A Quantitative Evaluation of Four Retirement Spending Models

James S. Welch, Jr. 2015

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Abstract

Traditional retirement planning assumes that disposable income is constant throughout retirement, before it is indexed to inflation. Demographic retirement spending data indicate that retirees spend more early in retirement, while they are physically active, and voluntarily spend less later in retirement. Four researchers reviewed retiree demographic spending data and proposed retirement spending models which fit their observations. We added these spending models to a linear programming based retirement calculator that computes maximum disposable income for the first year of retirement and applies a spending model to the remainder of retirement. We defined a base scenario and examined how the spending models behaved compared with the traditional constant spending model and with each other. We ran a series of tests to observe how the spending models perform when an assumption of the base scenario was perturbed. We conclude that a retiree may safely choose higher spending early in retirement while budgeting for lower disposable income later in retirement.

Keywords: retirement planning, Roth IRA, tax-deferred savings, linear programming, optimal spending plan, retirement spending, disposable income, spending models

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Introduction

The dual mandate of retirement planning is to not spend so fast that your savings run out before you do and to not spend so slowly that you astonish your grateful heirs with your generosity. The optimal retirement plan matches retiree **spending** to the changing needs of the different phases of retirement while satisfying a **Final Total Asset Balance (FTAB)** requirement. In this paper we compare five retirement spending models that, if executed properly, meet the dual mandate.

The **Traditional Spending Model (TSM)** assumes constant retirement spending, indexed to inflation, [Bengen 1994].

Four researchers independently surveyed retiree spending data and proposed **alternate spending models** that produce spending plans that fit their observed spending more closely than does TSM.

We present the results of computational experiments that compare alternate spending models' disposable income to TSM's and to each other. We define **disposable income** to be the nominal (i.e. indexed to inflation) amount of after-tax money available for personal consumption for the term of the retirement plan. **Initial disposable income** is the after-tax money available for spending for the first year of retirement.

Comment [A1]: Is "index to inflation" better?

We examine details of the computed plans to understand how they work. Our results are that the alternate spending models provide for significantly higher initial disposable income as

compared to TSM. We conclude that it is reasonable for the retiree to adopt an alternate spending model that provides for 20% or more initial spending than TSM, provided that the retiree follows the alternate spending model's full spending plan and spends less later in retirement.

Literature Review

The alternate spending models that we review are:

1. The **Age Banding Model (ABM)** [Basu 2005],
2. The **Changing Consumption Model (CCM)** [Blanchett 2013],
3. The **Lifecycle of Spending Model (LSM)** [Roy 2014], and
4. The **Reality Retirement Planning (RRP)** model [Bernicke 2005].

Bernicke [2005] and Blanchett [2013] reviewed the issue of whether the spending reductions that they observed later in retirement are voluntary or are forced on retirees by necessity. Both researchers conclude that retirees choose to spend less later in retirement.

The Computational Platform

We used the **Optimal Retirement Planner (ORP)** as the computational platform for this study. ORP is a retirement calculator built on an off-the-shelf **Linear Programming (LP)** system [Welch 2015].[1]

ORP assumes three retirement savings accounts:

[1] ORP is available on the Internet at www.i-orp.com.

1. **Tax-deferred account (IRA)**[2] contributions from wages are exempt from personal income taxes. Distributions are taxed as personal income.
2. **Roth IRA** contributions from wages are subject to personal income taxes. Asset returns and distributions are not taxed.
3. **After-tax account** contributions can be from any source and are assumed to be already taxed as appropriate. Profits are taxed as incurred. Distributions are not taxed.

We define retirement **savings** to be the sum of the account balances for these three accounts.

ORP models Federal income taxes and the **Required Minimum Distribution (RMD)**[3].

A key feature of an LP model is its objective function. The objective function spans the model and yields a single value: the profit from doing the activities of the model. The LP optimizer maximizes the objective function value. **ORP's objective function is initial disposable income.** ORP maximizes its objective function while satisfying the requirements (constraints) of the model. An example of constraints is satisfying the selected spending model's requirements for each year of retirement while ending up with a zero FTAB. ORP maximizes initial disposable income and the spending model determines disposable income for the remainder of retirement.

[2] We refer to the collection of tax-deferred accounts as the IRA.
[3] For a list of abbreviations, please see Appendix A

We use the term **income** to connote maximum after tax disposable income. ORP computes income. Spending is what the retiree decides to do. Spending is less than income, for modeling purposes, in that ORP does not include credit card debt and home equity loans.

Maximum income is achieved by scheduling withdrawals from savings in a manner that minimizes income taxes on the IRA withdrawals plus 85% of Social Security benefits while maximizing compounded returns on all accounts.

We now briefly review the alternate spending models of this study.

Age Banding Model (ABM)

The *Age Banding Model for Planning Retirement Needs* [Basu 2005] refines the application of inflation to retirement spending. The Age Banding Model does these things:

- Divides spending into three categories (**Basic Living, Leisure, and Healthcare**)[4] and assigns each category its own inflation rate. Our inflation rates for Leisure and Healthcare are 2.33 times[5] the Basic Living inflation rate.

[4] Basu models a fourth category; taxes. For modeling purposes there are two kinds of taxes: personal income taxes and real estate taxes. ORP already models personal income taxes outside of the spending model. We include real estate taxes in the Basic Living category.

[5] Basu assumes a 3% Basic Living inflation rate and a 7% inflation rate for Leisure and Healthcare. The ratio of Healthcare or Leisure to basic living is 2.33. The Basic Living inflation rate is a settable parameter.

- Each category is assigned a proportion of total spending, which, when multiplied times the category's inflation rate, yields a weighted inflation rate for that category. The ABM inflation rate is the sum of the weighted category rates.
- At ages 65, 75, and 85 category proportions are adjusted to provide for less Basic Living and Leisure spending, and for more Healthcare.

ORP uses ABM's spending computation in maximizing income.

Changing Consumption Model (CCM)

Blanchet [2013] uses the *RAND Health and Retirement Study* data set as the data source for his **Changing Consumption Model (CCM)**. Using nonlinear curve fitting, he approximates the CCM's annual, real change in consumption[6] (Δ_{age}) with the function:

Δ_{age} = 0.00008*age2 + 0.0125*age – 0.0066 * ln(ExpTar) + 54.6% where 59 < age < 96

ExpTar is the after-tax *expenditure target* for the first year of retirement. Our estimate of ExpTar is 5% of initial savings plus Social Security benefits. This is just a rough estimate because ExpTar is what ORP is maximizing. The definition of ExpTar means that Δ_{age} is not only a function of age but also of initial income.

[6] Blanchett uses the terms, spending, consumption, and expenditure as synonyms. We prefer spending as something the retiree chooses to do and income is that money that may or may not be spent.

Although Δ_{age} may be non-negative at the age boundaries (60 and 95), it is negative away from the boundaries. This means that consumption declines at a nonlinear rate for older retirees.

ORP's income is based on CCM's consumption. An age's disposable income (di_{age}), except for the first year of retirement, is based on the income of the previous age for all ages in retirement:

$$di_{age} = di_{age-1} * (1 + inflation + \Delta_{age})$$

The Lifecycle of Spending Model (LSM)

Comment [A2]: I'm not sure what to do with this hightligh. So I got rid of it.

In her paper, *The Lifecycle of Spending*, Roy [2014] surveyed the spending of 1.5 million retirement U.S. households who use Chase Bank mortgage, debit, and credit cards to do a majority of their spending. She concludes that in an environment with 2.5% inflation, actual retiree spending has a constant annual spending adjustment of 0.545%. This value reflects both inflation and age related reduced spending.

The **Lifecycle of Spending Model (LSM)** income (di_{age}) adjustment is based on LSM's rate of spending change:

$$di_{age} = di_{age\ -1} * (1 + (inflation - 1.5) * 0.00545)$$

Inflation is an input parameter. 1.5 is a translation constant. According to Roy's results when inflation is 2.5%, then the LSM inflation index is 0.545%. We subtract 1.5 from inflation so that the above equation gives this result. Other inflation values are adjusted accordingly. The LSM spending adjustment is constant for all retirement ages.

Reality Retirement Planner (RRP)

Bernicke's **Reality Retirement Planner (RRP)** is based on data drawn from the Bureau of Labor Statistics' *Consumer Expenditure Survey*. He categorizes retirement spending into 5 year intervals as shown in Table 1.

Table 1: Consumer Expenditure Survey Broken Down into 5-Year Age Groups

Age	Average Annual Age Expenditures	5 Year Spending Decrease	Annual Spending Decrease (δ_{age})
55-59	$45,062	-	0
60-64	$38,218	16.7%	3.34%
65-69	$32,103	16.0%	3.20%
70-74	$27,517	14.3%	2.86%
80+			0

- δ_{age} is the annual average of the percentage spending decrease over the 5 year interval.
- For ages 60 and younger, and ages 80 and older the spending reduction is zero and spending increases at the rate of inflation.

ORP's income (di) adjustment for RRP is:

$$di_{age} = di_{age-1}*(1 + inflation - \delta_{age})$$

from the second year of retirement to age 80. ORP maximizes initial income and the remainder of retirement spending is derived from it.

Bernicke includes a numeric example of RRP in his paper. In Appendix B we compare Bernicke's RRP to ORP's RRP results and show that the two implementations agree on the shape of their spending curves but disagree on initial income (assumed by Bernicke, computed by ORP).

The Experiment

The experiment is to define a base scenario and then run a series of tests to measure the alternate spending models' performance.

The Base Scenario Defined

Our **base scenario** is for a single, 65 year old retiree with $1,000,000 in retirement savings distributed across all three retirement savings accounts:

1. The IRA contains $400,000
2. The Roth IRA contains $350,000
3. The after-tax[7] account balance is $250,000.

These proportions were chosen by computing accumulation phase savings for a 30 year old who allocates 1/3 of their annual retirement savings to each of the three accounts. The accumulated asset totals were evaluated at age 65. The Roth IRA account balance is lower than the IRA because of income taxes deducted from the Roth IRA contributions. The after-tax account balance is even lower due to income taxes deducted from contributions and because the 15% capital gains tax paid on annual investment returns reduces compounding[8] [Saftner and Fink, 2004].

We further assume:

[7] The literature frequently uses the term taxable account for what we call the after-tax account. In our view all accounts are taxable because they are taxed either before the money enters, as it accrues, or as it is distributed.

[8] Our simplifying assumption is that the after-tax account is invested exclusively in mutual funds which pass through capital gains annually with only minor unrealized capital gains. We assume there are no fixed income investments and thus negligible dividends. Since the after-tax account in depleted early in most plans after-tax tax consideration are safely ignored.

Comment [A3]: The software does model dividends in the after-tax account but that is not an issue because I assume no fixed income investments.

I added footnote 9 to discuss treatment of capital gains.

Comment [A4]: Does this overstate the impact because unrealized capital gains taxes are deferred until the time of sale? Does the software distinguish between taxes on dividends, realized capital gains, and unrealized?

1. A 27 year planning horizon (to age 92).
2. Zero FTAB, i.e. there is no estate. (Of course if the retiree does not live to age 92 any remaining savings are the estate.)
3. 2.5% annual inflation.
4. All three retirement savings accounts have the same 5% ROR[9].

Comment [A5]: This is a compounded return. And it is nominal? So with 2.5% inflation, the real return is 2.5%?

Comment [A6]: I added the next paragraph to address this issue.

I also just discovered that I can add comments to comments. There is no end to wonders of Word?

Inflation and ROR apply to separate parts of the process. Assets increase in value by their ROR, each year they are not distributed. Assets do not lose monetary value from inflation. Income is indexed to inflation.

With the exception of one test we do not model Social Security benefits in order to concentrate on spending issues.

The Base Scenario Examined

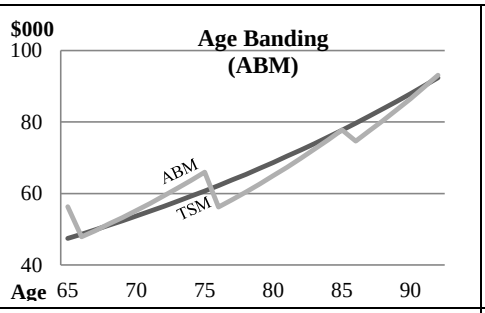
Our first test is to solve the base scenario with each of the spending models and observe model income behavior. Figure 1 graphically contrasts TSM income to alternate spending models' income.

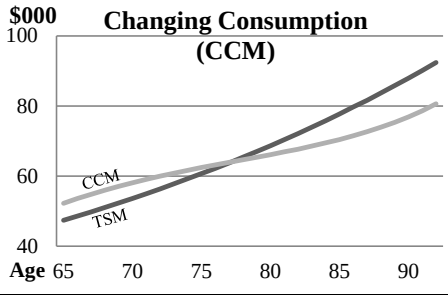
[9] The focus of this study is on spending models without the need to address the confounding impact of different RORs for the three accounts. Coppersmith and Sumutka [2011] assumed different RORs for different accounts in their LP model with the outcome being transfers between accounts when their optimizer maximized asset returns.

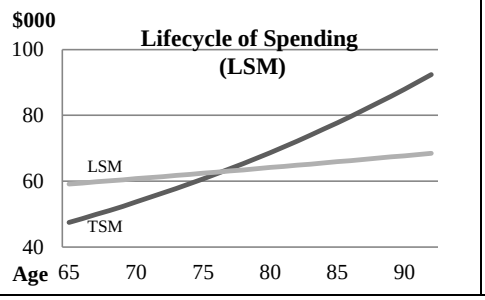
Figure 1: Compare Traditional Spending Model Income to the Alternate Spending Models

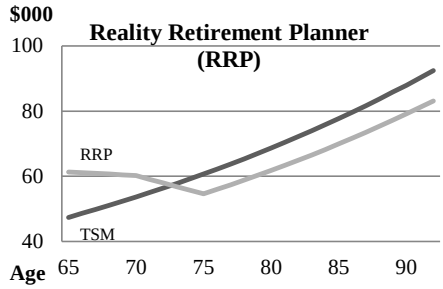
Assumptions:

- The Base scenario with no embellishments.









Discussion:

- Each panel contrasts one alternate spending model to TSM.

Comment [A7]: The two colors in these graphs must work in black and white. Perhaps blue becomes black, and orange becomes gray.

Comment [A8]: I have abandoned color in favor of black and white and 50 shades of gray. I added the longer name for this first graph but I figure I don't need to for subsequent figures as the reader become accustomed to the abbreviations.

The alternate spending models show higher initial income and lower final income than does TSM. This gives the retiree the funds to enjoy a more active early retirement.

ABM's saw tooth pattern is according to the model's specification. Between category adjustments ABM's income growth is faster than TSM because Leisure and Healthcare expenses inflate faster than Basic Living's inflation rate. ABM's first adjustment occurs at age 65, the retirement age, but it doesn't take effect until age 66. Thus, initial income occurs on the last year of full spending (age 65) before the first retirement adjustment.

CCM's income is nonlinear with higher income at the start when the retirees are more active, reduced real income with flat nominal income at mid-plan, and increased income at the end to accommodate higher healthcare costs.

LSM's fixed 0.545% annual adjustment accounts for both reduced spending and 2.5% inflation. Real income is being reduced every year.

Early in retirement RRP's income falls at a precipitous rate but, at age 75, reverts to constant income, indexed to inflation.

Table 2 summarizes the application of the four spending models to the base scenario.

Table 2: Base Scenario Income Summary

Assumptions:

- Base scenario with no embellishments, the same test as Figure 1.

Inflation	TSM $000		ABM %		CCM %		LSM %		RRP %	
	Initial	Total	Initial	Cost	Initial	Cost	Initial	Cost	Initial	Cost
Nominal	47	1,891	18.6%	1.0%	10.2%	3.1%	24.6%	5.7%	29.3%	3.9%
Real	47	1,328	18.6%	0.5%	10.2%	1.5%	24.6%	2.7%	29.3%	1.9%

Discussion:

- The *Nominal* row shows income with 2.5 % inflation.
- The *Real* row shows total income with inflation removed.
- The Traditional Spending Model (TSM) columns are in thousands of dollars.
- *Initial* is income for the first year of retirement; the optimizer's objective function. Nominal initial income and real initial income are the same by definition.
- *Total* is the sum of all TSM income over the span of retirement. The Nominal Total value is misleading in some sense because it mixes valuable dollars early in the plan with less valuable dollars late in the plan. Nonetheless, it is useful for comparison purposes.
- The alternate spending models' Initial entries are the percentage differences between the alternate spending models' values and the corresponding TSM entries. For example, the LSM initial income is 24.6% greater than TSM's initial income.
- The alternate spending models' *Cost* entries are the percent reduction in total alternate spending models' income relative to total TSM income. This is a measure of the percentage that total income is reduced by adopting alternate spending models. For example, ABM sacrifices 1.0% of total, nominal income by increasing initial income 18.6% above TSM.

Comment [A9]: Interesting table. To make more clear, please spell out abbreviations. Also, the Initial percentages seem like withdrawal rates. I wonder if instead of expressing initial TSM as dollars, it could be a withdrawal rate, and initial withdrawal rates could be listed for each scenario. This might be easier to understand.

Comment [A10]: In the paragraph following the table I have tried to clarify the distinction between withdrawals and income, as I use the term. I have to be careful here. Income is model output and input to the retirees budget.

I prefer the abbreviations because it keeps the table compact. Going the full name route would make it ungainly. The names of the spending models are not commonly known and the abbreviations are just as good by this time.

Conventional retirement planning is all about managing retirement savings and the assumed, initial **withdrawal rate** (first year withdrawals divided by beginning savings) as the starting point. The *Initial* column of Table 2 measures the after-tax, disposable funds available for personal consumption during the first year of retirement. In this scenario initial savings withdrawals are greater than initial income because taxes have to be paid. Initial income is not a surrogate for initial withdrawals or for the withdrawal rate.

Since the alternate spending models show higher initial income and lower final income than TSM, we conclude that the alternate spending models transfer money from late retirement to early retirement where presumably the retiree is more able to enjoy the benefits. The positive Cost percentages indicate that it is not an exact transfer. Additional money spent early in retirement does not benefit from return compounding toward the end of retirement and may increase income taxes on IRA withdrawals.

We utilize the format of Table 2 throughout our paper without further explanation.

Alternate Spending Models' Income Changes

For all retirement ages except the first, alternate spending model income (di) is computed as:

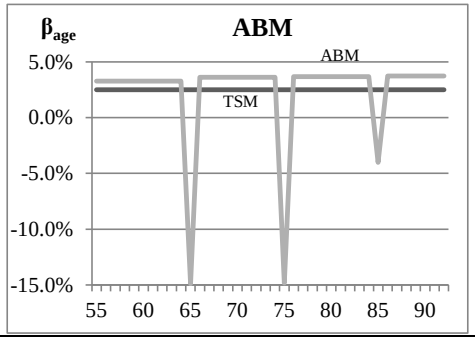
$$di_{age} = (1 + \beta_{age)} * di_{age-1}$$

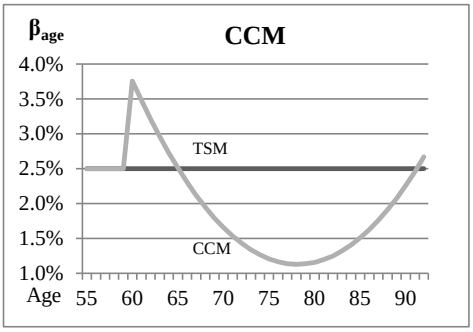
where β_{age} depends on the spending model being tested. Figure 2 illustrates the values of the multiplier β_{age} as generated by the four alternate spending models.

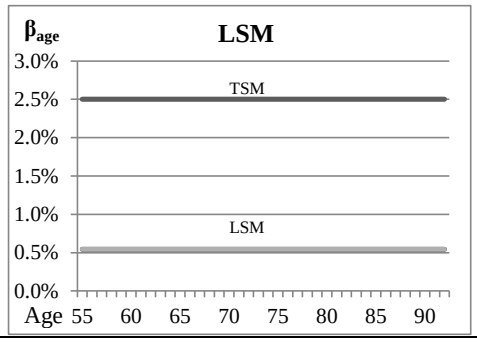
Figure 2: Income Rate Change for Each Year of the Base Scenario

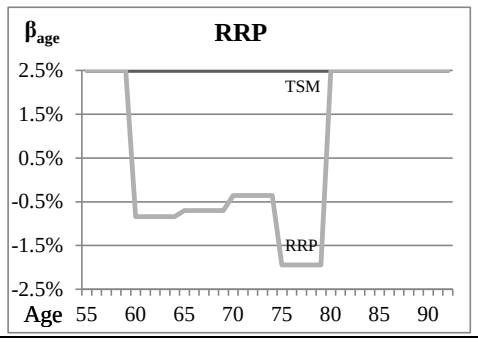
Assumptions:

- Base scenario.
- Retiree's age and retirement age are set to 55 to show each alternate spending model's active age range.









Discussion:

- The y-axis is β_{age}, the percent modification to the previous year's disposable income. These values are from one of the optimizer's internal tables.
- TSM's 2.5% constant inflation rate appears in every graph as a reference point.
- CCM is active from age 60 through age 92 and acts like TSM outside of this range, i.e. $\beta_{age} = 0$.
- LSM is active throughout retirement. LSM is defined to be 0.545% at 2.5% inflation.
- RRP is active only from age 60 through age 75 and acts like TSM outside of this range.

Because of the higher inflation rates for Leisure and Healthcare ABM's inflation rate is higher than TSM's. The re-proportioning of spending categories keeps ABM from running out of control. At age 75, 15% is a substantial income reduction.

For early retirees CCM increases income above what it was entering retirement. The CCM smile [Blanchett 2013] decreases early in retirement, flattens out in mid plan as the retiree's activity level decreases, and then increases in the latter part of the plan as healthcare expenses increase.

RRP's spending-change graph reflects its stepwise definition where values are drawn from Table 1.

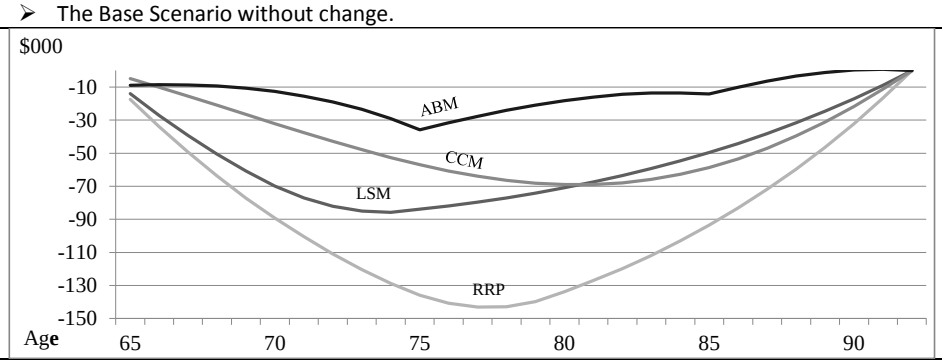
Inheritance Prospects

Life is uncertain and if the retiree should demise before the end of their plan whatever is left in their savings is their estate. Figure 3 shows the difference between the TSM estate and the alternate spending models' estates for each year of retirement.

Figure 3: Savings Balance Deficits

Assumptions:

- The Base Scenario without change.



Discussion:

- The graph shows the alternate spending models' savings balance minus the TSM savings balance. This is the estate deficit should the retiree not live to full term.

Comment [A11]: This figure will need some work to be understandable when in black and white.

Also, the same colors should be used for both sides. It took me a while to realize that RRP was gray on the left and orange on the right.

Comment [A12]: The left panel was more confusing than enlightening so I deleted it.

Most retirees end their retirement plan with a termination age beyond age 90. This is a conservative choice because there is fair probability that they will live that long. But actuarial data show that the end will more than likely come sooner. If the retiree chooses to follow an alternate spending model then the heirs' bequests will be reduced for a major part of the plan. This makes sense as a consequence of accelerated spending early in retirement.

Sources of Funds

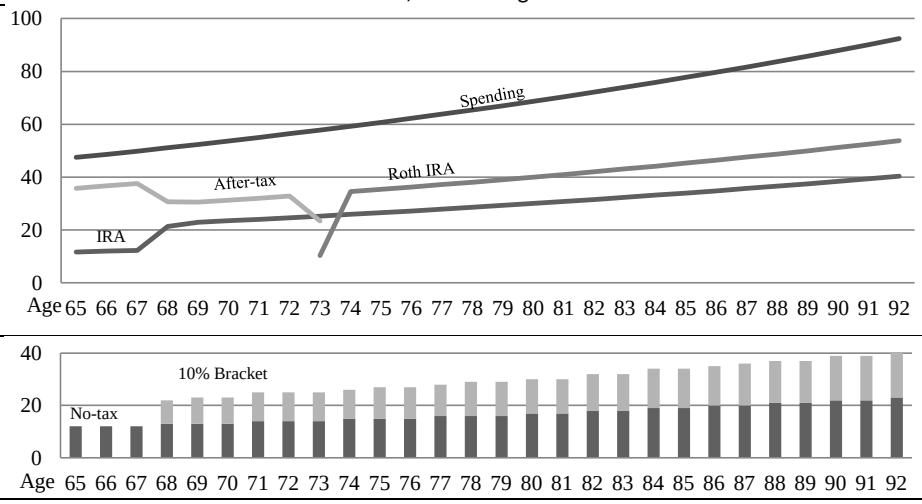
Maximizing income is all well and good but where does the money come from? In this section we look at how the alternate spending models differ in the way they withdraw from the savings accounts.

We first consider TSM withdrawals and then contrast them to alternate spending models' withdrawal. Figure 4 shows TSM savings account withdrawals and how the IRA withdrawals are taxed.

Figure 4: TSM Withdrawals and Federal Income Tax Brackets

Assumptions:

- Base scenario with no embellishments, same as Figure 1.



Discussion:

- The top line of the upper panel is constant income increased each year by 2.5% inflation.
- The remaining lines of the upper panel show account withdrawals.
- In the absence of other sources, income is the sum of savings withdrawals minus taxes on IRA withdrawals.
- The lower panel shows income subject to taxes, distributed across income tax brackets. The bars are divided into segments. Each segment represents money that is taxed in a tax bracket. The No-tax segment represents money that is excluded from taxes, i.e. the standard deduction, personal exemption and the age 65 or older exclusion. The 10% bracket segment represents IRA withdrawals that are taxed at the 10% rate.

The story being told here is with the IRA as the central character and with the others playing supporting roles. Distributions are made from the IRA for the entire term of the plan, at

the top of either the No-tax or the 10% bracket. Remaining income requirements are filled in from either the after-tax account early in the plan or the Roth IRA after the after-tax account is depleted. At first IRA withdrawals are tax free as the after-tax account supplies most of the income. At age 68 after-tax account withdrawals decline and IRA withdrawals jump to the top of the 10% bracket. This is a consequence of LP's balancing tax minimization against the maximization of asset returns. When the after-tax account is depleted the Roth IRA satisfies the remainder of income.

The RMD is of no consequence because IRA withdrawals, at the top of the 10% bracket, are well above the RMD.

The Figure 4 withdrawal strategy showed how LP balances other activities as it maximizes income:

1. Distribute the after-tax account first because its ROR is reduced by the capital gains tax making the after-tax account ROR less than the untaxed 5% RORs of the other accounts. (If the capital gains tax is zero then our results will be different.)
2. Preserve the IRA because of its tax deferred return compounding.
3. Distribute the IRA without taxes.
4. Keep the IRA distributions at the top of the 10% tax bracket.
5. Satisfy the RMD.
6. Preserve the Roth IRA because of its tax-free compounding and its tax-free distributions.

Comment [A13]: After-tax ROR, right? All accounts have 5% ROR?

Comment [A14]: I trust that this is better.

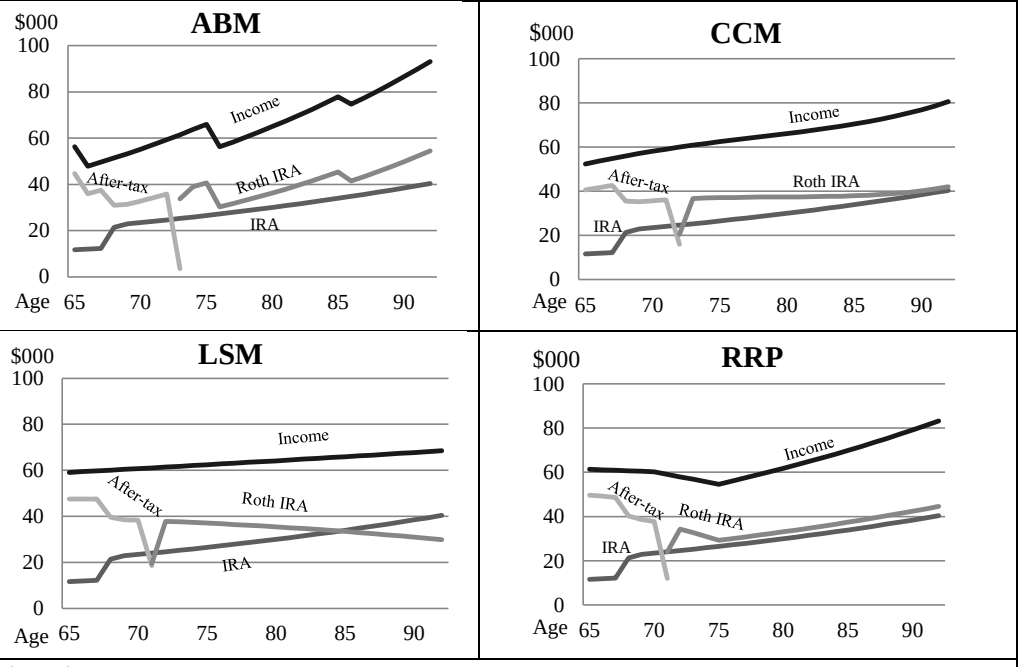
Satisfying these sometimes contradictory constraints is the essence of the application of LP to retirement planning.

Figure 5 shows income and savings account withdrawals for the alternate spending models.

Figure 5: Alternate Spending Model Withdrawal Plans

Assumptions:

- Base scenario with no embellishments, the same as Figure 1.



Discussion:

- IRA withdrawals are at a steady rate at the top of the 10% tax bracket.
- Roth IRA withdrawals follow income for ABM and RRP.
- The LSM panel shows Roth IRA withdrawals declining as the plan progresses even though income is increasing. This is because LSM's revised "inflation rate" of 0.545% is much less than the IRA's 5% ROR.

The alternate spending models' withdrawal strategies are similar to TSM's. Differences in spending models are reflected in the after-tax and the Roth IRA account withdrawals. IRA withdrawals are pegged to the top of the 10% tax bracket. As retirement progresses the changes in income are reflected in the Roth IRA distributions for all models.

The age that the after-tax account is depleted shows all three accounts having distributions in the same year. This occurs in only one year but at different ages for different spending models.

Sensitivity Analysis

With sensitivity analysis we modify one base scenario assumption and assess the impact on the alternate spending models relative to TSM and to each other.

The linear program's optimizer minimizes taxes while it maximizes the compounding of asset returns. In the following tests tax minimization is mostly hidden from view. Asset compounding is very much in evidence because increasing income in the early years of retirement reduces assets and thus reduces subsequent years' compounding of returns on those now spent assets.

The assumptions that we modify in this analysis are Social Security benefits, savings account balances, ROR, and longevity.

Social Security

Social Security Benefits increase income subject to personal income taxes. This, in turn, affects the savings distribution plan because IRA withdrawals are sensitive to income taxes.

Table 3: Social Security Benefits Effect on Nominal Income

Assumptions:

- Base scenario with the Social Security **Primary Insurance Amount (PIA)** as the independent variable. PIA is the amount of benefits due at **Full Retirement Age (FRA)**, age 66 in this case. The PIA is in thousands of dollars.
- Social Security benefits begin at age 66, the retiree's FRA. There are no Social Security Benefits during the first year of retirement.

PIA	TSM $000		ABM %		CCM %		LSM %		RRP %	
$000	Initial	Total	Initial	Cost	Initial	Cost	Initial	Cost	Initial	Cost
0	47	1,891	18.6%	1.0%	10.2%	3.1%	24.6%	5.7%	29.3%	3.9%
10	56	2,225	18.6%	1.0%	11.7%	3.5%	24.6%	5.7%	29.3%	3.9%
20	64	2,558	18.6%	1.0%	12.9%	3.8%	24.5%	5.8%	29.2%	4.0%
30	73	2,890	18.6%	1.0%	14.0%	4.1%	24.5%	5.8%	29.2%	4.0%

Discussion:

- Adding Social Security benefits increases income by an amount smaller than the benefit. 85% of benefits are subject to personal income taxes. Taxes reduce income.
- Beginning benefits at age 66 causes the first year IRA withdrawals to be large enough to cover spending at 50% above the amount of the second and subsequent years.

Comment [A15]: Are these real or nominal?

Comment [A16]: Nominal – I changed the title.

Of the alternate spending models, only CCM is sensitive to increasing the PIA. As the PIA increases, the gap between CCM and TSM widens. Recall that the CCM function definition includes the natural log of ExpTar. ORP estimates ExpTar as 5% of initial savings plus the PIA. Because of ExpTar, Blanchett's [2013] function generates curves that are not linearly related to TSM as are the other alternate spending models. For larger PIAs the CCM spending curves shift away from TSM accounting for increasing initial income. CCM is the most sensitive to Social Security benefits.

Savings Account Size

Larger retirement savings increase income and may push IRA withdrawals into higher tax brackets.

Table 4: Initial Savings Account Sizes Effect on Nominal Income

Assumptions:

- Base scenario except initial savings balance is the independent variable.
- Savings sizes are in millions of dollars.
- Account sizes are increased proportionally to the total saving size.

	TSM $000		ABM %		CCM %		LSM %		RRP %	
Size	Initial	Total	Initial	Cost	Initial	Cost	Initial	Cost	Initial	Cost
$1M	47	1,891	18.6%	1.0%	10.2%	3.1%	24.6%	5.7%	29.3%	3.9%
$2M	93	3,702	18.6%	1.0%	15.9%	4.5%	24.6%	5.7%	29.3%	3.9%
$3M	137	5,465	18.6%	1.0%	19.4%	5.2%	24.6%	5.7%	29.3%	3.9%
$4M	181	7,198	18.6%	1.0%	21.8%	5.8%	24.6%	5.7%	29.3%	3.9%
$5M	224	8,921	18.6%	1.0%	23.8%	6.2%	24.6%	5.7%	29.4%	3.9%

Discussion:

- Increasing savings increases the size of the IRA whose larger distributions increase taxes, which decreases income.

Except for CCM the Table 4 alternate spending model percentages are similar to those in Table 3. As with Social Security benefits CCM is sensitive to savings account balances.

Rate of Return (ROR)

The ROR reflects the retiree's investment strategy. A low ROR indicates a willingness to sacrifice asset returns to achieve portfolio stability. A high ROR indicates a desire to achieve greater returns by tolerating a higher level of volatility. Since these models are deterministic, as opposed to probabilistic, their results are more realistic for low RORs because low volatility more closely approximates the constant ROR assumption.

Table 5: Rates of Return Effect on Nominal Income

Assumptions:

- Base scenario except for ROR which is the independent variable.

ROR	TSM $000		ABM %		CCM %		LSM %		RRP %	
%	Initial	Total	Initial	Cost	Initial	Cost	Initial	Cost	Initial	Cost
0	25	999	19.8%	0.0%	13.8%	0.0%	32.2%	0.0%	34.6%	0.0%
1	29	1,155	19.6%	0.2%	13.0%	0.6%	30.6%	1.2%	33.6%	0.7%
5	47	1,891	18.6%	1.0%	10.2%	3.1%	24.6%	5.7%	29.3%	3.9%
10	76	3,033	17.3%	2.7%	7.2%	5.8%	18.3%	10.5%	23.9%	7.9%

Discussion:

- As the ROR increases initial TSM income increases.
- The alternate spending model initial income advantage over TSM declines for larger RORs due to the loss of real compounding of reduced asset returns and increased taxes.
- The cost of early, larger distributions grows as ROR increases.

All of the retirement spending models are sensitive to ROR.

Higher ROR increases income. As early income increases the assets that generate returns decrease. This reduces compounding later in the plan, more so for higher RORs than for low RORs. Thus Cost increases as ROR increases.

For the purpose of comparison, RORs are considered average rates and the volatility of the RORs would impact all spending models similarly.

Inflation

Table 6 shows the effect of inflation on the retirement spending models.

Table 6: Inflation's Effect on Nominal Income

Assumptions:

- Standard scenario except inflation rate is the independent variable.
- For ABM the inflation rate is the Basic Living inflation rate.

Inflation	TSM $000		ABM %		CCM %		LSM %		RRP %	
%	Initial	Total	Initial	Cost	Initial	Cost	Initial	Cost	Initial	Cost
0	62	1,735	31.6%	4.5%	8.7%	3.1%	8.8%	2.4%	27.1%	4.3%
2.5	47	1,891	25.0%	1.0%	10.2%	3.1%	24.6%	5.7%	29.3%	3.9%
5	35	2,053	3.2%	-2.4%	11.7%	3.0%	45.9%	8.7%	31.3%	3.3%
10	18	2,356	-28.8%	-6.8%	14.5%	2.4%	112.1%	12.9%	34.1%	2.0%

Discussion:

- ABM's negative values at higher inflation rates are a consequence of Healthcare's inflation rate being 2.33 times the Basic Living inflation rate and by increasing Healthcare's proportion of spending at age 85.

All of the models are sensitive to inflation.

Increasing the inflation rate decreases TSM initial income because the same assets are consumed at a faster rate. Total spending rises because it includes inflated dollars at the end of the plan. The alternate spending models' initial income also decrease but at a slower rate relative to TSM because, in a high inflationary environment, it is profitable to move spending forward from the end of the plan.

Longevity

A common way to protect against outliving savings is to set the plan termination to an age which has little likelihood of being reached [Tresidder 2012]. Such a strategy trades lower initial income for a higher comfort factor. In Table 7 we view the consequences of this strategy.

Table 7: Longevity Effect on Income

Assumptions:

- Base scenario except for life expectancy. Retiree's age at the end of the plan is the independent variable.

Term	TSM $000		ABM %		CCM %		LSM %		RRP %	
Age	Initial	Total	Initial	Cost	Initial	Cost	Initial	Cost	Initial	Cost
80	72	1,393	17.0%	0.9%	5.1%	1.1%	14.0%	1.9%	22.5%	2.8%
90	50	1,798	18.6%	1.1%	10.8%	3.2%	22.9%	4.9%	53.1%	3.7%
95	44	2,038	18.4%	0.7%	13.1%	4.4%	27.1%	7.0%	60.9%	4.0%
100	40	2,307	17.5%	-0.3%	14.7%	5.1%	31.1%	9.2%	66.5%	4.2%

Discussion:

- As the term of the plan increases, savings are spread over a longer period of time causing initial income to decrease.
- The compounding of asset returns over a longer time period will increase total income.
- ABM's uneven results are a consequence of Healthcare's inflation rate being 2.33 times the Base Living inflation rate and the increasing of Healthcare's proportion of income at age 85.

All of the models are sensitive to changes in the length of the plan.

Conclusion

Financial advisors and retirees benefit from being aware of spending plan issues. Some factors to be considered when considering an alternative spending model are:

1. **Initial disposable income** (Table 2): The purpose of the alternate spending models is to plan retirement spending to match spending levels to what the retiree typically needs. This may bring money forward from late in retirement to early retirement when the retiree is more active.
2. **Cost of the strategy** (Table 2): Savings withdrawals early in retirement reduce the compounding of savings returns, and correspondingly reduce disposable

income over the totality of retirement. Different alternate spending models have different costs.

3. **Estate size for ages in the mid 80's** (Figure 3): Most retirees plan their finances with the assumption that they will live into their 90's. Retirees should consider that their mortality path may be similar to the general population [Gravity and Levity Blog 2009] making the size of the estate in the early 80's something to be considered. The plan does not end at age 85 but the savings during the mid 80s are the estate.

If we accept the retirement survey data as credible, the fit of the spending models to the data as reasonable, and the optimizer as accurate, then younger retirees can benefit from increasing their spending early in retirement and then letting nature take its course.

The models presented here compute maximum initial disposable income and show a strategy for safely achieving that spending. Now the heavy lifting begins. Sustaining income in retirement combines the arts of portfolio management, capital preservation, and flexible spending [Pfau 2015].

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Appendix A: Abbreviations

ABM: Basu's [2005] Age Banding Model proportions annual spending into categories, assigns a different inflation rate to each category, and adjusts the category proportions based on age.

CCM: The Changing Consumption Model is Blanchett's [2013] model for varying retirement spending using a non-linear function that tracks consumption over retirement.

ExpTar: The after-tax, total expenditure (spending) target for CCM's first year of retirement. ORP's estimate of ExpTar is 5% of the sum of initial saving account balances plus Social Security Benefits.

FTAB: Final Total Account Balance is the sum of all three savings accounts at the end of the plan. FTAB is also known as the plan's *estate*. The FTAB is a settable parameter.

FRA: Full Retirement Age is the age at which a person first becomes entitled to full or unreduced retirement benefits.

LSM: *The Lifecycle of Spending Model* [Roy 2014] tracks retirement spending across retirement based on credit card data.

PIA: Principle Insurance Amount is the amount of Social Security benefits for which the retiree is eligible at FRA**.**

ROR: is the profit on an investment expressed as a percentage of investment's value.

Comment [A17]: Try to make this into just a list of abbreviations as a way to reduce the article length

Comment [A18]: Done

RRP: Reality Retirement Planning is Bernicke's [2005] model for varying retirement spending based on Bureau of Labor Statistics' data.

Appendix B: Bernicke's Example

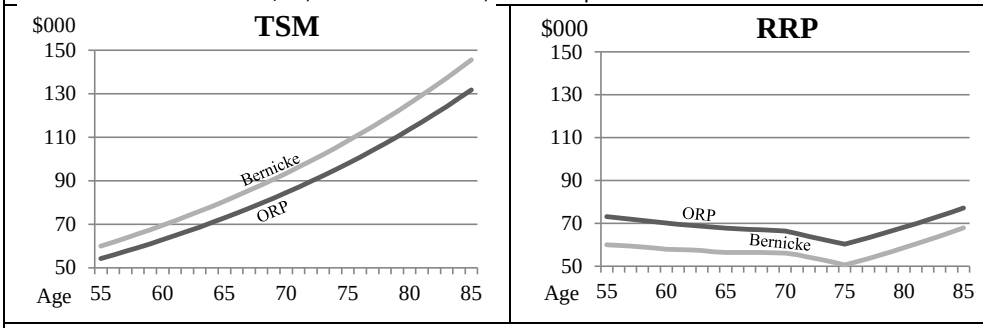
Bernicke's [2005] paper includes a *Hypothetical Retirement Income Projection* example. He uses the FTAB method to compare his RRP model to TSM.

Figure 6 compares ORP's TSM and RRP income to Bernicke's TSM and RRP income. The purpose of this comparison is to validate ORP's rendering of RRP.

Figure 6: Comparison of ORP Income to Bernicke's Example

Assumptions:

- A 55 year old married couple,
- Both are retiring at age 55,
- 30 year plan ending at age 85,
- $12,000 Social Security benefits for each spouse beginning at age 62. (This translates to PIA of $16,000.),
- 2% per year increase in Social Security benefits,
- 3% spending inflation rate,
- $800,000 in a 401K, with no other savings,
- 8% 401K ROR.
- ORP assumes a zero FTAB; Bernicke computes the FTAB.
- Bernicke assumes $60,000 initial income; ORP computes the maximum initial income.



Discussion:

- The left panel compares ORP's and Bernicke's disposable income for the TSM spending model.
- The right panel compares ORP's and Bernicke's disposable income for Bernicke's RRP spending model.
- Income is after personal income taxes have been paid.

Bernicke assumes a tax rate of 15.3% before age 62 and 9.6% thereafter. ORP reports that 37% of taxable income falls into 15% bracket throughout retirement with an average tax rate of 8.8%.

In the left panel ORP's initial income is $55,000 which is less than Bernicke's assumed $60,000. This is consistent with Bernicke's TSM depleting savings five years early. $60,000 initial spending is too high. In the right panel ORP's initial spending is $73,000 which is greater than Bernicke's assumed $60,000 initial income. This underspending is consistent with Bernicke's $2.3M FTAB.