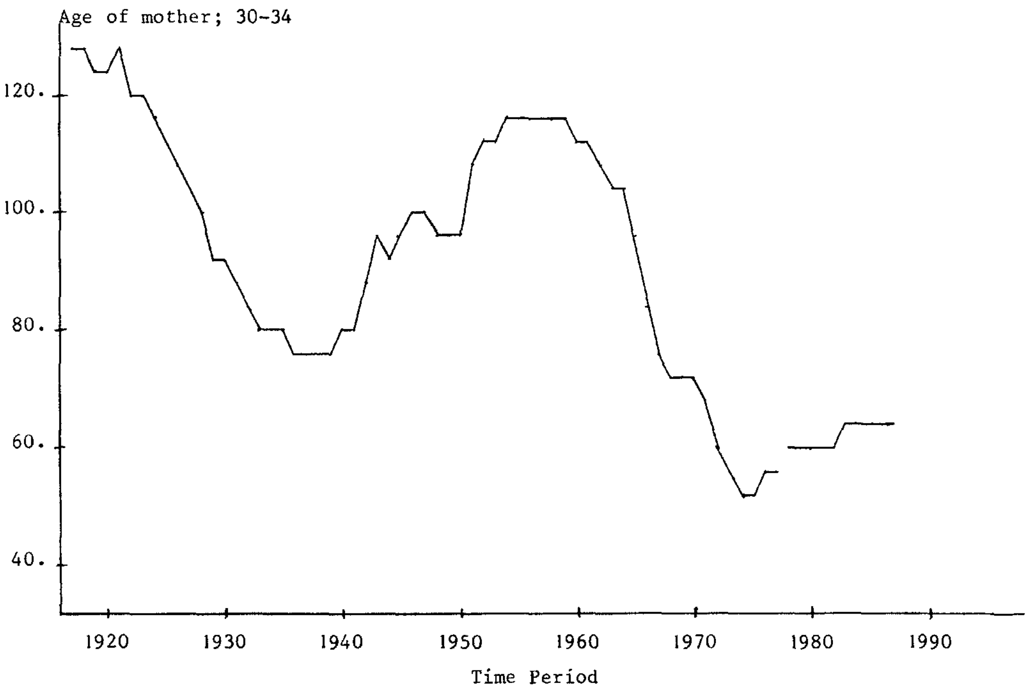
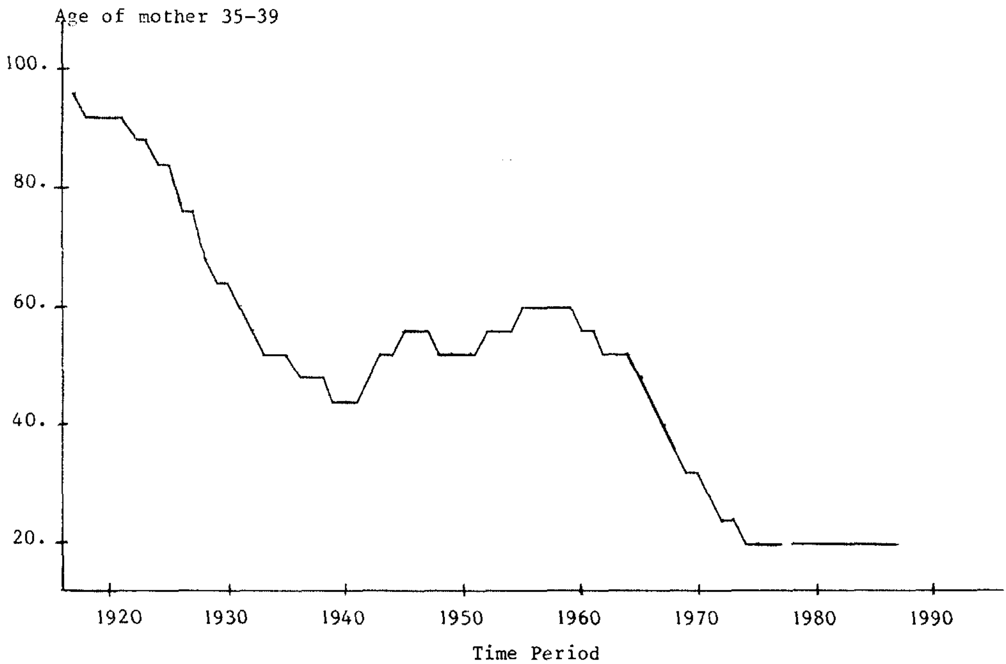


Figure 1 (continued)



MR. RADCLIFFE: Thank you, Jim. It is time now to take questions from the floor.

MR. BRIAN L. HIRST: Mr. Woody had interest rates back to 1899 with a range all the way up to 9% and Mr. Hickman had the birth rates back during much of the century. There have been events which have occurred which would obviously have impact on those rather than just the random distribution, for example, the birth control pill in the last 20 or 25 years and the hyper-inflation we have seen the last decade. What measures do you use for cutting off the data to reflect the most current environment even though it may give you a much smaller data base and much more variance?

MR. WOODDY: In the case of the interest rates it was obvious that we could not use those old rates as any indicator of the future. That is why we went to changes in the interest rates. If we had 900 interest rates we had 899 changes in interest rates from one month to the next. We calculated the actual change. We then calculated the correlation of those changes or deltas, where i_1 minus i_0 is delta i, with i. We found something like .5, so we decided to divide delta i by i. That brought the correlation down to something like .2. We were willing to say that the changes were essentially uncorrelated.

We could use those delta i over i's as the basis for probability distribution. We were drawing the values of delta i over i by use of random numbers and starting with 6% as the interest rate in January of the first year of the simulation. We determined a change of delta i over i and applied the first one to 6%, the next one to whatever February turned out to be, the next one to whatever March turned to be, etc. That is how we obtained our 31 years of interest rates for each month for those 31 years.

It probably would have been a good idea to segment the period, in particular, to take the last ten years, if it were available, to see how those compare with the earlier period and to see if we really are in a new world in the changes that we are observing.

MR. HICKMAN: In answer to your question, science is not a completely objective business; there is a considerable art to it. In the birth rate business, we simply analyzed it to death. We analyzed all kinds of time periods. But, we worship at the church of parsimony, that is, in our view simple models are to be preferred to complex models. We would prefer to subdivide the period to get a simple model rather than to use the whole 20th century which would require very complex models. We still thought we have enough data to estimate our parameters fairly well.

MR. VANDERHOOF: I do not have confidence in purely statistical models because they say that the past and the future were drawn from the same stochastic process. To include what is going on with the world you have to include more than a stochastic process. For example, the stochastic process which produced interest rates over the last 50 years, if it is purely a stochastic process, does not include inflation. Inflation should be included. Inflation is not purely a stochastic process. It depends on the structural equations of the entire economy. When you have included the structural equations of the entire economy, you have much more complex things. I do not have confidence in the use of the past and the assumption that the future is going to be drawn from the same stochastic box.

MR. FRANCISCO BAYO: I work with the Social Security Administration as Deputy Chief Actuary in charge of long-range projections. First, I would like to congratulate the Panel for the excellent presentation. I am particularly pleased with the directness and simplicity of the remarks by Professor Hickman. I would like to express, however, a few words of caution about the overall subject being discussed.

It is essential that we do not allow our users (consultees, advisees, or the public in general) to ascribe to us more knowledge than we really possess. No human being, regardless of this expertise and of all the hardware and software available to him, knows exactly what the future will bring. Our capabilities are particularly limited in those areas in which human reactions, expectations, anxieties, etc..., are important ingredients.

The move from point-estimates to range-estimates has been a definite improvement, but has not been without difficulties. The speed of modern computers has permitted us to offer three or more estimates when previously we could offer only a single, best estimate. However, some of our users have been acting as if it were impossible for actual events to fall outside of the projected range. In Social Security, we have done our best to indicate to the Congress that the various projections we present are not exhaustive of all the possible outcomes. Nevertheless, we actuaries often get blamed when the economy does not perform according to expectations.

I believe that the most reasonable approach to this situation would be to take the accusation in stride, to redouble our efforts to provide better estimates, and to educate our users more effectively about the uncertainties in the projections. But recently, I have heard suggestions that we could avoid being blamed for adverse outcomes by moving to presentations involving probabilistic distributions of all possible outcomes based on reputedly "stochastic" procedures. I cannot agree with the reasoning behind this proposal. I do not believe that anyone will ever be able to design a procedure that will keep the politicians from blaming others for adverse experiences.

I do believe, however, that we should try to move from range-estimates to "probability-estimates". But this move should be predicated on the fact that now we have better tools and increased knowledge, and on the belief that the best way for us to continue improving our projections is to use these tools and to devote more effort to increase our knowledge further. Let us be careful, however, to avoid unfounded claims about what we can do. Let us do our best to keep others from attributing to us unrealistic powers. In summarizing, I would say, he who has failed to project a range cannot logically claim to know the whole distribution.

MR. RADCLIFFE: Thank you very much. That was a very good summarization of our meeting.