A New Approach for a Forecasting Model in the Estimation of Social Security Benefits

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This paper developed a new way in which Social Security benefits are estimated in response to the reforms to Social Security to retain its financial solvency. The present research carefully presented the current methodology to calculate the Social Security benefits and carefully examined changes to the methodology to estimate Social Security benefits. More specifically, the proposed methodology included functional specifications such as a linear spline, a cubic spline, and a cubic smooth function that would be fitted between the index factor and the cumulative number of years a beneficiary receives the benefits. After a functional relationship was derived, the best fit specification was determined based on the data used to estimate future Social Security benefits.

INTRODUCTION

Social Security benefits are an important factor to be considered for a person planning to retire. The foundation of retirement is based on a three-legged stool: Social Security, employer-sponsored retirement benefits, and personal savings. Social Security benefits play a critical role in one's retirement plan. Hence, a critical study of the basis of calculation of Social Security benefits is useful. The methodology used in calculating Social Security benefits is discussed first, detailed steps are provided second, and finally, a practical example is considered in the calculation of the benefits. Then, the existing methodology (the old approach) is discussed. Lastly, suggestions for improvement of the existing model are suggested.

EXISTING RESEARCH

The providing of social security retirement benefits is a major government program in every industrialized nation. In fact, in the United States, this program accounts for more than 20% of the federal budget. The underlying principle for such programs is that some people lack the foresight to save for their retirement years. These programs do not come without costs for these governments, but the difficulties arise determining an optimal level of benefits against the costs. In addition, these benefits have as many provisions that can create large variations in the effective marginal tax rate for otherwise very similar people (Boskin et al., 1987; Feldstein and Samwick, 1992). Given these provisions, Liebman, Luttner, and Seif (2009) exploited these discontinuities of these five provisions of the Social Security benefits formula:

1. Social Security benefits depend on only the 35 highest years of indexed earnings, thus creating jumps in effective Social Security tax rates that depend on which years are included among the 35 highest years.
2. A person receives total benefits that are the greatest of either 100 percent of the person's own retired worker benefits or 50 percent of the benefit of the individual's spouse; thus, there is a discontinuity in the benefits around the point where the Social Security benefit of one spouse is doubled that of the other spouse.
3. The provisions governing Social Security benefits for widows create discontinuities in marginal benefits.
4. The kink points in the Social Security benefits schedule create discontinuities in marginal benefits.
5. There is a discontinuity at the point where the person reaches sufficient quarters of earnings (generally 40, but lower for earlier cohorts) to become fully vested.

These provisions create discontinuities when determining the effective Social Security tax rate under the assumption there is no uncertainty about the future labor supply of the person and their spouse. However, they concluded that labor supply is completely unresponsive to the incentives generated by the Social Security benefit rules. They found evidence that people are more likely to retire when the effective marginal Social Security tax is high. Furthermore, Coile and Gruber (2007) examined how incentives from social security affect people' retirement behavior. They examined the impact of Social Security incentives on male retirement via the forward-looking models whereby individuals consider the incentives to work in all future years. From these forward-looking incentive models, Social Security benefits are significant determinants towards retirement. They also concluded that Social Security policies that increase the incentives to work at older ages can cut the labor force exit rate of older workers.

Peoples' intentions with regard to Social Security claiming ages are sensitive to how the early versus late claiming decision is framed. Given peoples' desire to retire from the labor force, some people may not make fully rational optimizing choices when it comes to choosing a claiming date for their benefits (Brown, Kapteyn, and Mitchell, 2013). In recent years, mortality rates have fallen and these declines in mortality will have an impact on financial solvency of Social Security and other programs because people will live longer. Predictions of future mortality rates will have an impact on Social Security and other social programs because there is an emerging consensus that public expenditures will increase as age-specific mortality rates continue to decrease (Leonhardt, 2011). Van Solinge and Henkens (2010) indicated that subjective life expectancy is a reason that is taken into account when determining to retire. In fact, older people with longer time horizons prefer to retire later. When it comes to actual behavior; however, such time horizons do not seem to play a major role.

Many demographers and policy analysts at the Social Security Administration forecast that the mortality rates will continue to decline in the foreseeable future, but a few assess a peak decline in mortality rates will occur because of the rise in obesity (Olshansky et al., 2005). There is a narrow consensus about the size of these declines in mortality rates because past mortality rates have, in general, been conservative (Oeppen and Vaupel, 2002). Despite these declines in mortality rates, peoples' intentions to claim their social security benefits may be based on their own mortality risk that will influence them to claim their benefits coupled with the wish to annuitize wealth. More specifically, those with very low subjective probabilities of survival retire earlier than those with higher subjective probabilities, but the differences between these two groups are not large. Regardless in the differences in mortality, many workers claim their benefits as soon as they are eligible (Hurd, Smith, and Zissimopoulos, 2004; Wu, Stevens, and Thorp, 2015).

THE EXISTING METHODOLOGY

Existing Methodology to Calculate the Social Security Benefits

The first step is to determine if a person is even entitled to the Social Security benefits. To be fully insured, a person must have accrued a certain number of credits. If a person is born after January 2, 1929, he or she needs 40 credits to receive full-retirement benefits. The commissioner of the Social Security Administration (SSA) determines the amount of earnings that will equal a credit each year (http://www.bankrate.com/finance/retirement/how-social-security-benefits-are-calculated.aspx). The three important steps for calculation of Social Security benefits are stated below:

1. Calculate the average indexed monthly earnings (AIME) in the 35 highest-earning years after age 21 up to the Social Security wage base. The ceiling changes each year. For example, the ceiling was $11,100 in 2012 and $13,700 in 2013.
2. Divide the AIME into three segments. These are called bend points (which are adjusted each year after inflation). There are three bend points. Together, these give what is known as primary insurance amount (PIA). Table 1 gives the bend points for each year. For the year 2014, the first bend point BP_1 is $816, and the second bend point BP_2 is $4,917.
3. The first bend point of AIME is multiplied by a weighted factor of 0.9.
4. The difference between the first bend point and the second bend point of AIME is multiplied by a weightage factor of 0.32.
5. The difference between the actual AIME and the second bend point (which is essentially the third bend point BP_3 is multiplied by a weightage factor of 0.15.
6. The sum of all three amounts (all from AIME) gives the primary insurance amount PIA of the worker.
7. This is the exact amount of Social Security benefits for a person retiring at the age of 66. In the case of the person retiring exactly at age 62, the benefit will be 25% less the person's primary insurance amount (PIA).

An Illustrative Example

Example 1: Assume a 62 year old man who was born in 1950, and his total indexed earnings over his 35 highest-earning years were $2 million in 2012. By dividing his total earnings by 420 months gives an AIME of $4,762. Now applying the factors as discussed in this section,

The first bend point provides a benefit of $690.30 ($767 x 0.9 = $690.30).
The second bend provides a benefit of $1,234.24 ($3,857 x 0.32 = $1,234.24)
The third bend point provides a benefit of $20.70 ($138 x 0.15 = $20.70).

The sum of these three bend points is$1,945.24 (http://www.bankrate.com/finance/retirement/how-social-security-benefits-are-calculated.aspx)

TABLE 1
THE PRIMARY INSURANCE AMOUNT (PIA)
(in dollars)

Year	First	Second
1979	$180	$1,085
1980	194	1,171
1981	211	1,274
1982	230	1,388
1983	254	1,528
1984	267	1,612
1985	280	1,691
1986	297	1,790
1987	310	1,866
1988	319	1,922
1989	339	2,044
1990	356	2,145
1991	370	2,230
1992	387	2,333
1993	401	2,420
1994	422	2,545
1995	426	2,567
1996	437	2,635
1997	455	2,741
1998	477	2,875
1999	505	3,043
2000	531	3,202
2001	561	3,381
2002	592	3,567
2003	606	3,653
2004	612	3,689
2005	627	3,779
2006	656	3,955
2007	680	4,100
2008	711	4,288
2009	744	4,483
2010	761	4,586
2011	749	4,517
2012	767	4,624
2013	791	4,768
2014	816	4,917
2015	826	4,980

Source: http://www.socialsecurity.gov/OACT/COLA/bendpoints.html.

THE EXISTING METHODOLOGY: A DETAILED ASSESSMENT

The current methodology to calculate benefits by Social Security is shown in Table 2.

TABLE 2
STEPS TO CALCULATE THE CURRENT SOCIAL SECURITY BENEFITS

Step	Calculation in the Step	Description of the Variables used in the Calculation
Step 1	Obtaining AE_i (Actual Earning in the i^{th} year)	
Step 2	Calculating $IE_i=AE_i*IF_i$	IF_i is the Index Factor in the i^{th} year and IE_i is the Indexed Earning in the i^{th} year
Step 3	Computing $MIE=\Sigma(IE_i^*)$	where MIE is the sum of the IE_i^* or the highest indexed earnings.
Step 4	Compute AIME using $\mathbf{AIME} = \frac{\mathbf{MIE}}{\mathbf{420}}$	AIME is the Average Indexed Monthly Earnings which is MIE divided by 420 months.
Step 5	Computing EMR66=PIA	

Using the three bend points for the year 2014 stated in steps 3 to 5 of the existing methodology section, the calculations for PIA are shown below. The calculations show the estimated monthly retirement (EMR) benefit for a 66 year old individual:

$(EMR66)_1=PIA_1=0.9*816=734.4$
$(EMR66)_2=PIA_2 = 0.32*(4,917-816) =1312.32$
$(EMR66)_3=PIA_3=0.15*(AIME- 4,917) =544.7$

Note that PIA_3 or $(EMR66)_3$ uses an AIME value of 8,548.38 for the example under consideration. Also, PIA_1 and PIA_2 are purely dependent on the first and second bend points for the year under consideration (2014 in this example) given in Table 1. Meanwhile, PIA_3 uses AIME and the value of the second bend point. Hence,

$$EMR66= (EMR66)_1 + (EMR66)_2 + (EMR66)_3= PIA_1 + PIA_2 + PIA_3$$

This gives a total value of PIA_3 or EMR66 as $2,591.74 using the above expression. An alternate expression for EMR66 has been derived for the earnings of 2014, which is

$$EMR66=PIA= 0.15*AIME + 1,309.17$$

It varies from year to year as it uses bend points which also vary from year to year.
Equation (1) shows these steps,

$$EMR66= PIA= 0.\mathbf{15} * \frac{\sum \boldsymbol{IE_i^*}}{\mathbf{420}} + \mathbf{1,209.17} \tag{1}$$

where

IE_i = Indexed Earning in the i^{th} year
IE_i^* = The highest values of the indexed earnings

Illustrative Example

This example gives detailed calculations based on the above methodology, and the results are presented in Table 3.

TABLE 3
INDEXED EARNINGS (IE)

i		AE	IF	IE	IE*
Year	Maximum Earnings	Actual Earnings	Index Factor	Indexed Earnings	
1979	$22,900	$24,000	3.86	$92,640	$80,062.5
1980	$25,900	$24,500	3.54	$86,730	$80,500
1981	$29,700	$25,000	3.22	$80,500	$81,480
1982	$32,400	$26,250	3.05	$80,062.5	$82,500
1983	$35,700	$28,000	2.91	$81,480	$86,730
1984	$37,800	$30,000	2.75	$82,500	$92,640
1985	$39,600	$38,000	2.63	$99,940	$99,940
1986	$42,000	$40,000	2.56	$102,400	$100,760
1987	$43,800	$42,000	2.41	$101,220	$101,220
1988	$45,000	$44,000	2.29	$100,760	$102,400
1989	$48,000	$47,000	2.21	$103,870	$102,950
1990	$51,300	$50,000	2.11	$105,500	$103,180
1991	$53,400	$52,000	2.03	$105,560	$103,180
1992	$55,500	$54,000	1.93	$104,220	$103,500
1993	$57,600	$57,000	1.92	$109,440	$103,870
1994	$60,600	$59,000	1.87	$110,330	$104,220
1995	$61,200	$60,000	1.79	$107,400	$104,310
1996	$62,700	$61,000	1.71	$104,310	$105,500
1997	$65,400	$64,000	1.62	$103,680	$105,560
1998	$68,400	$67,000	1.54	$103,180	$105,600
1999	$72,600	$71,000	1.45	$102,950	$105,800
2000	$76,200	$75,000	1.38	$103,500	$106,650
2001	$80,400	$79,000	1.35	$106,650	$106,800
2002	$84,900	$82,000	1.33	$109,060	$107,400
2003	$87,000	$86,000	1.30	$111,800	$107,880
2004	$87,900	$87,000	1.24	$107,880	$108,070
2005	$90,000	$89,000	1.20	$106,800	$109,060
2006	$94,200	$92,000	1.15	$105,800	$109,180
2007	$97,500	$96,000	1.10	$105,600	$109,440
2008	$102,000	$101,000	1.07	$108,070	$110,000
2009	$106,800	$105,000	1.09	$114,450	$110,330
2010	$106,800	$106,000	1.06	$112,360	$111,000
2011	$106,800	$106,000	1.03	$109,180	$111,800
2012	$110,000	$110,000	1.00	$110,000	$112,360
2013	$113,700	$111,000	1.00	$111,000	$114,450
				Σ IE*=	3,590,322.5

6. By applying equation (1), the value of EMR66=PIA is $2,591 which matches exactly with the calculations based on steps 1 through 7 of the Social Security retirement benefits document (www.socialsecurity.gov) and bankrate.com. (http://www.bankrate.com/finance/retirement/how-social-security-benefits-are-calculated.aspx)

A NEW METHODOLOGY

An important point to note is that the whole calculation of Social Security benefits using the present methodology is based on the primary insurance amount, which is a three-legged stool consisting of essentially three bend points with associated weightage factors of 90%, 32%, and 15%. The data for AIME and PIA is shown in Table 4.

TABLE 4
PLOT POINTS FOR PIA AND AIME (2014 COHORT)

Average Indexed Monthly Earnings (AIME)	Primary Insurance Amount (PIA)
$0	$0
$408	$367
$816	$734
$2,867	$1,391
$4,917	$2,047
$5,459	$2,128
$6,000	$2,209

Source: http://www.socialsecurity.gov/OACT/COLA/bendpoints.html)

The plot of this data is shown in Figure 1.

FIGURE 1
PLOT OF AIME AND PIA

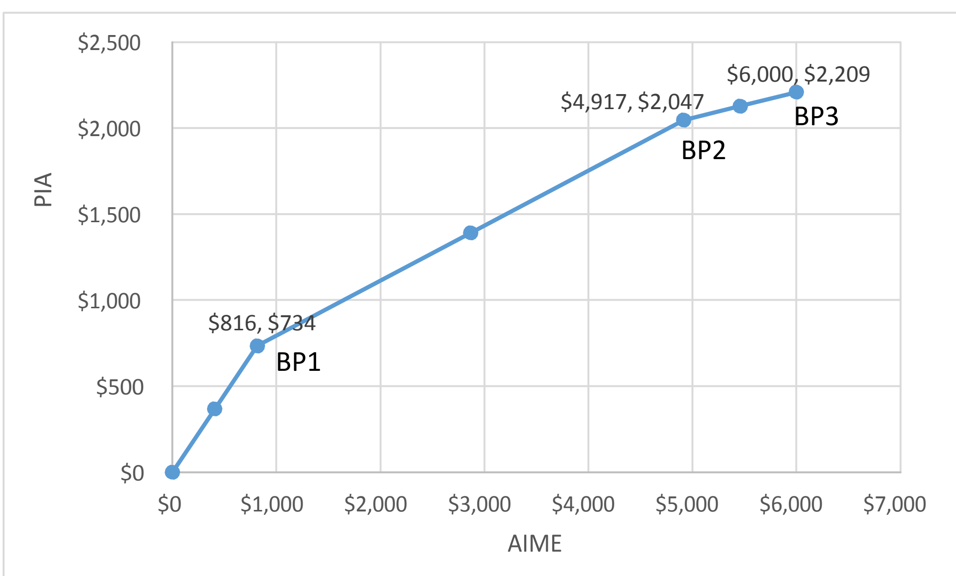


Table 3 shows the PIA values at discrete points. Hence, it is important to develop a functional relationship between AIME and PIA. In this way, if an individual's earnings are not exactly the same as AIME listed in Table 3, one can use the equation developed in this paper to calculate the exact PIA instead of executing the tedious calculations. A linear spline, a cubic spline, and a cubic smooth curve are fitted to determine best fit, and the results are shown in Table 3. All three cases are discussed below.

Case 1. Fitting linear spline, the three equations for the three segments, are as follows:
Segment 1:
PIA=0.8995*AIME (2)

Segment 2:
PIA=0.32*AIME+472.745 (3)

Segment 3:
PIA=0.1496*AIME+1311.49 (4)

The validity of the fitted equations is checked using the correlation coefficient (r) and the standard error of estimate ($S_{y/x}$). These values for each segment are given below:

$r_1=1$ $(S_{y/x})_1=0.008944 < (S_y)_1=367$

$r_2=0.999$ $(S_{y/x})_2=1.16046 < (S_y)_2=656.5$

$r_3=0.999$ $(S_{y/x})_3=0.194729 < (S_y)_3=81$

where S_y is standard deviation. The above results show that the linear spline is a good fit.

Case 2: Cubic Spline
If a cubic spline relation is fitted, the equations are given as follows:
Segment 1:
$$PIA= -7.63\times10^{-8} *AIME^3 +0.95* AIME \quad (5)$$

Segment 2:
$$PIA= 2.2\times10^{-8} AIME^3 - 2.99\times10^{-4} *AIME^2+1.48551*AIME-621.562 \quad (6)$$

Segment 3:
$$PIA= -7.6\times10^{-9} AIME^3+0.0001368 AIME^2-0.663 AIME+2903.04 \quad (7)$$

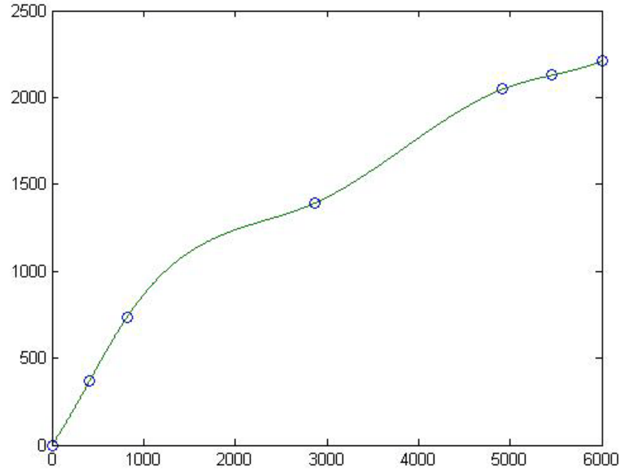
In this case, the correlation coefficient (r) and the standard error of estimate (Sy/x) values are:
$r_1=0.99$ $(S_{y/x})_1=15.42 < (S_y)_1=367$

$r_2=0.7168$ $(S_{y/x})_2=647.32 < (S_y)_2=656.5$

$r_3=0.999$ $(S_{y/x})_3=3.99 < (S_y)_3=81$

The above results show that the cubic spline is a good fit. The actual plot is shown in Figure 2.

FIGURE 2
CUBIC SPLINE



<u>Case 3. Cubic smooth curve</u>

If a cubic smooth curve relation is fitted, the equation is given as follows:

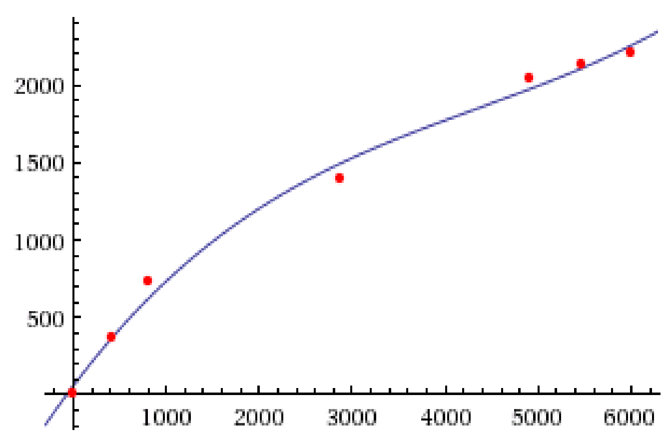
$$PIA = 1.01626\times10^{-8}\ AIME^{3} - 0.000132925\ AIME^{2} + 0.797697\ AIME + 58.6945 \qquad (8)$$

In this case, the correlation coefficient (r) and the standard error of estimate ($S_{y/x}$) values are:

$r=0.9966$ $\qquad S_{y/x} = 81.29 < S_y = 908.463$

The above results show that a cubic smooth curve is also a good fit. However, the correlation coefficients for a linear and a cubic spline are more than that of a cubic smooth curve. However, it is recommended that a linear spline should be used for calculation of PIA for the general population. The plot is shown on Figure 3 for the cubic specification.

FIGURE 3
CUBIC SMOOTH CURVE



Using this curve, the new values for PIA and weightage factors are summarized in Table 5:

TABLE 5
PIA AND WEIGHTAGE FACTORS

			New PIA and Weightage factors			
AIME	PIA Existing Linear Curve		Cubic Spline		Cubic Smooth Curve	
	PIA	Weightage factor	PIA	Weightage factor	PIA	Weightage factor
$816	$734	0.899	$733.78	0.8992	$626.62	0.76791
$4,917	$2047	0.4163	$2,046.99	0.4163	$1,975.36	0.40174
$6,000	$2209	0.3681	$2,208.24	0.3680	$2,254.7	0.3757

CONCLUSIONS

Table 4 shows the old and new weightage factors for the three cases of linear spline, cubic spline, and cubic smooth curve. However, as discussed earlier, since the correlation coefficient for the cubic smooth curve is less than that of the linear spline and cubic spline, it is not recommended. Furthermore, since the correlation coefficients for both linear and cubic spline are approximately the same, which implies that there is no advantage of using a complicated higher order spline than the linear spline, it is recommended that the linear spline be used to calculate the Social Security benefits for the public. The most important result of this study is the development of an equation using a linear spline for the existing data provided by the Social Security Administration and formalizes the method of calculation of the personal insurance amount (PIA) and the final Social Security benefit. If this equation is used, it will help the public to calculate their Social Security benefits easily instead of executing the detailed steps as stated by the Social Security Administration. Hence, the new suggested method to calculate Social Security benefits is mathematically more desirable than the current methodology.

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