SOCIAL SECURITY AS AN INVESTMENT: A MONTE CARLO INVESTIGATION

by

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CHAPTER I

INTRODUCTION

Problem Statement

First installed in 1935 and subsequently changed by later amendments, the Social Security system in the United States today claims to cover nine out of every ten working people of the nation (p. 5, [13]). Known as the OASDI (Old-Age-Survivors-Disability Insurance) program, the purpose of the system is implied by its name: to provide economic security for the majority of American workers and their dependents. In exchange, these workers contribute to the system through deductions from their monthly paychecks of amounts varying with their incomes, under the term FICA (Federal Insurance Contribution Act). Upon their retirement, death, or disability, they and their dependents start to receive monthly benefits from the system. The amount of benefits is determined by a set of rules, and in general, depends on the amount of earlier contributions. The system is mandatory for all the people in professions and jobs which it covers.

As perceived by the originators and many current proponents of the system, the Social Security system is a form of insurance. Thus it is only natural that the tendency of system evaluations has been to compare the Social Security program with private insurance plans as well as with other forms of money savings and investments. However, due to the nature of the system benefits structure (which often leaves the people it covers with uncertainty as to exactly what they will receive for their contributions), most of the attempts at comparison have fallen short of their goal. This can be observed through a survey of literature concerned with evaluating the system; there is a lack of development of formal methods which evaluate the system quantitatively and extensively.

The Social Security System

Before surveying the related literature, a brief description of the system is given so as to provide a clearer view of the difficulty encountered in evaluating it. The description is based on actual Social Security rules and regulations as of March 1974, as stated in [13].

FICA Tax Contributions

Under the FICA terms, the employer and employee each contribute to the system monthly an amount equal to a percentage rate of the annual salary of the employee. There is a maximum taxable ceiling on the annual salary. For example, the 1974 tax rate was 5.85% with a ceiling of $13,200. It is noted that recently these two figures have been climbing rapidly, thus giving more incentive to criticize the system.

Eligibility for Benefits

Not all the contributors to the system are eligible for benefits. In order to be eligible a worker must have earned a number of credits, termed quarters of coverage, by the time he becomes disabled, retires, or dies. A worker is credited with one quarter of coverage for each calendar quarter during which his salary exceeds or equals $50. The number of quarters required of a worker who reaches 65 (62 for a woman) or dies is shown in Table I.

TABLE I

REQUIRED QUARTERS OF COVERAGE FOR

RETIREMENT OR DISABILITY BENEFITS

Year	Required Quarters
1975	24
1979	28
1983	32
1987	36
1991 or after	40

A worker who becomes disabled also needs to have credits for the last twenty calendar quarters. Requirements are eased for younger workers. A worker less than twenty-four years old needs only six quarter credits out of the last twelve, and one younger than thirty-one years old needs only twenty out of the last forty.

Benefits Structure

The monthly benefits received depend on the average monthly wage (AMW), which is the average of covered earnings under Social Security during the work career. Only a number of highest earnings must be counted (i.e., a number of years of lower earnings might be disregarded). This number depends on the year of birth of the worker and is three years lower for women than for men.

The basic monthly benefit is termed PIA (Primary Insurance Amount). All other secondary benefits (for spouse or children) are given as a percentage of PIA. The computational relationship between PIA and AMW is shown in Table II.

The total family monthly benefit is subject to a maximum ceiling MFB (Maximum Family Benefit). MFB is related to AMW as shown in Table III.

The rules regarding secondary benefits and eligibility are summarized in Figures 1 through 3.

Literature Review and Discussion

Although a considerable number of studies regarding the Social Security system exist, few of them contain a quantitative economic analysis.

Of interest is an article by Warren Shore [10] which bears the typical traits of journalistic observation and criticism. In his

TABLE II

COMPUTATIONAL RELATIONSHIP BETWEEN PIA AND AMW

PIA =

	119.89% of the first	$110	of AMW
+	43.61% next	$290	
+	40.75% next	$150	
+	47.90% next	$100	
+	26.64% next	$100	
+	22.20% next	$250	
+	20.00% next	$100	

subject to a minimum of $93.80

TABLE III

RELATIONSHIP BETWEEN AMW AND MFB

AMW	MFB
under $628	117.2% of the first $436 of AMW
	+ 58.6% next $191
	subject to a minimum of 150.0% of PIA
$628 or more	1.75 times PIA

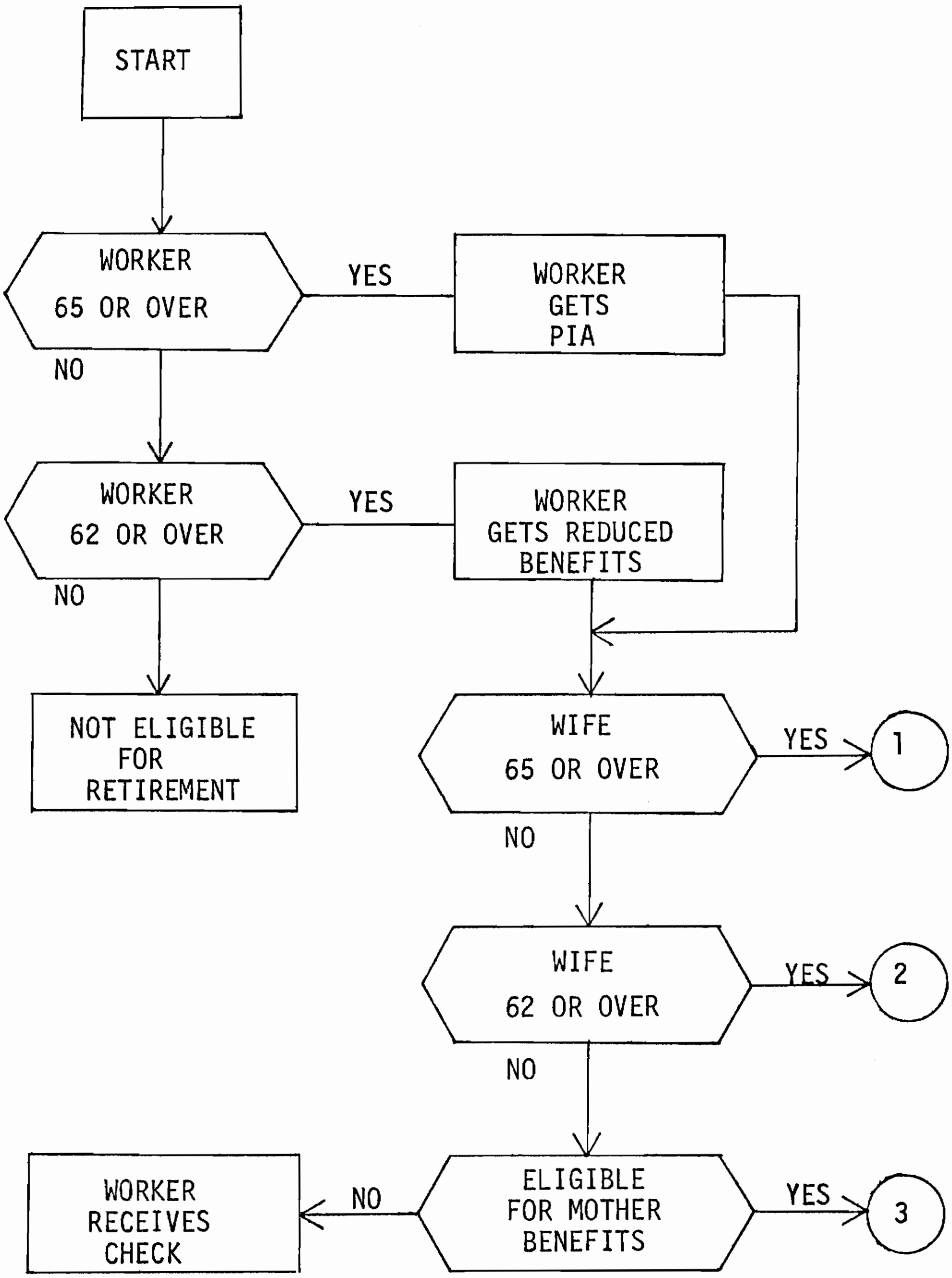


Figure 1

Flow Chart for Retirement Benefits

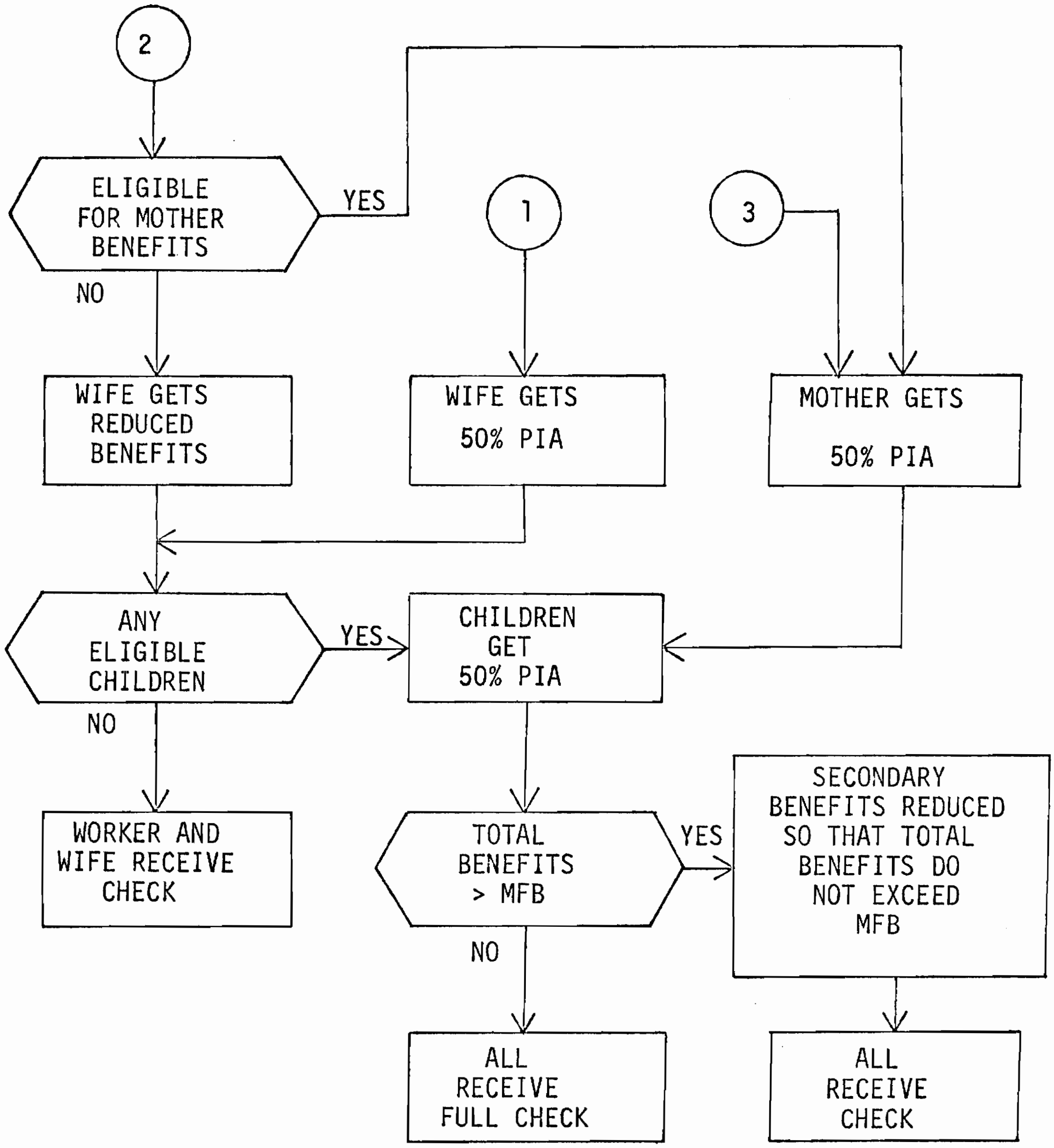


Figure 1 (continued)

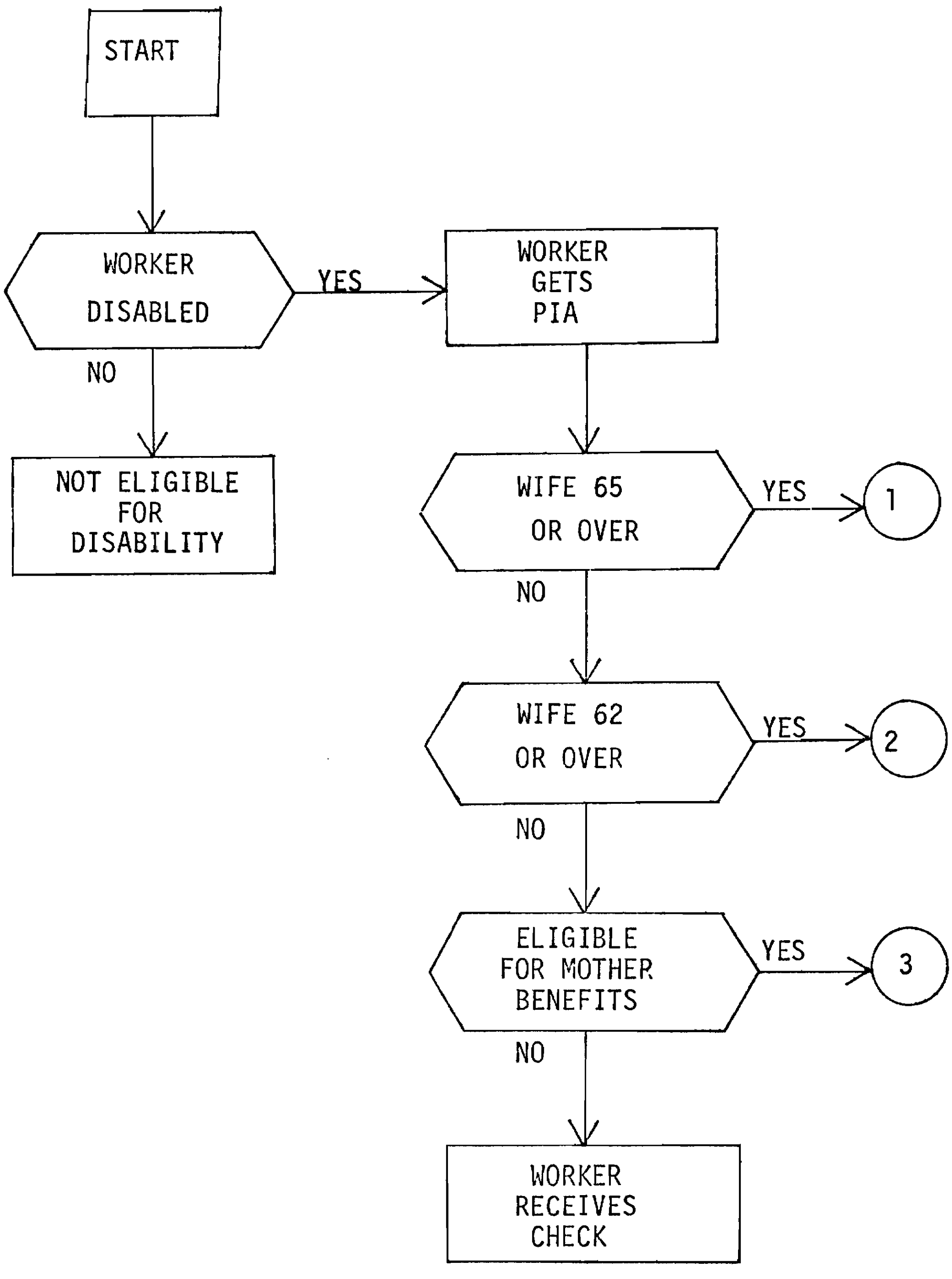
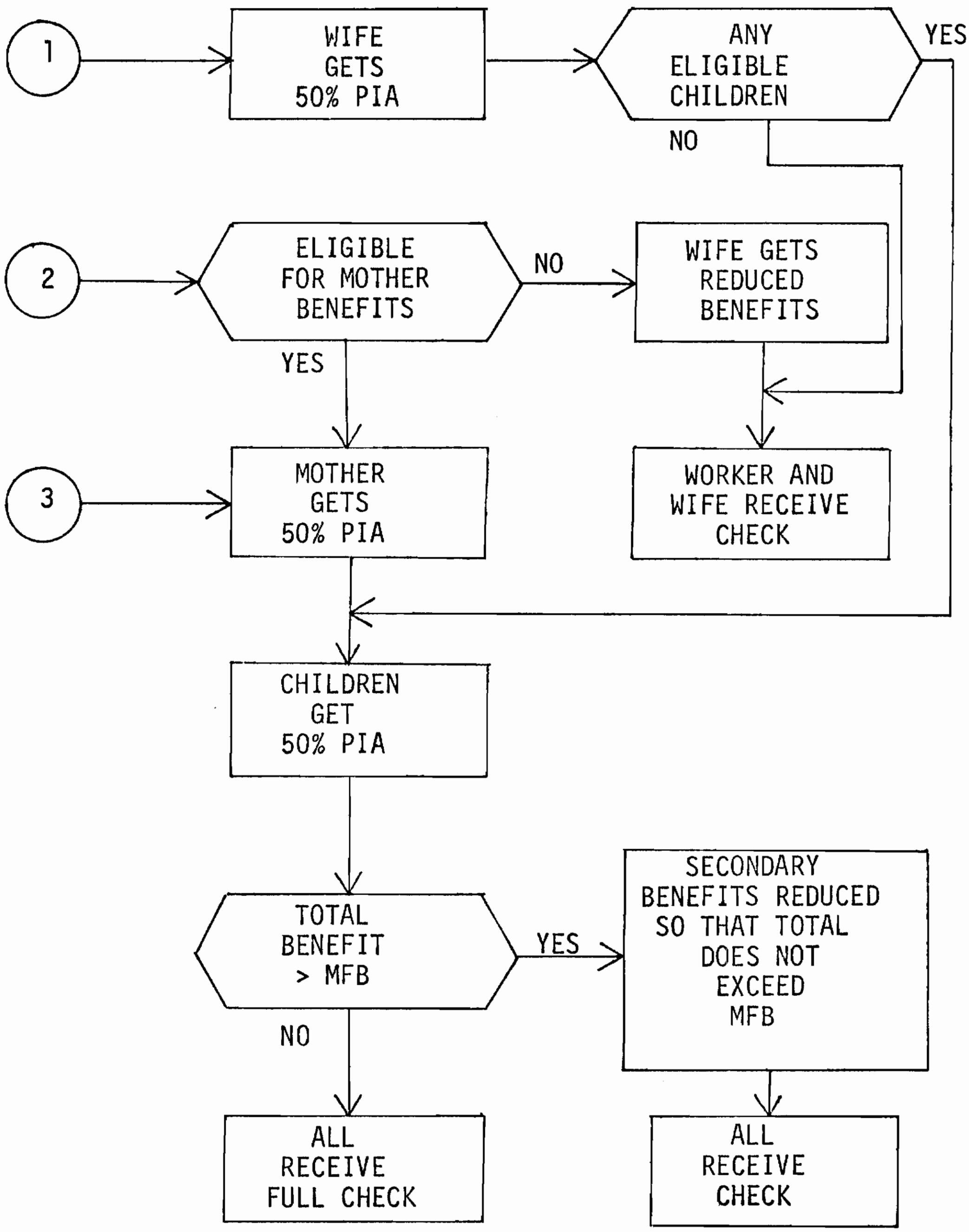


Figure 2

Flow Chart for Disability Benefits



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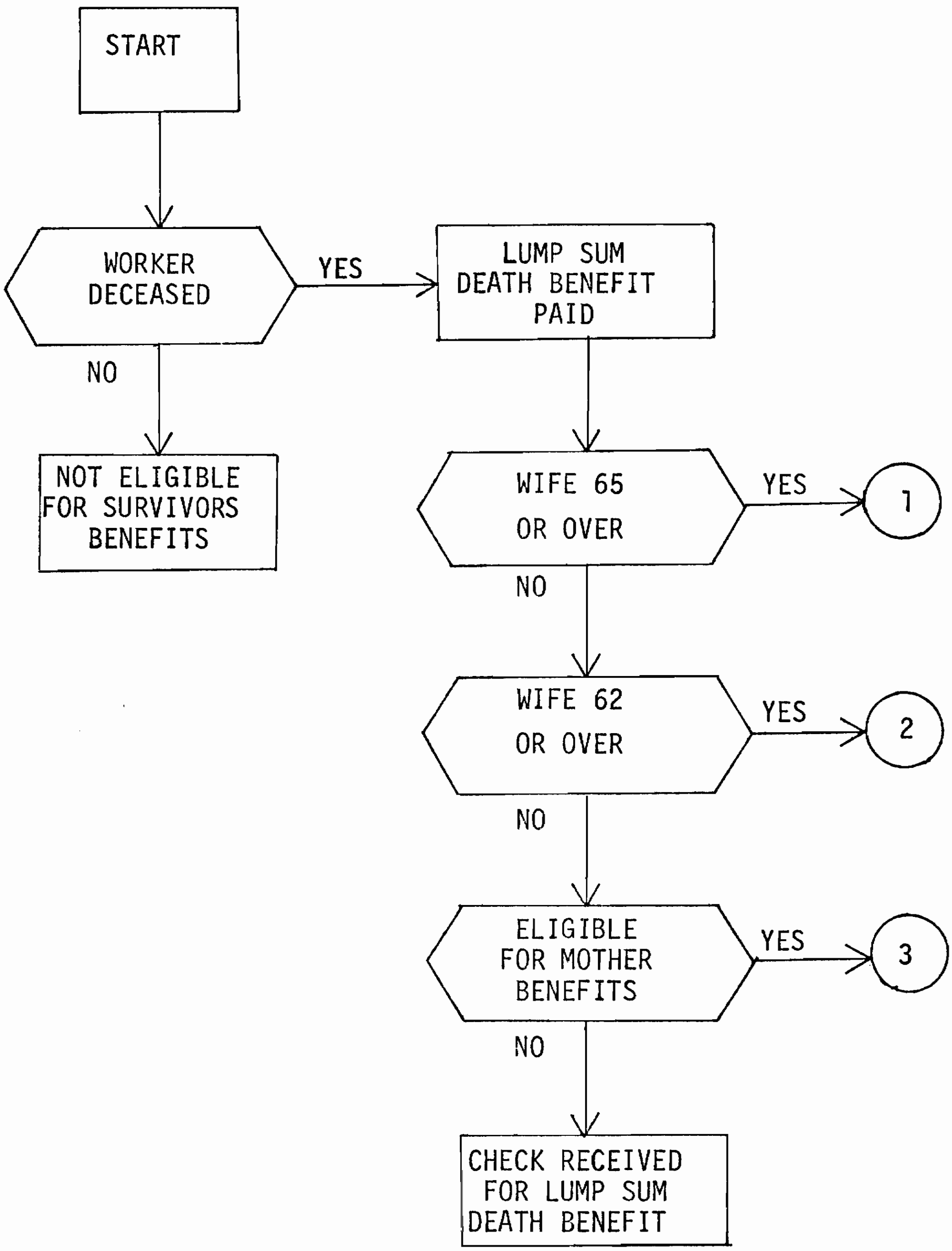

Figure 3

Flow Chart for Survivors Benefits

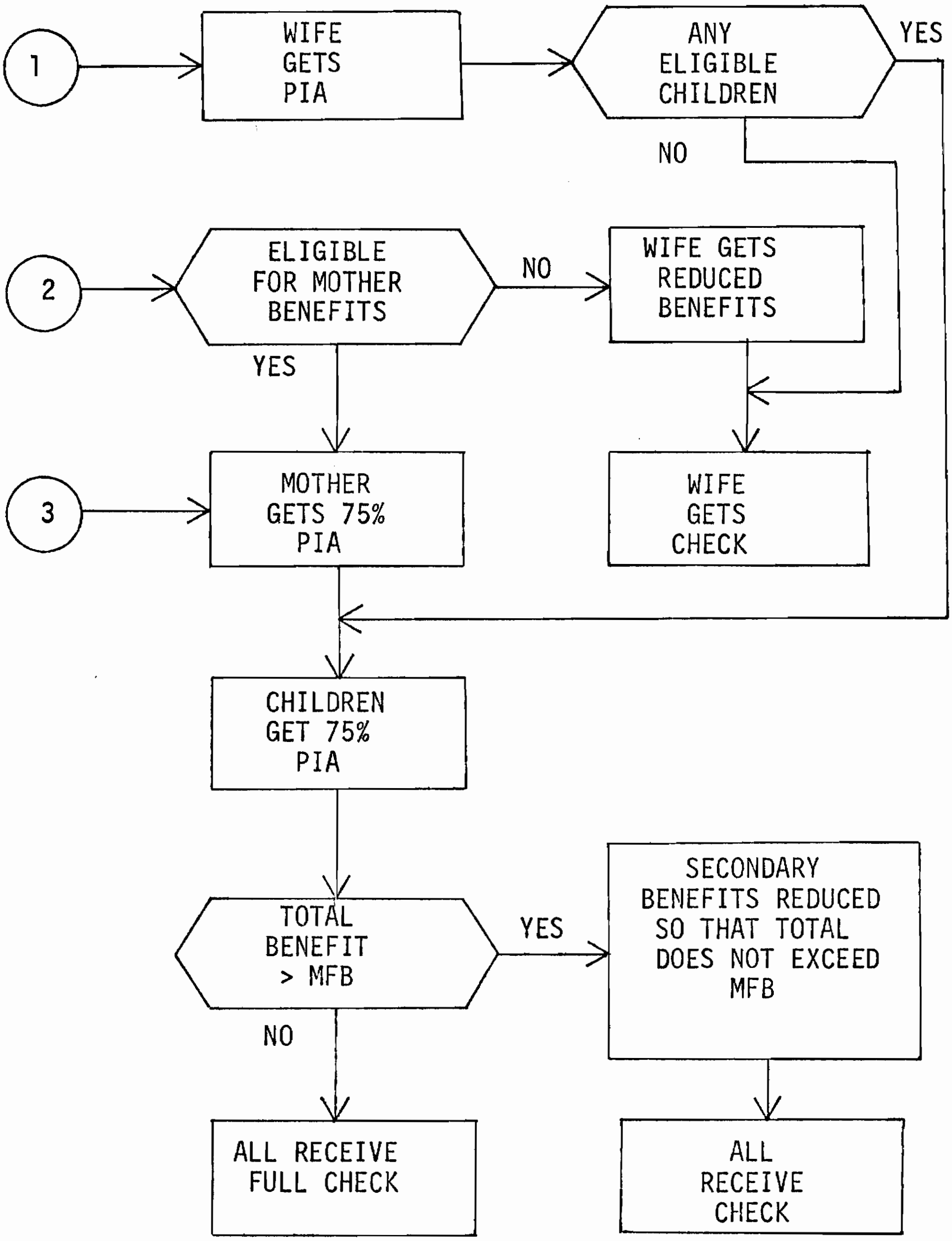

Figure 3 (continued)

article, Shore cites rather extreme individual examples with detailed figures, and compares costs and benefits of the Social Security program with those of private insurance plans. The comparison shows that the former is far less attractive, especially for the now under-forty worker.

A paper by Otto Eckstein [2] provides a somewhat more general view of the system. He considers the benefits/cost ratios for different levels of salary and at different points in time of the history of the Social Security program. The study shows that the contribution dollars buy fewer and fewer benefits as time goes on. He also gives specific values for the survivors and disability benefits, but makes no attempt to account for them. Also, it is not clear how he arrives at the ratio figures. Another study by Joseph Pechman, et al. [8] gives the profile of the aged-worker population and the economic effect of the Social Security system on this population. In addition, this study also provides individual equity calculations, i.e., benefits-tax calculations, for the OASI program (excluding the disability portion). To arrive at the results shown, a constant discount rate is assumed in order to calculate the present worth of accumulated tax paid by both employer and employee (assuming that money paid by employer is actually a part of the employee's compensation). This figure is then compared with the present worth of the amount needed to purchase a life annuity that provides monthly payments equal to OASI monthly benefits. Further assumptions include equal ages for husband and wife for a married couple and all secondary benefits (for spouse and children) are ignored. In their calculations, estimates of present mortality rates are used and assumed to remain constant. The conclusion drawn by the authors is that there is no basis for the view that unfair treatment is being given to the young workers. Robert Myers in his paper (p. 83, [5]) also comes to a similar conclusion.

A study by Joe Sullivan [14] uses an engineering economy approach to calculate the rate of return on tax money paid for five particular cases with assumed sets of characteristics (with respect to the worker's age, earnings and family status). For each case, the worker's work career is assumed to end according to one of the three outcomes (p. 30, [14]). For example, the worker only dies after retirement and never becomes disabled during his life. Estimates of life expectancy and the probability of becoming disabled (assumed to be constant) are incorporated in the calculations.

In evaluating the Social Security system, the individual equity as represented by the rate of return is certainly a valuable measurement. Even though the values of these rates of return are by no means conclusive with respect to the value of the Social Security program, they do say something about its performance toward the individual citizen's economic well-being. However, in determining the rate of return, consideration must be given to the probabilistic elements which govern an individual's life history and thereby affect his earnings as well as the future monthly amount of the benefits he and his dependents will receive. These elements include age at death, possibility of becoming disabled and age at disability onset, number of children and their dependency status, marriage and divorce, and so on. Thus the rate of return in consideration is itself a probabilistic variable. It is desirable in calculating this expected rate of return that a model be constructed which includes all the elements mentioned above. In all the studies only Pechman, et al.

paid some attention to the death element, and Sullivan to both death and disability. However, the measurement which Pechman, et al. used was a benefits/tax ratio, and as it turns out, Sullivan's rate of return is a population overall rate of return, not an individual expected rate of return, as will be explained in Chapter II.

Thesis Objective and Organization

This study addresses the problem of developing a method to assess the individual expected rate of return using available demographic data on birth, death, marriage, divorce and disability. In Chapter II, the general approach is presented with clarification on the distinction between the population overall rate of return and individual expected rate of return given; and the undesirability of an analytical solution to the problem is shown. In Chapter III, a simulator is constructed to handle the problem. In Chapter IV, the simulator is used to estimate the rates of return for four out of five cases studied by Sullivan (these cases seem to be representative of large segments of the United States population). Next, a component-breakdown of the rate of return is made so as to enable a separate value assessment of the Disability-Survivors benefits and the Retirement benefits. In addition, a study is made on the two factors that might play an important role in determining the rate of return, namely salary level and the worker's age (where an older age implies an earlier entry in the system). To provide a proper evaluation of the system from a total cost point of view, the rates of return in the same four cases are re-evaluated, this time taking into account the employer's contribution. Since the input demographic data is subject to change over time, an analysis of variance is performed to determine the effect that fluctuation in input data might have on the rate of return. Chapter V concludes the study by summarizing the results and recommending possible future areas of study on this subject.

CHAPTER II

AN ANALYTIC MODEL

Introduction

In this chapter, a solution method for solving the problem described in Chapter I is discussed. This method is based on an Engineering Economy approach to the problem. Basically, Engineering Economy is concerned with evaluating and comparing different alternatives or courses of action. Comprehensive descriptions of its principles and techniques can be found in any formal Engineering Economy textbook; for example, the one by Grant and Ireson [3] or one by Morris [4]. The particular technique used in this study is known as the rate of return technique.

First, the individual expected rate of return and the overall population rate of return are defined and their mathematical expressions are derived. Next, clarification of the distinction between these two rates of return is given; the rate of return which Sullivan used in his study is then identified as the overall population rate of return. Finally, by considering the computational procedure to be used to obtain numerical values for the rates of return, the difficulties inherent in an analytic solution procedure are shown and justification of the use of simulation is presented.

General Approach Development

Consider a population of N primary individuals having the same characteristics with respect to age, sex, race, salary and family status as at time $t = 0$. All these individuals "enter" the Social Security system when they start to pay the FICA tax, and "leave" the system when benefits paid to them and their dependents (secondary individuals) end, say at time T_i, $i = 1,2,3,\ldots N$. Let $T = \max_i \{T_i\}$ and the population be observed again at this point in time.

Also, suppose that all the sets of events that happen to the individuals of the population and affect the amounts of tax and benefits they pay and receive can be classified into a finite number of n non-identical outcomes (each of which is a particular sequence of events). Thus, the population under consideration can be divided into n mutually exclusive sets, each containing k_i primary individuals, $i = 1,2,3,\ldots n$, with $\sum_{i=1}^{n} k_i = N$.

Each individual of set i will make a series of tax payments P_{ih}, $h = 1,2,3,\ldots \ell_i$, where ℓ_i is the number of payments with the first payment made at time $t = 1$. He will receive a series of benefits F_{ij}, $j = 1,2,3,\ldots m_i$, where m_i is the number of receipts with the first one occuring at time $t = t_i$. The present worths at time $t = 0$ of the two series at a discount rate r are, respectively:

$$PWP_i = \sum_{h=1}^{\ell_i} P_{ih} (1+r)^{-h} \tag{1}$$

$$PWF_i = \sum_{j=1}^{m_i} F_{ij} (1+r)^{-(t_i+j-1)} \tag{2}$$

The rate of return on the tax paid can be obtained by setting the difference of PWP_i and PWF_i equal to zero and solving for r. For each population set i, then, a rate of return r_i can be obtained. The expected rate of return for an individual who belongs to the total population in consideration as at time t = 0 is:

$$E[r] = \frac{1}{N} \sum_{i=1}^{n} k_i r_i$$

or

$$E[r] = \sum_{i=1}^{n} \frac{k_i}{N} r_i \tag{3}$$

The term $\frac{k_i}{N}$ is the probability p_i that an individual randomly picked out of the population at time T actually belongs to set i. Also, in this study it is assumed that each individual will enter and leave the system only once. Accordingly, the series of coefficients of the cash flow equation only changes signs once and therefore the uniqueness of the root obtained is guaranteed (p. 556, [3]).

If, instead of solving for r_i's, all the present worths of the tax payment series and all the present worths of the benefit receipt series are added up over all N individuals, this would yield:

$$PWP = \sum_{i=1}^{n} k_i PWP_i = \sum_{i=1}^{n} k_i \sum_{h=1}^{\ell_i} P_{ih} (1+r)^{-h} \tag{4}$$

$$PWF = \sum_{i=1}^{n} k_i PWF_i = \sum_{i=1}^{n} k_i \sum_{j=1}^{m_i} F_{ij} (1+r)^{-(t_i+j-1)} \tag{5}$$

PWP and PWF such as expressed in (4) and (5) are the present worths of amounts that the population as a whole pays and receives. Therefore, if the difference between PWP and PWF is set equal to zero:

$$PWP - PWF = \sum_{i=1}^{n} k_i \sum_{h=1}^{\ell_i} P_{ih} (1+r)^{-h}$$
$$- \sum_{i=1}^{n} k_i \sum_{j=1}^{m_i} F_{ij} (1+r)^{-(t_i+j-1)} = 0 \qquad (6)$$

and r is solved for, this would yield $r = R$, R the rate of return that the population as a whole might expect to have on the total amount of money it pays to the system. From this point on, R will be referred to as the overall population rate of return, or simply the overall rate of return.

Individual Expected Rate of Return versus Overall Rate of Return

By examining the above equations, it can be seen that the individual expected rate of return and the overall rate of return are not identical. The reason being that $E[r_i]$ is obtained by taking the weighted summation of r_i's (with weights p_i's) while the solution value of R in equation (6) can be considered as being directly and completely weighted by the volumes of money involved. To further demonstrate this point, for each outcome i let the two series of payments and receipts be represented by a single pair of one payment P_i and one receipt F_i made at time $t = 1$ and $t_i = T$ for all i's, respectively.

For r_i, from (1) and (2):

$$p_i\ (1+r)^{-1} - F_i\ (1+r)^{-T} = 0$$

$$p_i\ (1+r)^{-1} = F_i\ (1+r)^{-T}$$

$$(1+r)^{T-1} = F_i/P_i$$

$$r_i = (F_i/P_i)^{1/(T-1)} - 1$$

Thus,

$$E[r] = \sum_{i=1}^{n} p_i r_i = \sum_{i=1}^{n} p_i[(F_i/P_i)^{1/(T-1)} - 1] \tag{7}$$

As for R, from (4) and (5)

$$\sum_{i=1}^{n} k_i p_i\ (1+R)^{-1} = \sum_{i=1}^{n} k_i F_i\ (1+R)^{-T}$$

Divide both sides by N and replace $\frac{k_i}{N}$ by p_i:

$$\sum_{i=1}^{n} p_i P_i\ (1+R)^{-1} = \sum_{i=1}^{n} p_i F_i\ (1+R)^{-T}$$

$$(1+R)^{T-1} = \sum_{i=1}^{n} p_i F_i \Big/ \sum_{i=1}^{n} p_i P_i$$

$$R = \frac{\left(\sum_{i=1}^{n} p_i F_i\right)^{1/(T-1)}}{\left(\sum_{i=1}^{n} p_i P_i\right)^{1/(T-1)}} - 1 \tag{8}$$

Clearly, in general, E[r] and R as expressed by (7) and (8) are not equal. A simple numerical example would verify this.

Let T = 2, n = 2 and,

$p_1 = .4$; $P_1 = 2$; $F_1 = 10$

$p_2 = .6$; $P_2 = 3$; $F_2 = 30$

Then:

$$E[r] = (.4)(\frac{10}{2} - 1) + (.6)(\frac{30}{3} - 1) = 7 \text{ or } 700\%$$

$$R = \frac{(.4)(10) + (.6)(30)}{(.4)(\ 2) + (.6)(\ 3)} = 7.46 \text{ or } 746\%$$

Both of these rates of return are important and useful in an evaluation of the system. The individual expected rate of return should be more significant to an individual since it tells something about what he might expect to gain through his tax payments. On the other hand, if in calculating R all the payments P_{ih} are multiplied by 2, i.e., taking into account both the employer's and the employee's contributions, then from the point of view of the Social Security Administration R might be of more importance since it is the discount rate which the system is paying for the total amount of money it receives from a particular population with a certain set of characteristics. Thus R can be used in planning the use of the Social Security Trust Fund accordingly, especially when there is a shift of characteristic patterns in different segments of the country's population.

In this study, for each of the cases studied (in Chapter IV), both rates will be provided at the disposition of any use possible.

Sullivan's Rate of Return

From examination of Sullivan's method and probabilistic cash flow equations (pp. 34-40 [14]), it is clear that the rate of return he derived is the overall population rate as presented above.

For each case of his study, the number of main outcomes considered is three. These are:

a. The worker works until retirement (assumed to be at 65) and then dies sometime after.

b. The worker works until he is disabled and then dies sometime after.

c. The worker works and never becomes disabled but dies prior to retirement.

The worker's children are assumed to collect their benefits, if any, until they reach age twenty-two; his wife is assumed to live to her life expectancy and collect her benefits until then.

The events of interest as considered by Sullivan then are retirement, death, disability onset of the worker, the worker's children reaching "independent status" (age twenty-two), and death of his spouse. The cash flow equations have the form (pp. 40-41, [14]):

$$\sum_{i=1}^{3} (\text{PW Cost}_i)(p_i) = \sum_{i=1}^{3} (\text{PW}_i)(p_i) \tag{9}$$

where:

PW Cost_i = present worth of tax paid according to outcome i.

PW_i = present worth of benefits received according to outcome i.

p_i = probability of outcome i.

Furthermore, each outcome i is broken down in sub-outcomes according to the time of occurrence of the events considered. Each sub-outcome of outcome i is associated with two cash flow series and a conditional probability (of the sub-outcome occurrence given that outcome i occurs). The present worths PW Cost_i and PW_i are then calculated as conditional expected values of the sub-outcomes present worths. Enumeration of the sub-outcomes and calculation of the probabilities involved are performed with the aid of a computer; equation (9) is then solved to obtain the rate of return.

Now if both sides of equation (6) are divided by N and rearranged, the following is obtained:

$$\sum_{i=1}^{n} \frac{k_i}{N} \sum_{h=1}^{\ell_i} P_{ih} (1+R)^{-h} = \sum_{i=1}^{n} \frac{k_i}{N} \sum_{j=1}^{m_i} F_{ij} (1+R)^{-(t_i+j-1)} \qquad (10)$$

The similarity between (9) and (10) can be seen by noting that $\frac{k_i}{N} = p_i$, the probability of occurrence of outcome i. This demonstrates that the rate of return as calculated by Sullivan from equation (9) is the overall population rate.

Computational Procedure Consideration

Having established the general method of approach, consideration must now be given to the computational procedure involved. Basically, the procedure to be used should consist of:

a. Determine the probability p_i associated with each outcome i.

b. Set up the cash flow equations and solve for the rates of return, r_i's, and the overall population rate of return R.

The Probability p_i

Consider the five types of events that might influence the amount of benefits received by an individual: birth of a child, death, marriage, divorce and disability onset. Each outcome i, defined as a particular sequence of events, might differ from another by the types of event, the number of events it includes, as well as the order of events. Furthermore, on a discrete time scale, two sequences of events, outcomes i and j, that consist of the same types, number, and order of events, might still differ from each other by the time of occurrence of each of these events. Thus, realistically speaking, the number of possible outcomes is finite but extremely large. Even if all the possible outcomes can be identified, with certain assumptions, the task of deriving the probabilities p_i's can be quite cumbersome.

For the purpose of illustration, assume that the probabilities of any one of the five events mentioned above occuring to an individual during any unit interval of time are constant and denote them by p_B, p_D, p_M, p_{DIV}, p_{DIS}, respectively for birth, death, marriage, divorce and disability onset. (A more detailed description of the events considered and input data involved is presented in Chapter III.) The probability that an individual presently at age a_1 will die at age a_2 is:

$$P_1\ (a_2) = (1-p_D)^{a_2-a_1}(p_D)$$

The probability that he will get married at age a_2, given that he presently is single, is:

$$P_2(a_2) = (1-p_M)^{a_2-a_1}(p_M)\ [1-\sum_{j=a_1}^{a_2} P_1(j)]$$

The probability that he will get married to someone of the same age at age j, then divorce at age a_2 is:

$$P_3(a_2) = P_2(j)\ [1 - \sum_{k=j+1}^{a_2} (1-p_D)]$$

$$[1 - \sum_{k=j+1}^{a_2} (1-p_D)^{k-j}(p_D)]\ [(1-p_{DIV})^{a_2-j+1}(p_{DIV})]$$

where the second and the third terms of the product are the probabilities that he and his wife will survive at least until age a_2.

The probability that he will become disabled at age a_2 is:

$$P_4(a_2) = (1-p_{DIS})^{a_2-a_1}(p_{DIS}) \; [1 - \sum_{j=a_1}^{a2} P_1(j)]$$

and finally, the probability that a couple of the same age a_1 will have a child at age a_2 is:

$$P_5(a_2) = (1-p_B)^{a_2-a_1}(p_B) \; [1 - \sum_{j=a_1}^{a_2} P_1(j)]^2$$

$$[1 - \sum_{j=a_1}^{a_2} (1-p_{DIV})^{j-a_1}(p_{DIV}) \; [1 - \sum_{k=a_1}^{j} P_1 \; (k)]^2]$$

Clearly, p_i, the probability of each outcome i, is a function of P_1, P_2, P_3, P_4, P_5 and the like. Given that the function can be explicitly expressed in a fairly manageable form for a particular sequence of events, the valuation of p_i is still further complicated by the nature of the event probabilities, i.e., p_B, p_D, and so on. The fact is that these probabilities are known to be dependent on other characteristics of the individual in consideration such as age, sex, race and so on. For instance, the probability of a woman having a child depends on her age and parity (number of previous live births); the birth probability data is available in tabular form and cannot be approximated by a closed-form expression without losing much of its accuracy. In other words, a closed-form expression for p_i is difficult to obtain, if not impossible, and there seems to be no other alternative than to rely upon numerical evaluations for p_i's with the aid of a computer such as done in Sullivan's study. Note that it is still assumed that the number of outcomes is finite and the outcomes themselves can be identified under certain assumptions.

Solution Method for the Cash Flow Equations

For a given sequence of events, a cash flow equation can be derived, based on the Social Security rules and regulations (summarized in Chapter I). Consider next the method to be used to solve an irregular cash flow equation such as the ones encountered in this problem. So far, the only known method is trial and error, i.e., the present worths of the two series are evaluated at successive "better" estimates of the rate of return in question until the difference between the two present worths is not significantly different from zero, or two successive best estimates of the rate are not significantly different from each other. Obviously, this can be done most efficiently by a computer.

Justification of the Use of Simulation

Thus all the facts that can be observed so far in looking at the computational aspect of the approach developed seem to point to another, yet better alternative in handling this problem, namely, simulation. As expressed by Naylor, et al. (p. 6, [6]):

> "Simulation has been found to be an extremely effective tool for dealing with problems of this type, i.e., when the observed system may be so complex that it is impossible to describe it in terms of a set of mathematical equations for which it is possible to obtain analytic solutions which could be used for predictive purposes."

In this case, simulation is clearly more desirable than a combination of exhaustive enumeration and evaluation of p_i's, and numerical techniques to be used to solve the cash flow equations.

CHAPTER III

SIMULATION MODEL

Introduction

Simulation as a tool in system analysis is used in solving problems in which closed form mathematical expressions cannot be derived. Of particular interest are studies of economic and demographic systems that involve modeling of human populations [1], [7]. The accuracy with which a simulation model represents a real life situation depends on the number and impact of the assumptions made on the processes involved in the problem. The purpose of this discussion is to describe these processes, their representative counterparts in the simulator, and the assumptions made.

General Characteristics of the Simulator

As determined by the context of the problem, the function of the simulator consists of three tasks: first, starting with a given set of characteristics of an individual (with respect to age, sex, race, family status, and salary level), generate the complete sequence of events in the individual's life history that are relevant to the calculation of the rates of return. These are to be based on the statistical information provided by input demographic data.

Second, from this sequence of generated events, determine the series of tax payments and benefit receipts that would result according to the Social Security rules and regulations.

Third, each simulation run thus represents one possible life history and provides a pair of series of payments and receipts with a respective r_i, the individual rate of return. After making a number of runs, E[r], the expected individual rate of return, and R, the overall population rate of return, are calculated by the method presented in Chapter II.

Since the payments and receipts occur monthly, the appropriate time scale is discrete with one unit of time representing one month. However, the simulated time span for each run in months is rather large, representing as it does most of a human lifetime. For example, the simulated time span for an individual who starts to work at age twenty and dies at age seventy would be 600 months. Therefore, an efficient time-flow mechanism should use a variable time-increment.

Given an individual's demographic characteristics such as age, sex, and race, statistical data on the occurrences of five types of events, birth, death, marriage, divorce, and disability onset, are available in the form of annual rates or probabilities of occurrence. It is thus necessary to convert these annual values into monthly probabilities of occurrence, assuming that for any of the five types of events mentioned above, the probabilities of occurrence in different months of a year are identical. Let p_m and p_a be respectively the monthly and the annual values of the probability of occurrence. Clearly, the probability that the event does not occur during a year is $(1 - p_m)^{12}$ or alternatively $(1 - p_a)$, thus:

$$(1 - p_m)^{12} = (1 - p_a)$$

or:

$$p_m = 1 - (1 - p_a)^{1/12}$$

Over the interval of time where this monthly probability of occurrence remains unchanged, the time until occurrence, in months, of the particular event in consideration then is geometrically distributed. It is given by: (p. 275, [9]):

$$\frac{\ln(1 - r)}{\ln(1 - p_m)} \leq t < \frac{\ln(1 - r)}{\ln(1 - p_m)} + 1 \tag{11}$$

where t is time until occurrence and r is a uniform random number.

This procedure is used for all five types of events cited above. Note that for the type of event for which the probability of occurrence is "time-dependent", the procedure might have to be repeated a number of times before the time until occurrence of the event can be obtained. To illustrate this, consider an event which has a probability of occurrence $p = p_i$ for a person of age a where $a_i \leq a < a_{i+1}$, $i = 1,2,3,\ldots.\ n$. If the value $t = t_1$ obtained from (11) is such that $(a + t_1) < a_{i+1}$, the procedure terminates. If $(a + t_1) \geq a_{i+1}$ then $p = p_{i+1}$ is used. Suppose this time $t = t_2$ is obtained. If $(a_{i+1} + t_2) < a_{i+2}$ then the procedure terminates with the time until occurrence being equal to $(a_{i+1} + t_2 - a)$; if not, the procedure repeats itself again with $p = p_{i+2}$ and so on. This applies to the events of birth, death, and marriage for which the probabilities are age-dependent, and divorce for which the probability is marriage-duration-dependent.

The programming language chosen for the simulator is FORTRAN IV since its capabilities as a simulation language are adequate for the type of model dealt with in this study and it offers ease of computation programming and efficiency. The complete listing of the computer program for the simulator is given in Appendix A.

Simulator Structure Description

The simulator consists of a main program, a subroutine called DATA which handles all the system input data (i.e., demographic and Social Security data), and thirty other subroutines which can be classified according to their functions into three modules as follows:

1. Life Module.
2. Social Security Module.
3. Statistical and Output Module.

The first two modules perform the three tasks mentioned previously. The last one is responsible for checking the termination criterion and providing final output results.

Main Program

As the simulation begins, the Main Program first activates subroutine DATA which reads system input data. Next, the Main Program reads information on the individual in consideration. This consists of:

1. Age, sex, race, marital status of the individual, and age at marriage, if married.
2. Age, sex, race of spouse, if the individual is married.
3. Age, sex of dependent children, if any.
4. Salary history of the primary individual.

Although in the simulator there is no mechanism provided to project future salary increases, anticipated higher future salary levels may be entered as input data.

The Main Program then proceeds to generate a sequence of initial events. This is done by first generating all the relevant events that can occur to the individual; if any two of them are competitive, then only the one that occurs first will be actually allowed to occur. To illustrate this, consider the case of the individual who is single. The possible initial events are: death, becoming disabled, retirement, and marriage. If the event of marriage is generated after the event of death, then the individual will remain single all his life, or if retirement is generated after disability onset, then retirement will not actually occur.

After the entire sequence is obtained, the events are processed in chronological order by sequentially updating the simulator clock time. As each of these events occurs, the status of the primary individual and secondary individuals are updated. At that point in time, possible future events are generated, based on the new status, and added to the sequence which already exists. Also, as each event happens, a check is made to determine whether benefit receipts would begin, or, if the individuals are already in the process of receiving benefits, then whether the amount of the monthly benefits would change.

Each simulation run terminates when the last event of the sequence is processed and no relevant future event is possible. From the two series of payments and receipts, r_i is then calculated. After every pre-specified number of n runs, E[r] is estimated, R is calculated for that particular group of n runs, and a check is made to determine whether the termination criterion is met. If this is the case the simulation itself terminates with the output of results.

Life Module

The subroutines of this module are responsible for scheduling possible events and other minor tasks, which may be created by the occurrence of the events; for example, determining the age of a marriage partner upon the occurrence of marriage, or sex of a child upon birth. The functional description of these subroutines can be conveniently arranged according to the type of event associated with each of them.

A. Birth

For a married individual, births are scheduled as initial events at the start of a simulation run, or as regular events upon the occurrence of marriage. If the time of occurrence of a birth is smaller than the time of occurrence of a marriage dissolution (through death of one marriage partner or divorce), that birth will be allowed to occur. The minimum time interval between two successive births is assumed to be ten months. The annual probability of a woman giving birth varies with both her age and parity (number of previous live births). Statistics compiled in the annual volumes of Vital Statistics of the United States [18] provides these probabilities for women between 15 and 44 years old (in five-year age groups) and of eight parity groups (from 0 to 7 or higher), such as shown in Table 1 of Appendix B.

Subroutine BIRTH is used in conjunction with subroutines RANDU (which provides a uniform random number) and GEOME (which provides a geometric random number) to schedule births. Upon the occurrence of a birth, the sex of the child is determined by subroutine BISEX according to the birth sex ratio male/female. This ratio has remained fairly constant during recent years and is approximately 1.060.

B. Death

In the same fashion that births are scheduled, deaths are scheduled by subroutine DEATH as initial events for a married couple at the start of a simulation run, and for a marriage partner upon the occurrence of marriage. The probability of dying in a given year depends on a person's age, sex, and race. This probability is higher for male than female and higher for a non-white person than for a white person. Also, it starts out with a high value for a newborn child, decreases until he reaches ten years old and increases again as he gets older. Values for this probability are available in the annual volumes of the Statistical Abstract of the United States [16] in tabular form such as shown in Table 2 of Appendix B, for each combination sex-race (white and non-white) group at each age.

C. Marriage

Marriage is scheduled at the start of a simulation run for a single individual, or upon a dissolution of marriage, by subroutine MARRY. A previous study of marriages by the U. S. Public Health Service [17] shows that the probability of a person getting married varies with that person's age, sex and previous marital status (single, divorced, or widowed). In this study, then, differentiation is made with regard to these three variables and values for the probabilities are obtained [17] for different age groups for each combination of sex and previous marital status. They are shown in Table 3, Appendix B.

Upon the occurrence of marriage, the age, race, and marital status of the prospective marriage partner are determined using subroutine MARPA. For age, data are available [17] in the form of percentage distribution of marriages over the difference in ages between bride and groom. They are as shown in Table 4 of Appendix B. Race of a marriage partner is determined by means of probabilities of inter-racial marriages [17], given that a marriage does occur and given the race of one partner. Race differentiation considered is white versus non-white, thus these probabilities constitute a 2 by 2 matrix, as shown in Table 5, Appendix B. Similarly, the previous marital status is determined. The previous marital status probability matrix is shown in Table 6 of Appendix B. Note that this previous marital status has to be determined before the age of the partner can be estimated, since, as shown, the distribution of marriages by age difference is also a function of previous marital status of both bride and groom.

In the case of a prospective female partner whose previous marital status is either widowed or divorced, her parity has to be determined, since her probability of giving birth in the future depends on this. Since no distribution of parity is available separately for widowed and divorced women, the parity distribution for all women compiled in the Vital Statistics of the United States [18] is used as an approximation. Table 7 of Appendix B shows this distribution in terms of percentage of the previously married women population in eight parities (from 0 to 7 or higher) for five age groups. From this data, subroutine PARDI generates the parity for the marriage partner with her already determined age.

Also, upon the occurrence of marriage, future birth(s), death, and divorce are scheduled and tested for actual occurrences. This task is performed in subroutine SPOUSE by calling the appropriate event scheduling subroutines: BIRTH, DEATH, and DIVOR.

D. Divorce

Divorce is scheduled at the start of a simulation run or upon the occurrence of a marriage by subroutine DIVOR. If the time scheduled is after either of the partners' death, then the event will not occur. Studies of the U. S. Bureau of Census [15] provide the probability of a divorce in relation to the duration of the marriage, race, and sex of one partner. Values of this probability are shown in Table 8 of Appendix B. In the simulation, the race and sex of the primary individual is used as a basis for choosing the appropriate probability.

E. Retirement

Retirement is scheduled by subroutine RETIR, using the distribution of age at retirement for men and women obtained from the Social Security statistics [11]. This distribution is shown in Table 9 of Appendix B.

F. Disability

Disability onset is scheduled by subroutine DISAB. Values of the annual probability of becoming disabled, as obtained from the Social Security statistics [12], vary with respect to geographic location. In this study, the overall national value, .00642, is used.

G. Dependency Status of the Worker's Children

According to Social Security regulations, a worker's child is eligible for benefits, when due, only if this child is either single and under eighteen, or disabled, or a student and under twenty-two. Thus, the dependency status of a child might terminate by early death, marriage, or termination of education (after eighteen), and unless the child is disabled, it terminates at age twenty-two.

Therefore, at the start of a simulation run or at each birth during the run, death, marriage, and disability onset are scheduled for each of the worker's children. This is done by subroutine CHILD in conjunction with the event scheduling subroutines described previously. The distribution of age at the termination of education prior to reaching twenty-two, however, is unknown. In this study it is assumed that the child continues to go to school until he is eighteen and thereafter might terminate his schooling with equal probabilities at any time before he turns twenty-two. Subroutine INDEP is used to assess this age.

In addition to the subroutines already mentioned, there is subroutine FILE that can also be classified as belonging to the LIFE module. This subroutine is used to add an event that will actually occur to the sequence of events already existing.

Social Security Module

The subroutines of this module are responsible for establishing the cash flow equations and calculating the individual rate of return r_i and the overall rate of return R.

A. Assessing Taxes and Benefits

At the occurrence of retirement, death, or disability onset to the primary individual, the tax-paying period ends. Through subroutine SOSEC, subroutine TAXBE is called to assess the series of tax payments. For each period where the salary level remains unchanged, the monthly amount of the tax payment is determined by applying the tax rate and taxable salary ceiling on the salary of that period. Next, subroutine COVER is used to determine the number of quarters of coverage credited to the primary individual and his eligibility. Subroutine BENEF is then used to calculate the Average Monthly Wage (AMW), the Primary Insurance Amount (PIA), and the Maximum Family Benefits (MFB). From that point subroutine SOSEC is used in determining the amount of monthly benefits and adjusting this amount along with the occurrences of the following events in the sequence.

According to regulations of the Social Security program, the spouse of the worker is not eligible for benefits unless she is sixty-two or older, or unless any of her children is also eligible for child's benefits. Subroutine SPBEN is used to calculate her benefits if she is eligible or schedule the future date when she becomes eligible (upon reaching sixty-two) if she is not.

B. The Rates of Return

From the series of payments and receipts, a rate of return r_i is calculated for each run. In the cases where neither the primary individual nor his dependents are eligible for benefits, the rate of return cannot be assessed. These cases are defined as total loss cases and separated from the rest of all runs when calculating $E[r]$. This implies that the expected individual rate of return calculated in this fashion is actually an expected individual rate of return, given that the individual will be eligible for benefits. For the total loss cases, the amounts of tax paid are calculated from the series of payments at an arbitrarily chosen discount rate of 6%. Statistics on these amounts are provided in the output data, together with the probability that a total loss case will occur. It turns out that in all the individual cases studied in Chapter IV, this probability is practically negligible, since its values are usually zero, with the highest value observed equal to .02. This means that for all practical purposes, the expected individual rate of return is approximately equal to the expected individual rate of return, given eligibility.

After every n simulation runs, the mean E[r] and variance V[r] are calculated and a check is made to determine whether the termination criterion, which will be described later, is met.

Theoretically, R, the overall rate of return for a population with a given starting set of characteristics, is not a random variable. However, the value of R determined through simulation is subject to error, since it is never possible to obtain all the outcomes that can happen. In other words, such a value of R is only an estimate of the true value. It is thus desirable that statistics on this obtained value be provided. The procedure used in this study is to estimate R for a number of population of size n, i.e., estimate R after every n runs for that particular group of n runs, and calculate the mean E[R] and variance V[R] at the end of the simulation. The value of n chosen is fifty, since it is observed that both E[r] and E[R] are fairly stable after fifty runs, which implies that the make-up of fifty outcomes is a good representation of the make-up of the set of real-life outcomes. Again, it should be kept in mind that V[R] is introduced purely by simulation, i.e., theoretically V[R] = 0.

The solution procedure used to calculate r_i's as well as R from the cash flow equations is a combination of two procedures. The first one, commonly used, is to start out with two arbitrarily chosen values r' and r'', calculate the corresponding differences D' and D'' between the two present worths PWP (of the tax payments) and PWF (of the benefit receipts). From these values interpolation (or extrapolation) is made to arrive at r''', i.e.:

$$r''' = r' - D' \frac{(r'' - r')}{(D'' - D')}$$

Next, set r' - r'' = r''' and the procedure continues until either D'' is not significantly different from zero or r' and r'' obtained are not significantly different from each other. This is done by subroutine FESTI, which in turn issues calls to subroutine PRESE to obtain present worths evaluated at $r = r'$ and $r = r''$.

This procedure, however, converges relatively slowly due to the curvature of D = PWP - PWF as a function of r. This is the reason for using a second supporting search procedure. Using starting values $r' = .00001$ and $r'' = .01$, termination criterion $|r'' - r| \leq .0001$ and $|D''| \leq 100.$, an initial estimate for r is obtained. A bracketed interval is then imposed on the estimated r, i.e., $(r - \delta, r + \delta)$, where δ is a controlled positive constant, and a search is made over this interval for a value of r at which $|D|$ is minimized. Several search procedures are available as described by Wilde and Beightler, [19], among which are the Fibonnacci and the Golden Section search techniques. The latter is chosen due to its convenient characteristic in locating points at which evaluations of D are to be made. Also, as noted by Wilde and Beightler, the Golden Section search gives a final interval only about 17% longer than that obtainable by Fibonnacci search. The final interval of uncertainty is given by:

$$d_n = \frac{d_0}{(1.618)^{n-1}}$$

where d_0 is the length of the initial interval, i.e., $d_0 = 2\delta$. Subroutines RRATE, SUB1 (for r_i), and SUB2 (for R) are used for the search with $d_0 = .012$ and $n = 20$. Thus, the final interval of uncertainty in which the solution r is located has the length of:

$$d_n = \frac{.024}{(1.618)^{19}} \simeq 2.56 \times 10^{-6}$$

After obtaining the final interval, the value of r is taken to be the average of the two interval endpoint values.

The values of r_i's and R, as obtained by solving the cash flow equations, are monthly rates. They are converted into effective annual rates and recorded.

Statistical and Output Module

A. Termination Criterion

Since the goal of the simulation is to obtain estimates of E[r] and E[R], a termination criterion for the simulation can be developed based on the obtainable length of the confidence intervals for these variables.

For large sample sizes, $\bar{r}$, the estimate of E[r] is approximately normally distributed with mean equal to E[r] and variance s^2/n where s^2 is the sample variance of r_i, n is the sample size. The lower and upper limits of the confidence interval on $\bar{r}$, subject to the type I error probability α, are given by:

$$U_{\bar{r}}, L_{\bar{r}} = \bar{r} \pm z_{1-\alpha/2} \frac{s}{\sqrt{n}}$$

where z is the standard normal deviate. This yields:

$$U_{\bar{r}} - L_{\bar{r}} = 2z_{1-\alpha/2} \frac{s}{\sqrt{n}}$$

It is often more desirable to base the termination criterion on the relative magnitude of this length with respect to $\bar{r}$ rather than on the absolute magnitude $(U_{\bar{r}} - L_{\bar{r}})$ itself. In other words, if:

$$l\bar{r} = U_{\bar{r}} - L_{\bar{r}}$$

then the termination criterion can be specified by assigning to l the desired value ℓ_c. Thus, the sample size n* required to meet the criterion can be found by solving

$$\ell_c = \frac{2z_{1-\alpha/2} \frac{s}{\sqrt{n^*}}}{\bar{r}}$$

$$\sqrt{n^*} = \frac{2z_{1-\alpha/2}\, s}{\ell_c \bar{r}}$$

$$\overline{n^*} = \left[\frac{2z_{1-\alpha/2}\, s}{\ell_c \bar{r}}\right]^2$$

A similar termination criterion can be developed based on the confidence interval for $\bar{R}$. Although V[R] is quite small, calculation of the confidence interval for $\bar{R}$ has to be based on the student's t distribution (due to small sample sizes) which gives larger intervals than the normal distribution. Due to this fact, the former criterion, based on the confidence interval for $\bar{r}$, if used would be redundant, since it would be met sooner than the latter. However, it is used in this study without the latter, since in most cases the confidence interval for $\bar{R}$ is only slightly larger than one of $\bar{r}$ (with $\ell_c = .20$) and one additional sample point for R means fifty additional simulation runs.

The termination criterion is monitored by subroutine STAT. Once it is met, this subroutine calculates final statistics (mean, variance, confidence interval) for the two rates of return and the amount of money lost for the total loss cases. For the amount of money lost, the confidence interval calculated is also based on the student's t distribution rather than the normal.

In addition to the two rates of return, another measurement is also provided by the simulator, namely, the payoff ratio. This is defined as the ratio of present worth of the benefits received over the present worth of tax paid for a run, with both present worths evaluated at an arbitrarily chosen interest rate of 6% annually. Statistics on this ratio are also calculated. This is done by subroutine RATIO.

B. Outputs

The output data provided by the simulator includes statistics on the rates of return, amount of tax money lost and the payoff ratio. For the first run, the events generated are printed together with the resulting series of payments and receipts, and the corresponding individual rate of return, as an example. This is done by subroutines OUTP2 and OUTP3. Subroutine OUTP1 prints the input information on the individual in consideration. An example of program output is shown in Figure 4.

Figure 4

An Example of Program Output

```
***** SOCIAL SECURITY AS AN INVESTMENT *****
      ANALYSIS OF THE RATES OF RETURN

* BASE DATE : JANUARY 1 ST OF   1975 *

*** INPUT INFORMATION ON SUBJECT ***

* SUBJECT *
AGE :    26 YEARS    0 MONTHS
RACE : WHITE
SEX : MALE
MARITAL STATUS : MARRIED
NUMBER OF DEPENDENT CHILDREN :    2

* SPOUSE *
AGE :    26 YEARS    0 MONTHS
RACE : WHITE

* CHILD(   1) *
AGE :     2 YEARS    0 MONTHS
SEX : FEMALE

* CHILD(   2) *
AGE :     0 YEARS    1 MONTHS
SEX : MALE
```

```
* SALARY EARNING HISTORY OF SUBJECT *
STARTING DATE   $/MONTH
     1/ 1971     1100.00


*** SIMULATED EVENTS OF SUBJECT.S LIFE HISTORY FOR THE FIRST RUN ***

EVENT DATE :    7/ 1977
BIRTH OF CHILD (   3)
SEX : FEMALE

EVENT DATE :    5/ 1984
BIRTH OF CHILD (   4)
SEX : MALE

EVENT DATE :   12/ 1993
TERMINATION OF CHILD(   1).S EDUCATION

EVENT DATE :    7/ 1996
TERMINATION OF CHILD(   2).S EDUCATION

EVENT DATE :    4/ 1998
MARRIAGE OF CHILD(   3)

EVENT DATE :   11/ 2001
DEATH OF SPOUSE
```

EVENT DATE :   9/ 2003
TERMINATION OF CHILD(4).S EDUCATION

EVENT DATE :   1/ 2013
RETIREMENT OF SUBJECT

EVENT DATE :   5/ 2029
DEATH OF SUBJECT

*** SIMULATED TAX/BENEFITS CASH FLOW SERIES FOR THE FIRST RUN ***

* TAX PAYMENTS SERIES *

STARTING DATE	$/MONTH
1/ 1971	29.90
1/ 1972	34.50
1/ 1973	43.65
1/ 1974	48.50
1/ 1975	52.80
1/ 2011	64.35

NUMBER OF QUARTERS OF COVERAGE CREDITED =   168
NUMBER OF WORKING YEARS MUST BE COUNTED IN BENEFITS COMPUTATION = 38
AVERAGE MONTHLY WAGE = $ 1100.00
PRIMARY INSURANCE AMOUNT = $ 404.97
MAXIMUM FAMILY BENEFITS = $ 708.69

```
* BENEFITS SERIES *
STARTING DATE  $/MONTH
     1/ 2013     377.97
     5/ 2029     255.00

RATE OF RETURN (FIRST RUN) FOR THE ABOVE SERIES =  0.34697E 01 % YEARLY



TERMINATION CRITERION MET :
   SAMPLE SIZE REQUIRED =    86
   SAMPLE SIZE TAKEN =      137

* INDIVIDUAL EXPECTED RATE OF RETURN *
   MEAN =       0.63660E 01
   VARIANCE =   0.51040E 01
   95% CONFIDENCE INTERVAL FOR THE MEAN :
     LOWER BOUND =  0.59877E 01
     UPPER BOUND =  0.67443E 01

* NO TOTAL LOSS CASE OBSERVED *

*** END OF SIMULATION ***
```

```
* PAYOFF RATIO STATISTICS AT 6% YEARLY INTEREST RATE *
   E(R) =        0.11700E 01
   V(R) =        0.15115E 01
   95% CONFIDENCE INTERVAL FOR THE MEAN :
     LOWER BOUND =  0.10495E 01
     UPPER BOUND =  0.12905E 01

* OVERALL RATE STATISTICS *
   MEAN =        0.66955E 01
   VARIANCE =   0.05863E 00
   95% CONFIDENCE IFOR THE MEAN (SAMPLE SIZE =      3 )
     LOWER BOUND =  0.60940E 01
     UPPER BOUND =  0.72970E 01
```

CHAPTER IV

CASE STUDIES AND ANALYSES

Introduction

In this chapter the simulation model is used for case studies. Four out of five cases considered by Sullivan (p. 13, [14]) are examined, as they seem to be representative of large segments of the United States population. The rates of return in these cases are evaluated, based on the same 1972 rules and regulations as in Sullivan's study; and a comparison of the results is made. Next, the same four cases are re-evaluated, using 1974 Social Security rules and regulations. By a minor modification of the model, the rates of return are separated into two components corresponding to the Disability-Survivors portion and the Old-Age, or Retirement, portion, which enables separate value-assessment for each of them. Analysis is performed to determine the significance of salary level and the worker's age in fixing the rates of return. Finally, a sensitivity analysis is presented for the five types of input data: birth, death, marriage, divorce, and disability rates.

Description of Cases Studied

The first case examined is that of a man twenty-six years old. He started to work at the age of eighteen (just after high school) at the minimum wage as required by law. At twenty-one he married someone of his own age. They have two children, the first one arriving when the parents were twenty-three years old and the second one when the parents were twenty-five.

The second case is that of a twenty-six year old college graduate who started to work at twenty-two. His earnings are large enough so that he pays the maximum amount of Social Security tax. At age twenty-two he married someone of his own age. They have two children, the first child arriving when the parents were twenty-four and the second one just arrived.

The third case is of a man of twenty-six who started to work at eighteen. His job only pays the minimum wage as required by law. He remains unmarried all his life.

The fourth case is of a man twenty-six years old who started to work at age twenty-two. His earnings are large enough so that he pays the maximum Social Security tax. He remains unmarried all his life.

In his study, Sullivan did not mention the minimum and maximum wages used. However, the minimum wage can be reasonably assumed to be roughly \$320 monthly, based on a minimum \$2 hourly rate, and the maximum wage to be \$13,200 annually, which is the maximum taxable income for the FICA tax.

In order to evaluate the third and fourth cases, the marriage process is completely suppressed.

Results and Discussion

Comparison of Analytic and Simulated Overall Rates of Return

The results obtained from the simulation and those computed by Sullivan are tabulated in Tables 4 and 5. As can be expected, the two sets of overall population rates of return bear some degree of resemblance. For the first and third cases, the analytically computed overall rates fall within the 95% confidence intervals of the corresponding simulated overall rates. In other words, a null hypothesis that the two corresponding

TABLE IV

INDIVIDUAL EXPECTED RATE OF RETURN

(Based on 1972 Social Security Rules)

Case	Mean	Variance	95% Confidence Interval Limits	
1	6.0420	3.6700	3.7703	6.3137
2	5.5574	4.5973	5.2493	5.8665
3	4.8865	8.8179	4.4586	5.3144
4	4.7868	16.4210	4.3400	5.2336

TABLE V

OVERALL POPULATION RATE OF RETURN

(Based on 1972 Social Security Rules)

Case	Mean	Variance	95% Confidence Interval Limits		Sullivan's Results
1	7.3028	.08484	6.8394	7.7662	7.7
2	5.9334	.08922	5.4582	6.4086	4.6
3	4.3340	.12213	3.7780	4.8900	4.2
4	2.9119	.13171	2.5763	3.2475	2.4

overall rates in each of the two cases are equal cannot be rejected at a significance level $\alpha = .05$. Since an overall rate is heavily weighted by the volume of money involved, any bias created by the restrictions which are imposed on the analytic model would get larger with a higher salary level. Thus, this explains the significant difference between the corresponding overall rates in the second and fourth cases.

Secondary Benefits

To obtain more up-to-date estimates, the rates of return are re-evaluated using 1974 Social Security rules and regulations as described in Chapter I. The results are shown in Tables 6 and 7.

Examination of the results reveals that the individual expected rate of return is significantly higher in the first case than in the third, and significantly higher in the second than in the fourth. A similar relationship can be observed among the overall rates of return of the four cases. This is due to the fact that the primary individuals in the third and fourth cases remain unmarried throughout their lives. Therefore, there is no possibility of receiving any secondary (dependent) benefits, which can be large. For instance, the maximum amount of secondary benefits, which is the difference between the Maximum Family Benefit MFB and the Primary Insurance Amount PIA, for an Average Monthly Wage AMW of $628 or more is three-fourths of one PIA.

Disability-Survivors Benefits versus Retirement Benefits

A similar breakdown of the individual expected rate of return and the overall rate of return each into two component rates representing the Disability-Survivors benefits and Retirement benefits is performed. By disregarding the simulation runs in which the worker retires, and

TABLE VI

INDIVIDUAL EXPECTED RATE OF RETURN

(Based on 1974 Social Security Rules)

Case	Mean	Variance	95% Confidence Interval Limits	
1	7.4434	5.1720	7.1148	7.7720
2	6.3660	5.1040	5.9877	6.7443
3	5.6381	11.1270	5.2755	6.0008
4	4.0247	17.3320	3.6344	4.4150

TABLE VII

OVERALL POPULATION RATE OF RETURN

(Based on 1974 Social Security Rules)

Case	Mean	Variance	95% Confidence Interval Limits	
1	7.6843	.04639	7.3416	8.0270
2	6.6955	.05863	6.0940	7.2970
3	5.6818	.36407	5.1238	6.2399
4	4.9324	.27219	4.5062	5.3686

and disregarding the runs in which the worker becomes disabled or dies before he can retire, these two components are obtained for the individual expected as well as the overall rates of return for the second and fourth cases. They are shown in Tables 8 and 9.

In both cases, and for both the individual and the overall rates, the Disability-Survivors component is significantly higher, while the Retirement component is significantly lower than the corresponding rate itself. Clearly, this can be expected, since the former component represents a situation which results in a relatively short series of payments and a longer series of receipts, while the latter component represents a situation in which the reverse is true.

Salary and the Worker's Age Factors

Since most of the previous studies of the Social Security program [2], [10], using the payoff ratio, lead to the common conclusion that tax money buys fewer and fewer benefits as time goes on, this conclusion is investigated, using the rates of return as measurement.

In this analysis of the effect of the worker's present age, the second case above is used with a minor change: the ages of the worker and spouse are set at twenty-five years. To move back on the system time scale, the base date (at which the present worths of cash flow series are evaluated) is decreased by five, ten, and fifteen years. Thus, given that the worker in the last three cases is still alive today, his age would be thirty, thirty-five, and forty, respectively. Also, the date of starting to work in each case is decreased by the same amount as the base date. These four cases are then evaluated at different levels of the worker's monthly salary; they are \$500, \$700, \$900, \$1100,

TABLE VIII

COMPONENT BREAKDOWN OF THE

INDIVIDUAL EXPECTED RATE OF RETURN

Case	Whole Rate	Mean Retirement Component	Disability-Survivors Component
2	6.3660	5.5961	9.4150
4	4.0247	2.9672	4.4856
	95% Confidence Interval Lower and Upper Limits		
2	5.9877	5.4429	8.9544
	6.7443	5.6990	9.8756
4	3.6344	2.7988	4.1307
	4.4150	3.1356	4.8405

TABLE IX

COMPONENT BREAKDOWN OF THE OVERALL RATE OF RETURN

Case	Whole Rate	Mean Retirement Component	Disability-Survivors Component
2	6.6955	5.6460	9.5665
4	4.9324	3.0038	5.4914
	95% Confidence Interval Lower and Upper Limits		
2	6.0940	5.5655	9.0775
	7.2970	5.7264	10.0556
4	4.5062	2.8193	5.1436
	5.3686	3.1884	5.8392

and $1300. The results are shown in Tables 10 and 11. The termination criterion used insures that the 95% confidence intervals are less than ±20% of the rates of return. In most cases they range between ±.15% to ±.20% annually. From these results, it might be concluded that the time at entering the system is not a significant factor. As for salary levels, on the basis of those considered, the conclusion can be drawn that they do not result in significantly different rates of return. Also, note that the two salary levels of $1100 and $1300 result in the same rate of return, since they are equal and greater than the maximum taxable salary level.

Tax Paid by Employer as the Employee's Compensation

According to Social Security contribution regulations, an employer has to contribute an amount equal to the amount contributed by his employee. It is generally argued that this amount is actually a part of the employee's compensation. Also, from a cost point of view, it is reasonable to include the employer's contribution while estimating the rates of return. An overall rate of return calculated in this fashion certainly would be of interest to the Social Security Administration, since this is the rate of interest they pay for the money they receive from a particular population. To calculate the rates of return in this case, it is only necessary to double or multiply by two all the tax payments of each cash flow equation. The four cases that have been used throughout this chapter are evaluated again and the results are shown in Tables 12 and 13.

There is a marked decrease in the rates of return when compared to the results obtained in the cases where the employer's contribution is

TABLE X

SALARY AND AGE FACTORS

INDIVIDUAL EXPECTED RATE OF RETURN

	Age			
Salary	25	30	35	40
500	6.6219	6.7001	6.7432	6.7660
700	6.5440	6.6034	6.6215	6.6581
900	6.4146	6.4239	6.4934	6.5850
1100	6.3324	6.3864	6.4188	6.4357
1300	6.3324	6.3864	6.4188	6.4357

TABLE XI

SALARY AND AGE FACTORS

OVERALL RATE OF RETURN

	Age			
Salary	25	30	35	40
500	6.8217	6.9357	6.9921	7.2637
700	6.7289	6.8133	6.9543	7.2172
900	6.6918	6.7819	6.9216	7.1111
1100	6.6586	6.6964	6.8437	6.9942
1300	6.6586	6.6964	6.8437	6.9942

TABLE XII

INDIVIDUAL EXPECTED RATE OF RETURN

WITH EMPLOYER'S CONTRIBUTION

Case	Mean	Variance	95% Confidence Interval Limits	
1	4.3740	2.0920	4.2195	4.5284
2	4.2501	2.8272	4.0639	4.4363
3	4.3053	12.4420	3.9242	4.6865
4	3.2405	18.7060	2.8396	3.6414

TABLE XIII

OVERALL POPULATION RATE OF RETURN

WITH EMPLOYER'S CONTRIBUTION

Case	Mean	Variance	95% Confidence Interval Limits	
1	5.1716	.04429	4.9956	5.3476
2	4.4416	.07557	4.2450	4.6382
3	3.0032	.23634	2.5536	3.4529
4	2.9217	.18412	2.6148	3.2286

not accounted for. Also, it can be observed that the greater the rates in the former cases, the greater the decrease seems to be.

Sensitivity Analysis

To provide an estimate of the effect that changes or accuracy of the five main types of system input data, namely birth, death, marriage, divorce and disability, might have on the rates of return, a sensitivity analysis is performed on the individual expected rate of return, using the second case of the four cases. This is done by means of a five-way analysis of variance where each of the five processes mentioned above is considered as one factor. For each factor, three levels are used with each level obtained by multiplying all the present values of rates or probabilities by a multiplier arbitrarily chosen. These multipliers are shown in Table 14. Since there are five factors with three levels each, this would result in 3^5 or 243 combinations or cells. For each cell, the number of replicates used is fifty, since it is observed that with approximately fifty runs, the estimated means of the individual rates of return become fairly stable. Using the computer statistical program BMD 02V developed by the UCLA Medical Center, the mean-square is calculated for each main effect, all linear paired interaction effects and the error term (within cells). Denoting the five factors as 1, 2, 3, 4, and 5 respectively for birth, death, marriage, divorce, and disability, the mean-squares and the f-ratio are shown in Table 15. From this table it can be concluded that only changes in the death rates and disability rates, within the levels considered, are significant at $\alpha = .05$. Also, a change in marriage rates in combination with a change in death rates (interaction term 23) or with a change in disability rate (interaction term 35) is significant.

TABLE XIV

PROCESS MULTIPLIERS

Process	Multiplier Level 1	Level 2	Level 3
Birth	.9	1.0	1.1
Death	.8	.9	1.0
Marriage	.9	1.0	1.1
Divorce	.9	1.0	1.1
Disability	.8	.9	1.0

TABLE XV

ANALYSIS OF VARIANCE RESULTS

Source of Variation	d. f.	Mean-Squares	F-Ratio	F-Ratio $\alpha = .05$	(critical)[1] $\alpha = .10$
1	2	15.76330	1.03	3.00	2.30
2	2	186.25777	12.20		
3	2	26.08347	1.75		
4	2	33.35970	2.18		
5	2	95.16689	6.23		
12	4	23.21318	1.52	2.37	1.94
13	4	6.01651	.38		
14	4	10.49815	.68		
15	4	19.05542	1.25		
23	4	37.56297	2.45		
24	4	18.25565	1.20		
25	4	10.52819	.68		
34	4	17.41788	1.14		
35	4	44.55428	2.92		
45	4	9.95034	.65		
Error	11907	15.27104			

[1]Mendenhall. Tables of Percentage Points of the F-Distribution. The Design and Analysis of Experiments. Belmont, California: Wadsworth Publishing Company, Inc., 1968.

To provide further knowledge about the variational relationship between death and disability rates and the rates of return, the rates of return are evaluated for the second case, using five equally spaced level multipliers for death rates and the disability rate. The results are shown in Tables 16 through 19. As can be seen from these figures, both rates of return increase as a result of decreasing death rates and an increasing disability rate. This is to be expected, since a proportional decrease in death rates would have the effect of lengthening the benefit receipts series at the end; and an increase in the disability rate would tend to shift the weight from the lower value retirement component of the rates of return to the higher value disability component.

The above results of the variational relationship between the death rate and the rates of return have some further implications. For instance, other things being equal, a non-white person would have a lower expected rate of return than a white person, since the death rates for non-whites in general is between 10% to 30% higher than for whites throughout the age groups. Similar consideration could be given to other factors such as an individual's profession or health condition which affects his death probabilities.

TABLE XVI

DEATH FACTOR AND THE INDIVIDUAL EXPECTED RATE OF RETURN

Level	Multiplier	Mean	Variance	95% Confidence Interval Deviate ±
1	.80	5.7315	1.4629	.1334
2	.85	5.6960	.7702	.0953
3	.90	5.6868	1.0183	.1077
4	.95	5.5536	1.0285	.1084
5	1.00	5.3731	3.1850	.1588

TABLE XVII

DEATH FACTOR AND THE OVERALL POPULATION RATE OF RETURN

Level	Multiplier	Mean	Variance	95% Confidence Interval Deviate ±
1	.80	6.6252	.23585	.4201
2	.85	6.3716	.07891	.2430
3	.90	6.3401	.10725	.2581
4	.95	6.3212	.27757	.4558
5	1.00	6.1261	.16133	.2929

TABLE XVIII

DISABILITY FACTOR AND THE INDIVIDUAL EXPECTED RATE OF RETURN

Level	Multiplier	Mean	Variance	95% Confidence Interval Deviate ±
1	.80	5.7315	1.4629	.1134
2	.85	5.7700	.9698	.1107
3	.90	5.8528	1.1741	.1164
4	.95	6.2511	3.9833	.2150
5	1.00	6.8610	1.0952	.1147

TABLE XIX

DISABILITY FACTOR AND THE OVERALL POPULATION RATE OF RETURN

Level	Multiplier	Mean	Variance	95% Confidence Interval Deviate ±
1	.80	6.6252	.23585	.4201
2	.85	6.7805	.06956	.2281
3	.90	6.8822	.11631	.2689
4	.95	7.1063	.14491	.3293
5	1.00	7.7489	.21306	.3993

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS FOR FURTHER STUDIES

Summary and Conclusion

The main purpose of this study has been to develop a procedure to evaluate the Social Security System as an investment. The rate of return experienced by participants in the system is the measurement used to evaluate the system performance. The procedure developed takes into account the uncertainty of human life. The resulting procedure may be viewed as a predictive model that can be used in future planning for the system; for instance, evaluation of proposed changes in rules and regulations.

The case studies and analysis in Chapter IV serve to illustrate this use. The four cases examined, although hypothetical, are good representations of large segments of the population and thereby lead to valid conclusions about the system.

The Social Security program, more commonly viewed as an insurance program, is nevertheless a public social program. Accordingly, it tends to give more protection to the people who most need it. The results in Chapter IV consistently confirm that this goal is fairly well achieved. Other things being equal, an individual with a family receives a considerably higher rate of return than one who remains single throughout his life. Similarly, an individual with a low salary level, and therefore more susceptible to financial disaster, is given a somewhat higher rate of return than one with a high salary level. However, the difference between the rates of return for any two given salary levels is not significant unless there is a wide difference between the levels. When an individual whose work career ends by disability onset is compared to one whose work career ends through retirement, he is seen to make fewer payments and his benefits are also lower. Because there is a reduction in the quarters of coverage required at age 24 and 31, and also a preset minimum of benefits, his rate of return is still significantly higher than that of the retired person.

Also, by noting as a factor the figures obtained in the analysis of time at entering the system, it can be asserted that the claim by Eckstein [2] that tax dollars buy fewer and fewer benefits as time goes on, is true. However, the reduction is not severe, since there is not a significant difference between the rates of return.

Finally, if the employer's contribution to the system is not considered as actual compensation of the worker, then from the worker's point of view the gain from the Social Security is fair. The rates of return, which vary between 6% to 7% annually, can be favorably compared to the return obtained in other forms of money savings. On the other hand, if the employer's contribution is considered as a part of the worker's compensation, or looking at the Social Security system from the total cost (contribution)-versus-benefits point of view, then the results in Table 12 show that the rates of return are in general somewhat low. This can be viewed as the price that has to be paid to afford a public social program such as the Social Security.

In summary, if one single conclusion has to be drawn from this study, then it is that the Social Security system has, to a good extent, achieved its designated goal.

Recommended Areas for Future Studies and Improvements

A model, whether it be mathematical or simulation, is at best only an approximation of the real situation it represents. The degree of accuracy of a model in general depends on the understanding of the mechanism of the phenomenon in consideration and the availability as well as the accuracy of input data necessary for the analysis. In this particular study, the latter is the limiting case. For example, by examining the sensitivity analysis performed in Chapter IV, the desired degree of accuracy in the rates of return can be weighed against the cost of achieving more accuracy in death and disability data.

Throughout this study, the effect of inflation is not considered. The reason is that inflation is determined by the larger scale system of the national economy; and the occurrence of inflation is likely to cause an increase in the tax rate as well as in benefits. All of these occurrences are quite unpredictable. However, for the purpose of system planning, these three factors might be treated as controlled independent variables to be built into the model. Such a model would be quite useful in policy making for the Social Security Administration.

The model built in this study can also be used to estimate total revenues and cost of the system. By collecting data on the distribution of characteristics on age, sex, and family status of the country's population, a representative sample population can be obtained and used as input individual data for the simulator. With some modification, desired figures such as projected revenues and costs of the system can be obtained.

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BIBLIOGRAPHY

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APPENDIX A

SIMULATOR PROGRAM LISTING

APPENDIX A

SIMULATOR PROGRAM LISTING

The computer program for the simulator is written in FORTRAN IV language. A storage region of 180K is needed for use on the FORTRAN G compiler for an IBM 370/158 system. To facilitate the use as well as possible future modifications of the program, the following brief description of key variables is provided.

Description of Key Variables

AMFB(I): Maximum Family Benefits for run Ith

AMW(I): Average Monthly Wage

IELE(I): 0-1 variable for benefit eligibility status at run Ith, 1 represents being eligible

IEVEN(I,J): contains information on event ith with
IEVEN(I,1): event occurrence time
(I,2): event code. The code used is as follows:

Code	Event
1	Birth
2	Death
3	Marriage
4	Divorce
5	Disability Onset
6	Child Reaching "Independent Status"

IEVEN(I,3): code of person to whom the event occurs. Code 1 is for the primary individual, 2 for his (or her) marriage partner, 3, 4,... for the first, second, ... child.

IEVEN(I,4): age of the person to whom the event occurs at event occurrence (in months)

IND1(I,J): contains information on the individuals involved, with I = 1,2,3,4... respectively for the primary individual, the marriage partner, the first child, second child,... etc., and the following arrangement:

IND1(I,1):	present age (in months)
(I,2):	sex
(I,3):	race
(I,4):	marital status with code 1,2,3,4 respectively for single, married, divorced and widowed
(I,5):	age at marriage, if applicable
(I,6):	parity
(I,7):	number of dependent children
(I,8):	age at disability onset
(I,9):	age at death
(I,10):	age at retirement
(I,11):	age at reaching "independent status"
DIND1(I,J):	the save-duplicate of IND1(I,J)

IPAS(I): Number of uniform series of payments for run Ith

IQC(I): Number of quarters of coverage credited during run Ith

IRES(I): Number of uniform series of benefits for run Ith

ITNOW: Simulator Clock Time

ITST(I): Time at which first benefits receipt is made for run Ith

IYBA: Base year of the individuals' ages

IYCO: Number of years to be counted in computing benefits

MAG(I): Number of marriage age groups for the Ith marital status category, with I = 1,2,3 respectively for single, divorced and widowed

NLOST: Number of total loss cases

NPSA: Number salary history data point

NRAT: Number of individual rates of return r_i

NRUN: Number of runs

NUPA(I,J): Number of payments of the Jth uniform series of tax payments of the Ith run

NURE(I,J): Number of receipts of the Jth uniform series of benefit receipts of the Ith run

PAYM(I,J): Jth uniform series of payments of run Ith

PBIRT(I,J): Birth probabilities for women of age group I and parity J

PBSEX: Probability that child will be male at birth

PDEAT(I,J):	Death probability for a person of age I and of sex-race combination J, with J = 1,2,3,4 respectively for white male, non-white male, white female, and non-white female
PDISA:	Disability onset probability
PDIVO(I,J):	Divorce probability for a person of sex-race combination J at Ith year of marriage
PMAAP(I,J):	Cumulative probability of a difference PMAAP(I,1) for the J previous marital status combination, J = 2,3,4,5
PMAAR(I):	Inter-racial probability matrix
PMARR(I,J,K)	Marriage probability for individuals of previous marital status I (I = 1,2,3 respectively for single, divorced, widowed) and age group K. J = 2 for men and 3 for women. PMARR(I,1,K) is the corresponding age interval upper limit
PMASP(I,J):	Probability matrix of the previous marital status of a marriage partner
PLOST:	Probability of a total loss case
PPAR(I,J):	Cumulative probability of a woman of age group I having parity J
PRLOS(I):	Present worth of amount of money lost in the Ith total loss case
PRETI(I,J):	Cumulative probability of retiring at age J for men and women (for I = 1 and 2 respectively)
SALAR(I,J):	Ith salary history data point with J = 1,2 respectively for starting date (on simulator time scale, origin being January of the base year IYBA and unit time interval being one month)
SOTAX(I,J):	Social Security tax rate schedule data point I with J = 1,2,3 respectively for starting year when it goes into effect, maximum salary taxable, and tax rate
WAGE(I,J):	Monthly wage level corresponding to the Jth uniform series of tax payment of run I

```
C     ************************************************************
C       MAIN PROGRAM
C     ************************************************************
        INTEGER W
        INTEGER DINDI(20,12)
        COMMON /ZERO/ITNOW
        COMMON /EIGHT/INDI(20,12)
        COMMON /NINE/IEVEN(20,4)
        COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
        COMMON /E/WAGE(50,75),PAYM(50,75),NUPA(50,75),IPAS(50)
        COMMON /F/ITST(50),RECE(50,15),NURE(50,15),IRES(50)
        COMMON /G/ISW1,ISW2
        COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
        COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
        COMMON /UP/PCON
        COMMON /DOWN/NT
        COMMON /SSR/S,S2
        DIMENSION ISA(50,2)
C     ************************************************************
C       T - DISTRIBUTION WITH ALPHA = .05 (TWO TAILS)
C     ************************************************************
        DIMENSION T(10)
        DATA T/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,2.22
       >8/
C     ************************************************************
C       W IS INPUT UNIT NUMBER
C     ************************************************************
        W=5
C     ************************************************************
C       READ IN SYSTEM INPUT (DEMOGRAPHIC & SOCIAL SECURITY) DATA
C     ************************************************************
        CALL DATA
```

```
C     ***********************************************************************
C       READ IN :
C          BASE YEAR
C          NUMBER OF PROBLEMS
C          MINIMUM SAMPLE SIZE FOR THE INDIVIDUAL EXPECTED RATE OF RETURN
C          MAXIMUM SAMPLE SIZE FOR THE OVERALL RATE OF RETURN
C          CRITICAL VALUE L(C) (TERMINATION CRITERION)
C     ***********************************************************************
      READ(W,100)IYBA,NPRO,IPUNC,NNT
      READ(W,20)PCON
   20 FORMAT(F10.4)
C     ***********************************************************************
C       INITIALIZE KEY-VARIABLES
C     ***********************************************************************
      DO 50 I=1,20
      TAXRA(I,1)=(SOTAX(I,1)-IYBA)*12
      TAXRA(I,2)=SOTAX(I,2)/12.
   50 TAXRA(I,3)=SOTAX(I,3)
      DO 3000 LP=1,NPRO
      NLOST=0
      NRAT=0
C     ***********************************************************************
C       READ IN INFORMATION ON THE PRIMARY AND SECONDARY INDIVIDUALS
C     ***********************************************************************
      READ(W,100)(DINDI(1,J),J=1,8)
  100 FORMAT(8I5)
      IF(DINDI(1,4).EQ.2) GO TO 130
      DO 120 J=1,8
  120 DINDI(2,J)=0
      NPO=1
      GO TO 140
  130 READ(W,100)(DINDI(2,J),J=1,8)
```

```
      NPO=2
  140 IF(DINDI(1,7).EQ.0) GO TO 150
      NPO=2+DINDI(1,7)
      READ(W,100)((DINDI(I,J),J=1,8),I=3,NPO)
  150 DO 160 I=1,NPO
  160 DINDI(I,12)=DINDI(I,1)
      READ(W,100)NPSA
      READ(W,165)((ISA(I,J),J=1,2),SALAR(I,2),I=1,NPSA)
  165 FORMAT(4(2I5,F10.2))
      DO 170 I=1,NPSA
  170 SALAR(I,1)=(ISA(I,2)-IYBA)*12.+ISA(I,1)-1
      XI= DINDI(1,1)/12.
      II=XI
      X=II
      IF(XI.GT.X) II=II+1
      IYB=IYBA-II
      IF(IYB.LT.1900) IYB=1900
      IF(IYB.GT.1929) IYB=1929
      IYCO=9+(IYB-1900)-3*(DINDI(1,3)-1)
      CALL OUTP1(DINDI)
C    ****************************************************************
C       SIMULATION STARTS
C    ****************************************************************
      DO 1200 NT=1,NNT
      DO 1150 NRUN=1,50
C    ****************************************************************
C       SCHEDULE AN INITIAL SEQUENCE OF EVENTS
C    ****************************************************************
  180 NE=0
      NP=NPO
      NC=NPO
      IF(NC.EQ.1) NC=2
```

```
      DO 190 I=1,NC
      DO 185 J=1,8
  185 INDI(I,J)=DINDI(I,J)
      INDI(I,12)=DINDI(I,12)
  190 CONTINUE
      ISW1=0
      ISW2=0
      IF(NP-2)260,220,200
C     ******************************************************************
C     PRIMARY INDIVIDUAL HAS DEPENDENT CHILDREN
C     ******************************************************************
  200 DO 210 I=3,NP
      NE=NE+1
      CALL CHILD(I,NE)
  210 CONTINUE
      IF(INDI(2,1).EQ.0) GO TO 260
C     ******************************************************************
C     PRIMARY INDIVIDUAL IS MARRIED
C     ******************************************************************
  220 CALL DEATH(INDI(2,1),INDI(2,2),INDI(2,3),ITE1,INDI(2,9))
      CALL DEATH(INDI(1,1),INDI(1,2),INDI(1,3),ITE2,INDI(1,9))
      CALL DISAB(INDI(1,1),ITE3,IAE3)
      CALL DIVOR(INDI(1,1),INDI(1,2),INDI(1,3),INDI(1,5),ITE4,IAE4)
      CALL RETIR(INDI(1,1),INDI(1,3),ITE5,IAE5)
  221 IF(ITE3.GE.ITE2.OR.ITE3.GE.ITE5) GO TO 230
      NE=NE+1
      CALL FILE(NE,ITE3,5,1,IAE3)
      INDI(1,8)=IAE3
      GO TO 240
  230 IF(ITE5.GE.ITE2) GO TO 240
      NE=NE+1
      CALL FILE(NE,ITE5,7,1,IAE5)
```

```
      INDI(1,10)=IAE5
  240 NE=NE+1
      CALL FILE(NE,ITE2,2,1,INDI(1,9))
      IF(ITE4.GE.ITE1.OR.ITE4.GE.ITE2) GO TO 250
      NE=NE+1
      CALL FILE(NE,ITE4,4,1,IAE4)
      INDI(2,5)=INDI(2,1)+ITE4-ITNOW
      GO TO 251
  250 NE=NE+1
      CALL FILE(NE,ITE1,2,2,INDI(2,9))
      INDI(2,5)=0
C    ************************************************************************
C     SCHEDULE ADDITIONAL BIRTH(S)
C    ************************************************************************
  251 IF=2
      IF(INDI(1,3).EQ.2) IF=1
      IMIN=0
      IF(NP.EQ.2) GO TO 254
      IL=2400
      DO 253 I=3,NP
  253 IL=MIN0(IL,INDI(I,1))
      IF(IL.LE.10) IMIN=10-IL
  254 IANT=INDI(IF,1)+IMIN
  255 CALL BIRTH(IANT,INDI(IF,6),ITE5,IAE5)
      ITE5=ITE5+IANT-INDI(IF,1)
      IT=MIN0(ITE1,ITE2,ITE3,ITE4)
      IF(ITE5.GE.IT) GO TO 400
      NE=NE+1
      CALL FILE(NE,ITE5,1,IF,IAE5)
      INDI(1,6)=INDI(1,6)+1
      INDI(2,6)=INDI(2,6)+1
      IANT=IAE5+10
```

```
      GO TO 255
C     ******************************************************************
C       PRIMARY INDIVIDUAL IS SINGLE
C     ******************************************************************
  260 CALL DEATH(INDI(1,1),INDI(1,2),INDI(1,3),ITE1,INDI(1,9))
      CALL DISAB(INDI(1,1),ITE2,IAE2)
      IF(INDI(1,4).NE.5) GO TO 265
      ITE3=2400
      GO TO 266
  265 CALL MARRY(INDI(1,1),INDI(1,3),INDI(1,4),ITE3,IAE3)
  266 CALL RETIR(INDI(1,1),INDI(1,3),ITE4,IAE4)
  267 IF(ITE2.GE.ITE1.OR.ITE2.GE.ITE4) GO TO 270
      NE=NE+1
      CALL FILE(NE,ITE2,5,1,IAE2)
      INDI(1,8)=IAE2
      GO TO 280
  270 IF(ITE4.GE.ITE2) GO TO 280
      NE=NE+1
      CALL FILE(NE,ITE4,7,1,IAE4)
      INDI(1,10)=IAE4
  280 NE=NE+1
      CALL FILE(NE,ITE1,2,1,INDI(1,9))
      IF(ITE3.GE.ITE1.OR.ITE3.GE.ITE2) GO TO 400
      NE=NE+1
      CALL FILE(NE,ITE3,3,1,IAE3)
      INDI(1,5)=IAE3
C     ******************************************************************
C       SEARCH FOR THE NEXT EVENT
C     ******************************************************************
  400 MINT=2400
      JEVEN=0
      DO 420 J=1,NE
```

```
      IF(IEVEN(J,1).LT.0.OR.IEVEN(J,1).GE.MINT) GO TO 420
      MINT=IEVEN(J,1)
      JEVEN=J
  420 CONTINUE
      IF(JEVEN)1000,1000,430
  430 IEVEN(JEVEN,1)=-IEVEN(JEVEN,1)
C    ************************************************************************
C     UPDATE AGES
C    ************************************************************************
      IF(NP-2)446,444,444
  444 NO=2
      IF(INDI(2,1).EQ.0) NO=3
      DO 445 I=NO,NP
  445 INDI(I,1)=INDI(I,1)+MINT-ITNOW
  446 INDI(1,1)=INDI(1,1)+MINT-ITNOW
C
      ITNOW=MINT
      IEC=IEVEN(JEVEN,2)
      IPC=IEVEN(JEVEN,3)
      IAEO=IEVEN(JEVEN,4)
C    ************************************************************************
C     UPDATE STATUS OF THE INDIVIDUALS AND SCHEDULE ADDITIONAL EVENTS
C    ************************************************************************
C
C    ************************************************************************
C     OCCURRING EVENT IS A BIRTH
C    ************************************************************************
      IF(IEC.NE.1) GO TO 450
      NP=NP+1
      INDI(NP,1)=0
      INDI(NP,2)=MAX0(INDI(1,2),INDI(2,2))
      CALL BISEX(INDI(NP,3))
```

```
      INDI(NP,4)=1
      INDI(NP,5)=0
      INDI(NP,8)=0
      INDI(NP,12)=0
      NE=NE+1
      CALL CHILD(NP,NE)
      INDI(1,7)=INDI(1,7)+1
      INDI(2,7)=INDI(2,7)+1
      GO TO 900
C     ******************************************************************
C       OCCURRING EVENT IS A DEATH
C     ******************************************************************
  450 IF(IEC.NE.2) GO TO 500
      IF(IPC.NE.1) GO TO 480
      IF(INDI(1,4).NE.2) GO TO 900
      INDI(2,4)=4
      CALL MARRY(INDI(2,1),INDI(2,3),INDI(2,4),ITE,IAE)
      IF(IAE-INDI(2,9))470,900,900
  470 NE=NE+1
      CALL FILE(NE,ITE,3,2,IAE)
      INDI(2,5)=IAE
      GO TO 900
  480 IF(INDI(2,4).NE.2) GO TO 900
      IF(NP.EQ.2) NP=1
      INDI(1,4)=4
      CALL MARRY(INDI(1,1),INDI(1,3),INDI(1,4),ITE,IAE)
      IF(IAE.GE.INDI(1,9)) GO TO 900
      IF(INDI(1,8).GT.0.AND.IAE.GE.INDI(1,8)) GO TO 900
      NE=NE+1
      CALL FILE(NE,ITE,3,1,IAE)
      DO 490 J=1,12
  490 INDI(2,J)=0
```

```
      GO TO 900
C     ***************************************************************
C       OCCURRING EVENT IS A MARRIAGE
C     ***************************************************************
  500 IF(IEC.NE.3) GO TO 600
      IF(IPC.EQ.1) GO TO 520
      GO TO 900
  520 IF(NP.EQ.1) NP=2
      CALL SPOUS(NE)
      GO TO 900
C     ***************************************************************
C       OCCURRING EVENT IS A DIVORCE
C     ***************************************************************
  600 IF(IEC.NE.4) GO TO 650
      INDI(1,4)=3
      CALL MARRY(INDI(1,1),INDI(1,3),INDI(1,4),ITE,IAE)
      IF(IAE.GE.INDI(1,9)) GO TO 900
      NE=NE+1
      CALL FILE(NE,ITE,3,1,IAE)
      DO 610 J=1,12
  610 INDI(2,J)=0
      GO TO 900
C     **************************************************************
C       OCCURRING EVENT IS A CHILD REACHING INDEPENDENT STATUS
C     **************************************************************
  650 IF(IEC.NE.6) GO TO 900
      INDI(1,7)=INDI(1,7)-1
      INDI(2,7)=INDI(2,7)-1
C     ***************************************************************
C       CHECK AND UPDATE STATUS OF THE INDIVIDUALS WITH RESPECT TO THE SOCIAL
C       SECURITY SYSTEM
C     ***************************************************************
```

```
  900 IF(ISW2.EQ.1) GO TO 910
      CALL SOSEC(NE,IAEO,IEVEN(JEVEN,2),IPC)
  910 IF(NT.NE.1) GO TO 400
      IF(NRUN.EQ.1) CALL OUTP2(IAEO,IEC,IPC,NP)
      GO TO 400
 1000 IF(IELE(NRUN))1030,1030,1027
C    ******************************************************************
C      CALCULATE THE INDIVIDUAL RATE OF RETURN
C    ******************************************************************
 1027 NRAT=NRAT+1
      CALL RRATE(NRUN)
      RATES(NRAT)=(1.+RATES(NRAT))**12-1.
      GO TO 1145
 1030 NLOST=NLOST+1
      CALL PRESE(NRUN,.005,0,PRLOS(NLOST))
 1145 ITNOW=0
      IF(NT.NE.1) GO TO 1150
      IF(NRUN.EQ.1) CALL OUTP3
 1150 CONTINUE
      NRUN=NRUN-1
C    ******************************************************************
C      CHECK TERMINATION CRITERION
C    ******************************************************************
      CALL STAT(ITERM)
C    ******************************************************************
C      CALCULATE PAYOFF RATIO
C    ******************************************************************
      CALL RATIO(0)
C    ******************************************************************
C      CALCULATE THE OVERALL RATE OF RETURN
C    ******************************************************************
      CALL RRATE(0)
```

```
      RATE(NT)=(1.+RATE(NT))**12-1.
      IF(NT.LT.2) GO TO 1200
      IF(IPUNC.GT.C.AND.NRAT.LT.IPUNC) ITERM=0
      IF(ITERM.EQ.1) GO TO 1500
 1200 CONTINUE
      NT=NNT
      WRITE(6,1400)
 1400 FORMAT(1H ,T05,'*** SIMULATION ENDS WITHOUT TERMINATION CRITERION
     >BEING MET ***')
 1500 CALL RATIO(1)
C    *******************************************************************
C     CALCULATE THE OVERALL RATE OF RETURN STATISTICS
C    *******************************************************************
      SUM=0.
      SUM2=0.
      DO 1800 I=1,NT
      SUM=SUM+RATE(I)
 1800 SUM2=SUM2+RATE(I)**2
      RMEAN=SUM/NT
      RVAR=(SUM2-NT*RMEAN**2)/(NT-1.)
      RMEAN=RMEAN*100.
      RVAR=RVAR*10000.
      XNT=NT
      RX=T(NT-1)*SQRT(RVAR)/SQRT(XNT)
      RL=RMEAN-RX
      RU=RMEAN+RX
      WRITE(6,1900)RMEAN,RVAR,NT,RL,RU
 1900 FORMAT(//T05,'* OVERALL RATE STATISTICS *'/T08,'MEAN = ',T20,E12.5
     >/T08,'VARIANCE = ',T20,E12.5/T08,'95% CONFIDENCE INTERVAL FOR THE
     >MEAN (SAMPLE SIZE = ',I5,' ) :'/T10,'LOWER BOUND = ',E12.5/T10,'UP
     >PPER BOUND = ',E12.5//)
 3000 CONTINUE
```

```
      STOP
      END
C     *****************************************************************
      SUBROUTINE DATA
C     *****************************************************************
C       SUBROUTINE DATA READS IN SYSTEM INPUT (DEMOGRAPHIC & SOCIAL SECURITY)
C       DATA
C     *****************************************************************
      INTEGER W
      COMMON /ZERO/ITNOW
      COMMON /ONE/PBIRT(6,8),ISD1
      COMMON /TWO/PDEAT(101,4),ISD2
      COMMON /THREE/MAG(3),PMARR(3,6,3),ISD3
      COMMON /FOUR/PDIVO(18,4),ISD4
      COMMON /FIVE/PMASP(2,3),PMAAP(14,5),PMARP(2),ISD5
      COMMON /SIX/PBSEX,ISD6
      COMMON /SEVEN/PDISA,ISD7
      COMMON /TEN/PPARI(6,7),ISD9
      COMMON /A/PINDE(4),ISD8
      COMMON /B/PRETI(2,8),ISD10
      COMMON /C/IYBA,IYCO,NPSA,SCTAX(25,3),SALAR(50,2),TAXRA(25,3)
      COMMON /ALPHA/O(2,3),P(2,2),Q(4,2)
      W=5
      READ(W,10)ISD1,ISD2,ISD3,ISD4,ISD5,ISD6,ISD7,ISD8,ISD9,ISD10
   10 FORMAT(10I5)
      READ(W,20)((PBIRT(I,J),J=1,8),I=1,6)
   20 FORMAT(8F10.2)
   25 FORMAT(6F10.2)
      DO 30 I=1,6
      DO 30 J=1,8
   30 PBIRT(I,J)=1.-(1.-PBIRT(I,J)/1000.)**(1./12.)
      READ(W,20)((PDEAT(I,J),J=1,4),I=1,101)
```

```
      DO 40 I=1,101
      DO 40 J=1,4
   40 PDEAT(I,J)=1.-(1.-PDEAT(I,J)/1000.)**(1./12.)
      READ(W,10)MAG
      DO 50 I=1,3
      N=MAG(I)
      READ(W,25)((PMARR(I,J,K),K=1,3),J=1,N)
      DO 50 J=1,N
      DO 50 K=2,3
      PMARR(I,J,K)=1.-(1.-PMARR(I,J,K)/1000.)**(1./12.)
   50 CONTINUE
      READ(W,60)PMARP
   60 FORMAT(10F8.3)
      READ(W,60)((PMASP(I,J),J=1,3),I=1,2)
      READ(W,60)((PMAAP(I,J),J=1,5),I=1,14)
      READ(W,20)((PDIVO(I,J),J=1,4),I=1,18)
      DO 70 I=1,18
      DO 70 J=1,4
   70 PDIVO(I,J)=1.-(1.-PDIVO(I,J)/1000.)**(1./12.)
      READ(W,80)PBSEX,PDISA
   80 FORMAT(8F10.5)
      PBSEX=1./(1.+PBSEX)
      PDISA=1.-(1.-PDISA)**(1./12.)
      READ(W,80)PINDE
      DO 90 I=1,6
      READ(W,80)(PPARI(I,J),J=1,7)
      DO 90 J=2,7
   90 PPARI(I,J)=PPARI(I,J)+PPARI(I,J-1)
      READ(W,80)((PRETI(I,J),J=1,8),I=1,2)
      READ(W,100)((SOTAX(I,J),J=1,3),I=1,20)
  100 FORMAT(4(F6.0,F8.0,F6.3))
      DO 110 I=1,20
```

```
  110 SOTAX(I,3)=SOTAX(I,3)/100.
      READ(W,150)((O(I,J),J=1,3),I=1,2),((P(I,J),J=1,2),I=1,2),((Q(I,J),
     >J=1,2),I=1,4)
  150 FORMAT(20A4)
      ITNOW=0
      RETURN
      END
C     **********************************************************************
      SUBROUTINE FILE(K,ITE,IC,IIC,IAE)
C     **********************************************************************
C     SUBROUTINE FILE RECORDS THE EVENT THAT WILL ACTUALLY OCCUR
C     **********************************************************************
      COMMON /NINE/IEVEN(20,4)
      IEVEN(K,1)=ITE
      IEVEN(K,2)=IC
      IEVEN(K,3)=IIC
      IEVEN(K,4)=IAE
      RETURN
      END
C     **********************************************************************
      SUBROUTINE RANDU(IX,IY,YFL)
C     **********************************************************************
C     SUBROUTINE RANDU GENERATES A UNIFORMLY DISTRIBUTED RANDOM NUMBER
C     **********************************************************************
      IY=IX*65539
      IF(IY)50,60,60
   50 IY=IY+2147483647+1
   60 YFL=IY
      YFL=YFL*.4656613E-9
      RETURN
      END
C     **********************************************************************
```

```
      SUBROUTINE GEOME(IX,P,NX)
C    ******************************************************************************
C     SUBROUTINE GEOME GENERATE A GEOMETRICALLY DISTRIBUTED RANDOM NUMBER
C    ******************************************************************************
      CALL RANDU(IX,IY,R)
      IX=IY
      X=ALOG(R)/ALOG(1.-P)
      NX=X
      D=X-NX
      IF(D)60,60,50
   50 NX=NX+1
   60 RETURN
      END
C    ******************************************************************************
      SUBROUTINE BIRTH(IAN,IPAR,ITE,IAE)
C    ******************************************************************************
C     SUBROUTINE BIRTH SCHEDULES A BIRTH
C    ******************************************************************************
      COMMON /ZERO/ITNOW
      COMMON /ONE/PBIRT(6,8),ISEED
      IAE=IAN
      JP=IPAR+1
      IF(IAN-180)60,60,50
   50 IF(IAN-480)80,70,70
   60 IA=1
      GO TO 100
   70 IA=6
      GO TO 100
   80 IA=(IAN-180.)/60.+1.
  100 IF(JP.GT.7) JP=7
  105 IF(PBIRT(IA,JP).GT.0.) GO TO 110
      IAE=180+IA*60
```

```
      IA=IA+1
      GO TO 105
  110 CALL GEOME(ISEED,PBIRT(IA,JP),IT)
      IF(IA.EQ.6) GO TO 200
      ID=180+IA*60-IAE
      IF(IT-ID)200,120,120
  120 IA=IA+1
      IAE=IAE+ID
      GO TO 110
  200 IAE=IAE+IT
      ITE=ITNOW+IAE-IAN
      RETURN
      END
C    ************************************************************************
      SUBROUTINE DEATH(IAN,IR,IS,ITE,IAE)
C    ************************************************************************
C     SUBROUTINE DEATH SCHEDULES A DEATH
C    ************************************************************************
      COMMON /ZERO/ITNOW
      COMMON /TWO/PDEAT(101,4),ISEED
      JC=2*(IR-1)+IS
      IAE=IAN
      IF(IAN-1200)60,50,50
   50 IA=101
      GO TO 70
   60 IA=IAN/12.+1.
   70 CALL GEOME(ISEED,PDEAT(IA,JC),IT)
      IF(IA.EQ.101) GO TO 200
      ID=IA*12-IAE
      IF(IT-ID)200,120,120
  120 IA=IA+1
      IAE=IAE+ID
```

```
      GO TO 70
  200 IAE=IAE+IT
      ITE=ITNOW+IAE-IAN
      RETURN
      END
C     ************************************************************
      SUBROUTINE MARRY(IAN,IS,IM,ITE,IAE)
C     ************************************************************
C     SUBROUTINE MARRY SCHEDULES A MARRIAGE
C     ************************************************************
      COMMON /ZERO/ITNOW
      COMMON /THREE/MAG(3),PMARR(3,6,3),ISEED
      JC=IS+1
      IAE=IAN
      XIAN=IAN
      M=IM-1
      IF(M.EQ.0) M=1
      N=MAG(M)
      DO 20 I=1,N
      IF(XIAN-PMARR(M,I,1))50,40,20
   20 CONTINUE
      IA=N
      GO TO 60
   40 IA=I
      GO TO 60
   50 IA=I-1
      IF(IA.EQ.0) IA=1
   60 CALL GEOME(ISEED,PMARR(M,IA,JC),IT)
      IF(IA.EQ.MAG(M)) GO TO 200
      IAA=IA+1
      ID=PMARR(M,IAA,1)-IAE
      IF(IT-ID)200,120,120
```

```
  120 IA=IAA
      IAE=IAE+ID
      GO TO 60
  200 IAE=IAE+IT
      ITE=ITNOW+IAE-IAN
      RETURN
      END
C    ***********************************************************************
      SUBROUTINE DIVOR(IAN,IR,IS,IAM,ITE,IAE)
C    ***********************************************************************
C     SUBROUTINE DIVOR SCHEDULES A DIVORCE
C    ***********************************************************************
      COMMON /ZERO/ITNOW
      COMMON /FOUR/PDIVO(18,4),ISEED
      IAE=IAN
      IDM=IAN-IAM
      JC=2*(IS-1)+IR
      IF(IDM-12)10,10,15
   10 IA=1
      GO TO 60
   15 IF(IDM-192)20,30,50
   20 IA=IDM/12.
      GO TO 60
   30 IA=16
      GO TO 60
   50 IA=(IDM-192.)/60.+16.
      IF(IA.GT.18) IA=18
   60 CALL GEOME(ISEED,PDIVO(IA,JC),IT)
      IF(IA.EQ.18) GO TO 200
      IF(IA-16)70,80,80
   70 ID=(IA+1)*12-IDM
      GO TO 90
```

```
 80 ID=192+(IA-15)*60-IDM
 90 IF(IT-ID)200,120,120
120 IA=IA+1
    IDM=IDM+ID
    GO TO 60
200 IDM=IDM+IT
    IAE=IAM+IDM
    ITE=ITNOW+IAE-IAN
    RETURN
    END
C   ************************************************************************
    SUBROUTINE DISAB(IAN,ITE,IAE)
C   ************************************************************************
C   SUBROUTINE DISAB SCHEDULES A DISABILITY ONSET
C   ************************************************************************
    COMMON /ZERO/ITNOW
    COMMON /SEVEN/PDISA,ISEED
    CALL GEOME(ISEED,PDISA,IT)
    IAE=IAN+IT
    ITE=ITNOW+IAE-IAN
    RETURN
    END
C   ************************************************************************
    SUBROUTINE RETIR(IAN,IS,ITE,IAE)
C   ************************************************************************
C   SUBROUTINE RETIR SCHEDULES RETIREMENT
C   ************************************************************************
    COMMON /ZERO/ITNOW
    COMMON /B/PRETI(2,8),ISEED
    CALL RANDU(ISEED,IY,R)
    ISEED=IY
    DO 20 J=1,8
```

```
      IF(R-PRETI(IS,J))30,30,20
   20 CONTINUE
   30 IAE=744+(J-1)*12
      IF(IAE.LE.IAN) IAE=IAN+1
      ITE=ITNOW+IAE-IAN
      RETURN
      END
C     ************************************************************************
      SUBROUTINE MARPA(IAN,IR,IS,IM,IAM,IMR,IMM)
C     ************************************************************************
C     SUBROUTINE MARPA DETERMINES AGE, RACE, AND PREVIOUS MARITAL STATUS
C     OF A MARRIAGE PARTNER
C     ************************************************************************
      COMMON /FIVE/PMASP(2,3),PMAAP(14,5),PMARP(2),ISEED
C     ************************************************************************
C     DETERMINE RACE
C     ************************************************************************
      CALL RANDU(ISEED,IY,R)
      ISEED=IY
      IMR=1
      IF(R.GT.PMARP(IR)) IMR=2
C     ************************************************************************
C     DETERMINE PREVIOUS MARITAL STATUS
C     ************************************************************************
      CALL RANDU(ISEED,IY,R)
      ISEED=IY
      IMM=1
      IF(IM.GE.3) IM=IM-1
      IF(R.GT.PMASP(IS,IM)) IMM=2
      IF(IM.GE.3) IM=2
C     ************************************************************************
C     DETERMINE AGE
```

```
C     ******************************************************************
         JC=IM+2*(IMM-1)+1
         IF(IS.EQ.2) JC=IMM+2*(IM-1)+1
         CALL RANDU(ISEED,IY,R)
         ISEED=IY
         IF(R-PMAAP(1,JC))10,10,20
      10 ID=PMAAP(1,JC)
         GO TO 70
      20 IF(R-PMAAP(14,JC))40,60,60
      40 DO 50 I=2,14
         IF(R-PMAAP(I,JC))45,46,50
      45 P=PMAAP(I-1,JC)
         PP=PMAAP(I,JC)
         ID=(R-P)/(PP-P)*(PMAAP(I,1)-PMAAP(I-1,1))
         GO TO 70
      46 ID=PMAAP(I,1)
         GO TO 70
      50 CONTINUE
         GO TO 70
      60 ID=120
      70 I=1
         IF(IM.EQ.2) I=-1
         IAM=IAN+I*ID
         RETURN
         END
C     ******************************************************************
         SUBROUTINE SPOUS(NE)
C     ******************************************************************
C        SUBROUTINE SPOUS SCHEDULES BIRTH(S), DIVORCE, AND DEATH FOR A
C        MARRIAGE PARTNER UPON THE OCCURRENCE OF MARRIAGE
C     ******************************************************************
         COMMON /ZERO/ITNOW
```

```
      COMMON /EIGHT/INDI(20,12)
      COMMON /NINE/IEVEN(20,4)
      IT=INDI(1,9)-INDI(1,1)+ITNOW
      CALL MARPA(INDI(1,1),INDI(1,2),INDI(1,3),INDI(1,4),INDI(2,1),INDI
     >(2,2),IMM)
      INDI(1,4)=2
      INDI(2,4)=2
      INDI(2,3)=3-INDI(1,3)
      CALL DEATH(INDI(2,1),INDI(2,2),INDI(2,3),ITE,INDI(2,9))
      CALL DIVCR(INDI(1,1),INDI(1,2),INDI(1,3),INDI(1,1),ITE1,IAE1)
      IF(INDI(1,3).EQ.2) GO TO 100
C    ************************************************************************
C      PRIMARY INDIVIDUAL IS MALE
C    ************************************************************************
      INDI(2,6)=0
      IF(IMM.NE.1) CALL PARDI(INDI(2,1),INDI(2,6))
      IANT=INDI(2,1)+6
   50 CALL BIRTH(IANT,INDI(2,6),ITE2,IAE2)
      ITE2=ITE2+IANT-INDI(2,1)
      IF(ITE2.GE.IT.OR.ITE2.GE.ITE.OR.ITF2.GE.ITE1) GO TO 200
      NE=NE+1
      CALL FILE(NE,ITE2,1,2,IAE2)
      IANT=IAE2+10
      INDI(1,6)=INDI(1,6)+1
      INDI(2,6)=INDI(2,6)+1
      GO TO 50
C    ************************************************************************
C      PRIMARY INDIVIDUAL IS FEMALE
C    ************************************************************************
  100 IANT=INDI(1,1)+6
  150 CALL BIRTH(IANT,INDI(1,6),ITE2,IAE2)
      ITE2=ITE2+IANT-INDI(1,1)
```

```
      IF(ITE2.GE.IT.OR.ITE2.GE.ITE.OR.ITE2.GE.ITE1) GO TO 200
      NE=NE+1
      CALL FILE(NE,ITE2,1,1,IAE2)
      IANT=IAE2+10
      INDI(1,6)=INDI(1,6)+1
      INDI(2,6)=INDI(2,6)+1
      GO TO 150
  200 IF(ITE1.GE.IT.OR.ITE1.GE.ITE) GO TO 210
      NE=NE+1
      CALL FILE(NE,ITE1,4,1,IAE1)
      INDI(2,5)=INDI(2,1)+ITE1-ITNOW
      RETURN
  210 NE=NE+1
      CALL FILE(NE,ITE,2,2,INDI(2,9))
      INDI(1,5)=ITNOW
      INDI(2,5)=0
      RETURN
      END
C    ************************************************************************
      SUBROUTINE CHILD(I,NE)
C    ************************************************************************
C     SUBROUTINE CHILD SCHEDULES MARRIAGE, TERMINATION OF EDUCATION,
C     DEATH, AND DISABILITY ONSET FOR A CHILD
C    ************************************************************************
      COMMON /EIGHT/INDI(20,12)
      COMMON /NINE/IEVEN(20,4)
      DIMENSION IAA(4,3)
      CALL DEATH(INDI(I,1),INDI(I,2),INDI(I,3),ITE,INDI(I,9))
      IF(INDI(I,8))50,50,20
   20 INDI(I,11)=INDI(I,9)
      CALL FILE(NE,ITE,6,I,INDI(I,11))
      RETURN
```

```
   50 CALL DISAB(INDI(I,1),IAA(1,2),IAA(1,3))
      NO=1
      IF(IAA(1,3).GE.264.OR.IAA(1,3).GE.INDI(I,9)) NO=2
      CALL INDEP(INDI(I,1),IAA(3,2),IAA(3,3))
      CALL MARRY(180,INDI(I,3),1,IT,IAA(4,3))
      INDI(I,5)=IAA(4,3)
      IAA(4,2)=IT+180-INDI(I,1)
      IAA(1,1)=5
      IAA(2,1)=2
      IAA(3,1)=6
      IAA(4,1)=3
      IAA(2,2)=ITE
      IAA(2,3)=INDI(I,9)
      MIN=ITE
      DO 80 J=NO,4
   80 MIN=MINO(MIN,IAA(J,2))
      DO 90 J=NO,4
      IF(IAA(J,2).EQ.MIN) GO TO 100
   90 CONTINUE
  100 IF(J.NE.1) GO TO 110
      INDI(I,8)=IAA(1,3)
      INDI(I,11)=INDI(I,9)
      CALL FILE(NE,ITE,6,I,INDI(I,11))
      RETURN
  110 CALL FILE(NE,IAA(J,2),6,I,IAA(J,3))
      RETURN
      END
C    ************************************************************************
      SUBROUTINE BISEX(I)
C    ************************************************************************
C     SUBROUTINE BISEX DETERMINES SEX OF A CHILD UPON BIRTH
C    ************************************************************************
```

```
      COMMON /SIX/PBSEX,ISEED
      I=1
      CALL RANDU(ISEED,IY,R)
      ISEED=IY
      IF(R.GT.PBSEX) I=2
      RETURN
      END
C    *********************************************************************
      SUBROUTINE INDEP(IAN,ITE,IAE)
C    *********************************************************************
C     SUBROUTINE INDEP SCHEDULES THE TERMINATION OF EDUCATION OF A CHILD
C    *********************************************************************
      COMMON /ZERO/ITNOW
      COMMON /A/PINDE(4),ISEED
      CALL RANDU(ISEED,IY,R)
      ISEED=IY
      DO 10 I=1,4
      IF(R-PINDE(I))20,20,10
   10 CONTINUE
   20 IAE=216+(I-1)*12
      IF(IAE.LT.IAN) IAE=IAN
      ITE=ITNOW+IAE-IAN
      RETURN
      END
C    *********************************************************************
      SUBROUTINE PARDI(IAN,IPAR)
C    *********************************************************************
C     SUBROUTINE PARDI DETERMINES PARITY OF A FEMALE MARRIAGE PARTNER
C    *********************************************************************
      COMMON /TEN/PPARI(6,7),ISEED
      IR=(IAN-180.)/60.+1.
      IF(IR.LE.0) IR=1
```

```
      IF(IR.GT.6) IR=6
      CALL RANDU(ISEED,IY,R)
      ISEED=IY
      DO 20 J=1,7
      IF(R-PPARI(IR,J))30,30,20
   20 CONTINUE
   30 IPAR=J-1
      RETURN
      END
C    ***************************************************************************
      SUBROUTINE SOSEC(NE,IAN,IEC,IPC)
C    ***************************************************************************
C     SUBROUTINE SOSEC DETERMINES AND UPDATES THE STATUS OF THE INDIVIDUALS
C     WITH RESPECT TO THE SOCIAL SECURITY SYSTEM UPON OCCURRENCE OF EACH
C     EVENT
C    ***************************************************************************
      COMMON /ZERO/ITNOW
      COMMON /EIGHT/INDI(20,12)
      COMMON /F/ITST(50),RECE(50,15),NURE(50,15),IRES(50)
      COMMON /G/ISW1,ISW2
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      IF(ISW1)50,50,500
   50 IF(IPC.NE.1) RETURN
      IF(IEC.EQ.2.OR.IEC.EQ.5.OR.IEC.EQ.7) GO TO 55
      RETURN
C    ***************************************************************************
C     END OF TAX PAYING PERIOD
C    ***************************************************************************
   55 CALL TAXBE(IAN,IEC)
      ITST(NRUN)=ITNOW
      IRES(NRUN)=0
```

```
      IF(IELE(NRUN).NE.0) GO TO 60
      ISW2=1
      RETURN
C     ************************************************************************
C       ELIGIBLE FOR BENEFITS
C     **********************************************************************44
   60 ISW1=1
C     ************************************************************************
C       PI        PRIMARY BENEFIT
C       SP        MOTHER BENEFIT
C       CHI       CHILD BENEFIT
C       XL        DEATH LUMP SUM
C     ************************************************************************
      XL=0.
      PI=0.
      SP=0.
      CHI=0.
      IF(IEC.EQ.2) GO TO 65
      PI=PIA(NRUN)
      IF(IEC.EQ.5.OR.INDI(1,1).GE.780) GO TO 65
      PI=(1.-(780-INDI(1,1))*(5./900.))*PIA(NRUN)
   65 IF(INDI(1,4).NE.2) GO TO 100
      IF(IEC.EQ.2) GO TO 70
      CALL SPBEN(NE,0,SP)
      GO TO 100
   70 CALL SPBEN(NE,1,SP)
  100 CHI=INDI(1,7)*.5*PIA(NRUN)
      IF(IEC.EQ.2) CHI=INDI(1,7)*.75*PIA(NRUN)
      IF(IEC.NE.2) GO TO 130
      XL=3.*PIA(NRUN)
      XL=AMIN1(255.,XL)
      TOTAL=SP+CHI
```

```
      TOTAL=AMIN1(AMFB(NRUN),TOTAL)
      RECE(NRUN,1)=TOTAL+XL
      NURE(NRUN,1)=1
      IRES(NRUN)=1
      IF(TOTAL)110,110,120
  110 ISW2=1
      RETURN
  120 RECE(NRUN,2)=TOTAL
      IF(RECE(NRUN,2).EQ.1.E-9) RECE(NRUN,2)=0.
      KR=2
      ITLAS=ITNOW+1
      RETURN
  130 TOTAL=PI+SP+CHI
      TOTAL=AMIN1(AMFB(NRUN),TOTAL)
      RECE(NRUN,1)=TOTAL
      KR=1
      ITLAS=ITNOW
      RETURN
C    ***********************************************************************
C      ADJUST THE BENEFITES RECEIVED UPON OCCURENCES OF APPROPRIATE EVENTS
C    ***********************************************************************
  500 IF(IEC.NE.1) GO TO 505
C    ***********************************************************************
C      EVENT IS A BIRTH
C    ***********************************************************************
      GO TO 570
C    ***********************************************************************
C      EVENT IS A DEATH
C    ***********************************************************************
  505 IF(IEC.NE.2) GO TO 530
      IF(IPC.NE.1) GO TO 520
      PI=0.
```

```
      IF(INDI(1,4).NE.2) GO TO 510
      CALL SPBEN(NE,1,SP)
  510 CHI=INDI(1,7)*.75*PIA(NRUN)
      GO TO 600
  520 SP=0.
      GO TO 630
C    ************************************************************************
C     EVENT IS A MARRIAGE
C    ************************************************************************
  530 IF(IEC.NE.3) GO TO 550
      IF(IPC.NE.1) GO TO 540
      CALL SPBEN(NE,0,SP)
      GO TO 630
  540 IF(INDI(1,7).EQ.0) SP=0
      INDI(2,4)=5
      GO TO 630
C    ************************************************************************
C     EVENT IS A DIVORCE
C    ************************************************************************
  550 IF(IEC.NE.4) GO TO 560
      SP=0
      GO TO 630
C    ************************************************************************
C     EVENT IS A CHILD REACHING INDEPENDENT STATUS
C    ************************************************************************
  560 IF(IEC.NE.6) GO TO 596
      IF(INDI(1,7).EQ.0) GO TO 590
      IF(INDI(1,1)-INDI(1,9))570,580,580
  570 CHI=INDI(1,7)*.5*PIA(NRUN)
      IF(IEC.EQ.1.AND.INDI(1,7).EQ.1) GO TO 594
      GO TO 630
  580 CHI=INDI(1,7)*.75*PIA(NRUN)
```

```
      GO TO 630
  590 CHI=0.
      IF(INDI(1,4).NE.2) GO TO 630
      IF(INDI(2,4).NE.5) GO TO 594
      SP=0.
      GO TO 630
  594 IF(INDI(2,4).NE.2) GO TO 595
      CALL SPBEN(NE,0,SP)
      GO TO 630
  595 CALL SPBEN(NE,1,SP)
      GO TO 630
  596 IF(IEC.NE.8) RETURN
      IF(SP.EQ.1.E-9) GO TO 594
      IEC=0
      RETURN
  600 XL=3.*PIA(NRUN)
      XL=AMIN1(255.,XL)
      TOTAL=SP+CHI
      TOTAL=AMIN1(AMFB(NRUN),TOTAL)
      NURE(NRUN,KR)=ITNOW-ITLAS
      KR=KR+1
      RECE(NRUN,KR)=TOTAL+XL
      NURE(NRUN,KR)=1
      IRES(NRUN)=IRES(NRUN)+2
      IF(TOTAL)110,110,620
  620 KR=KR+1
      RECE(NRUN,KR)=TOTAL
      IF(RECE(NRUN,KR).EQ.1.E-9) RECE(NRUN,KR)=0.
      ITLAS=ITNOW+1
      RETURN
  630 TOTAL=PI+SP+CHI
      TOTAL=AMIN1(AMFB(NRUN),TOTAL)
```

```
      NURE(NRUN,KR)=ITNOW-ITLAS
      IRES(NRUN)=IRES(NRUN)+1
      IF(TOTAL)110,110,650
  650 KR=KR+1
      RECE(NRUN,KR)=TOTAL
      IF(RECE(NRUN,KR).EQ.1.E-9) RECE(NRUN,KR)=0.
      ITLAS=ITNOW
      RETURN
      END
C    ******************************************************************
      SUBROUTINE SPBEN(NE,ISIG,SP)
C    ******************************************************************
C     SUBROUTINE SPBEN SCHEDULES THE DATE WHEN A MARRIAGE PARTNER WHO
C     PRESENTLY IS NOT ELIGIBLE FOR BENEFITS WILL BECOME ELIGIBLE
C    ******************************************************************
      COMMON /ZERO/ITNOW
      COMMON /EIGHT/INDI(20,12)
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      IF(ISIG)10,10,50
C    ******************************************************************
C     FOR RETIREMENT BENEFITS
C    ******************************************************************
   10 SP=.5*PIA(NRUN)
      IF(INDI(1,7).GT.0.OR.INDI(2,1).GE.780) RETURN
      SP=(.5-(780-INDI(2,1))*(2.5/360.))*PIA(NRUN)
      IF(INDI(2,1).GE.744) RETURN
      SP=0.
      IF(INDI(2,5).NE.0.AND.INDI(2,5).LE.744) RETURN
      IF(INDI(2,9).LE.744) RETURN
      SP=1.E-9
      NE=NE+1
```

```
      ITE=ITNOW+744-INDI(2,1)
      CALL FILE(NE,ITE,8,2,744)
      RETURN
C    ************************************************************
C     FOR DISABILITY-SURVIVOR BENEFITS
C    ************************************************************
   50 SP=PIA(NRUN)
      IF(INDI(1,7).GT.0.OR.INDI(2,1).GE.780) RETURN
      SP=(1.-(780-INDI(2,1))*(1.9/400.))*PIA(NRUN)
      IF(INDI(2,1).GE.720) RETURN
      SP=0.
      IF(INDI(2,5).NE.0.AND.INDI(2,5).LE.720) RETURN
      IF(INDI(2,9).LE.720) RETURN
      SP=1.E-9
      NE=NE+1
      ITE=ITNOW+720-INDI(2,1)
      CALL FILE(NE,ITE,8,2,720)
      RETURN
      END
C    ************************************************************
      SUBROUTINE TAXBE(IAN,IEC)
C    ************************************************************
C     SUBROUTINE TAXBE DETERMINES THE AMOUNT OF TAX PAID AND ELIGIBILITY
C     FOR BENEFITS
C    ************************************************************
      COMMON /ZERO/ITNOW
      COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
      COMMON /E/WAGE(50,75),PAYM(50,75),NUPA(50,75),IPAS(50)
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
C    ************************************************************
C     DETERMINE THE TAX PAYMENT SERIES
```

```
C     ****************************************************************************
      ISIG=0
      DO 50 I=1,NPSA
      IF(ITNOW-SALAR(I,1))60,60,50
   50 CONTINUE
      SALAR(NPSA+1,1)=ITNOW
      GO TO 90
   60 NTEM=NPSA
      NPSA=I-1
      ITEM=SALAR(I,1)
      SALAR(I,1)=ITNOW
      ISIG=1
   90 DO 100 I=1,20
      IF(SALAR(1,1)-TAXRA(I,1))120,130,100
  100 CONTINUE
      KK=1
      KS=1
      K=1
      GO TO 200
  120 KT=I-1
      GO TO 135
  130 KT=I
  135 KS=1
      K=1
      XL=SALAR(1,1)
  140 WAGE(NRUN,K)=AMIN1(SALAR(KS,2),TAXRA(KT,2))
      PAYM(NRUN,K)=WAGE(NRUN,K)*TAXRA(KT,3)
      X1=SALAR(KS+1,1)
      X2=TAXRA(KT+1,1)
      IF(X2-X1)150,160,170
  150 NUPA(NRUN,K)=X2-XL
      XL=X2
```

```
      KT=KT+1
      K=K+1
      IF(KT-20)140,190,190
  160 NUPA(NRUN,K)=X1-XL
      XL=X1
      IF(KS.EQ.NPSA) GO TO 240
      KS=KS+1
      KT=KT+1
      K=K+1
      IF(KT-20)140,190,190
  170 NUPA(NRUN,K)=X1-XL
      XL=X1
      IF(KS.EQ.NPSA) GO TO 240
      KS=KS+1
      K=K+1
      GO TO 140
  190 WAGE(NRUN,K)=AMIN1(SALAR(KS,2),TAXRA(20,2))
      PAYM(NRUN,K)=WAGE(NRUN,K)*TAXRA(20,3)
      NUPA(NRUN,K)=SALAR(KS+1,1)-TAXRA(20,1)
      IF(KS.EQ.NPSA) GO TO 240
      KK=KS+1
      K=K+1
  200 DO 220 I=KK,NPSA
      WAGE(NRUN,K) =AMIN1(SALAR(I,2),TAXRA(20,2))
      PAYM(NRUN,K)=WAGE(NRUN,K)*TAXRA(20,3)
      NUPA(NRUN,K)=SALAR(I+1,1)-SALAR(I,1)
      K=K+1
  220 CONTINUE
      K=K-1
  240 IPAS(NRUN)=K
C     ***********************************************************************
C     DETERMINE ELIGIBILITY
```

```
C     ************************************************************************
      CALL COVER(SALAR(1,1),IQC(NRUN))
      IF(IEC.NE.5) GO TO 300
      IF(IAN.GE.288) GO TO 250
      IF(IQC(NRUN)-6)350,400,400
  250 IF(IAN.GE.372) GO TO 300
      IF(IQC(NRUN)-20.)350,400,400
  300 IYN=ITNOW/12.+IYBA
      IYN=6+(IYN-1975)/4.
      IYN=IYN*4
      IF(IYN.GT.40) IYN=40
      IF(IQC(NRUN)-IYN)350,310,310
  310 IF(IEC.NE.5) GO TO 400
  320 ITN=ITNOW/3.
      X=3*ITN-120
      IF(X.LT.SALAR(1,1)) X=SALAR(1,1)
      CALL COVER(X,IQ)
      IF(IQ-20)350,400,400
  350 IELE(NRUN)=0
      CALL BENEF
      AMFB(NRUN)=0.
      PIA(NRUN)=0.
      IF(ISIG.EQ.1) GO TO 410
      RETURN
  400 IELE(NRUN)=1
      CALL BENEF
      IF(ISIG.EQ.0) RETURN
  410 SALAR(NPSA+1,1)=ITEM
      NPSA=NTEM
      RETURN
      END
C     ************************************************************************
```

```
      SUBROUTINE COVER(XX,IQC)
C     ************************************************************
C      SUBROUTINE COVER CALCULATES THE NUMBER OF QUARTERS OF COVERAGE
C      CREDITED TO THE PRIMARY INDIVIDUAL
C     ************************************************************
      COMMON /ZERO/ITNOW
      COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
      X=XX
      IQC=0
      JI=ITNOW/3.
      JJ=ITNOW-3*JI
      DO 20 I=1,NPSA
      IF(X-SALAR(I,1))30,40,20
   20 CONTINUE
      K=NPSA
      GO TO 50
   30 K=I-1
      GO TO 50
   40 K=I
   50 II=X/3.
      IJ=X-3*II
      IF(IJ.EQ.0) GO TO 90
      IF(IJ.LT.0) IJ=-IJ
      XM=0.
      DO 80 I=1,IJ
      XM=XM+SALAR(K,2)
      X=X+1.
      IF(K.EQ.NPSA) GO TO 80
      IF(X.GE.SALAR(K+1,1).AND.K.LT.NPSA) K=K+1
   80 CONTINUE
      IF(XM.GE.50.) IQC=IQC+1
   90 IF(II.GE.0.AND.JI.NE.0) II=II+1
```

```
      II=JI-II
      IF(II.EQ.0) GO TO 145
      IF(K.EQ.NPSA) GO TO 130
      DO 120 I=1,II
      IF(K.EQ.NPSA) GO TO 125
      XM=0.
      IF(X+2..LT.SALAR(K+1,1)) GO TO 116
      DO 115 J=1,3
      IF(K.EQ.NPSA) GO TO 110
      IF(X.GE.SALAR(K+1,1).AND.K.LT.NPSA) K=K+1
  110 XM=XM+SALAR(K,2)
      X=X+1.
  115 CONTINUE
      GO TO 117
  116 XM=3*SALAR(K,2)
      X=X+3.
  117 IF(XM.GE.50.) IQC=IQC+1
  120 CONTINUE
  125 II=II-I+1
  130 IF(SALAR(NPSA,2).LT.16.66) RETURN
      IQC=IQC+II
  145 IF(JJ.EQ.0) RETURN
      XM=0.
      X=ITNOW-JJ
      DO 150 I=1,JJ
      XM=XM+SALAR(K,2)
      X=X+1
      IF(X.GE.SALAR(K+1,1).AND.K.LT.NPSA) K=K+1
  150 CONTINUE
      IF(XM.GE.50.) IQC=IQC+1
      RETURN
      END
```

```
C     ************************************************************************
         SUBROUTINE BENEF
C     ************************************************************************
C        SUBROUTINE BENEF CALCULATES THE AVERAGE MONTHLY WAGE (AMW), THE
C        PRIMARY INSURANCE AMOUNT (PIA), AND THE MAXUMUM FAMILY BENEFITS (MFB)
C     ************************************************************************
         COMMON /ZERO/ITNOW
         COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
         COMMON /E/WAGE(50,75),PAYM(50,75),NUPA(50,75),IPAS(50)
         COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
         COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
         DIMENSION ANNU(60)
C     ************************************************************************
C        CALCULATE THE AVERAGE MONTHLY WAGE
C     ************************************************************************
         DO 05 I=1,60
      05 ANNU(I)=0.
         II=SALAR(1,1)/12.
         IJ=II*12-SALAR(1,1)
         JI=ITNOW/12.
         JJ=ITNOW-12*JI
         IYE=JI-II
         IF(IJ.NE.0) IYE=IYE+1
         IF(JJ.NE.0) IYE=IYE+1
         IF(IYE.GT.IYCO) GO TO 50
         K=IPAS(NRUN)
         SUM=0.
         DO 10 I=1,K
      10 SUM=SUM+WAGE(NRUN,I)*NUPA(NRUN,I)
         AMW(NRUN)=SUM/(IYCO*12)
         IF(IELE(NRUN).EQ.0) RETURN
         GO TO 220
```

```
 50 IEN=IYE
    IF(JJ.NE.0) IEN=IEN-1
    IK=1
    IL=1
    IF(IJ.NE.0) GO TO 60
    IKOUN=12
    GO TO 70
 60 IKOUN=IJ
 70 JKOUN=NUPA(NRUN,IL)
 80 IF(IKOUN-JKOUN)90,110,130
 90 ANNU(IK)=ANNU(IK)+IKOUN*WAGE(NRUN,IL)
    IF(IK-IEN)100,100,150
100 JKOUN=JKOUN-IKOUN
    IK=IK+1
    IKOUN=12
    GO TO 80
110 ANNU(IK)=ANNU(IK)+IKOUN*WAGE(NRUN,IL)
    IF(IK-IEN)120,120,150
120 IK=IK+1
    IL=IL+1
    IF(IL.GT.IPAS(NRUN)) IL=IPAS(NRUN)
    IKOUN=12
    GO TO 70
130 ANNU(IK)=ANNU(IK)+JKOUN*WAGE(NRUN,IL)
    IF(IK-IEN)140,140,150
140 IKOUN=IKOUN-JKOUN
    IL=IL+1
    IF(IL.GT.IPAS(NRUN)) IL=IPAS(NRUN)
    GO TO 70
150 IF(JJ.EQ.0) GO TO 160
    ANNU(IK)=JJ*WAGE(NRUN,IL)
160 IY=IYE-IYCO
```

```
      DO 200 I=1,IY
  170 XMIN=10.E9
      DO 180 J=1,IYE
      IF(ANNU(J).GE.XMIN) GO TO 180
      JMIN=J
      XMIN=ANNU(J)
  180 CONTINUE
      ANNU(JMIN)=10.E9
  200 CONTINUE
      SUM=0.
      DO 210 I=1,IYE
      IF(ANNU(I).LT.10.E9) SUM=SUM+ANNU(I)
  210 CONTINUE
      AMW(NRUN)=SUM/(IYCO*12)
      IF(IELE(NRUN).EQ.0) RETURN
C    ***************************************************************************
C     CALCULATE THE PRIMARY INSURANCE AMOUNT
C    ***************************************************************************
  220 PIA(NRUN)=1.1989*AMIN1(110.,AMW(NRUN))
      IF(AMW(NRUN).LE.110.) GO TO 240
      D=AMW(NRUN)-110.
      PIA(NRUN)=PIA(NRUN)+.4361*AMIN1(290.,D)
      IF(D.LE.290.) GO TO 255
      D=D-290.
      PIA(NRUN)=PIA(NRUN)+.4075*AMIN1(150.,D)
      IF(D.LE.150.) GO TO 255
      D=D-150.
      PIA(NRUN)=PIA(NRUN)+.4790*AMIN1(100.,D)
      IF(D.LE.100.) GO TO 250
      D=D-100.
      PIA(NRUN)=PIA(NRUN)+.2664*AMIN1(100.,D)
      IF(D.LE.100.) GO TO 260
```

```
      D=D-100.
      PIA(NRUN)=PIA(NRUN)+.2220*AMIN1(250.,D)
      IF(D.LE.250.) GO TO 260
      D=D-250.
      PIA(NRUN)=PIA(NRUN)+.2000*AMIN1(100.,D)
      GO TO 260
  240 IF(AMW(NRUN).LE.76.) PIA(NRUN)=93.80
C    ************************************************************************
C     CALCULATE THE MAXIMUM FAMILY BENEFITS
C    ************************************************************************
  250 IF(AMW(NRUN).GE.628.) GO TO 260
  255 AMFB(NRUN)=1.1172*AMIN1(436.,AMW(NRUN))
      IF(AMW(NRUN).LE.436.) RETURN
      D=AMW(NRUN)-436.
      AMFB(NRUN)=AMFB(NRUN)+.5860*D
      FLOOR=1.5000*PIA(NRUN)
      IF(AMFB(NRUN).LT.FLOOR) AMFB(NRUN)=FLOOR
      RETURN
  260 AMFB(NRUN)=1.75*PIA(NRUN)
      RETURN
      END
C    ************************************************************************
      SUBROUTINE RRATE(NRSIG)
C    ************************************************************************
C     SUBROUTINE RRATE DETERMINES THE FINAL SOLUTION OF THE CASH FLOW
C     EQUATION BY USING THE GOLDEN SECTION SEARCH PROCEDURE
C    ************************************************************************
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /DOWN/NT
      DIMENSION P(4),R(4)
      G1=(3.-SQRT(5.))/2.
      G2=1.-G1
```

```
    NCH=1
    C=.012
 05 CALL FESTI(NRSIG)
    IF(NRSIG)10,10,20
 10 R(1)=RATE(NT)-C
    R(4)=RATE(NT)+C
    GO TO 25
 20 R(1)=RATES(NRAT)-C
    R(4)=RATES(NRAT)+C
 25 R(2)=(R(4)-R(1))*G1+R(1)
    R(3)=(R(4)-R(1))*G2+R(1)
    NCOUN=4
    DO 50 J=1,4
    IF(NRSIG)30,30,40
 30 CALL SUB1(R(J),P(J))
    GO TO 50
 40 CALL SUB2(NRSIG,R(J),P(J))
 50 CONTINUE
 60 IF(P(2)-P(3))100,150,200
100 IF(NCOUN-20)110,140,140
110 R(4)=R(3)
    P(4)=P(3)
    R(3)=R(2)
    P(3)=P(2)
    R(2)=(R(4)-R(1))*G1+R(1)
    NCOUN=NCOUN+1
    IF(NRSIG.EQ.0) CALL SUB1(R(2),P(2))
    IF(NRSIG.NE.0) CALL SUB2(NRSIG,R(2),P(2))
    GO TO 60
140 IF(NRSIG.EQ.0) RATE(NT)=.5*(R(1)+R(3))
    IF(NRSIG.NE.0) RATES(NRAT)=.5*(R(1)+R(3))
    GO TO 245
```

```
150 IF(NCOUN-20)160,190,190
160 R(1)=R(2)
    P(1)=P(2)
    R(4)=R(3)
    P(4)=P(3)
    R(2)=(R(4)-R(1))*G1+R(1)
    R(3)=(R(4)-R(1))*G2+R(1)
    NCOUN=NCOUN+2
    IF(NRSIG)170,170,180
170 CALL  SUB1(R(2),P(2))
    CALL  SUB1(R(3),P(3))
    GO TO 60
180 CALL  SUB2(NRSIG,R(2),P(2))
    CALL  SUB2(NRSIG,R(3),P(3))
    GO TO 60
190 IF(NRSIG.EQ.0) RATE(NT)=.5*(R(1)+R(4))
    IF(NRSIG.NE.0) RATES(NRAT)=.5*(R(1)+R(4))
    GO TO 245
200 IF(NCOUN-20)210,240,240
210 R(1)=R(2)
    P(1)=P(2)
    R(2)=R(3)
    P(2)=P(3)
    R(3)=(R(4)-R(1))*G2+R(1)
    NCOUN=NCOUN+1
    IF(NRSIG.EQ.0) CALL  SUB1(R(3),P(3))
    IF(NRSIG.NE.0) CALL  SUB2(NRSIG,R(3),P(3))
    GO TO 60
240 IF(NRSIG.EQ.0) RATE(NT)=.5*(R(2)+R(4))
    IF(NRSIG.NE.0) RATES(NRAT)=.5*(R(2)+R(4))
245 IF(NCH.EQ.2) RETURN
    NCH=NCH+1
```

```
      C=C/2.
      IF(NRSIG)250,250,270
  250 RSUB=RATE(NT)
      CALL SUB1(RSUB,PSUB)
      GO TO 280
  270 RSUB=RATES(NRAT)
      CALL SUB2(NRSIG,RSUB,PSUB)
  280 IF(PSUB.LE.1.E2) RETURN
      GO TO 05
      END
C     *****************************************************************
      SUBROUTINE FESTI(NRSIG)
C     *****************************************************************
C     SUBROUTINE FESTI PROVIDES THE INITIAL ESTIMATE SOLUTION OF THE
C     CASH FLOW EQUATION BY SUCCESSIVE INTERPOLATIONS
C     *****************************************************************
      COMMON /E/WAGE(50,75),PAYM(50,75),NUPA(50,75),IPAS(50)
      COMMON /F/ITST(50),RECE(50,15),NURE(50,15),IRES(50)
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      COMMON /DOWN/NT
      IF(NRSIG)10,10,90
C     *****************************************************************
C     OVERALL POPULATION RATE OF RETURN CASH FLOW EQUATION
C     *****************************************************************
   10 R0=.00001
      R1=.01
      P0=0.
      P1=0.
      NCOUN=1
      DO 50 I=1,NRUN
      CALL PRESE(I,R0,0,PR)
```

```
      P0=P0-PR
      CALL PRESE(I,R1,0,PR)
      P1=P1-PR
      IF(IELE(I).EQ.0) GO TO 50
      CALL PRESE(I,R0,1,PR)
      P0=P0+PR
      CALL PRESE(I,R1,1,PR)
      P1=P1+PR
   50 CONTINUE
   55 IF(ABS(P1-P0).LE.1.E-10) GO TO 80
      R2=-P0*(R1-R0)/(P1-P0)
      DR=ABS(R2-R1)
      IF(DR.LE.1.E-4) GO TO 80
      IF(NCOUN.GT.10) GO TO 80
      R0=R1
      R1=R2
      P0=P1
      P1=0.
      NCOUN=NCOUN+1
      DO 60 I=1,NRUN
      CALL PRESE(I,R1,0,PR)
      P1=P1-PR
      IF(IELE(I).EQ.0) GO TO 60
      CALL PRESE(I,R1,1,PR)
      P1=P1+PR
   60 CONTINUE
   70 IF(ABS(P1)-1.E2)80,80,55
   80 RATE(NT)=R1
      RETURN
C     ************************************************************************
C        INDIVIDUAL RATE OF RETURN CASH FLOW EQUATION
C     ************************************************************************
```

```
 90 R0=.00001
    R1=.01
    I=NRSIG
    NCOUN=1
    CALL PRESE(I,R0,0,PA)
    CALL PRESE(I,R0,1,RE)
    P0=RE-PA
    CALL PRESE(I,R1,0,PA)
    CALL PRESE(I,R1,1,RE)
    P1=RE-PA
100 IF(ABS(P1-P0).LE.1.E-10) GO TO 150
    R2=-P0*(R1-R0)/(P1-P0)
    DR=ABS(R2-R1)
    IF(DR.LE.1.E-4) GO TO 150
    IF(NCOUN.GT.10) GO TO 150
    R0=R1
    R1=R2
    P0=P1
    NCOUN=NCOUN+1
    CALL PRESE(I,R1,0,PA)
    CALL PRESE(I,R1,1,RE)
    P1=RE-PA
120 IF(ABS(P1)-1.E2)150,150,100
150 RATES(NRAT)=R1
    RETURN
    END
C   ************************************************************************
    SUBROUTINE SUB1(R,P)
C   ************************************************************************
C     SUBROUTINE SUB1 CALCULATES THE ABSOLUTE DIFFERENCE BETWEEN THE TWO
C     PRESENT WORTHS OF THE OVERALL POPULATION RATE OF RETURN CASH FLOW
C     EQUATION
```

```
C     ************************************************************
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      P=0.
      DO 50 I=1,NRUN
      CALL PRESE(I,R,0,PR)
      P=P-PR
      IF(IELE(I).EQ.0) GO TO 50
      CALL PRESE(I,R,1,PR)
      P=P+PR
   50 CONTINUE
      P=ABS(P)
      RETURN
      END
C     ************************************************************
      SUBROUTINE SUB2(I,R,P)
C     ************************************************************
C     SUBROUTINE SUB2 CALCULATE THE ABSOLUTE DIFFERENCE BETWEEN THE TWO
C     PRESENT WORTHS OF THE INDIVIDUAL RATE OF RETURN CASH FLOW EQUATION
C     ************************************************************
      CALL PRESE(I,R,0,PA)
      CALL PRESE(I,R,1,RE)
      P=ABS(RE-PA)
      RETURN
      END
C     ************************************************************
      SUBROUTINE PRESE(NR,RI,ISI,PR)
C     ************************************************************
C     SUBROUTINE PRESE CALCULATES THE PRESENT WORTH OF A SERIES OF PAYMENTS
C     OR A SERIES OF RECEIPTS
C     ************************************************************
      COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
```

```
      COMMON /E/WAGE(50,75),PAYM(50,75),NUPA(50,75),IPAS(50)
      COMMON /F/ITST(50),RECE(50,15),NURE(50,15),IRES(50)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      IF(RI.LE.-1.) RI=-.9999
      RII=(1.+RI)**12-1.
      PR=0.
      IF(RII+.900)01,02,02
   01 RII=-.900
      GO TO 04
   02 IF(RII-2.)05,03,03
   03 RII=2.
   04 RI=ALOG(1.+RII)/12.
      RI=EXP(RI)-1.
   05 IF(ISI)10,10,100
C   *******************************************************************
C     CALCULATE THE PRESENT WORTH OF A RECEIPT SERIES
C   *******************************************************************
   10 IT=SALAR(1,1)-1
      N=IPAS(NR)
      DO 30 I=1,N
      IF(PAYM(NR,I).EQ.0.) GO TO 20
      IS=1
      IF(RI.LT.0.) IS=-1
      R=ABS(RI)
      IF(R.NE.0.) GO TO 11
      X=1.E70
      GO TO 15
   11 X=-(ALOG10(R)+NUPA(NR,I)*ALOG10(1.+RI))
      IF(X.GT.-70.) GO TO 12
      X=0.
      GO TO 15
   12 IF(X.LT.70.) GO TO 14
```

```
      X=1.E70
      GO TO 15
   14 X=1./(R *(1.+RI)**NUPA(NR,I))
   15 P=PAYM(NR,I)*(1./RI-IS*X)
      ITT=IT/12.
      IDT=IT-ITT*12
      P=P/((1.+RI)**IDT)
      IS=1
      IF(P.LT.0.) IS=-1
      Q=ABS(P)
      IF(Q.LT.1.E-10) GO TO 20
      X=ALOG10(Q)-ITT*ALOG10(1.+RII)
      IF(X.LE.-70.) GO TO 16
      IF(X.GE.70.) GO TO 17
      GO TO 18
   16 PR=PR+IS*1.E-70
      GO TO 20
   17 PR=PR+IS*1.E70
      GO TO 20
   18 PR=PR+P/((1.+RII)**ITT)
   20 IT=IT+NUPA(NR,I)
   30 CONTINUE
      RETURN
C     ************************************************************************
C     CALCULATE THE PRESENT WORTH OF A PAYMENT SERIES
C     ************************************************************************
  100 IT=ITST(NR)-1
      N=IRES(NR)
      DO 130 I=1,N
      IF(RECE(NR,I).EQ.0.) GO TO 120
      IS=1
      IF(RI.LT.0.) IS=-1
```

```
      R=ABS(RI)
      IF(R.NE.0.) GO TO 104
      X=1.E60
      GO TO 111
104   X=-(ALOG10(R)+NURE(NR,I)*ALOG10(1.+RI))
      IF(X.GT.-70.) GO TO 105
      X=0.
      GO TO 111
105   IF(X.LT.60.) GO TO 110
      X=1.E60
      GO TO 111
110   X=1./(R *(1.+RI)**NURE(NR,I))
111   P=RECE(NR,I)*(1./RI-IS*X)
      ITT=IT/12.
      IDT=IT-ITT*12
      P=P/((1.+RI)**IDT)
      IS=1
      IF(P.LT.0.) IS=-1
      Q=ABS(P)
      IF(Q.LT.1.E-10) GO TO 120
      X=ALOG10(Q)-ITT*ALOG10(1.+RII)
      IF(X.LE.-70.) GO TO 112
      IF(X.GE.60.) GO TO 114
      GO TO 115
112   PR=PR+IS*1.E-70
      GO TO 120
114   PR=PR+IS*1.E60
      GO TO 120
115   PR=PR+P/((1.+RII)**ITT)
120   IT=IT+NURE(NR,I)
130   CONTINUE
      RETURN
```

```
      END
C     ************************************************************************
      SUBROUTINE STAT(ITERM)
C     ************************************************************************
C     SUBROUTINE STAT CHECK THE TERMINATION CRITERION; IF THIS IS MET,
C     IT PROCEEDS TO CALCULATE STATISTICS ON THE INDIVIDUAL EXPECTED RATE
C     OF RETURN AND THE AMOUNT OF MONEY LOST FOR THE TOTAL LOSS CASES.
C     ************************************************************************
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /UP/P
      COMMON /DOWN/NT
      DIMENSION HISTO(10,2)
      DIMENSION T(10)
      DATA Z/1.96/
      DATA T/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,2.22
     >8/
C     ************************************************************************
C     CHECK THE TERMINATION CRITERION
C     ************************************************************************
      ITERM=0
      IF(NRAT.LE.1.AND.NT.LE.1) RETURN
      IF(NRAT.LE.1) GO TO 220
   10 SUM=0.
      SUM2=0.
      DO 50 I=1,NRAT
   50 SUM=SUM+RATES(I)
      XMEAN=SUM/NRAT
      DO 55 I=1,NRAT
   55 SUM2=SUM2+(RATES(I)-XMEAN)**2
      XVAR=SUM2/(NRAT-1)
      XDEV=SQRT(XVAR)
      IF(NRAT.LE.30) GO TO 70
```

```
      XL=XMEAN-3.*XDEV
      XU=XMEAN+3.*XDEV
      ND=0
      I=1
   60 RATES(I)=RATES(I+ND)
      IF(RATES(I).LT.XL.OR.RATES(I).GT.XU) GO TO 65
      I=I+1
      IF(I.LE.NRAT) GO TO 60
      IF(ND.EQ.0) GO TO 70
      WRITE(6,66)ND
   66 FORMAT(1H0,T05,'NUMBER OF POINTS DISCARDED = ',I5)
      GO TO 10
   65 ND=ND+1
      NRAT=NRAT-1
      IF(I.GT.NRAT) GO TO 10
      GO TO 60
   70 WRITE(6,80)XMEAN,XVAR
   80 FORMAT(1H0,T05,'MEAN = ',E12.5,T30,'VARIANCE = ',E12.5)
      RMIN=1.E9
      RMAX=-1.E9
      DO 100 I=1,NRAT
      RMIN=AMIN1(RMIN,RATES(I))
  100 RMAX=AMAX1(RMAX,RATES(I))
      DR=(RMAX-RMIN)/10.
      DO 110 I=1,10
      HISTO(I,1)=RMIN+(I-1)*DR
  110 HISTO(I,2)=0.
      DO 120 I=1,NRAT
      J=(RATES(I)-RMIN)/DR+1.
      IF(J.GT.10) J=10
  120 HISTO(J,2)=HISTO(J,2)+1.
      DO 125 I=1,10
```

```
  125 HISTO(I,2)=HISTO(I,2)*100./NRAT
      IF(NRAT.LE.30) RETURN
      C=XDEV/XMEAN
      NSAM=(2.*Z*C/P)**2
      IF(NRAT.GE.NSAM) GO TO 180
      IF(NLOST.GE.30) GO TO 240
      RETURN
C   ******************************************************************
C     TERMINATION CRITERION IS MET
C     CALCULATE STATISTICS ON THE INDIVIDUAL RATE OF RETURN
C   ******************************************************************
  180 XNR=NRAT
      XL=XMEAN-Z*XDEV/SQRT(XNR)
      XU=XMEAN+Z*XDEV/SQRT(XNR)
      XMEAN=XMEAN*100.
      XVAR=XVAR*10000.
      XL=XL*100.
      XU=XU*100.
      WRITE(6,200) NSAM,NRAT,XMEAN,XVAR,XL,XU
  200 FORMAT(////T05,'TERMINATION CRITERION MET :'/T08,'SAMPLE SIZE REQU
     >IRED =',T30,I5/T08,'SAMPLE SIZE TAKEN = ',T30,I5//T05,'* INDIVIDUA
     >L EXPECTED RATE OF RETURN STATISTICS *'/T08,'MEAN = ',T20,E12.5/
     >T08,'VARIANCE = ',T20,E12.5/T08,'95% CONFIDENCE INTERVAL FOR THE M
     >EAN :'/T10,'LOWER BOUND = ',E12.5/T10,'UPPER BOUND = ',E12.5//)
      ITERM=1
      IF(NLOST.NE.0) GO TO 220
      WRITE(6,210)
  210 FORMAT(1H0,T05,'NO TOTAL LOSS CASE OBSERVED'/T05,'*** END OF SIMUL
     >ATION ***'/)
      RETURN
C   ******************************************************************
C     CALCULATE AMOUNT OF MONEY LOST FOR THE TOTAL LOSS CASES
```

```
C     ****************************************************************************
  220 IF(NLOST.GE.2) GO TO 240
      N=NRAT+NLOST
      WRITE(6,230)N,PRLOS(1)
  230 FORMAT(1H0,T05,'ONE CASE OF TOTAL LOSS OBSERVED OUT OF ',I4,' CASE
     >S'/T05,'PRESENT WORTH OF AMOUNT LOST AT AN INTEREST RATE OF 6% YEA
     >RLY   = ',E12.5///T05,'*** END OF SIMULATION ***'/)
      RETURN
  240 X=NLOST
      SUM=0.
      SUM2=0.
      N=NRAT+NLOST
      PLOST=X/N
      DO 250 I=1,NLOST
      SUM=SUM+PRLOS(I)
  250 SUM2=SUM2+PRLOS(I)**2
      PRM=SUM/NLOST
      PRV=(SUM2-NLOST*PRM**2)/(NLOST-1)
      PRD=SQRT(PRV)
      NTL=NLOST-1
      IF(NTL.GT.10) NTL=10
      PL=PRM-T(NTL)*PRD/SQRT(X)
      PU=PRM+T(NTL)*PRD/SQRT(X)
  255 WRITE(6,260)PLOST,N,PRM,PRV,PL,PU
  260 FORMAT(1H0,T05,'PROBABILITY OF OCCURENCE OF TOTAL LOSS CASE = ',E1
     >2.5/T08,'(SAMPLE SIZE = ',I5,')'/T05,'STATISTICS ON THE PRESENT WO
     >RTH OF AMOUNT LOST AT 6 % YEARLY  INTEREST RATE :'/T08,'MEAN = ',
     >T20,E12.5/T08,'VARIANCE = ',T20,E12.5/T08,'95% CONFIDENCE INTERVAL
     > FOR THE MEAN :'/T10,'LOWER BOUND =',T30,E12.5/T10,'UPPER BOUND ='
     >,T30,E12.5)
      C=PRD/PRM
      NS=(2.*Z*C/P)**2
```

```
      IF(ITERM.EQ.O.AND.NLOST.GE.NS) GO TO 280
  265 WRITE(6,270)NS
  270 FORMAT(1H ,T08,'APPROXIMATE SAMPLE SIZE REQUIRED TO OBTAIN A 95% C
     >ONFIDENCE INTERVAL FOR THE MEAN'/T08,'OF PRESENT WORTH OF AMOUNT L
     >OST IN THE CASE OF TOTAL LOSS WITH WIDTH'/T08,'EQUAL  P *MEAN IS',
     >I10/)
      IF(ITERM.EQ.1) WRITE(6,275)
      RETURN
  275 FORMAT(//T05,'*** END OF SIMULATION ***'//)
  280 ITERM=1
      WRITE(6,290)
  290 FORMAT(1HO,T05,'TERMINATION CRITERION MET :')
      GO TO 265
      END
C    ************************************************************************
      SUBROUTINE RATIO(ISIG)
C    ************************************************************************
C     SUBROUTINE RATIO CALCULATES THE PAYOFF RATIO AND ALL ITS STATISTICS
C    ************************************************************************
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      COMMON /DOWN/NT
      COMMON /SSR/SUM,SUM2
      IF(ISIG)05,05,110
   05 IF(NT.GT.1) GO TO 10
      SUM=0.
      SUM2=0.
   10 DO 100 I=1,NRUN
      CALL PRESE(I,.005,0,PA)
      RE=0.
      IF(IELE(I).EQ.1) CALL PRESE(I,.005,1,RE)
      R=RE/PA
```

```
      SUM=SUM+R
  100 SUM2=SUM2+R**2
      RETURN
  110 XNR=NT*50.
      RMEAN=SUM/XNR
      RVAR=(SUM2-NRUN*RMEAN**2)/(XNR -1)
      RL=RMEAN-1.96*SQRT(RVAR)/SQRT(XNR)
      RU=RMEAN+1.96*SQRT(RVAR)/SQRT(XNR)
      WRITE(6,200)RMEAN,RVAR,RL,RU
  200 FORMAT(1H0,T05,'* PAYOFF RATIO STATISTICS AT 6% YEARLY INTEREST RA
     >TE *'/T08,'E(R) = ',T20,E12.5/T08,'V(R) = ',T20,E12.5/T08,'95% CON
     >FIDENCE INTERVAL FOR THE MEAN :'/T10,'LOWER BOUND = ',E21.5/T10,'U
     >PPER BOUND = ',E12.5)
      RETURN
      END
C     ******************************************************************
      SUBROUTINE OUTP1(INDI)
C     ******************************************************************
C     SUBROUTINE OUTP1 PRINTS THE INPUT INFORMATION ON THE INDIVIDUALS
C     ******************************************************************
      COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
      COMMON /ALPHA/A(2,3),B(2,2),D(4,2)
      DIMENSION INDI(20,12)
      WRITE(6,15)IYBA
   15 FORMAT(1H1/T05,'***** SOCIAL SECURITY AS AN INVESMENT *****'/T11,
     >'ANALYSIS OF THE RATES OF RETURN'//
     >T05,'* BASE DATE : JANUARY 1 ST OF ',I6,' *'//)
      IA1=INDI(1,1)/12.
      IA2=INDI(1,1)-12*IA1
      I=INDI(1,2)
      J=INDI(1,3)
      K=INDI(1,4)
```

```
      IF(K.EQ.5) K=1
      WRITE(6,20)IA1,IA2,(A(I,L),L=1,3),(B(J,L),L=1,2),(D(K,L),L=1,2),
     >INDI(1,7)
   20 FORMAT(T05,'*** INPUT INFORMATION ON SUBJECT ***'/T05,'* SUBJECT *
     >'/T05,'AGE : ',I4,' YEARS',I4,' MONTHS'/T05,'RACE : ',3A4/T05,'SEX
     > :',2A4/T05,'MARITAL STATUS : ',2A4/T05,'NUMBER OF DEPENDENT CHILD
     >REN : ',I3)
      IF(INDI(1,4).NE.2) GO TO 35
      IA1=INDI(2,1)/12.
      IA2=INDI(2,1)-12*IA1
      I=INDI(2,2)
      WRITE(6,30)IA1,IA2,(A(I,L),L=1,3)
   30 FORMAT(//T05,'* SPOUSE *'/T05,'AGE : ',I4,' YEARS',I4,' MONTHS'/
     >T05,'RACE : ',3A4/)
   35 IF(INDI(1,7).EQ.0) GO TO 60
      NC=INDI(1,7)
      DO 40 I=1,NC
      IA1=INDI(I+2,1)/12.
      IA2=INDI(I+2,1)-12*IA1
      K=INDI(I+2,3)
   40 WRITE(6,50)I,IA1,IA2,(B(K,L),L=1,2)
   50 FORMAT(/T05,'* CHILD(',I3,') *'/T05,'AGE : ',I4,' YEARS',I4,' MONT
     >HS'/T05,'SEX : ',2A4)
   60 WRITE(6,70)
   70 FORMAT(//T05,'* SALARY EARNING HISTORY OF SUBJECT *'/T05,'STARTING
     > DATE',T20,'$/MONTH'/)
      DO 75 I=1,NPSA
      II=SALAR(I,1)/12.
      IJ=IYBA+II
      JI=SALAR(I,1)-II*12+1
      IF(JI.LE.0) JI=JI+12
      IF(SALAR(I,1).LT.0..AND.JI.NE.1) IJ=IJ-1
```

```
   75 WRITE(6,80)JI,IJ,SALAR(I,2)
   80 FORMAT(T08,I3,'/',I5,T20,F8.2)
      WRITE(6,100)
  100 FORMAT(1H1/T05,'*** SIMULATED EVENTS OF SUBJECT.S LIFE HISTORY FOR
     > THE FIRST RUN ***'//)
      RETURN
      END
C     ************************************************************************
      SUBROUTINE OUTP2(IAN,IEC,IPC,NP)
C     ************************************************************************
C     SUBROUTINE OUTP2 PRINTS THE EVENTS OF THE INDIVIDUAL'S LIFE HISTORY
C     FOR THE FIRST RUN
C     ************************************************************************
      COMMON /ZERO/ITNOW
      COMMON /EIGHT/INDI(20,12)
      COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
      COMMON /ALPHA/A(2,3),B(2,2),D(4,2)
      IF(IEC.EQ.0.OR.IEC.EQ.8) RETURN
      II=ITNOW/12.
      IJ=IYBA+II
      JI=ITNOW-II*12+1
      WRITE(6,50)JI,IJ
   50 FORMAT(/T05,'EVENT DATE : ',I3,'/',I5)
      IF(IEC.NE.1) GO TO 70
      J=INDI(NP,3)
      NK=NP-2
      WRITE(6,60)NK,(B(J,L),L=1,2)
   60 FORMAT(T05,'BIRTH OF CHILD (',I3,')'/T05,'SEX : ',2A4)
      RETURN
   70 IF(IEC.NE.2) GO TO 90
      IF(IPC.NE.1) GO TO 80
      WRITE(6,75)
```

```
 75 FORMAT(T05,'DEATH OF SUBJECT')
    RETURN
 80 WRITE(6,85)
 85 FORMAT(T05,'DEATH OF SPOUSE')
    RETURN
 90 IF(IEC.NE.3) GO TO 110
    IF(IPC.NE.1) GO TO 100
    WRITE(6,95)INDI(2,1)
 95 FORMAT(T05,'MARRIAGE OF SUBJECT'/T05,'AGE OF SPOUSE : ',I5)
    RETURN
100 WRITE(6,105)
105 FORMAT(T05,'REMARRIAGE OF SPOUSE')
    RETURN
110 IF(IEC.NE.4) GO TO 120
    WRITE(6,115)
115 FORMAT(T05,'MARRIAGE DISSOLUTION BY DIVORCE')
    RETURN
120 IF(IEC.NE.5) GO TO 130
    WRITE(6,125)
125 FORMAT(T05,'SUBJECT.S BECOMING DISABLED')
    RETURN
130 IF(IEC.NE.6) GO TO 180
    NC=IPC-2
    IF(INDI(IPC,1).NE.INDI(IPC,9)) GO TO 150
    IF(INDI(IPC,8).EQ.0) GO TO 140
    WRITE(6,135)NC,INDI(IPC,8)
135 FORMAT(T05,'DEATH OF (DISABLED) CHILD(',I3,')'/T05,'AGE AT DISABIL
   >ITY ONSET : ',I5)
    RETURN
140 WRITE(6,145)NC
145 FORMAT(T05,'DEATH OF CHILD(',I3,')')
    RETURN
```

```
  150 IF(INDI(IPC,1).NE.INDI(IPC,5)) GO TO 160
      WRITE(6,155)NC
  155 FORMAT(T05,'MARRIAGE OF CHILD(',I3,')')
      RETURN
  160 WRITE(6,165)NC
  165 FORMAT(T05,'TERMINATION OF CHILD(',I3,').S EDUCATION')
      RETURN
  180 IF(IEC.NE.7) RETURN
      WRITE(6,185)
  185 FORMAT(T05,'RETIREMENT OF SUBJECT')
      RETURN
      END
C     *******************************************************************
      SUBROUTINE OUTP3
C     *******************************************************************
C     SUBROUTINE OUTP3 PRINTS THE TAX PAYMENT SERIES, THE BENEFIT RECEIPT
C     SERIES, AND THE CORRESPONDING INDIVIDUAL RATE OF RETURN FOR THE FIRST
C     RUN
C     *******************************************************************
      COMMON /C/IYBA,IYCO,NPSA,SOTAX(25,3),SALAR(50,2),TAXRA(25,3)
      COMMON /E/WAGE(50,75),PAYM(50,75),NUPA(50,75),IPAS(50)
      COMMON /F/ITST(50),RECE(50,15),NUPE(50,15),IRES(50)
      COMMON /H/NRUN,NRAT,RATE(50),RATES(500),NLOST,PLOST,PRLOS(500)
      COMMON /Z/IELE(50),IQC(50),AMW(50),PIA(50),AMFB(50)
      IT=SALAR(1,1)
      K=IPAS(1)
      WRITE(6,50)
   50 FORMAT(1H1/T05,'*** SIMULATED TAX/BENEFITS CASH FLOW SERIES FOR TH
     >E FIRST RUN ***'///T05,'* TAX PAYMENTS SERIES *'/T05,'STARTING DAT
     >E',T20,'$/MONTH')
      DO 100 I=1,K
      II=IT/12.
```

```
      IJ=IYBA+II
      JI=IT-II*12+1
      IF(JI.LE.0) JI=JI+12
      IF(IT.LT.0.AND.JI.NE.1) IJ=IJ-1
      WRITE(6,60)JI,IJ,PAYM(1,I)
   60 FORMAT(T03,I3,'/',I5,T20,F8.2)
  100 IT=IT+NUPA(1,I)
      WRITE(6,110)IQC(1)
  110 FORMAT(/T05,'NUMBER OF QUARTER OF COVERAGE CREDITED = ',I5)
      IF(IELE(1).EQ.1) GO TO 140
      WRITE(6,120)
  120 FORMAT(T05,'SUBJECT IS NOT ELIGIBLE FOR BENEFITS')
      RETURN
  140 WRITE(6,150)IYCG,AMW(1),PIA(1),AMFB(1)
  150 FORMAT(T05,'NUMBER OF WORKING YEARS MUST BE COUNTED IN BENEFITS CO
     >MPUTATION = ',I3/T05,'AVERAGE MONTHLY WAGE = ',T35,'$',F8.2/T05,'P
     >RIMARY INSURANCE AMOUNT = ',T35,'$',F8.2/T05,'MAXIMUM FAMILY BENEF
     >ITS = ',T35,'$',F8.2)
      IT=ITST(1)
      K=IRES(1)
      WRITE(6,160)
  160 FORMAT(//T05,'* BENEFITS SERIES *'/T05,'STARTING DATE',T20,'$/MONT
     >H'/)
      DO 200 I=1,K
      II=IT/12.
      IJ=IYBA+II
      JI=IT-II*12+1
      WRITE(6,60)JI,IJ,RECE(1,I)
  200 IT=IT+NURE(1,I)
      R1=RATES(1)*100.
      WRITE(6,210)R1
  210 FORMAT(/T05,'RATE OF RETURN (FIRST RUN) FOR THE ABOVE SERIES = ',
```

```
     >E12.5,' % YEARLY')
      RETURN
      END
C    ***********************************************************************
```

APPENDIX B

SIMULATOR SYSTEM INPUT DATA

TABLE I

AGE-PARITY SPECIFIC BIRTH PROBABILITIES[2]

Age	Parity 0	1	2	3	4	5	6	7 or higher
15 - 19	.055	.257	.000	.000	.000	.000	.000	.000
20 - 24	.140	.241	.176	.188	.217	.000	.000	.000
25 - 29	.135	.200	.123	.112	.121	.149	.181	.228
30 - 34	.072	.102	.069	.066	.072	.089	.109	.161
35 - 39	.023	.036	.026	.030	.038	.051	.065	.107
40 - 44	.005	.006	.005	.008	.012	.018	.024	.047

[2] U. S. Public Health Service. Vital Statistics of the United States, Part A: Natality. Annual Volumes. Government Printing Office, Washington, D. C.

TABLE II

AGE-SEX-RACE SPECIFIC DEATH PROBABILITIES[3] $\times 10^{-3}$

Age	White		Non-white	
	Male	Female	Male	Female
Under 1	21.33	16.08	35.18	28.58
1	1.18	1.07	2.32	1.88
2	0.81	0.66	1.54	1.22
3	0.70	0.55	0.94	0.88
4	0.58	0.49	0.87	0.67
5	0.80	0.41	0.85	0.59
6	0.59	0.37	0.80	0.51
7	0.43	0.33	0.56	0.45
8	0.31	0.29	0.41	0.39
9	0.25	0.26	0.35	0.35
10	0.24	0.24	0.38	0.33
11	0.30	0.24	0.49	0.34
12	0.42	0.27	0.68	0.38
13	0.60	0.32	0.94	0.47
14	0.84	0.39	1.25	0.58
15	1.11	0.48	1.61	0.72
16	1.37	0.56	2.00	0.86
17	1.60	0.62	2.38	0.98
18	1.75	0.64	2.73	1.06
19	1.86	0.65	3.07	1.12
20	1.96	0.65	3.43	1.19
21	2.05	0.65	3.78	1.27
22	2.09	0.66	4.05	1.35
23	2.05	0.66	4.19	1.44
24	1.96	0.66	4.26	1.54
25	1.85	0.67	4.29	1.64
26	1.76	0.68	4.35	1.75
27	1.69	0.70	4.47	1.89
28	1.66	0.73	4.67	2.06
29	1.67	0.78	4.95	2.25
30	1.70	0.84	5.24	2.47
31	1.74	0.90	5.55	2.69
32	1.81	0.98	5.87	2.92
33	1.91	1.06	6.20	3.18
34	2.05	1.16	6.56	3.44
35	2.21	1.26	6.94	3.73
36	2.40	1.38	7.35	4.03
37	2.62	1.51	7.81	4.34
38	2.87	1.66	8.33	4.66
39	3.15	1.82	8.90	4.99
40	3.47	2.00	9.53	5.34

[3] U. S. Bureau of Census, Statistical Abstracts of the United States Annual Volumes. Government Printing Office, Washington, D. C.

Table II, continued

41	3.83	2.20	10.18	5.74
42	4.21	2.40	10.81	6.10
43	4.63	2.61	11.39	6.51
44	5.08	2.83	11.96	6.95
45	5.59	3.07	12.54	7.42
46	6.14	3.34	13.19	7.92
47	6.76	3.62	13.98	8.44
48	7.45	3.94	14.94	8.98
49	8.21	4.28	16.06	9.55
50	9.04	4.65	17.27	10.18
51	9.93	5.05	18.52	10.84
52	10.93	5.47	19.84	11.59
53	12.04	5.92	21.22	12.44
54	13.26	6.40	22.66	13.37
55	14.55	6.93	24.21	14.42
56	15.94	7.51	25.86	15.55
57	17.47	8.13	27.57	16.76
58	19.18	8.78	29.33	18.04
59	21.04	9.48	31.17	19.42
60	23.06	10.26	33.11	20.77
61	25.18	11.13	35.22	22.29
62	27.33	12.12	37.59	24.34
63	29.46	13.25	40.32	27.12
64	31.61	14.54	43.40	30.47
65	33.80	15.92	46.52	34.17
66	36.19	17.45	49.82	37.85
67	39.00	19.23	53.84	41.27
68	42.41	21.34	58.88	44.15
69	46.36	23.74	64.79	46.52
70	50.59	26.65	68.11	49.38
71	55.18	29.39	71.87	52.79
72	59.70	32.39	74.81	54.19
73	63.89	35.66	77.53	56.89
74	67.85	39.26	80.96	57.83
75	71.86	43.21	83.46	59.91
76	76.17	47.54	88.73	62.01
77	81.13	52.33	94.51	65.34
78	86.86	57.65	99.98	69.28
79	93.40	63.62	104.08	74.42
80	100.79	70.36	108.48	80.26
81	108.87	78.06	116.96	87.15
82	117.26	86.97	125.07	96.64
83	125.58	97.49	134.55	106.48
84	132.69	110.11	140.51	118.76
85	138.02	125.61	147.62	129.04
86	145.21	135.42	154.01	138.27
87	152.00	146.90	161.25	149.12
88	161.85	157.18	166.56	160.48

Table II, continued

89	167.85	163.39	172.21	168.97
90	172.17	169.98	179.82	174.47
91	178.66	174.56	184.08	180.95
92	183.86	180.75	189.26	186.69
93	189.41	186.89	196.87	191.37
94	195.89	191.54	203.96	195.54
95	202.70	196.81	210.89	201.77
96	209.49	200.24	217.12	206.75
97	217.85	205.64	226.97	210.89
98	225.48	209.97	235.69	215.96
99	233.37	215.60	244.21	221.24
100	238.85	222.19	256.06	228.49

TABLE III

AGE-SEX SPECIFIC MARRIAGE PROBABILITIES[3]

Age and previous marital status	Men	Women
First marriages		
14 - 17	.0030	.0241
18 - 19	.0713	.1534
20 - 24	.1843	.2305
25 - 44	.1254	.0958
45 - 64	.0144	.0099
65 and over	.0038	.0011
Widowed		
25 - 44	.2156	.0721
45 - 64	.0703	.0162
65 and over	.0159	.0021
Divorced		
14 - 24	.5470	.5154
25 - 44	.3434	.1874
45 - 64	.1072	.0424
65 and over	.0260	.0076

[3]Source: U. S. Public Health Service. Marriages, Trends, Characteristics. United States. Special Reports, Series 21, No. 21. Government Printing Office, Washington D.C.

TABLE IV

CUMULATIVE MARRIAGES PERCENTAGE DISTRIBUTION BY

AGE DIFFERENCE BETWEEN BRIDE AND GROOM[4]

Age Difference (in years)	F of Bride		R of Bride	
	F of Groom	R of Groom	F of Groom	R of Groom
Bride Younger				
20	.002	.052	.004	.032
15 - 19	.006	.117	.017	.085
10 - 14	.023	.271	.055	.210
5 - 9	.146	.603	.186	.445
4	.228	.694	.242	.507
3	.354	.777	.315	.574
2	.524	.843	.400	.639
1	.717	.894	.502	.707
Same Age	.878	.936	.602	.773
Bride Older				
1	.948	.958	.683	.827
2	.973	.969	.744	.864
3	.985	.978	.796	.896
4	.991	.984	.838	.919
5 - 9	.999	.995	.948	.975
10	1.000	1.000	1.000	1.000

Notation: F = First Marriage
R = Remarriage

[4]Source: U. S. Public Health Service. Marriages, Trends and Characteristics. United States. Special Reports, Series 21, No. 21. Government Printing Office, Washington D.C.

TABLE V

INTER-RACIAL MARRIAGE PROBABILITY MATRIX[5]

		Race of the other partner	
		White	Non-white
Race of one partner (given)	White	.9943	.0057
	Non-white	.0411	.9589

[5]Source: U. S. Public Health Service. Marriages, Trends and Characteristic. Special Reports, Series 21, No. 21. Government Printing Office, Washington D.C.

TABLE VI

PREVIOUS MARITAL STATUS PROBABILITY MATRIX[6]

Marital status and sex	Marital status of partner: Single	Previously married
Single		
Men	.916	.084
Women	.916	.084
Widowed		
Men	.163	.837
Women	.182	.818
Divorced		
Men	.359	.641
Women	.357	.643

[6]Ibid.

TABLE VII

PARITY DISTRIBUTION OF WOMEN[7]

Age (in years)	Parity 0	1	2	3	4	5	6	7
15 - 19	.935	.055	.009	.001	.000	.000	.000	.000
20 - 24	.554	.245	.134	.041	.012	.003	.002	.000
25 - 29	.215	.218	.281	.165	.073	.029	.012	.007
30 - 34	.098	.126	.254	.234	.144	.073	.037	.034
35 - 40	.090	.101	.225	.225	.157	.089	.064	.055
40 - 44	.108	.121	.232	.209	.139	.079	.067	.045

[7]Source: U. S. Public Health Service. Vital Statistics of the United States, Part A: Natality, Annual Volumes. Government Printing Office, Washington D.C.

TABLE VIII

MARRIAGE DURATION SPECIFIC DIVORCE PROBABILITIES[8] $\times 10^{-3}$

Marriage Duration (in years)	White Men	White Women	Non-white Men	Non-white Women
1	11	9	11	12
2	14	23	15	13
3	16	21	30	13
4	12	15	11	11
5	14	9	12	20
6	14	10	9	6
7	9	11	32	14
8	12	11	10	21
9	9	11	24	17
10	8	3	10	12
11	9	9	5	10
12	10	12	10	24
13	6	7	5	17
14	3	8	1	5
15	3	5	17	14
16 - 20	4	6	11	6
21 - 25	4	3	5	7
26 or more	2	2	5	2

[8]Source: U. S. Bureau of Census. Probabilities of Marriage, Divorce, and Remarriage. Current Population Reports. Special Studies, Series 23, No. 32, 1970. Government Printing Office, Washington D.C.

TABLE IX

AGE AT RETIREMENT CUMULATIVE DISTRIBUTION[9]

Age	Men	Women
62	.460	.670
63	.600	.750
64	.730	.820
65	.960	.950
66	.970	.960
67	.980	.970
68	.990	.980
69	.995	.990
70	1.000	1.000

[9]Source: Social Security Administration. Social Security Bulletin. No. 3, Vol. 35, March 1972. Government Printing Office, Washington D.C.

VITA

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Nguyen quang Hân

SOCIAL SECURITY AS AN INVESTMENT:

A MONTE CARLO INVESTIGATION

by

Han Quang Nguyen

(ABSTRACT)

This study addresses the problem of assessing the value of Social Security as an investment for an individual with given characteristics. The characteristics considered are age, sex, race, marital status, and salary earning history.

The problem formulation takes into account the uncertainties of human life, i.e., the probabilistic characteristics of the events that an individual may experience and may affect his tax payments and the benefits he will receive. These events are birth of a child, death, marriage, divorce, retirement, and disability onset. The measurements used are the individual expected rate of return and the overall population rate of return. The former is expected to be more important to an individual, while the latter is more significant to the Social Security Administration. The difficulties inherent in an analytic solution procedure to obtain numerical values for these rates are shown.

Using actual demographic and social security data, the use of the model is illustrated through case studies. The four cases examined, although hypothetical, represent large segments of the United States population. Additional analyses are performed to assess the value of separate components of the total benefits, including secondary, retirement, and disability-survivor benefits. The effect on the rates of return of the two factors, salary level and age of the individual, is examined.

A sensitivity analysis for five types of input data, birth, death, marriage, divorce and disability, is included.