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Cumulative Average Pricing Method for Estimating Average Service Life

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by

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CUMULATIVE AVERAGE PRICING METHOD OF ESTIMATING RETIREMENT PRICE

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The study determined if accuracy of estimation of retirement price of industrial equipment was affected by using a cumulative average pricing (CAP) method at varying conditions of inflation rate, service life, and life characteristics. The study also determined the accuracy of estimating the average life of unaged data by simulated plant record (SPR) method. Thirty-six experiments were conducted at varying conditions of inflation rate, curve type and average life. The study was conducted for two left modal curves, two symmetrical modal curves and two right modal curves at 20 and 40 years average life using three different inflation rates: 3%, 6%, and 9%.

The findings indicated that there is significant error in calculating the retirement price using CAP at high inflation rates. The SPR method can be used to approximate the life characteristics and average life of unaged data.

It was concluded that CAP method may be used to estimate the retirement price of unaged data when the inflation rate is less than 3%.

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CHAPTER I

INTRODUCTION

Background

Industry regularly installs new property and retires old property. Property may be retired due to wear out or new technologies that make the property obsolete. When financially accounting for retirement property, a price must be assigned for each unit of retired property. The dollar value placed on the retired property effects both the plant balance and the depreciation base. This information is used to calculate the depreciation accrual for the plant. Different pricing systems available so the choice of pricing methods should be made with full knowledge of cost and its consequences. (Wolf & Fitch, 1994, p. 210).

Pricing systems can be divided into two broad categories: (1) Pricing based on aged retirements, and (2) pricing based on unaged retirements. Pricing based on aged retirement provides more information on cost of a unit retired, but it also requires identification of the age of the unit, then using the historical cost to price the unit. So, the added cost of aged retirement depends on the physical characteristics of the property to be retired and the efficiency of the record-keeping system. National Association of Railroad and Utilities Commissioners (1968, p. 41) noted that "accurate and complete historical data are vital to the proper determination of retirement unit costs." Pricing by age accurately provides the retirement price and the age of the retired units.

Pricing based on unaged retirements eliminates the need for maintaining unit records from all vintage groups and requires less effort, as compared with pricing based on aged retirements for the units retired each year. The disadvantage is less information is available than in systems based on aged retirements. The short-run savings resulting from the reduced effort required by the unaged system are compensated by long term indirect costs that are difficult to estimate (Wolf & Fitch, 1994, p. 212).

Three methods can be used to price retirements based on unaged retirements: (1) first in first out pricing (FIFO), (2) last in first out pricing (LIFO), and (3) cumulative average pricing (CAP).

First In First Out Pricing

The first in first out (FIFO) method assumes the retired unit is the oldest unit in service. The unit is priced using average cost of the oldest vintage. Accuracy of this method in estimating the actual price relies on three factors. The first factor is inflation rates. The closer the inflation rates are to zero, the smaller the variations. The second factor is the shape of the survivor curve. If the life of each unit is equal to average life (which is also the maximum life), then the retired unit is the oldest unit and FIFO pricing is correct (Wolf & Fitch, 1994, p. 213). However, the FIFO method will not be accurate for any other curve because the average life is less than the maximum life and the retired unit is probably not the oldest unit. The third factor is the growth rates. Average age of the annual property retirements is stable at average life only when additions equal retirements. When the number of units is growing, the average age of annual retirements is less than the average age of the property. Thus, the greater the growth in units, the less accurate the assumption that the retirement unit is the oldest unit. Usually, the FIFO system will overestimate the age and, assuming a positive rate of inflation, underprice the retired units. "The accuracy of the FIFO pricing system is dependent upon the combination of the inflation rate, the curve shape, and the growth rate of the account" (Wolf & Fitch, 1994, p. 214).

Last In First Out Pricing

Last in first out pricing (LIFO) assumes that the retired unit is the most recent addition. This method underestimates the age of retired units, so along with a positive inflation rate, LIFO pricing overprices retirements. This method is rarely used to price retirements.

Cumulative Average Pricing

Cumulative Average Pricing(CAP) is a popular method of estimating the price of retirements. Unit costs are weighted by the number of additions-- but not their age. In a growing account and with a positive inflation rate, this average will have a tendency to underestimate the retirement cost. As with FIFO pricing, variation depends on the inflation rate, the shape of the survivor curve, and the growth of the account.

Inflation affects pricing retirements: With no inflation, estimating retirement price by any method produces the same result. LIFO method underestimates the service life and overestimates the retirement price. This method assumes that the retired unit is the most recent addition, thus, the higher the inflation rate the higher the estimate of retirement price. FIFO method overestimates the service life and underestimates the retirement price. Using this method, the retired unit is assumed to be the oldest unit. Using this method, high inflation results in underestimating the retirement price. LIFO and FIFO are two extreme methods in estimating the retirement price.

To understand the results of CAP, one must note important conditions, such as inflation rate, service life, types of survivor curve, and growth rates. The attempt, in this study, is to learn the effects of cumulative average pricing on the estimate of average service life using a hypothetical account. In this account, simulated conditions, such as life characteristics, inflation rate, and average life, were varied to allow the researcher to compare retirement price using unaged data with a cumulative average pricing to retiremnt pricing using aged data.

Problem Statement

There are two systems used to establish retirement price. One system is based on the age of the unit. The other systems does not require trackig the age of the retiring unit but it does use one of three methods FIFO, LIFO or CAP. These three methods rely on inflation rate, account growth, and shape of survivor curve to caluclate the retirement price.

> The importance of difference between the two types of system (i.e., the accuracy of the system) depends on factors that include the amount of difference in the price of the retirement, the additional cost of aging the retirement, the relative dollar value of the account, and the degree of important management places on estimates of depreciation. Though the immediate effect may be small, over time the cumulative error can become large, and effort required to evaluate and correct that error can be time-consuming and expensive (Wolf & Fitch, 1994, p. 216).

Purpose of the Study

The purpose of this study is to compare the effect of cumulative average pricing on the estimate of average service life with estimated life using aged retirement. The account is a simulated, hypothetical model with varied life characteristics, growth rate, and prices. The intent is to learn the accuracy of estimating retirement price by CAP versus estimating retirement price calculated by an actual system.

CHAPTER II

DESIGN AND METHODOLOGY

This chapter describes the design and methodology of this study beginning by reviewing the computer model designed by Shelly Brown (White, Houshyar & Brown, 1993), that was used in this study. Next is the explanation of how the computer model was used to compare the pricing methods based on aged data and unaged data in calculating units balance (number of units in use), units retired (number of units retired), dollar balance (value of units in operation), and dollars retired for vintage groups following the R2-5 Iowa curve. Addressed in this chapter is the extension to different Iowa curves at varying conditions of inflation rate and average life by extending the Lotus macro. Also explained in this chapter are the reasons for selecting the specific parameters and the scaling factors used to calculate plant balance and dollar balance of vintage groups with a service life more than 20 years. Finally, it explains how the simulated computer program was used to compare the average life estimated by both the actual method and the CAP method.

Brief Review of Shelly Brown Computer Model

Robley Winfrey (Late), a civil engineer in Ames, Iowa, developed 18 curves that show the percentage of survival of units as a function of age. The curves are now known as Iowa type curves. There are seven symmetrical curves (S0-S5), six left modal curves (L0-L5), and five right modal curves (R1-R5). These curves are depicted as tables using percent surviving at 1% intervals of the average life of the unit (Winfrey, 1967). Shelly Brown used this information to design the computer model used in this study

Shelly Brown, then a student in the Industrial Engineering Department, developed a Lotus macro that calculates the percentage of surviving units as a function of age. The macro calculates the percent surviving units to the maximum life of the specified curve type. The table of values containing percentage surviving at 1% intervals of the average life is shown in the textbook Depreciation Systems by Wolf & Fitch, 1994.

Computation of Plant Balance and Plant Retirement for R2-5 Iowa Curve

A hypothetical plant account was developed to study the accuracy of estimating the retirement price by the CAP method. The account consists of 500 units initially installed in the middle of year 1988. Each year the number of additions are increased by 3%. The life characteristics of the units follows the Iowa type curve R2 with average life of five years . It was assumed that only two transactions can occur: (1) the addition of new units, and (2) the retirement of installed units.

Table 1 shows the hypothetical account from the beginning of 1989 until 1998. The horizontal rows show the number of units remaining in the beginning of each year for property groups installed during the year. The first column shows the number of units, the second column of the table shows the year the unit was installed. This is also known as the placement year. The remaining vertical column shows the balance of units remaining in service at the beginning of each year. This is also known as the experience year. The total row shows the total number of units remaining at the beginning of each year. Table 2 shows the retirements at the end of each year and is the companion to Table 1.

Table 1

Units Remaining in Service at the Beginning of Calendar Year for R2 Modal Curve With Average Life of 5 Years

Plant Balances at the Beginning of Each Year											
Number of Units	Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
500	1988	494	477	446	395	319	217	112	37	4	0
515	1989		509	491	459	407	328	223	115	38	4
530	1990			525	506	473	419	338	230	118	39
546	1991				540	521	487	432	348	237	122
563	1992					557	536	502	445	358	244
580	1993						573	553	517	458	369
597	1994							590	569	532	472
615	1995								608	586	548
633	1996									626	604
652	1997										645

Table 2 shows vintage retirements at the end of the year, computed by subtracting the previous year unit balance. The horizontal rows show the units retired each year from 1988 to 1997 in the corresponding vintage years. The row indicating the total shows the total number of units retired at the end of each calendar year.

Table 2

Units Retired During Calendar Year for R2 Modal Curve
With Average Life of 5 Years

	Units Retired During Each Year									
Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1988	6	17	31	51	76	102	105	75	33	4
1989		6	18	32	52	79	105	109	77	34
1990			6	19	33	54	81	108	112	80
1991				6	19	34	55	84	111	115
1992					6	20	35	57	86	114
1993						6	21	36	59	89
1994							7	21	37	60
1995								7	22	38
1996									7	23
1997										7
Total	6	23	55	108	186	295	409	497	544	564

Computation of Dollar Balance and Dollar Retired for R2-5 Iowa Curve

Since the annual financial reports are shown in dollars, the retired unit reflects on the unit balance in dollars. Weighing each unit in dollars is necessary so that retirements, although are reported in units, are measured in dollars (Wolf & Fitch, 1994, p. 27). The unit price may increase each year because of general increases in costs of materials and labor. This shows the presence of inflation. An inflation rate of 6% was used in Table 3 to calculate the annual increase in unit cost. Table 3 shows the dollars remaining in service at the beginning of each year. This Table was calculated by allocating the initial unit cost of one dollar per unit plus increased cost of 6% every year, for example, $1.00 in year 1988 inflates to $1.06 in year 1989 and so on. The horizontal rows show the dollars remaining at the beginning of each year from 1989 to 1998 in each placement group. The vertical column shows the dollars remaining at the beginning of the year shown above the column from each placement group. The row indicating the total shows the total dollars remaining each year. Table 4 shows the dollar retirements during each year and is a companion to Table 3. Dollar retirements are computed by subtracting the present year dollar balance (before the new installation) from the previous year dollar balance.

Table 3

Dollar Remaining in Service at the Beginning of Calendar Year for R2 Modal Curve With Average Life of 5 Years

Dollar Balances at the Beginning of Each Year											
$	Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
500	1988	484	477	446	395	319	217	112	37	4	0
546	1989		540	520	487	431	348	237	122	40	4
596	1990			589	568	531	471	380	259	133	44
651	1991				644	620	580	514	415	282	145
710	1992					703	677	633	561	453	308
776	1993						767	739	691	613	494
847	1994							838	807	755	669
925	1995								914	881	824
1010	1996									998	962
1102	1997										1090
Total		494	1017	1555	2093	2604	3060	3452	3806	4160	4541

Table 4

Dollars Retired During Calendar Year for R2 Modal Curve With Average Life of 5 Years

Dollars Retired During Each Year										
Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1988	6	17	31	61	76	102	105	75	33	4
1989		6	19	34	55	85	111	115	82	36
1990			7	21	37	60	91	121	126	89
1991				7	23	40	66	100	132	137
1992					8	25	44	72	109	144

Table 4--Continued

Dollars Retired During Each Year										
Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1993						9	28	48	78	119
1994							9	30	53	86
1995								10	33	57
1996									11	36
1997										12
Total	3	23	57	113	199	320	454	571	657	720

Computation of Dollar Balance and Dollar Retired for R2-5 Iowa Curve by Cumulative Average Pricing

Since the age of each retirement is known, the balance from each placement year can be maintained. This is called aged data. These data represent accurate annual records of the dollars of units retired and those units remaining in service. With unaged data the number of retired units is known, but the age of each retired unit is not known. The matrix just above the row showing the total in Tables 1 and 2 is not known, but the total number of units in operation and number of units retired is known. These data do not accurately represent annual records of the dollars of units retired and those remaining in service unless the unit cost remains constant each year. Dollar balances in Table 3 and dollars retired in Table 4 were calculated by using the aged data. The cumulative average pricing (CAP) method was used to calculate dollar balance and dollars retired from unaged data.

Table 5

Calculation of the Price of Units Retired by Cumulative Average Pricing for R2 Modal Curve With Average Life of 5 Years

Start of Year Balance				Additions		Retirements	
Year (1)	Units (2)	Cost $ (3)	Avg $ (4)	Units (5)	Costs $ (6)	Units (7)	Cost $ (8)
1988	0	0.00	1.0000	500	500.00	6	6
1989	494	494.00	1.0000	515	546.00	24	25
1990	985	1016.00	1.0314	530	596.00	35	56
1991	1460	1556.00	1.0657	546	651.00	105	115
1992	1898	2092.00	1.1022	563	710.00	187	206
1993	2274	2596.00	1.1416	580	776.00	295	336
1994	2559	3036.00	1.1864	597	847.00	409	485
1995	2747	3398.00	1.2369	615	925.00	497	614
1996	2865	3709.00	1.2945	633	1010.00	544	704
1997	2954	4015.00	1.3591	652	1102.00	564	766
1998	3042	4351.00	1.4303				

Table 5 shows the dollar balance and dollars retired by CAP. This method uses the average unit cost of the unit to price the unaged retirements. It begins with current dollars and units in the account to calculate the initial average unit cost. Both unit balance and dollar balance at the beginning of year 1989 is 500. The average unit cost during year 1988 is calculated by dividing the dollar balance by the unit balance, this is one dollar. During the following year, 1989, the new average unit cost (also called the rolling average) was calculated by identifying the numbers of units and dollars added to the account. By recording the number of units retired, dollars retired was calculated by multiplying the number of retired units with current average unit cost. The new end of year unit balance was calculated by adding the additions to and subtracting the retired units from the start of year's balance. The end of year dollar balance was calculated the same way. The new rolling average was calculated by dividing the end of year dollar balance by the end of year unit balance; this is one dollar during year 1989. This procedure was repeated for each year to compute the dollar balance and the dollars retired. Table 5 illustrates these calculations. On January 1, 1991, there were 1460 units and $1556 in service. The average unit cost at the beginning of 1991 was $1.0657. During 1991 546 units costing $651 were placed in service. During the year 108 units were retired and priced at $1.0657 each, resulting in a total retirement cost of $115. On January 1, 1992, the new balance equalled the old balance plus additions less retirements. In units, this was 1460 + 546 - 108 = 1898 and in dollars it was $1556 + $651 - $115 or $2092. The new average unit cost was $2092 divided by $1898 or $1.1022.

This study was made for one property group with life characteristics most similar to the R2-5 curve pattern. In other words, units whose average life is five years. This provides an understanding of methods used based on aged data and unaged data to estimate the retirement price. The purpose of this study was to learn how accurate is the CAP method in estimating the retirement price for placement groups of average life ranges from 20-40 years.

Development of a Lotus Macro to Simulate a Continuous Property Group

To compare unit balances using aged data with the unit balances using the CAP method, it is necessary to generate tables similar to Tables 1, 2, 3, 4 and 5. The simulated plant record method was used to estimate the average service life (this is discussed in more detail in last paragraphs of this chapter). The Lotus macro, written by Shelly Brown, was modified because calculating unit balance is very complicated. Calculation must include units retired, dollar balance and dollars retired for each curve type, inflation rate, and average life. The information needed to generate these tables with the Lotus macro is a curve type, average life, inflation rate, growth rate, initial number of units, and initial cost of a unit. The modified program computes dollar balance and dollars retired for both the actual method and CAP. The limitation of this program is small size of the Lotus spreadsheet (3000 rows and 300 columns), it can be used only for curves whose maximum life is less than 40 years. The Lotus macro is shown in Appendix A.

Selection of Parameters

To help depreciation professionals to analyze the accuracy of unaged data they frequently encounter, two left modal curves, two right modal curves and two symmetrical curves were used in this analysis. The curves used were L1, L3, R1, R3, S1 and S3. The reason for using the low modal curves is that the life characteristics of the majority of industrial property closely follows the low modal curves (Marston, Winfrey & Hempstead, 1963).

The study was made for typical property groups whose average lives are 20 and 40 years, since the average life of most industrial property ranges from 20 to 40 years.

A simple model is to assume that prices increase at a constant annual rate. The urban consumer price index (CPI-U) is a familiar example of an inflation Index. The annual CPI-U rate was between 3% and 9% in 21 of the 30 years during the period 1961 through 1990 (Wolf & Fitch, 1994, p. 213). Also, based on the fluctuation of inflation rates in the last 10 years in USA and in other countries, the study was made for 3%, 6% and 9% inflation rates.

A total of 36 experiments were conducted at varying conditions of a curve type, average life, and inflation rate to compare the results of the actual method and the CAP method. The complete list of conducted experiments is shown in Table 6.

Scaling Factor Used in This Analysis

Since the size of the Lotus spreadsheet is small, a scale was developed for those survivor curves whose maximum life is more than forty years. This scaling factor was used to compare the results of the actual method and CAP for those survivor curves whose maximum life is more than forty years.

The unit balance, units retired, dollar balance, and dollars retired were calculated every two years instead of every year for right and symmetrical modal

Table 6

List of Experiments Conducted to Study the Results of Actual Method and CAP Method in Estimating the Service Life

List of Experiments			
Experiment Number	Curve Type	Inflation Rate	Service Life
1	L1	.03	20
2	L1	.06	20
3	L1	.09	20
4	L1	.03	40
5	L1	.06	40
6	L1	.09	40
7	L1	.03	20
8	L3	.06	20
9	L3	.09	20
10	L3	.03	40
11	L3	.06	40
12	L3	.09	40
13	SI	.03	20
14	SI	.06	20
15	SI	.09	20
16	SI	.03	40
17	SI	.06	40
18	SI	.09	40
19	S3	.03	20
20	S3	.06	20
21	S3	.09	20
22	S3	.03	40

Table 6--Continued

List of Experiments			
Experiment Number	Curve Type	Inflation Rate	Service Life
23	S3	.06	40
24	S3	.09	40
25	R1	.03	20
26	R1	.06	20
27	R1	.09	20
28	R1	.03	40
29	R1	.06	40
30	R1	.09	40
31	R3	.03	20
32	R3	.06	20
33	R3	.09	20
34	R3	.03	40
35	R3	.06	40
36	R3	.09	40

curves of 40 years average life and left modal curve of 20 years average life. Scaling factor was calculated for 4 years instead of two for left modal curve with average life of 40 years because the L1-40 curve has the maximum life of 126 years. Table 7 shows the list of vintage groups whose maximum life is more than 40 years.

The accuracy of the scaling factor was first tested for small curves to detect the accuracy of the model. The scaling factor was developed because the unit balance and the units retired were calculated every two years instead of every year. This modification doubles the one year rate of units (500) by two, equaling 1000 units every two year period. The scaling factor also considered the effect of inflation on the dollar balance and dollars retired every two years instead of every year. The formula for calculating the effect of inflation rate is $\{(1+i)(1+i)-1\}$ where i =inflation rate.

Table 7

Vintage Groups With Maximum Life of More Than 40 Years

Curve Type	Average Life	Maximum Life
L1	20	63
L1	40	126
L3	20	47
L3	40	94
R1	40	82
R3	40	68
S1	40	80
S3	40	77

The model was tested for accuracy with right, left and symmetrical curves with five and ten years average life. Slight variations in the estimate of dollar balance and dollars retired were found when using this scaling factor. The differences in the dollar balance and the dollars retired varied with the inflation rate. It was found that inflation rates of 3%, 6%, and 9% the scaling model overestimated the dollar balance and dollars retired. These differences were finally considered and the scaling models were adjusted using an adjustment formula ((1 + i)(1 + i) -1)+ i/16.

When an inflation rate was 3%, the new dollar balance was calculated by considering twice the units added and the inflation rate considered was ((1+.03)(1+.03)-1)+.015/8. When an inflation rate was 6%, the dollar balance was calculated using twice the unit added and the inflation rate considered was ((1+.06)(1+.06)-1)+.03/8. When the inflation rate was 9%, the dollar balance was calculated by using twice the unit added and the inflation rate considered was ((1+.09)(1+.09)-1)+.045/8. These inflation rates and units were used to compute the dollar balance for two years.

Since the left modal curves have the widest range of life. The similar method was used to calculate dollar balance for four years for left modal curves with 40 years average life.

Application of Simulated Plant Record (SPR) Method

Simulated plant record (SPR) method is a unique technique used to analyze unaged data. This method provides an indication of both the service life and the curve type, accounting for its widespread use for analyzing unaged data. The SPR model has two variations; to either simulate balances or retirements. In this study the balance was simulated to estimate both the retirement price and the curve type.

The program requires the history of the annual additions, retirements and the most recent account balance. Before the calculation can start, a test band must be specified. This test band defines the year in which balances are to be simulated. The closer the simulated balance to the observed balance, the more accurate the estimate of survivor curve, describing the life characteristic of the observed property. The program simulates for all the 18 Iowa type curves and gives the output as average life of all Iowa curves close to the simulated balance. The SPR program was used for estimating the average life by using dollar addition, retirement, and recent balance calculated by both the actual method and CAP in each of the 36 different experiments and the average life was calculated..

An example is presented to explain the principles of the SPR method when simulating balances. SPR computer output (shown in appendix B) was generated by simulating the balances estimated using cumulative average pricing method for account 31. This hypothetical account was generated by using Iowa R3-20 curve to calculate retirements. Before starting the simulated computer program a file was created using the history of annual additions, retirements, and recent balance (see Appendix C). The example test band begin with the year 1901 and extending to 1932, and simulated balances for every year.

The SPR program simulated balances for all the 18 Iowa curves and gave the simulated and observed balances for S5, L5, and R5 curves, since the observed balance more closely follows the simulated balance than the rest of the curves. The first column in the output shows the year in which the balances were simulated. The second and third columns show the simulated and observed balances. The deviation between the observed and simulated balances is shown in the column four. For example, in the year 1932, S5 curve, the simulated balance is $65822.2 and study balance is $62257 and the percentage difference between observed and study balance is 5.73. The program simulates balances from 1901 to 1932. This process was repeated for all curves and finally percentage survival versus years curve was plotted for those curves that the simulated balance is close to the observed balance shown in the computer output. (see Appendix B).

Analysis of SPR Output

The SPR program produces balances that simulate those that would result if the observed additions followed specific life characteristics. Since the SPR program uses all the 18 Iowa curves and closely matches each curve's observed balance, the selection of particular set of curves matched the observed balances better than those from other curves is based on conformance index and residual measure.

The conformance index (CI) is the statistic most often used to measure the goodness of fit. The conformance index is the average observed unit balance for the years in the test band divided by the residual measure. The residual measure is the square root of the average squared deviation and is proportional to sum of square deviation. The conformance index and residual measure is explained in more detail in Depreciation Systems by Wolf and Fitch.

Since the observed balance is independent of the curve used to simulate the balances, the CI is inversely proportional to the sum of squared deviations. Thus, the curve that reduces the sum of squared deviations will maximize the CI. The curve that best fit the observed balance is based on CI. A conformance index of 75 or more is said to be close based on experience (Bauhan, 1947).

In SPR output shown in appendix B the S5 curve with 13.7 years average life, L5 curve with 13.8 years average life, and R5 curve with 13.8 years average life have the highest CI of 17. These three curves most closely match with the observed balances as compared with the rest of the curves. Since according to Bauhan (1947) CI less than 25 is considered poor matching with the observed balance. Thus, it is sometimes difficult to interpret the SPR output. In this study an assumption was made in analyzing the SPR output that the survivor curve with highest CI more closely follows the life characteristics of observed balance than the rest of the curves.

Table 8 summarizes the SPR output based on a CI calculated using aged data. This table shows the CI and the average life of origin, left, right, and symmetrical modal curves that most closely match the observed balances.

It is clear from the Table 8 that as the inflation rate increases the conformance index also increases. For example L1-20 curve at 3% inflation rate closely matches with R1-19.8 having a conformance index of 142. At 6% inflation rate, the CI is 374, and at 9% inflation rate recorded the highest CI of 1222. It is also evident from Table 8 that when the average life was changed to 40 years all the four different modal curves have shown higher CI than at 20 years average life.

It can be observed from the results of this study that left, symmetrical, and right modal curves more closely matches with the observed balance than those of origin modal curves, since the origin modal curves have shown lower CI.

Table 8

Summary of SPR Experiments Conducted Using Aged Data
Based on Conformance Index

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
1	L1-20	.03	O1-20.6	L1-20	S0-19.8	R1-19.8
		CI	80	595	155	142
2	L1-20	.06	O1-21.4	L1-20	S0-19.8	R1-19.8
		CI	175	513	626	374
3	L1-20	.09	O1-22.8	L1-20	S1-18	R1-19.8
		CI	535	488	671	1222
4	L1-40	.03	O1-43.2	L1-40	S0-39.2	R1-39.2
		CI	203	514	652	393
5	L1-40	.06	O1-49.6	L1-40	S3-31.6	R4-31.2
		CI	1072	5790	1805	963
6	L1-40	.09	O1-59.2	L4-20.4	S0-39.6	R3-30
		CI	879	36302	9219	11138
7	L3-20	.03	O1-22.4	L3-20	S2-19.8	R3-19.8
		CI	21	470	286	137
8	L3-20	.06	O1-24.8	L3-20	S2-20	R3-19.8
		CI	39	14249	356	279
9	L3-20	.09	O1-28.8	L3-20	S2-20	R3-19.8
		CI	80	1088	379	730
10	L3-40	.03	O1-49.6	L3-40	S2-40	R3-39.6
		CI	40	101381	359	2
11	L3-40	.06	O1-70.2	L3-20	S3-38	R2-44
		CI	207	5510	1476	852
12	L3-40	.09	O1-113.6	L3-20	S2-40	R4-36.4
		CI	1556	1300	5576	5164

Table 8--Continued

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
11	L3-40	.06	O1-70.2	L3-20	S3-38	R2-44
		CI	207	5510	1476	852
12	L3-40	.09	O1-113.6	L3-20	S2-40	R4-36.4
		CI	1556	1300	5576	5164
13	S1-20	.03	O1-22.9	L2-20.3	S1-20.1	R2-19.9
		CI	21	336	169	183
14	S1-20	.06	O1-24.6	L2-20.3	S1-20	R2-19.9
		CI	33	299	2256	360
15	S1-20	.09	O1-27.4	L2-20.4	S1-20	R2-19.9
		CI	55	524	1692	632
16	S1-40	.03	O1-50.6	L2-40.6	S1-40	R2-39.8
		CI	33	284	1351	354
17	S1-40	.06	O1-63.4	L2-40.4	S2-40.2	R2-40
		CI	109	860	640	520
18	S1-40	.09	O1-83.8	L2-40.2	S1-40	R3-35.2
		CI	476	1408	3847	1329
19	S3-20	.03	O1-24.9	L4-19.9	S3-20.1	R4-19.9
		CI	14	281	346	161
20	S3-20	.06	O1-28.2	L4-19.9	S3-20.1	R4-19.9
		CI	23	468	523	24
21	S3-20	.09	O1-33.2	L4-20	S3-20	R4-39.6
		CI	38	414	888	523
22	S3-40	.03	O1-58.2	L4-39.8	S3-39.8	R4-39.4
		CI	23	395	637	260
23	S3-20	.06	O1-86	L4-39.6	S3-39.8	R4-39.6
		CI	77	1165	759	603
24	S3-20	.09	O1-141.2	L4-39.2	S3-40	R4-39.4
		CI	333	6304	2339	1976

Table 8--Continued

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
25	R1-20	.03	O1-21.8	L1-20.7	S0-20.1	R1-20
		CI	34	111	235	1390
26	R1-20	.06	O1-22.5	L1-20.5	S0-19.9	R1-20.1
		CI	54	192	303	406
27	R1-20	.09	O1-23.7	L1-20.3	S0-19.9	R1-20
		CI	92	324	395	1003
28	R1-40	.03	O1-45.2	L1-41.2	S0-39.8	R1-40
		CI	56	194	331	2684
29	R1-40	.06	O1-55	L1-38.2	S0-37.6	R1-39.8
		CI	843	2974	1074	846
30	R1-40	.09	O1-60.2	L1-41.2	S0-39.8	R1-40
		CI	880	190	395	2680
31	R3-20	.03	O1-27.6	L3-20.6	S2-20.4	R3-20
		CI	16	120	144	695
32	R3-20	.06	O1-30.6	L3-20.5	S2-20.3	R3-19.9
		CI	23	181	233	462
33	R3-20	.09	O1-34.8	L3-20.4	S2-20.3	R3-20
		CI	35	276	393	1372
34	R3-40	.03	O1-62.2	L3-41	S2-40.6	R3-40
		CI	24	191	244	2056
35	R3-40	.06	O1-82.8	L3-40.8	S2-40.6	R3-39.8
		CI	65	580	845	591
36	R3-40	.09	O1-118	L3-39.8	S2-40	R3-40.2
		CI	226	1685	939	1229

Table 9 summarizes SPR output based on CI calculated using the unaged data. The obtained results were different from that of aged data. The CI recorded for origin, left, symmetrical, and right modal curves remains almost the same despite the curve type, inflation rate and average life.

It is clear from the Table 9 that no other curve except L1-40 at 9% inflation rate showed a high CI. This may be due to the simulated balances poor match with the observed balances. Unlike aged data, the inflation rate does not affect the conformance index.

Table 9

Summary of SPR Experiments Conducted Using Unaged Data
Based on Conformance Index

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
1	L1-20	.03	O1-16.8	L3-15.8	S2-15.8	R2-15.8
		CI	19	23	23	23
2	L1-20	.06	O1-14.6	L5-12.6	S3-12.8	R5-12.3
		CI	22	23	23	23
3	L1-20	.09	O1-13.8	L4-11.4	S2-11.6	R1-12.6
		CI	38	38	38	38
4	L1-40	.03	O1-29.2	L4-25.6	S4-25.2	R3-26
		CI	22	23	23	23
5	L1-40	.06	O1-26.8	L3-21.6	S0-20	R2-22
		CI	81	82	81	82

Table 9--Continued

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
6	L1-40	.09	O1-26.8	L2-20.4	S6-17.6	R3-18.8
		CI	300	325	341	343
7	L3-20	.03	O1-17.6	L5-16	S5-16	R5-16
		CI	12	21	21	21
8	L3-20	.06	O1-15.2	L5-13.2	S6-13	R5-13
		CI	13	15	15	15
9	L3-20	.09	O1-13.8	L5-11.2	S6-11.2	R4-11.4
		CI	18	19	19	19
10	L3-40	.03	O1-30.4	L5-26	S5-26	R5-26
		CI	13	15	15	15
11	L3-40	.06	O1-26	L4-20.4	S4-20	R5-20
		CI	31	31	31	31
12	L3-40	.09	O1-26	L2-20	S5-17.6	R3-18.4
		CI	95	97	97	97
13	S1-20	.03	O1-19.3	L4-17.1	S2-17.4	R3-17.2
		CI	14	38	43	44
14	S1-20	.06	O1-17.4	L5-14.6	S3-14.8	R4-14.7
		CI	15	22	22	22
15	S1-20	.09	O1-15.8	L5-12.7	S4-12.6	R5-12.6
		CI	15	18	18	18
16	S1-40	.03	O1-35	L4-29.4	S3-29.6	R4-29.4
		CI	14	23	23	23
17	S1-40	.06	O1-29.4	L5-21.8	S5-21.8	R5-21.8
		CI	19	20	20	20

Table 9--Continued

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
18	S1-40	.09	O1-26.4	L5-18	S2-19	R5-17.8
		CI	30	30	30	30
19	S3-20	.03	O1-19.6	L5-17.2	S5-17.1	R5-17.2
		CI	10	27	27	27
20	S3-20	.06	O1-17.2	L5-14.6	S6-14.4	R5-14.6
		CI	10	15	15	15
21	S3-20	.09	O1-15.4	L5-12.4	S6-12.3	R5-12.3
		CI	12	13	13	13
22	S3-40	.03	O1-35	L5-29	S6-28.8	R5-29
		CI	10	15	16	16
23	S3-40	.06	O1-28	L5-21.2	S6-21	R5-21.2
		CI	15	15	15	15
24	S3-40	.09	O1-25.2	L3-18.6	S4-17.4	R3-18.2
		CI	26	26	26	26
25	R1-20	.03	O1-19.3	L2-18	S1-17.8	R2-17.6
		CI	20	41	50	53
26	R1-20	.06	O1-17.8	L3-15.4	S2-15.5	R2-15.8
		CI	19	27	28	28
27	R1-20	.09	O1-17.8	L3-15.3	S2-15.2	R2-15.6
		CI	19	26	27	27
28	R1-40	.03	O1-30.4	L4-22.8	S5-22.2	R3-23.4
		CI	22	23	23	23
29	R1-40	.06	O1-30.4	L4-22.8	S5-22.2	R3-23.4
		CI	22	23	23	23

Table 9--Continued

Experiment	Curve Type	Inflation Rate	Curves Matched With Observed Balances			
30	R1-40	.09	O1-33	L4-26.4	S2-26.4	R3-26.8
		CI	19	22	22	22
31	R3-20	.03	O1-22.5	L4-17.9	S4-17.8	R4-17.8
		CI	11	41	44	47
32	R3-20	.06	O1-20.1	L5-15.8	S5-15.7	R5-15.7
		CI	11	22	23	23
33	R3-20	.09	O1-18.2	L5-13.8	S5-13.7	R5-13.8
		CI	12	17	17	17
34	R3-40	.03	O1-39.8	L5-31.2	S5-31	R5-31
		CI	11	22	22	22
35	R3-40	.06	O1-32.4	L5-23.6	S5-23.4	R5-22.4
		CI	13	15	15	15
36	R3-40	.09	O1-28.8	L5-18.8	S5-18.6	R4-19.2
		CI	19	20	20	20

CHAPTER III

RESULTS AND DISCUSSION

This chapter summarizes the study results and reviews the implication for depreciation professionals using CAP in estimating the retirement price of industrial equipment. The purpose of this study was to compare the effect of CAP on the estimate of retirement price with the actual method, using varying condition of a life characteristic, average life, and inflation rate. The goal was to learn if there was a difference in estimating the retirement price between the actual method and cumulative average pricing.

Results

The raw data analyzed were the average service life estimated by both the actual method and the cumulative average pricing method. A simulated plant record (SPR) computer program was used to estimate the average service life at varying conditions by curve type, inflation rate, and average life. Total of 36 experiments were conducted (see Table 6) and the effect of life characteristic, inflation rate, and the average life on the estimate of average service life by cumulative average pricing method was studied. The results of this study are shown in Table 7.

Actual Method

Average retirement price estimated by actual method is given in Table 7. The actual method estimates the retirement price accurately despite the curve type, inflation rate, and the average life. These results were obtained by using the simulated plant record program. The program simulates for all the 18 Iowa type curves and gives the output as average life of all Iowa curves close to the simulated balance.

Cumulative Average Pricing

Average service life is estimated by cumulative average pricing method and the percentage error in calculating the average service is given in Table 10. For left modal curves, the percentage error in calculating the average service ranges from 20% to 53%. For symmetrical curves, the percentage error varies from 11% to 55.5%. The percentage error for right modal curves varies from 8.5% to 50.5% depending on the average life and the inflation rate.

Discussion

This study was conducted by developing a hypothetical account. The account initially has a zero balance and starts with an addition of 500 units every year. This study was made by assuming that only two transactions can occur, i.e., addition of new units and the retirements of old units. The SPR program was used to estimate the average service. The SPR model produces balances that simulate those that would result if the observed additions followed specific life characteristics. The simulated balances are compared with the observed balances that result from the unknown life characteristics that have to be estimated.

Table 10

Results of Experiments Conducted to Study the Accuracy of CAP in Estimating the Retirement Price

Percentage Error in Calculating Retirement Price by CAP			
Curve Type	Average Life in Years	Inflation Rate in Percentages	Percentage Error
L1	20	3	20
L3	20	3	18
S1	20	3	11
S3	20	3	13.5
R1	20	3	8.5
R3	20	3	9.5
L1	20	6	33
L3	20	6	32
S1	20	6	24
S3	20	6	26.5
R1	20	6	18.5
R3	20	6	19

Table 10--Continued

Percentage Error in Calculating Retirement Price by CAP			
Curve Type	Average Life in Years	Inflation Rate in Percentages	Percentage Error
L1	20	9	40
L3	20	9	39
S1	20	9	34
S3	20	9	36
R1	20	9	27
R3	20	9	28.5
L1	40	3	33
L3	40	3	33
S1	40	3	24
S3	40	3	29
R1	40	3	18
R3	40	3	20
L1	40	6	42
L3	40	6	47
S1	40	6	44
S3	40	6	47
R1	40	6	36

Table 10--Continued

Percentage Error in Calculating Retirement Price by CAP			
Curve Type	Average Life in Years	Inflation Rate in Percentages	Percentage Error
R3	40	6	38.5
L1	40	9	43
L3	40	9	53
S1	40	9	49.5
S3	40	9	55.5
R1	40	9	47
R3	40	9	50.5

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATION

Summary

The purpose of this study was to learn the accuracy of estimating the retirement price by cumulative average pricing. The results of cumulative average pricing were tested for two left modal, two right modal, and two symmetrical modal curves at an inflation rate of 3%, 6%, and 9% and at an average life of 20 years and 40 years.

It was learned that the cumulative average pricing (CAP) method overestimates the retirement price. This method is more sensitive to the inflation rate than service life and life characteristics of the unit. The higher the inflation rate, the higher will be the error in calculating the retirement price. Since it underestimates the average service life, cumulative average pricing results in overestimating the price of the retired units. The magnitude of error depends directly on inflation rate.

Conclusions

A simulated plant record (SPR) method can be used accurately to detect the life characteristic and average life of unaged data. This factor is evident when the SPR method was used to study the life characteristic of aged data.

CAP method is simple and easy to understand. The accuracy of estimating the retirement price depends mainly on inflation rates. Depreciation professionals concerned the accuracy of retirement price may not use CAP method to estimate the retirement price.

CAP can be preferred to actual method when the inflation rate is 3% or less and average life is less than 20 years to estimate the retirement price since it requires less effort as compared with actual method.

Recommendation

Depreciation professionals should think twice before using CAP in estimating the retirement price. The immediate effect may be small but over time the error is cumulative and has a significant impact on plant balance. The study reveals that the CAP cannot be used for estimating the retirement price when there is a high inflation rate.

Appendix A

Lotus Macros Used to Compute Dollar Balance

```
go          {windowsoff}{paneloff}
            {GETLABEL "Enter Curve Type..",C_TYPE}
            {GETNUMBER "Enter Average Life..",AVG_LIFE}
            {GETNUMBER "Enter Growth Rate..",GR_RATE}
            {GETNUMBER "Enter Inflation
            Rate..",INF_RATE}
            {GETNUMBER "Enter Initial Number of

            Units..",INT_UNIT}
            {GETNUMBER "Enter Cost of Unit..",COST_UNIT}
            {branch \a}
            {windowsoff}{paneloff}{calc}/rea211.c1000~
            /rec208.c210~
            {goto}curves~

LOOP2       {if@cellpointer("type")="b"}{goto}a1120~
            {windowson}{panelon}

            @cellpointer("contents")=curvetype}/c{end}
            {down}~dest~{branch loop1}{right}{branch
            loop2}
LOOP1       {let count,1}
            {goto}top~
            {if @mod(100,life*2)>0}{calc}{let
            count,0.5}{branch interp}
            {down 100/life/2}/c~{left}{end}{up}{down}~
LOOP3       {goto}top~{down
            100/life/2+100/life*(count-1)+1}
            {if @cellpointer("type")="b"}{left}{end}{up}
            {down}0~{branch end}{let count,counT+1}
            {down 100/life-1}/c~{left}{end}{up}{down}~
            {let count,count+1}{branch loop3}
            /dfage~0.5~1~count~
            {let max,count}{home}
            /ca211..b375~b25..c180~{branch \c}
            {windowson}{panelon}

\c          {goto}cq3~+e10
            {for counter,2,count,1,grthrate}{branch

             matmult}

            grthrate {d}+{u}*(1+e8)~

matmult     {goto}cr3~/dmm{home}{pgdn}{d 4}
            {r 2}.{end}{d}~cq3{goto}cr3~/rt{end}{d}~~{d}
            /re{end}{d}{for counter,1,count-1,1,macro_r}
            {d 2}{branch add}

macro_r     {r}
```

```
            /dmm{u}~{d}~{d}{r}~
            /rt{end}{d}~~{d}
            /re{end}{d}~

add         +@sum({u}.{end}{u}{end}{u}~)~{l}
            {FOR COUNTER,1,count-1,1,sum}TOTAL{d 2}
            {branch cap}

sum         ~/c{esc}{r}~~{l}

\e          /reb25..c34~
            /recq3..da12~

cap         PLANT RETIRED DURING CALENDER YEAR~{D 2}{R}~
            +cq3-cr3~{r}/c{ESC}{l}~~
           {forcounter,2,count-1,1,copy}{d}+1~{d}/c{esc}
            {u}~.{d 100}~{branch nextrow}

copy        {r}/c{esc}{l}~~

nextrow     {let count,count-1}
            {for counter,1,count,1,moveleft}
            {d}{r}{u 2}{branch endup}

moveleft {l}

endup       {l}{r}+{end}{u}{end}{u}{end}{u}{end}{l}
            {l}{r}-{end}{u}{end}{u}{end}{u}~
            {r}+{end}{u}{end}{u}{end}{u}{u}{l}-{end}
            {u}{end}{u}{end}{u}{u}~{r}
            /c{esc}{l}~.{end}{r}~{l}{d}{BRANCH RET}

RET         {for counter,1,count-4,1,matrix}
            {BRANCH REST}

MATRIX
            +{END}{U}{END}{U}{END}{U}{END}{U}{END}
            {U}{END}{U}{END}{U}{END}{U}~{R}+{END}
            {U}{END}{U}{END}{U}{END}{U}{U}{L}-{END}
            {U}{END}{U}{END}{U}{END}{U}{U}~{R}
            /C{ESC}{L}~.{END}{R}~{L}{D}

REST        +{END}{U}{END}{U}{END}{U}{END}{U}
           {END}{L}-{END}{U}{END}{U}{END}{U}{END}{U}~
           +{END}{U}{END}{U}{END}{U}{END}{U}{U}{L}-{END}
           {U}{END}{U}{END}{U}{END}{U}{U}~{R}
           /C{ESC}{L}~~{L}{D}
           +{END}{U}{END}{U}{END}{U}{END}{U}{END}
           {L}-{END{U}{END}{U}{END}{U}{END}{U}~{R}
           +{END}{END}{U}{END}{U}{U}{L}-{END}{U}{END}{U}
```

```
        {END}{U}{U}~{D}+{END}{U}{END}{U}
        {END}{U}{END}{U} -{END}{U}{END}
        {U}{END}{U}~{D}/RE{END}
        {D}~{D 2}{BRANCH SUM1}

SUM1    +@SUM({U}.{END}{U}{END}{U}~)~{L}
        {FOR COUNTER,1,COUNT,1,SUM2}TOTAL
        {BRANCH DOL}

SUM2    ~/C{ESC}{R}~~{L}

DOL     DOLLAR REMAINING~{D 2}{L 2}+E11~{D}
        {FOR COUNTER,1,COUNT,1,DOL1}{END}{U}
        {END}{U}{R}
        {BRANCH DOL2}


DOL1    +{U}*(1+E9)~{D}

DOL2    +E10~{D}{FOR

        COUNTER,1,COUNT,1,DOL3}{END}{U}{END}{U}{R}
        {BRANCH DOL4}


DOL3    +{U}*(1+E8)~{D}

DOL4    +{L}*{L 2}~{D}
        {FOR COUNTER,1,COUNT,1,DOL5}
        {end}{u}{end}{u}{r}
        {branch mat}

DOL5    +{L}*{L 2}~{D}

        /dmm.{end}{d}~{end}{d}{end}{d}{End}{d}{end}
        {d}{end}{d}~
        {end}{d}{end}{d}{end}{d}{end}{d}{end}{l}
        {end}{d}{end}{d}{r}~
        /rt.{end}{d}~~{d}/re{end}{d}~{r}

        /dmm{u}~{d}~{d}{r}~/rt.{end}{d}~~{d}/re{end}
        {d}~{r}{for counter,1,count-1,1,matr}
        /re{end}{u}{end}{r}{end}{u}~{l}{d 2}
        {branch drt}

matr    /dmm{u}~{d}~{d}{r}~/rt.{end}
        {d}~~{d}/re{end}{d}~{r}

drt     +@sum({u}.{end}{u}{end}{u}~)~{l}
        {for counter,1,count,1,dsum}TOTAL
        {D 2}{BRANCH DRT2}
```

```
DSUM      /C{ESC}{R}~~{L}

DRT2      DOLLAR RETIRED DURING CALENDER YEAR~
          {D 2}{R}~+{END}
          {U}{END}{U}{L}-{END}{U}{END}{U}~{R}
          /C{ESC}{L}~~
          {FOR COUNTER,2,COUNT,1,COPY2}{D}+1~{D}
          /C{ESC}{U}~.{D}
          {BRANCH NEXT}

COPY2     {R}/C{ESC}{L}~~

NEXT      {LET COUNT,COUNT-1}
          {FOR COUNTER,1,COUNT+1,1,MOVELFT}{D}{R}{U 2}
          {branch drt3}

          MOVE LFT {L}

drt3

          {l}{r}+{end}{u}{end}{u}{end}{u}{end}
          {l}{l}{r}-{end
          {end}{u}{end}{u}~{r}+{end}{u}{end}{u}
          {end}{u}{u}  -{end}{u}{end}{u}{end}{u}
          {u}~{r}/c{esc}{l}~.{end}
          {r}~{l}{d}{BRANCH DRT4}

DRT4      {FOR COUNTER,1,COUNT-3,1,matrix2}
          {branch rest2}

MATRIX2   +{end}{u}{end}{u}{end}{u}{end}{u}{end}
          {l}-{end}{u}
          {end}{u}{end}{u}{end}{u}~{r}+{end}
          {u}{end}{u}{end}{u}{end}{u}{u}{l}
          -{end}{u}{end}{u}{end}{u}{end}{u}{u}~{r}
          /c{esc}{l}~.{end}{r}~{l}{d}

rest2     +{end}{u}{end}{u}{end}{u}{end}
          {u}{end}{l}-{end}{u}
          {end}{u}{end}{u}{end}{u}~{r}+{end}{u}
          {end}{u} {end}{u}{end}{u}{u}{l}
          -{end}{u}{end}{u}{end}{u}{end}{u}{u}~{r}
          /c{esc}{l}~~{l}{d}+{end}{u}{end}{u}{end}
          {u}{end}{u}{end}{l}-{end}{u}{end}{u}
          {end}{u}{end}{u}~{r}+{end}{u}{end}{u}
          {end}{u}{u}{l}-{end}{u}
          {end}{u}{end}{u}{u}~{d}+{end}{u}{end}{u}
          {end}{u}{end}{l}
          -{end}{u}{end}{u}{end}{u}~{d}/re{end}{d}~{d

          2}{branch sum4}
```

```
SUM4     +@sum({u}.{end}{u}{end}{u}~)~{l}
         {for counter,1,count+1,1,sum5}TOTAL
         {D 2}{branch Cumlative}

SUM5     ~/C{ESC}{R}~~{L}

         DOLLAR REMAINING IN SERVICE BY C.A.P{D 2}{L}
        +{END}{U}{END}{U}{r}~
            {forcounter,1,count+1,1,copy3}{end}{u}{r}
             +{END}{U}{END}{U}{end}{u}{end}{u}{end}
             {u}{end}{u}/+cq3~ {r}+{end}{u}{end}{u}
             {end}{up}/+{end}{u}{end}{u}{end}{u}{end}
             {u}{end}{u}{end}{u}{end}{u}

              {D}/c{esc}{u}~~

              {r}/c{esc}{l}~~

              {END}{l}{R 2}/RT{end}{r}~{l}{d}~
              /re{end}{r}~{l}{end}{d}{d 4}
             PLANT RETIRED  BY C.A.P~

           +{END}{u}{end}{u}{end}{u}~{d}/c{esc}{u}~~
            {for counter,1,count,1,cum4}{BRANCH CUM5}

    CUM4      {D}/C{ESC}{U}~~

    CUM5   {GOTO}CQ3~{END}{D}{END}{d}{end}{d}{end}{d}
           {r}/rt.{end}{r}~

           {end}{d}{end}{d}{end}{d}{end}{d}{l}
           {d}{end}{d}{end}{d}
           {end}{d}{end}{d}{l}~{end}{d}{end}{d}
           {end}{d}{end}{d}{l}{end}{d}{end}{d}
           {l}{end}{d}{end}{d}{l}{branch cum6}

   CUM6      +{r}*{r 2}~{D}/C{ESC}{U}~~
             {FOR COUNTER,1,COUNT,1,CUM7}
              {end}{u}/rt{end}{d}~{end}{d}

              ~{r}{end}{u}{end}{u}{l}~
              +{end}{d}~{d}/c{esc}{u}~~
              {for counter,1,count,1,cum8}
              {end}{u}{l}-{r}+{r 2}~
              {d}+{u}-{r}+{r 2}~
              {for counter,1,count,1,cum9}
              {end}{u}/rt{end}{d}~{end}{r}{end}{d}
```

Appendix B

Output of Simulated Plant Record (SPR) Computer Program

```
** SIMULATED PLANT BALANCES METHOD COMPUTER PROGRAM **

DO YOU WANT TO SEE NECESSARY DIRECTIONS FOR YOUR RESPONSES?  n


CARRIERS     - ENTER UP TO 10 (EG.  787,389,105)
               (FOR REGIONS ENTER  0  & RETURN)
                                                          :  259

ACCOUNT      - ENTER  1  NUMBER (EG.  13)
                                                          :  31

               DO YOU WANT OPTIONS?  n

PLACEMENT YEARS 1900-1932     EXPERIENCE YEARS 1901-1932

            ENTER NUMBER OF BANDS (UP TO 5)
                                                          :  1

BAND # 1 - ENTER BOUNDARY YEARS, SEPARATED BY A COMMA (EG. 1970,1978)
                                                          :
1901,1932
            INCREMENT (EG.  4 = EVERY 4TH YEAR)
                                                          :  1

YOUR OUTPUT IS BEING PREPARED USING THE FOLLOWING INPUT FILES

P00259.031

*******************************************************************************


SIMULATED PROGRAM  5/ 3/95
SIMULATED PLANT-RECORD ANALYSIS
SIMULATED  V1.1.0  MS FORTRAN 4.0

CARRIERS     -
             259  LOUISVILLE & NASHVILLE R.R.CO.
ACCOUNT      -
             31   POWER-TRANSMISSION SYSTEMS

ACCOUNT CONTROL INFORMATION
------- ------- -----------
EARLIEST ADDITION   = 1900    LATEST ADDITION   = 1932
EARLIEST BALANCE    = 1901    LATEST BALANCE    = 1932
EARLIEST RETIREMENT = 1901    LATEST RETIREMENT = 1932    INPUT = ADD & RET



*******************************************************************************


SIMULATED PROGRAM   5/ 3/95
SIMULATED PLANT-RECORD ANALYSIS
SIMULATED  V1.1.0  MS FORTRAN 4.0

SIMULATED BALANCES METHOD
```

CARRIERS -
259 LOUISVILLE & NASHVILLE R.R.CO.
ACCOUNT -
31 POWER-TRANSMISSION SYSTEMS

ANALYSIS BAND = 1901 THRU 1932 INCREMENT = 1

DISP	MEAN	SSD	IV	CI	REI
S4	13.9 YRS.	.5711E+08	58.42	17	100.00
S5	13.7 YRS.	.5684E+08	58.28	17	100.00

YEAR	SIM BAL	STUDY BAL	PCT DIFFER
1932	65822.6	62257.	5.73
1931	60387.6	57866.	4.36
1930	55401.6	53830.	2.92
1929	50827.2	50109.	1.43
1928	46630.7	46666.	-.08
1927	42780.2	43463.	-1.57
1926	39247.5	40467.	-3.01
1925	36006.4	37647.	-4.36
1924	33033.0	34975.	-5.55
1923	30305.0	32429.	-6.55
1922	27802.6	29994.	-7.31
1921	25507.2	27659.	-7.78
1920	23401.5	25421.	-7.94
1919	21469.6	23279.	-7.77
1918	19696.8	21235.	-7.24
1917	18069.7	19293.	-6.34
1916	16573.8	17457.	-5.06
1915	15186.7	15727.	-3.44
1914	13871.7	14104.	-1.65
1913	12583.8	12585.	-.00
1912	11294.3	11168.	1.13
1911	10010.8	9850.	1.63
1910	8766.7	8625.	1.64
1909	7594.8	7489.	1.41
1908	6510.8	6438.	1.13
1907	5515.0	5467.	.88
1906	4601.0	4570.	.68
1905	3762.0	3743.	.51
1904	2993.0	2982.	.37
1903	2287.0	2281.	.26
1902	1639.0	1636.	.18
1901	1045.0	1044.	.10

DISP	MEAN	SSD	IV	CI	REI
S6	13.6 YRS.	.5687E+08	58.30	17	100.00
L3	14.5 YRS.	.6317E+08	61.44	16	99.99
L4	14.0 YRS.	.5845E+08	59.10	16	100.00
L5	13.8 YRS.	.5716E+08	58.45	17	100.00

YEAR	SIM BAL	STUDY BAL	PCT DIFFER
1932	65813.3	62257.	5.71
1931	60379.1	57866.	4.34
1930	55393.8	53830.	2.91
1929	50820.0	50109.	1.42
1928	46624.1	46666.	-.09
1927	42774.1	43463.	-1.59
1926	39241.9	40467.	-3.03
1925	36001.4	37647.	-4.37
1924	33028.3	34975.	-5.57
1923	30300.7	32429.	-6.56
1922	27798.7	29994.	-7.32
1921	25503.4	27659.	-7.79
1920	23397.0	25421.	-7.96
1919	21462.7	23279.	-7.80
1918	19683.5	21235.	-7.31
1917	[illegible]	[illegible]	[illegible]

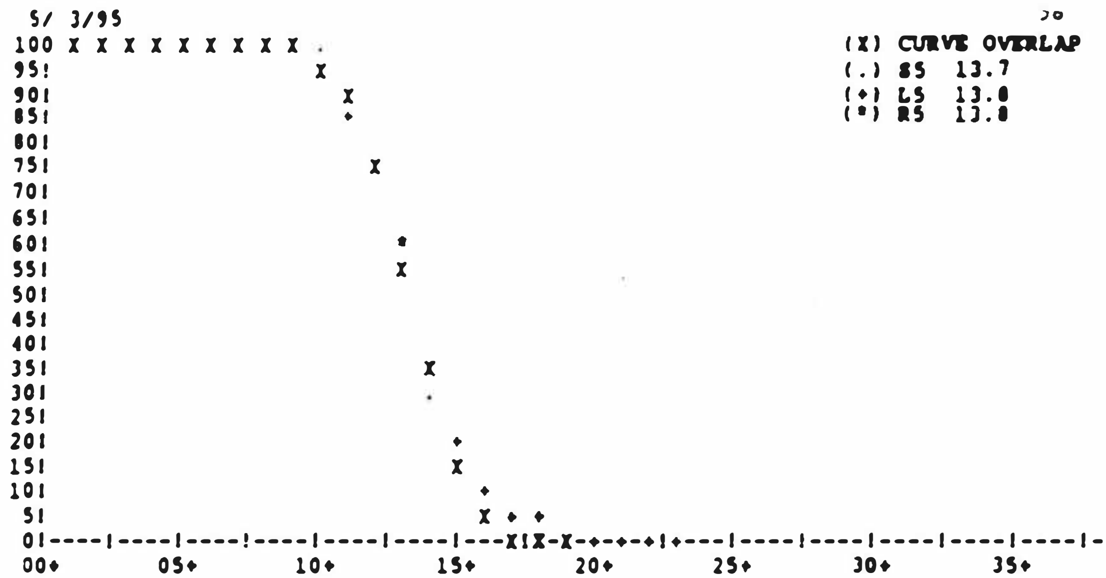
1916	16523.9	17457.	-5.35
1915	15108.1	15727.	-3.94
1914	13772.0	14104.	-2.35
1913	12482.5	12585.	-.81
1912	11208.8	11168.	.37
1911	9949.5	9850.	1.01
1910	8732.2	8625.	1.24
1909	7581.2	7489.	1.23
1908	6507.6	6438.	1.08
1907	5514.6	5467.	.87
1906	4601.0	4570.	.68
1905	3762.0	3743.	.51
1904	2993.0	2982.	.37
1903	2287.0	2281.	.26
1902	1639.0	1636.	.18
1901	1045.0	1044.	.10

R3	14.3 YRS.	.5898E+08	59.37	16	100.00
R4	14.0 YRS.	.5721E+08	58.47	17	100.00
R5	13.8 YRS.	.5677E+08	58.25	17	100.00

YEAR	SIM BAL	STUDY BAL	PCT DIFFER
1932	65900.1	62257.	5.85
1931	60458.7	57866.	4.48
1930	55466.8	53830.	3.04
1929	50887.0	50109.	1.55
1928	46685.6	46666.	.04
1927	42830.5	43463.	-1.46
1926	39293.6	40467.	-2.90
1925	36048.8	37647.	-4.25
1924	33071.8	34975.	-5.44
1923	30340.6	32429.	-6.44
1922	27835.3	29994.	-7.20
1921	25537.3	27659.	-7.67
1920	23429.1	25421.	-7.84
1919	21494.8	23279.	-7.66
1918	19720.0	21235.	-7.13
1917	18091.4	19293.	-6.23
1916	16593.6	17457.	-4.95
1915	15200.6	15727.	-3.35
1914	13867.9	14104.	-1.67
1913	12552.7	12585.	-.26
1912	11245.2	11168.	.69
1911	9964.5	9850.	1.16
1910	8737.0	8625.	1.30
1909	7581.2	7489.	1.23
1908	6506.5	6438.	1.06
1907	5514.1	5467.	.86
1906	4600.9	4570.	.68
1905	3762.0	3743.	.51
1904	2993.0	2982.	.37
1903	2287.0	2281.	.26
1902	1639.0	1636.	.18
1901	1045.0	1044.	.10

O1	18.2 YRS.	.1132E+09	82.26	12	89.20
O2	20.5 YRS.	.1162E+09	83.34	11	81.67
O3	27.8 YRS.	.1314E+09	88.62	11	69.87
O4	36.0 YRS.	.1378E+09	90.76	11	65.30

HIT RETURN KEY WHEN DONE VIEWING:


5/ 3/95
(X) CURVE OVERLAP
(.) RS 13.7
(+) LS 13.8
(*) RS 13.8
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
00+
05+
10+
15+
20+
25+
30+
35+

Appendix C

Example of Files to Run SPR Program

1900,11,	500.
1901,11,	545.
1902,11,	594.
1903,11,	648.
1904,11,	706.
1905,11,	769.
1906,11,	839.
1907,11,	914.
1908,11,	996.
1909,11,	1086.
1910,11	1184.
1911,11,	1290.
1912,11,	1406.
1913,11,	1533.
1914,11,	1671.
1915,11,	1821.
1916,11,	1985.
1917,11,	2164.
1918,11,	2359.
1919,11,	2571.
1920,11,	2802.
1921,11,	3054.
1922,11,	3329.
1923,11,	3629.
1924,11,	3956.
1925,11,	4312.
1926,11,	4700.
1927,11,	5123.
1928,11,	5584.
1929,11,	6086.
1930,11,	6634.
1931,11,	7231.
1932,11,	7882.
1900,61,	0.
1901,61,	1.
1902,61,	2.
1903,61,	3.
1904,61,	5.
1905,61,	8.
1906,61,	12.
1907,61,	17.
1908,61,	25.
1909,61,	35.
1910,61,	48.
1911,61,	65.
1912,61,	88.
1913,61,	116.
1914,61,	152.
1915,61,	198.
1916,61,	255.
1917,61,	328.
1918,61,	417.
1919,61,	527.
1920,61,	660.
1921,61,	816.
1922,61,	994.
1923,61,	1194.
1924,61,	1418.
1925,61,	1640.
1926,61,	1880.
1927,61,	2127.
1928,61,	2381.
[illegible]	[illegible]

[illegible]	[illegible]
1932,61,	3491.
1932,99,	62257.

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