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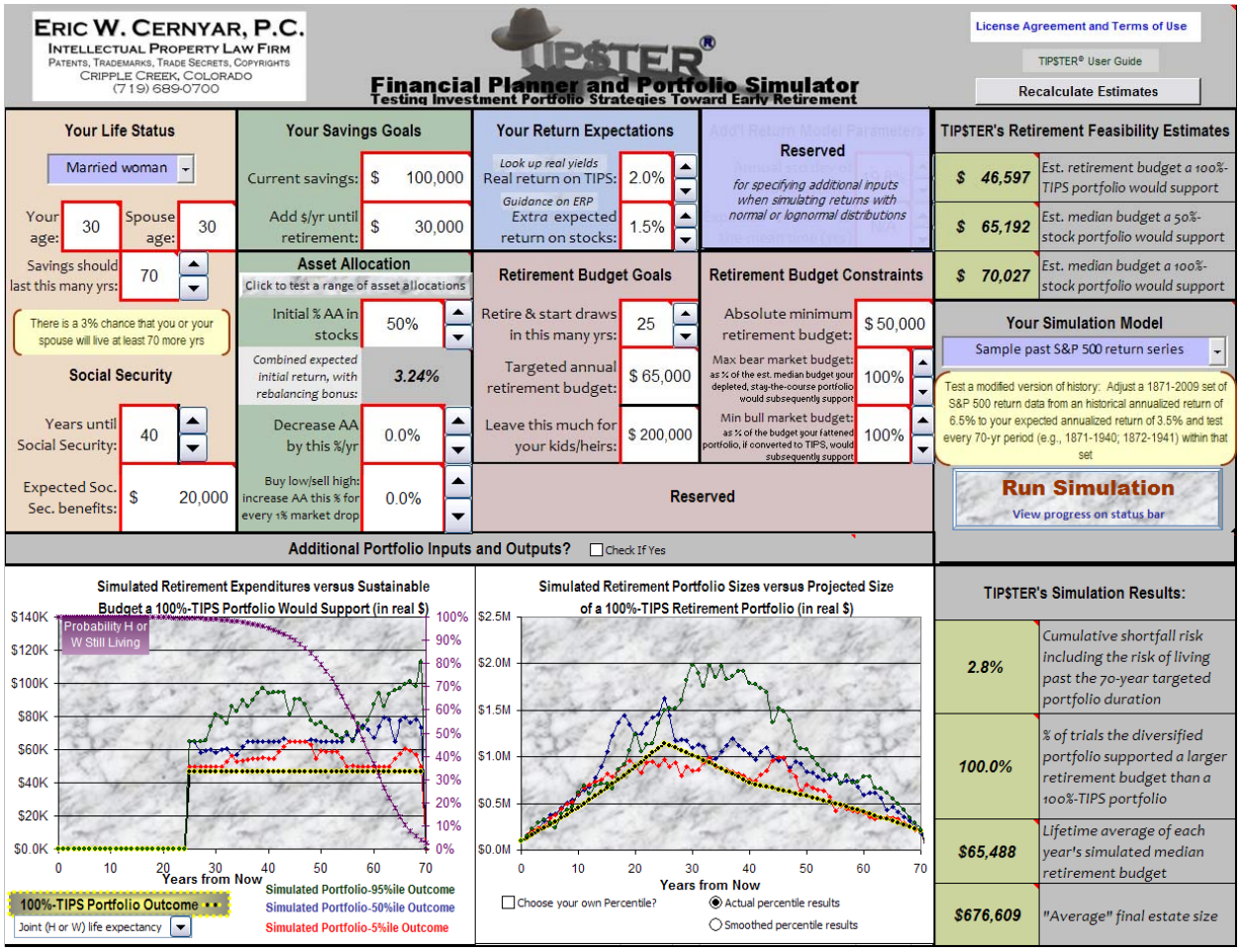
TIP$TER®

Financial Planner and Portfolio Simulator

Version 2

User Manual



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I. THE PROBLEM

> "For over fifteen years, academics and advisors have been frustrated by the difficulty in identifying a meaningful and measurable tolerance for risk. The process could be simplified if investors would simply 'know' their tolerance was a standard deviation of 15.22% or a maximum draw down of 20%."
>
> *David B. Loeper, Wealthcare Capital Management CEO, in "Modern Portfolio Reality (MPR): The Failures of Modern Portfolio Theory," Dec. 30, 2000 White Paper.*

Do you have any idea how much of your portfolio should be invested in stocks? Do you have a realistic grasp of the risks and the potential rewards of – say – a 40% allocation to stocks as opposed to an 80% allocation to stocks?

If you invest some of your money in stocks, do you have any idea how much you can safely withdraw from it per year, so you don't outlive your portfolio?

Do you have any idea – or have you underestimated – how comparatively well an ultra-safe portfolio invested in nothing but U.S. government inflation-protected bonds might perform? Or how comparatively large a retirement budget that such an all-bond portfolio would sustain?

Do you understand standard deviations and correlation coefficients? Can you glance at an "efficient frontier chart" (do you even know what that is?) that plots return against standard deviation risk of several potential portfolios and say – "Aha! I'm comfortable with a portfolio that has a 15.22% standard deviation – *but no more!* – of annual returns"?

When it comes to stocks, do you know the difference between the "average return" and the "annualized return"? If you've tried out any of the Monte Carlo simulation programs on the Web, do they tell you which kind of return the program wants you to specify as an input? And when you enter a return expectation, how do you come up with a reasonable number?

Did you ever get a shiny financial planning report from a financial advisor with color charts, graphs, projections, and statistics? Did the report critique your current asset allocation and suggest that you choose a different, more optimal asset allocation? Did the charts illustrate how big your portfolio was likely to grow if you followed your advisor's recommendations?

Did the report project the inflation-adjusted growth of your portfolio, or did it project the considerably-less-meaningful *nominal* growth of your portfolio? Do you have any idea what $100,000/year will buy 30-50 years from now? Are you sure you will be able to live on that?

You wouldn't happen to have an old copy of one of those reports with you, would you? Hmm, did you even do *half* as well as that report forecasted?

Does your financial advisor understand the math behind the report's fancy color charts? Or – more likely – is it just as much a black box to him as it is to you?

Do the big companies that created the software that produced your fancy financial planning report truly grasp the risks and potential rewards of different asset allocations? If they grasp those statistics, do they really believe in what they are selling? Or do they feed their advisor customers with optimistic return assumptions so that they will buy their products? After all, which of the following would you choose to be your advisor: the one who is all smiles, exudes confidence and gives you a sky-high forecast; and another who counsels caution and gives you a down-to-earth forecast?

Does your financial advisor's software make recommendations on the basis of *past* performance and *past* cross-correlation of different asset classes? Does the software perform a "Monte Carlo Simulation" using a questionable mathematical model of returns – one that assumes that all returns are "independently and identically distributed" – an assumption that grossly exaggerates potential long-term outcomes?

Do any of these questions leave you doubting the things you've heard about stocks, or the wisdom of your financial advisor's advice?

II. THE SOLUTION

A. TIP$TER® – An Overview

You should try out TIP$TER®. It was not designed as a splashy marketing tool to help financial advisors obtain and retain clients. It does not make absurdly optimistic assumptions (although you can, if you like, override its down-to-earth and easily-accessible default assumptions with more pollyannish assumptions) to generate absurdly optimistic forecasts. Rather, TIP$TER® was made by a sophisticated and sober do-it-yourself investor for likeminded investors.

TIP$TER® models the lifetime growth and depletion of a couple's retirement portfolio and the projected retirement budgets supported by that portfolio. It allows the couple to specify a savings plan, including Social Security and any other income source, and a targeted retirement budget and spending plan (including college expenses or leaving the kids an inheritance) that flexes with changing market conditions. TIP$TER® asks for inflation-adjusted inputs and generates inflation-adjusted and actuarially-weighted (using period life tables) outputs.

TIP$TER® asks the couple to specify an asset allocation policy – which may decline with age, tactically exploit bear markets and avoid bubbles, or remain constant – that splits and annually rebalances the savings between a diversified stock portfolio and a relatively "risk free" portfolio invested in Treasury Inflation Protected Securities ("TIPS").

TIP$TER® models the stock portion of the couple's portfolio using several different return models. The default model is an "exploratory simulation" of 1600+ overlapping intervals of "mean-adjusted" S&P 500 real monthly return data set. The data set, which extends from Jan. 1871 to at least 2009, is scaled from its sky-high 6.4% annualized real return down to a (hopefully more realistic) user-specified expected *annualized* real return. And TIP$TER® encourages the couple to specify an expected annualized return that is – as the Dividend

Discount Model teaches – approximately equal to the current dividend yield of the total stock market plus the anticipated long-term inflation-adjusted growth rate of those dividends. In this way, TIP$TER's default simulation model uses a historical pattern of volatility and serial correlation to model returns that no conventional Monte Carlo simulation approximates, but avoids the error of assuming that future returns will be anywhere as generous as the past.

TIP$TER® generates richly informative yet comprehensible charts detailing various percentile outcomes of the simulation, including the portfolio size and retirement budget supported by the portfolio over the span of the simulated interval. Most significantly, TIP$TER® compares the simulated outcomes with the portfolio size and retirement budgets that would have been sustained by a 100%-inflation-protected-bond portfolio. TIP$TER® also generates actuarially-weighted summary statistics, including the "life-adjusted" shortfall risk, the "life-adjusted" average retirement budget, and the actuarially-weighted average final estate size.

B. Who is TIP$TER® for?

A "tipster" is someone who provides advice on a speculative bet. But TIP$TER® does not provide advice on picking particular stocks or stock sectors. It's not a tool for day traders or for people who are looking for "tips" on how to beat the market.

Indeed, TIP$TER® doesn't advise you at all, because TIP$TER's outputs depend on *your* inputs. TIP$TER® provides an analytical framework by which you can educate and inform *yourself* on different investment strategies. For TIP$TER'S projected outcomes to have any value, you must educate *yourself* sufficiently to enter reasonable inputs into TIP$TER's analytical engine.

TIP$TER® compares, in very practical real-life terms, the projected benefits and risks of a simulated broadly diversified portfolio with a conservative, all-TIPS portfolio. If a 50-year old retires with $1,000,000, how much can she safely spend every year if she puts it all in TIPS? How much, by comparison, will she likely be able to spend if she invests 100% of it in a broad stock market index fund? What if she splits her portfolio 50/50 between TIPS and a TSM index fund? And what are the risks? What is the 5-percentile outcome (i.e., 5% of potential outcomes would be as bad or worse than this outcome) of having a 50%-TSM/50%-TIPS portfolio, relative to the comparable outcome the retiree can expect from an all-TIPS portfolio? And what is the retiree's risk of outliving her portfolio? TIP$TER® provides educated, realistic answers to these questions, subject – of course – to the user's specification of reasonable stock and bond return expectations.

TIP$TER® is for analytically-minded persons who are skeptical of short-term market-timing strategies to beat the market. TIP$TER® is for persons who understand the value of broad diversification, disciplined rebalancing, index funds, low expense ratios, and investing for the long term. TIP$TER® is also for risk-averse persons interested in using a mathematical tool to help them evaluate whether to invest anything in stocks – and if so, to what extent.

C. What kind of information does TIP$TER® provide?

1. Baseline retirement budget that an all-TIPS portfolio would sustain

As a user begins entering or editing inputs, TIP$TER® immediately projects a baseline, sustainable inflation-adjusted amount that an investor, and his or her spouse, if any, can hope to spend every year when they retire, assuming that they save according to plan and invest all of their holdings in TIPS.

Why TIPS? Because TIPS are perhaps the safest income investment available to American consumers. TIPS are issued and backed by the U.S. government, so they have essentially no credit risk. They are also pegged to inflation, eliminating much of the interest rate risk commonly associated with long-term bonds.

Although this user manual and the TIP$TER® interface labels ask you to enter the real return on TIPS, ***you can use any proxy you like – for example, your expected real return on tax-free municipal bonds – for the long-term expected "risk free rate" of return.***

TIP$TER® suggests TIPS only because they are arguably the best available proxy for a "risk free rate" of return. TIPS, however are not truly risk free. In the short term, TIPS valuations can fluctuate significantly. Only by holding a TIPS to maturity do you avoid short term volatility effects on long-term bonds. Also, when a TIP matures, TIP$TER® assumes that another will be available to replace it with the same real yield. That may not be the case.

Consider the example of Jack and Jill, a dual-income couple, both aged 30, with $100,000 in savings. In hopes of retiring by the time they reach 55 years old, Jack and Jill plan to *each* save $15,000/year in their respective 401(k) plans. Jack and Jill also figure that by the time they reach age 70, they can count on $20,000 in Social Security benefits each year. Because Jack and Jill want to avoid outliving their portfolio, they decide they need a portfolio that can last for 70 years – until they would be 100 years old.[1]

Jack and Jill look up the current real yield on TIPS on a financial website, like www.bloomberg.com or www.wsj.com, and discover that TIPS for a broad range of maturities currently yield about 2% after expenses and inflation.

As they enter these numbers into TIP$TER's spreadsheet, TIP$TER® projects that if Jack & Jill invest all their savings in TIPS (and continue reinvesting the income and matured TIPS in additional TIPS yielding the same real rate of return), their portfolio – eventually combined with Social Security – would likely sustain an inflation-adjusted retirement budget, starting 25 years from now, of $49,324/year. Between years 25 and 40, the TIPS portfolio would generate the entire $49,324/year. Between years 40 and 70, the TIPS portfolio would provide $29,324/year, and Social Security would provide the remaining $20,000/year. TIP$TER® also generates the following graphs:

[1] Jack and Jill could alternatively model the purchase of an inflation-adjusted "longevity annuity" (see § IV.D.3(g)), which would allow them to spend a shorter duration over their targeted portfolio life.

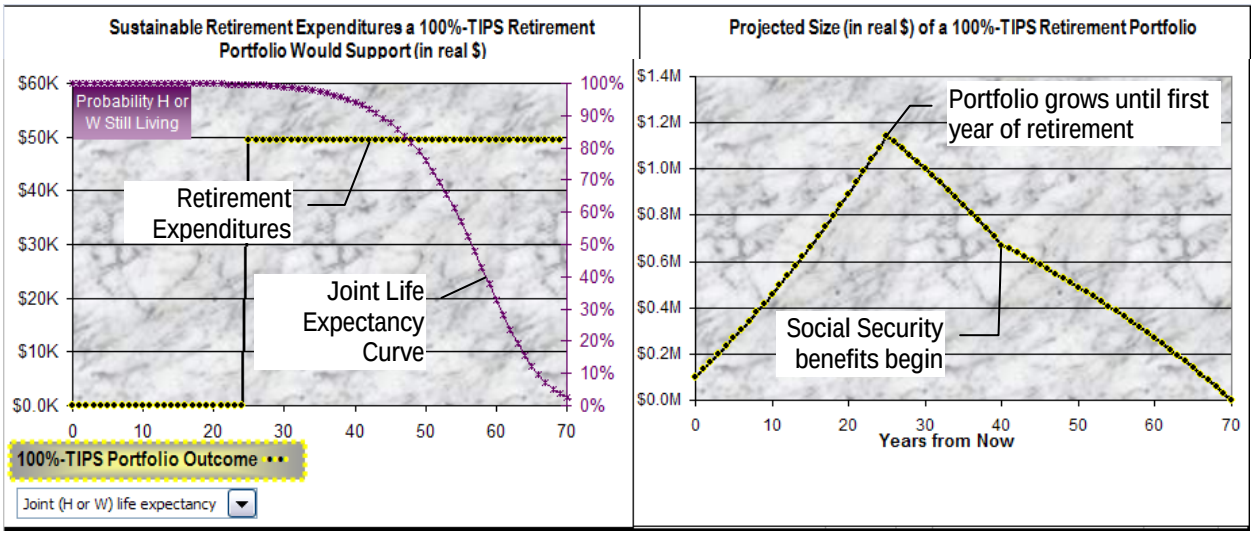


Figure 1: The left chart projects the annual retirement expenditures that Jack & Jill's portfolio, plus other retirement income sources (e.g., social security), could sustain if they put all their savings in TIPS. The right chart projects the growth and depletion of Jack & Jill's all-TIPS portfolio over the next 70 years.

The left chart shows that starting 25 years from now (when Jack and Jill, both currently 30 years old, reach 55 years of age), an all-TIPS portfolio strategy would support inflation-adjusted retirement expenditures of almost $50,000/year – and sustain that level of expenditures for 45 years. The joint life expectancy curve on the same chart shows that there is less than a 5% chance that either Jack or Jill would live to 100 years; so the likelihood is small that either of them would outlive this all-TIPS portfolio.

The chart to the right shows Jack and Jill's portfolio growing from its current balance of $100,000 to an inflation-adjusted balance of more than $1.1 million in 25 years. Two factors contribute to that growth – (1) the couple's annual $30,000 retirement contributions, and (2) the real, after-inflation 2% annual growth of their portfolio. From year 25 through year 40 – when Jack and Jill, then aged 70, plan to start collecting social security benefits – their portfolio balance declines from about $1.1 million in inflation-adjusted dollars to about $650,000 in inflation-adjusted dollars. Then, from year 40 through year 70, Jack and Jill deplete their portfolio more slowly, because $20K of their ~$50K in annual expenditures is supported by Social Security.

If Jack and Jill change any of the assumptions described above, TIP$TER's outputs will change accordingly.

2. Range of retirement budgets that a diversified portfolio would likely sustain

Having calculated the sustainable retirement budget that an all-TIPS portfolio could support, TIP$TER is prepared to project a range of retirement budgets their portfolio would likely support if a portion of it was invested in a TSM index.

Let's assume that Jack and Jill plan to invest 70% of their portfolio in a broadly diversified index of stocks, like the S&P 500 index, or – even better – a worldwide stock index. The 30% balance of the portfolio would be invested in TIPS. Jack and Jill plan to regularly rebalance their portfolio to maintain that 70/30 asset allocation.

Before TIP$TER® can project a range of potential outcomes for the couple's diversified portfolio, TIP$TER® needs Jack and Jill to specify the *extra* return, above and beyond the real yield on TIPS – commonly referred to as the "equity risk premium" – that the couple expects the broad index of stocks to yield. TIP$TER® also needs Jack and Jill to select a model for simulating the returns of the stock portion of their portfolio. By default, TIP$TER® will test Jack and Jill's portfolio against a data set of historical S&P 500 returns that has been *modified* to reflect Jack and Jill's forward-looking equity risk premium expectations. (More information on TIP$TER's simulation options is set forth in Section VII of this manual).

So what values should Jack and Jill enter for the expected risk premium? Section IV.C of this manual provides guidance on specifying reasonable values for the expected risk premium. For now, let's assume that Jack and Jill expect their diversified index of stocks to return 3.5% after inflation and expenses, which is 1.5% more than the TIPS.

TIP$TER® also needs Jack and Jill to specify how much of their portfolio they plan to put in stocks. Assume that Jack and Jill decide – based on advice they've heard from others – to test a 70% asset allocation to stocks.

TIP$TER® also needs Jack and Jill to specify their retirement budget goals and budget constraints. TIP$TER®'s interface and Section IV.F of this manual provide Jack and Jill with helpful suggestions on specifying potentially achievable retirement budget goals.

Assume that Jack and Jill specify a targeted annual inflation-adjusted retirement budget of $55,000, an absolute minimum annual inflation-adjusted retirement budget of $50,000, and a couple of other parameters – which are explained later – that dynamically adjust Jack and Jill's retirement budget depending on the simulated performance of the market.

After entering these values, and launching TIP$TER's simulation engine, TIP$TER® generates the following graphs:

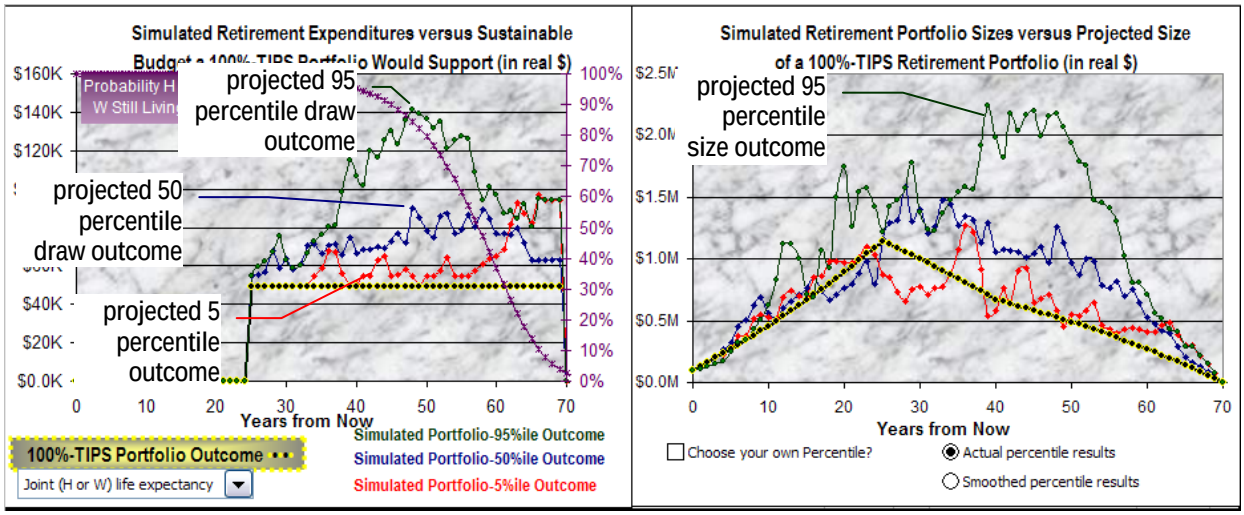


Figure 2: The left chart projects the annual retirement expenditures that the 95, 50, and 5 percentile simulated outcomes from Jack and Jill's 70%-stock/30%-TIPS portfolio, plus other retirement income sources (e.g., social security), would sustain. The right chart projects the corresponding 95, 50, and 5 percentile growth and depletion outcomes of the portfolio. The black and yellow lines represent the corresponding outcomes anticipated from a 100%-TIPS portfolio

As shown in the preceding chart, TIP$TER® continues to display – with black-and-yellow symbols signifying the "cautious" approach – the expected outcomes of a baseline all-TIPS portfolio. TIP$TER® also displays – with green, blue, and red symbols, respectively – the projected 95-percentile, median, and 5-percentile outcomes of the couple's 70/30 diversified portfolio.[2]

As is evident from the graph, the *median* outcomes of the diversified portfolio (shown in blue dots) generously outperform the comparable outcomes of the baseline all-TIPS portfolio (shown in black-and-yellow). But the *5-percentile* outcome of the diversified portfolio (shown in bright red dots) is pretty dismal by comparison. That means that in 5 percent of the simulations, the outcome of the diversified portfolio was as bad or worse than the outcome represented by the bright-red dots. In this way, TIP$TER® helps investors assess their risk tolerance.

3. The relative risks and rewards of a diversified portfolio vs. an all-TIPS portfolio as a function of asset allocation

What if Jack and Jill chose a 60/40, or a 50/50 asset allocation ("AA"), instead? In Fig. 3, TIP$TER® illustrates how the risks and rewards of Jack and Jill's diversified portfolio vary as a function of the percentage AA.

[2] A "95-percentile" outcome refers to an outcome that *surpassed* 95% of the simulated outcomes. A "5-percentile" outcome refers to an outcome that *underperformed* 95% of the simulated outcomes. A "median" outcome is right in the middle, surpassing 50% of the simulated outcomes and underperforming the other 50%.

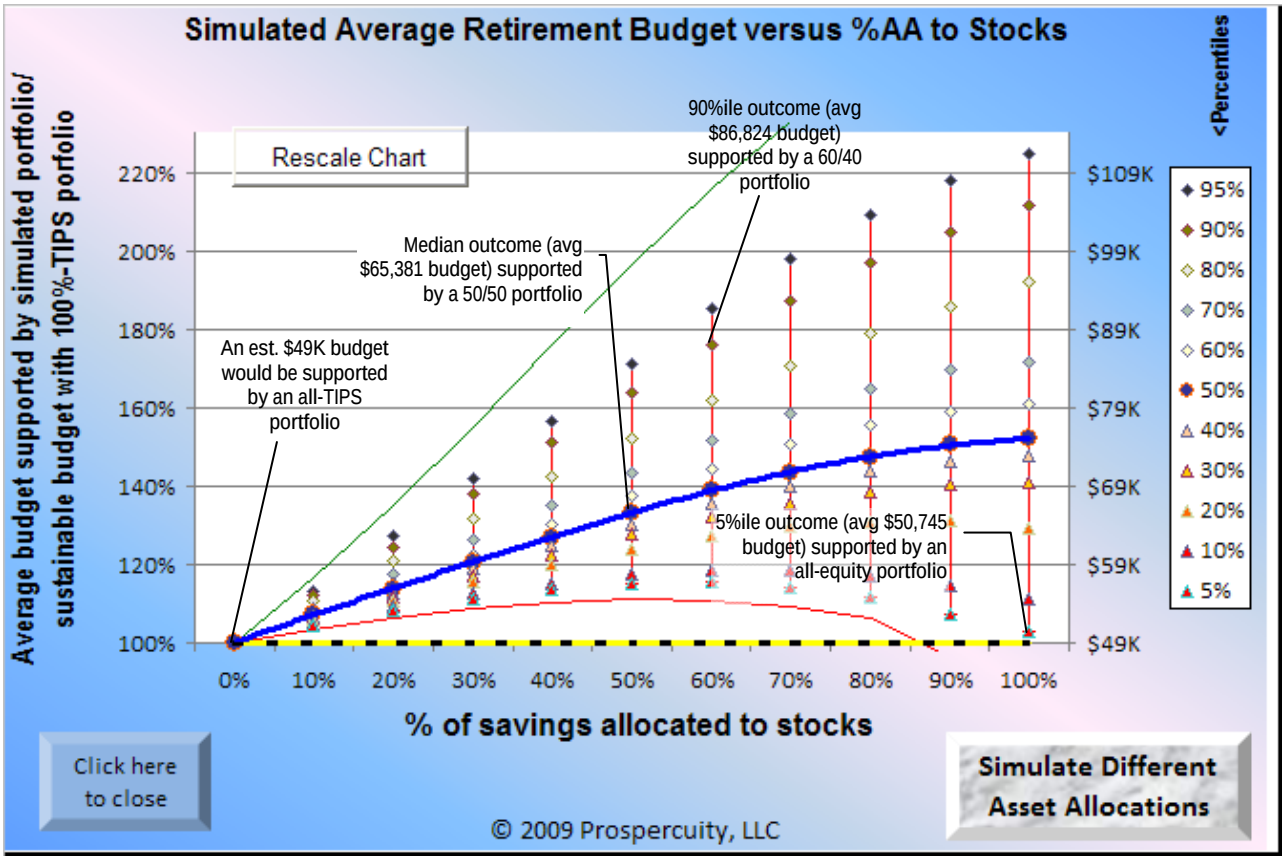


Figure 3: The Asset Allocation Risk/Reward Spectrum chart above projects the relative risks and rewards of a diversified portfolio compared to an all-TIPS portfolio as a function of the percentage allocation to stocks. The blue dots represent the median outcomes. The diamonds above the blue dots represent high-percentile outcomes. The triangles below the blue dots represent low-percentile outcomes. Finally, the green and red bands represent the most extreme (100% and 0%) outcomes.

The Asset Allocation Risk/Reward Spectrum chart displays the average retirement budgets supported by a series of simulated portfolios whose asset allocations range between 0% and 100% in stocks, with the remainder in TIPS. The portfolios are simulated with rebalancing.

The potential retirement budget associated with each simulated portfolio is presented both in average dollar terms and as the *percentage* of the retirement budget supported by an all-TIPS portfolio.

The purpose of the chart is to illustrate how both the relative expected "reward" (illustrated by the blue "median" outcome dots) and the risk (illustrated by the dispersion of yellow-to-red low-percentile outcome dots below the blue "median" outcome dots) of a diversified portfolio compares with an all-safe approach and increases as a function of asset allocation.

The **blue dots**, and the curve intersecting the blue dots, illustrate the **median** retirement budget supported by simulations of portfolios having the indicated asset allocations.

The **diamonds** above each blue dot represent the 60, 70, 80, 90, and 95 **percentile** outcomes, respectively, from the simulations. The **green line** at the top represents the ***absolute best outcome*** from the simulations.

The **triangles** below each blue dot represent the 40, 30, 20, 10, and 5 **percentile** outcomes from the simulations. The **red line** at the bottom represents the ***absolute worse outcome*** from the simulations.

Finally, the **yellow and black dotted line** represents the 100%-TIPS portfolio baseline

D. What are the bases of TIP$TER's projections?

In its preferred mode, TIP$TER® simulates the stock portion of a portfolio through "exploratory simulation" of a "mean-adjusted" historical S&P 500 return data set going all the way back to 1871. *See* Section VII(A).

TIP$TER® also gives you the option of simulating the stock portion of the portfolio using a stationary or mean-reverting normal, lognormal, double lognormal, or randomly-scrambled historical S&P 500 return distribution. *See* Section VII(B)-(G).

E. Why the name TIP$TER®?

Four reasons. First, stocks *are* inescapably speculative; and TIP$TER® *is* a tool for modeling the relative risks and rewards of stock investments. Second, all of TIP$TER's outputs are given in relation to the corresponding expectation of an all-TIPS portfolio. Third, TIP$TER® projects and illuminates the relationship between the risk, reward, and asset allocation of a diversified but regularly rebalanced portfolio. This is reflected by the first four letters of "TIPSTER," which symbolize "Testing Investment Portfolio Strategies." Fourth, the last three letters of "TIPSTER" stand for "To Enable Retirement," "To Enrich Retirement," and "Toward Early Retirement," which reflects TIP$TER's broad range of practical applications.

III. DOWNLOADING AND INSTALLING TIP$TER®

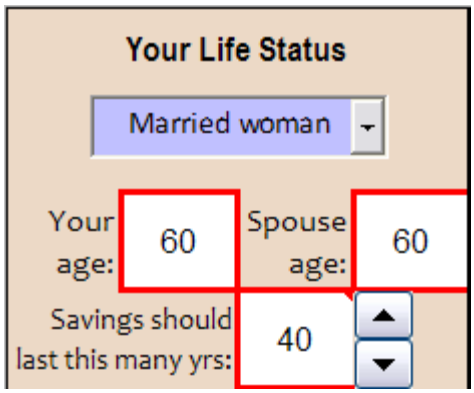
TIP$TER® is a spreadsheet that uses a considerable amount of Microsoft Visual Basic™ macro code. It is designed to run on Microsoft Excel™ 2003 or 2007 for Windows XP™ or Windows Vista.™ Currently, no versions of TIP$TER® have been tested to see if they can run on other platforms.

Since version 2.0, TIP$TER® is available as an Excel spreadsheet encapsulated as an executable file. The executable version was built using the LockXLS spreadsheet copy protection program. Users can freely use TIP$TER DIY for personal or academic use. But professionals who wish to use TIP$TER to advise third parties must use TIP$TER PRO, which requires registration to operate.

IV. GUIDANCE ON SPECIFYING TIP$TER'S INPUTS

TIP$TER® is exceptionally powerful because it lets you enter in a large range of income and expense inputs so that the portfolio TIP$TER® models bears a close resemblance to the portfolio most users would plan for their lives.

A. Your Life Status



1. What Difference Does My Marital Status Make?

TIP$TER® asks for you to enter your gender and marital status so that it uses the right set of actuarial values. If you are married, then you are probably most concerned with making your portfolio last until the *last* of you and your spouse dies. If you are single, then you are probably only concerned with making sure that your portfolio outlives *you*. If you are a single woman, you have a longer remaining life expectancy than would a single man.

2. Why Enter My Age?

In order to make relevant projections, TIP$TER® asks for your age, and if you are married, your spouse's age, so that it can factor in actuarial statistics from a "period life" table into its statistics. When it computes summary statistics – such as the "shortfall risk" and the "average" retirement budget over the life of the portfolio – TIP$TER® weights those statistics by the joint life expectancy of you and your spouse (if any).

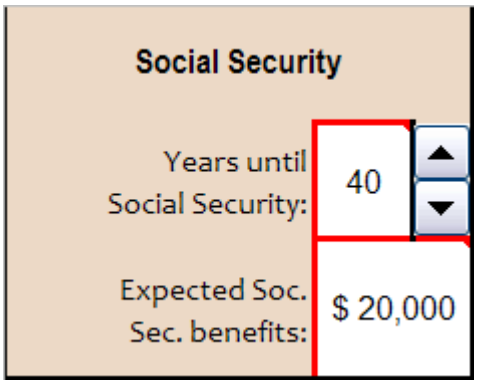
3. Targeted Portfolio Duration

Here, enter you many years you want to make your retirement savings last, counting from today.

Many retirees want to be able to maximize their annual retirement budget while minimizing their risk of an impoverished old age. Ideally, you could do this by building a nestegg designed to last for a limited period of time – for example, until the younger of the two spouses reaches age 85 – and then purchasing a longevity annuity (see section IV(D)(3)(h)) that would begin paying if and when you or your spouse reached that age. Unfortunately, it does not appear that there are any *inflation-adjusted* longevity annuities on the market right now.

To test a conventional retirement strategy – one that does not rely on annuities – you should choose a targeted portfolio duration that minimizes the risk of outliving your retirement savings. For example, you might want to assume that either you or your spouse will live to 95 years of age or longer. To do this, you would enter a number in this cell that is at least as great as 95 minus your age, or, if you have a younger spouse, 95 minus your spouse's age.

B. Your Social Security Inputs



1. Years Until Social Security

In the "Years until Social Security" cell, enter the number of years before you (or your spouse if he/she has the greater anticipated benefit) intend to start collecting Social Security.

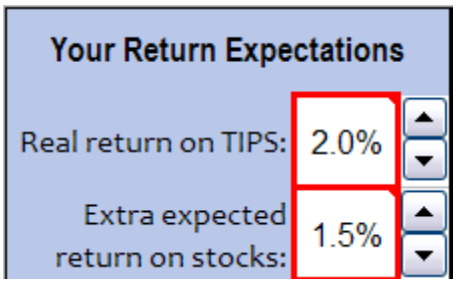
As you may already know, you can increase your anticipated annual Social Security benefit by delaying collection of that benefit, up to the age of 70. Delaying Social Security will likely reduce your risk of outliving your portfolio. It is somewhat like buying an inflation-adjusted longevity annuity that starts at age 70.

2. Expected Social Security Benefits

In the "Expected Soc. Sec. benefits" cell, enter the greater of you or your spouse's anticipated Social Security (SS) benefits. TIP$TER® assumes that this benefit will be paid out for as long as the last surviving spouse shall live. (Under Social Security, once one spouse dies, the surviving spouse is entitled to receive the greater of the two spouse's earned benefits.)

But what about the other spouse's social security benefit? Under Social Security, a married person – while his or her spouse is still alive – can receive the greater of his or her earned benefit or ½ of his or her spouse's benefit. You can account for this spousal benefit in the "Additional Portfolio Inputs and Outputs" section. There, input the second spouse's anticipated SS benefit, for a period of "Until either H or W dies." (Once one spouse dies, the surviving spouse would give up the lesser of the two spouse's benefits.)

C. Your Return Expectations



TIP$TER's projections depend critically on two return expectations that *you* need to specify. These are (1) the real return on TIPS; and (2) the *extra* annualized return you expect to earn on your diversified basket of stocks.

1. What is the Real Return on TIPS?

The value you enter for the "Real return on TIPS" is critical to TIP$TER's computation of a baseline retirement budget supported by an all-TIPS portfolio. Economists frequently use U.S. Treasuries as proxies for the so-called "risk-free" rate of return (which is an important economic concept). TIP$TER® uses TIPS as a proxy for the *real* (i.e., after-inflation) risk-free rate of return.

To determine this value, go online to find the prevailing real yield on TIPS of various maturities. There are several websites that disclose the *effective* inflation-adjusted (real) return

on TIPS. Vanguard's website reveals the effective rate on its VIPSX fund.[3] Barclay's website reveals the effective rate on its TIP ETF.[4] Bloomberg's website provides the real yields on TIPS with approximately 5, 10, and 20 year maturities.[5] The Wall Street Journal's website gives the real yields on specific TIPS coupons of various maturities.[6] Finally, the Federal Reserve's website reports the historical real yields on TIPS of various maturities.[7]

Make sure that whatever value you put in this cell takes into account any annual expense ratio that the mutual fund provider, ETF provider, and/or your investment advisor charges you. So, if you invest in a TIPS bond that has an effective real yield of 2.2%, but your investment advisor charges you 1%/year, click on the appropriate up/down spinners next to the "real return" cell until it shows "1.2%."

If you are buying TIPS in a taxable account, also make sure that you subtract an appropriate amount to cover your taxes. As explained in section IV.C.4 of this manual, TIP$TER assumes that your portfolio resides in tax shelters like IRAs, 401(k)'s, and pension funds. To the extent that your portfolio is likely to suffer a tax drag, you should account for that drag when you specify the real return you would expect from TIPS.

Caveat: In projecting the retirement draw that an all-TIPS portfolio would sustain, TIP$TER makes a few simplifying assumptions. First, TIP$TER assumes that the principal and expected yield on TIPS would be completely safe, and have no variance or correlation with your basket of "risky assets." Second, TIP$TER assumes that as your TIPS matured, you would be able to replace them with new TIPS yielding the *same* real interest rate.

Reality is more complex, of course. The principal on TIPS bonds fluctuates as interest rates change. And the longer the maturity, the more the principal fluctuates. If during retirement, you redeem your TIPS before they mature and, on average, at a discount, your all-TIPS portfolio will not be able to sustain as high a retirement draw as TIP$TER projects. Also, there is no guarantee that TIPS, in the future, will provide real returns as high as they currently boast. If future TIPS provide a considerably smaller real yield, your all-TIPS portfolio will not be able to sustain as high a retirement draw as TIP$TER projects.

An alternative, and perhaps more reliable proxy for the "risk-free" rate of return is the real return portion of I-Bonds. The principal of an I-bond, unlike a TIPS bond, does not fluctuate with current market interest rates, and therefore truly has no variance or correlation with equities. However, the annual purchase limits and low real yields (0.7% as of November 2008) for I-bonds make them an unattractive investment strategy for a large portfolio.

Considering everything, the average real yield from a blend of "laddered" TIPS of different maturities would make a pretty good – and attractive – proxy for a "risk-free rate." By building a "laddered" portfolio of TIPS, you can approximately match the maturities of different TIPS to the years in which you plan to redeem and spend them.

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[3] *See* https://personal.vanguard.com/us/JSP/Funds/Profile/VGIFundProfile0119Content.jsf?tab=0&FundId=0119.

[4] *See* http://us.ishares.com/product_info/fund/overview/TIP.htm.

[5] *See* http://www.bloomberg.com/markets/rates/index.html.

[6] *See* http://online.wsj.com/mdc/public/page/2_3020-tips.html?mod=topnav_2_3010.

[7] *See* http://www.federalreserve.gov/releases/h15/data.htm.

2. *How Much Extra Return Should I Expect for Stocks?*

After you enter the real return on TIPS, TIP$TER® asks that you enter the "Extra expected return on stocks." Economists fondly refer to this as the "equity risk premium."[8] The probable *median* outcome of your diversified portfolio is largely a function of the number you enter here, your overall asset allocation, and the risk-free rate of return you entered above.

If the expected annualized real return on stocks is 4%, and TIPS are yielding a real 2%, then stocks provide an "extra expected return" over TIPS of 2%.

(a) An Introduction to the Dividend Discount Model

What is a reasonable estimate for the annualized "extra return" you should expect from a diversified basket of stocks? That's a very good question, *and one that you should think carefully about* before deciding whether to invest in stocks.

In 2002, Robert D. Arnott and Peter L. Bernstein authored an article, published in the March/April 2002 issue of the Financial Analysts Journal, entitled "What Risk Premium is 'Normal.'"[9] There, the authors argue that expected long-term real returns on stocks can be expressed by the following "Dividend Discount" formula:

$$\mu = D + G - L$$

where:

μ = expected real stock return for stocks;
D = expected dividend yield for stocks;
G = expected real per capita GDP growth; and
L = percentage by which real dividend growth is expected to lag behind real per capita GDP growth.

For example, if the expected immediate dividend yield on a broad stock market index is 2% (D = 2%), real per capita GDP is expected to grow 2% per year (G = 2%), and real dividend growth is expected to lag behind real per capita GDP growth by 1% (i.e., L = -1%), then the expected real stock return μ is 3% (i.e., 2% + 2% - 1% = 3%). Moreover, if the applicable real risk-free rate is 2%, then in this example the broad stock market provides an expected "risk premium" of just 1% (i.e., 3% - 2% = 1%).

(b) Choosing Reasonable Values in Light of the Dividend Discount Model

How can *you* apply the "Dividend Discount" approach to computing the expected long-term return on the stock market? First, you need to find out the current dividend yield on a broad

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[8] Economists refer to the "equity risk premium" as the excess return on stocks by which the market compensates investors for taking on the higher risks of stocks.

[9] A copy of this article is available at http://www.mccombs.utexas.edu/faculty/keith.brown/AFPMaterial/Arnott-Bernstein%20FAJ02.pdf.

market index. Second, you need to estimate real per capita GDP growth (or, alternatively, world or regional per-capita productivity growth). Third, you need to estimate how much real dividend growth will lag behind real per capita growth.

The first part is not too difficult. You can quickly find the approximate dividend yield of a broad market index from several different sources. You can add up the dividends over the past year given off by a broad index fund, and divide it by the current market price of the fund. For example, the Vanguard 500 Index Fund (Ticker:VFINX) distributed quarterly dividends between the third quarter of 2007 and the second quarter of 2008 totaling $2.54/share. The price of a share of VFINX on September 9, 2008, was $113.23. $2.54 divided by $113.23 works out to a 2.24% dividend yield. The Vanguard European Stock Index Fund (Ticker:VEURX) distributed a single annual dividend at the end of 2007 of $1.215/share. The price of a share of VEURX on September 9, 2008, was $29.93. $1.215 divided by $29.93 works out to an attractive 4.06% dividend yield.

The second part – projecting future per capita economic growth – is more difficult. According to acclaimed author William Bernstein (not to be confused with the Peter Bernstein cited earlier in this manual), per capita real GDP growth in the United States averaged about 2% during the 20th century,[10] and the world's per-capita gross domestic product also grew at a pace of just over 2%/year from 1820 to 1998.[11] You can hope that real per capita GDP growth will continue at that same pace. Or, you can assume that as economies mature, the population ages, and as services make up an ever-increasing portion of GDP, per-capita GDP growth will slow down.

The third part – estimating how much real dividend growth will lag behind real per capita growth – is also a bit challenging. Fortunately, William Bernstein has published some historical insight on this factor as well. He compared real dividend growth rates with real per-capita GDP growth rates in 16 developed countries over the entire 20th century. In eight countries, including the U.S., that were not devastated by World Wars I, II, or the Spanish Civil War, real dividend growth rates lagged real per-capita GDP growth rates by an average of 1.11%/year. In the United States, specifically, the lag averaged 1.36%/year. In eight countries that were devastated by war, real dividend growth rates lagged real per-capita GDP growth rates by 3.7%/year.[12] Mr. Bernstein concluded that "at the dawn of the new millennium, the equity investor cannot expect a real return greatly in excess of a generally derisory dividend yield."

Mr. Bernstein's insights are indeed chilling. But this is all the more reason to project and compare the expected return on a diversified stock portfolio with the expected return of an all-TIPS portfolio.

So, using what you learned above, what return could someone, on September 9, 2008, reasonably expect from a broadly diversified U.S. index fund, assuming that U.S. continues to grow at historical rates and the average 1.11%/year dilution stays the same?

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[10] *See* http://www.efficientfrontier.com/ef/403/fairy.htm.

[11] *See* http://www.efficientfrontier.com/ef/902/gmm.htm.

[12] *See* http://www.efficientfrontier.com/ef/702/2percent.htm.

$$\mu = D + G - L - \textit{Index Fund Expenses}$$
$$= 2.24\% + 2\% (?) - 1.36\% - 0.1\%$$
$$= 2.8\%$$

And how much *extra* return over TIPS does that leave you? With 20-year TIPS yielding about 2% real as of September 9, 2008, only about 2.8% - 2% = 0.8%. *Ouch!*

3. What If I Have More Than Two Asset Classes?

TIP$TER's portfolio projections can be extended to slice-and-dice and other customized portfolios that are overweight in small stocks, value stocks, and the like, and that include REITS, commodities, and other types of investments.

All you need to do is estimate the collective "extra expected return" and "standard deviation" that you expect from the *combination* of all of your investments, not including TIPS. Enter *those* values into TIP$TER's "extra return" and "standard deviation" inputs. (See section VII(B)).

What if you don't know what returns and standard deviation to expect from your combination? There are many "mean-variance optimizers" (MVO) that calculate the *historical* return and standard deviation of various collections of assets. You can use the expected return and standard deviation outputs of any MVO you like as inputs into TIP$TER®.

But historical returns for different asset classes are an extremely poor indication of the future performance of those asset classes.

One alternative is to think in terms of the small and value premiums. Suppose you have a portfolio that is overweighted in small, value-oriented stocks. You could use the "Dividend Discount" model discussed in § IV.C.2 of this manual as a base amount, and then add to that base amount an estimated "small" premium, an estimated "value" premium, and an estimated "rebalancing" bonus. Some academics have attempted to quantify historical "small" and "value" premiums. But it is likely that the small and value premiums, if they persist at all, will be smaller in the future.

Another alternative is to use fundamental analysis to project the future returns of various asset classes, and then average those returns together in accordance with your asset allocation weights. If you are confident that you can reasonably project the standard deviations of and future correlations between those asset allocations, then using a MVO, you can also forecast the overall standard deviation of your portfolio.

To illustrate, in 2001, William Bernstein published his expectations for the future returns of various asset classes.[13] For example, he projected an expected real return of 3% for large U.S. stocks, 7% for small value stocks, and 5% for REITS. Shortly afterwards, small value stocks and

[13] See http://www.efficientfrontier.com/ef/701/cheap.htm.

REITS experienced tremendous returns. No doubt, the much richer valuations of small value stocks and REITS in 2008 would no longer justify such high return expectations going forward.

4. What about Inflation?

TIP$TER® fully accounts for inflation. All of the values, graphs, and charts you see in TIP$TER® indicate inflation-adjusted quantities. TIP$TER® assumes that the values you enter are also inflation-adjusted. So, for example, if you indicate that you expect to receive social security benefits worth $20,000/year in 40 years, TIP$TER® interprets that as $20,000/year in today's dollars.

5. What about Taxes?

TIP$TER® makes a simplifying assumption about taxes: that an investor can rebalance his or her retirement savings and reinvest the earnings – including interest income, dividends, and capital gains – from his retirement savings without immediately realizing any taxable income. Also, when specifying a targeted retirement budget, TIP$TER® assumes that the investor is specifying the pre-tax retirement budget. So it is important to specify a generous enough targeted retirement budget to pay all necessary taxes.

TIP$TER's simplifying assumption is suitable for most young middle-class investors. Today, most middle-class workers squirrel away the majority of their retirement savings in 401(k)s, IRAs, Roth IRAs, pension plans, and other tax-advantaged vehicles. Moreover, many buy-and-hold investors invest most or all of their taxable retirement savings in low-cost index funds, deferring taxes on any capital gains for years, perhaps all the way until they redeem some of their assets to fund their retirement budget. Also, many investors can maintain their targeted asset allocation, and effectively rebalance their entire portfolio, without ever owning bonds in a taxable account.

There are, however, some investors who would suffer a huge tax drag by investing in bonds. (Here's a spreadsheet that illustrates the effects of tax drag on a taxable TIPS portfolio as user-specified tax and withdrawal rates). For them, TIP$TER®'s simplifying assumption is not as suitable. TIP$TER® is still useful to the extent that they make return assumptions that reflect their after-tax expectations. However, taxes dreadfully complicate the effort of making educated return assumptions.

Depending on popular demand and the profitability, if any, of TIP$TER®, a future version may be developed that accounts for taxes, allows users to segregate their portfolio into taxable and tax-sheltered accounts, and assumes that the portfolio will be managed, rebalanced, and drawn down in the most tax-efficient manner.

D. Your Savings Goals

TIP$TER® asks that you specify a very basic set of retirement savings inputs. TIP$TER® also gives you the option of specifying a more complex set of portfolio inputs and outputs.

Your Retirement Savings	
Current retirement savings:	$ 100,000
Add $/yr until retirement:	$ 30,000

1. Current savings

In the "Current savings" cell, enter the current size of your retirement savings.

You ***should not*** include the value of your home, car, or other non-appreciating assets in this amount. You should only include assets on which you plan to depend for retirement.

If you are contemplating boosting your retirement by taking out a reverse mortgage on your home, enter the expected income stream from that reverse mortgage, and the year you expect it to begin, in the "Additional Portfolio Inputs and Outputs" section.

2. Additional Pre-retirement Contributions

In the "Add $/yr until retirement" cell, enter the additional annual (inflation-adjusted) contributions you plan to make to your retirement portfolio until retirement.

If you don't intend to contribute the same inflation-adjusted amount every year between now and retirement, you can provide a more customized description of your planned future retirement contributions in the "Additional Portfolio Inputs and Outputs" section, which is described below.

3. Additional Portfolio Inputs and Outputs

Additional Portfolio Inputs and Outputs? ☐ Check If Yes					
Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
PV = $			Lump Sum Annually for n years Until both H and W die Until either H or W dies	1	0.0%
PV = $			Annually for n years Until both H and W die Until either H or W dies Until retirement	1	0.0%
PV = $			Lump Sum Annually for n years Until both H and W die Until either H or W dies	1	0.0%
PV = $			Lump Sum Annually for n years Until both H and W die Until either H or W dies	1	0.0%
PV = $			Lump Sum Annually for n years Until both H and W die Until either H or W dies	1	0.0%

The "Additional Portfolio Inputs and Outputs" section greatly extends TIP$TER's practical reach. Here, you can specify up to five additional inputs and outputs to your portfolio – and with a great deal of specificity. You can specify the amount of any input (as a positive number) or output (as a negative number), the first year that the input or output is added or subtracted, the number of years that the input or output is added or subtracted, and the real, inflation-adjusted

growth rate of the input or output. The following subsections provide some practical uses of these input fields.

(a) Additional Customized Retirement Contributions

Earlier, this manual illustrated Jack and Jill's plans to annually contribute an additional $30,000/year, with inflation adjustments, to their retirement portfolio from now until retirement.

If you want to be *more* specific about your retirement contributions, enter zero in the "Add $/yr until retirement" cell, and instead enter your detailed retirement contribution plans here.

In the example illustrated in the graphic below, Jack and Jill have specified that they plan to contribute $5,000/year to their retirement portfolio starting 15 years from now. They also specify that they want to continue those contributions through the end of retirement by selecting "Until retirement" in the "Type" list box. Because Jack and Jill previously indicated their plans to retire in 25 years, TIP$TER® automatically calculates that the couple's contributions would occur over a 10-year period. Finally, Jack and Jill indicate that due to expected salary increases late in their career, they plan to increase their contributions at a real, above-inflation rate of 5%/year.

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
Customized Retirement Contributions PV = $42,474	$ 5,000	15	Annually for n years Until both H and W die Until either H or W dies Until retirement	10	5.0%

As Jack and Jill enter these additional inputs, TIP$TER® immediately recalculates the sustainable retirement expenditures an all-TIPS portfolio would support and regenerates the baseline graphs (illustrated in Fig. 1) with the new information.

(b) Spousal Social Security and other Pension Benefits

The "Additional Portfolio Inputs and Outputs" section allows you to specify a spousal social security or other pension benefit that you anticipate.

For example, assume that Jill expects – in addition to the $20,000/year social security benefit Jack expects to get when he turns 70 – her own $15,000/year social security benefit, based on her own earnings. Because Jack's anticipated benefit is larger, Jack and Jill listed Jack's $20,000 benefit in the "Expected Soc. Sec. benefits" cell (see § IV.B.2). Here, in the "Additional Portfolio Inputs and Outputs" section, they list Jill's anticipated $15,000/year benefit in the "Amount" cell. In "Yrs 'till event," they enter 40. In the "Type" list box, they select "Until either H or W dies," because at that time, the surviving spouse would elect to receive the greater of Jack and Jill's Social Security benefits. Based on actuarial statistics, TIP$TER® predicts that Jack and Jill will receive this additional income for two years before one of them is likely to die.

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
Jill's anticipated SS benefit PV = $13,454	$ 15,000	40	Lump Sum Annually for n years Until both H and W die Until either H or W dies	2	0.0%

(c) Additional Temporary Expenses

The "Additional Portfolio Inputs and Outputs" section allows you to specify temporary expenses – including pre-retirement expenditures – that you anticipate.

For example, imagine that Jack and Jill have a daughter Nancy who will be ready for college 10 years from now. Jack and Jill want to budget $25,000/year, in today's dollars, to defray Nancy's college expenses. In the "Amount" cell, Jack and Jill enter a negative $25,000. In the "Yrs 'till event" cell, Jack and Jill enter 10. Jack and Jill anticipate Nancy obtaining a 4-year education. So in the "Type" list box, Jack and Jill select "Annually for n years." And in the "# of Years" cell, they select the appropriate spinners until it reads "4." Finally, Jack and Jill also expect college tuition costs to increase faster than the rate of inflation. So in the "Increase/Decrease by real % per year" cell, Jack and Jill specify a real 3.6% increase in anticipated college costs per year.

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
College Expenses PV = -$83,985	$ (25,000)	10	Annually for n years Until both H and W die Until either H or W dies Until retirement	4	3.6%

As Jack and Jill enter these additional inputs, TIP$TER® immediately recalculates the sustainable retirement budget an all-TIPS portfolio would support and modifies the graphs illustrated in Fig. 1 to look like the graphs in Fig. 4.

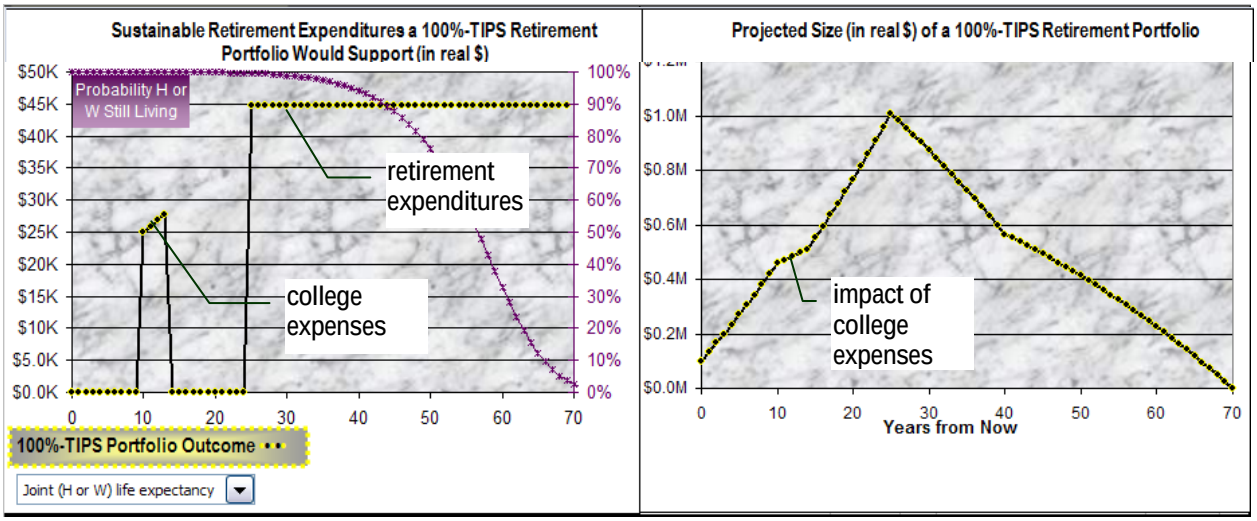


Figure 4: The chart to the left illustrates the expenditures – including 4 years of college tuition starting 10 years from now – sustained by Jack & Jill's portfolio. The chart to the right illustrates the changing size of Jack & Jill's portfolio – now as also impacted by those college expenses – over time.

(d) Receive an Anticipated Inheritance

The "Additional Portfolio Inputs and Outputs" section allows you to specify the impact of an anticipated inheritance (that you receive) on your retirement situation.

For example, imagine that Jack and Jill expect that by the time they are 70 years old, they will inherit $250,000 in today's dollars. So Jack and Jill specify $250,000 in the "Amount" cell and "40" in the "Yrs 'till event" cell. They also specify "Lump Sum" in the "Type" list box.

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
Inheritance PV = $113,223	$ 250,000	40	Lump Sum Annually for n years Until both H and W die Until either H or W dies	1	

As Jack and Jill enter these additional inputs, TIP$TER® immediately recalculates the sustainable retirement budget an all-TIPS portfolio would support and modifies the graphs illustrated in Fig. 1 to look like the graphs illustrated in Fig. 5.

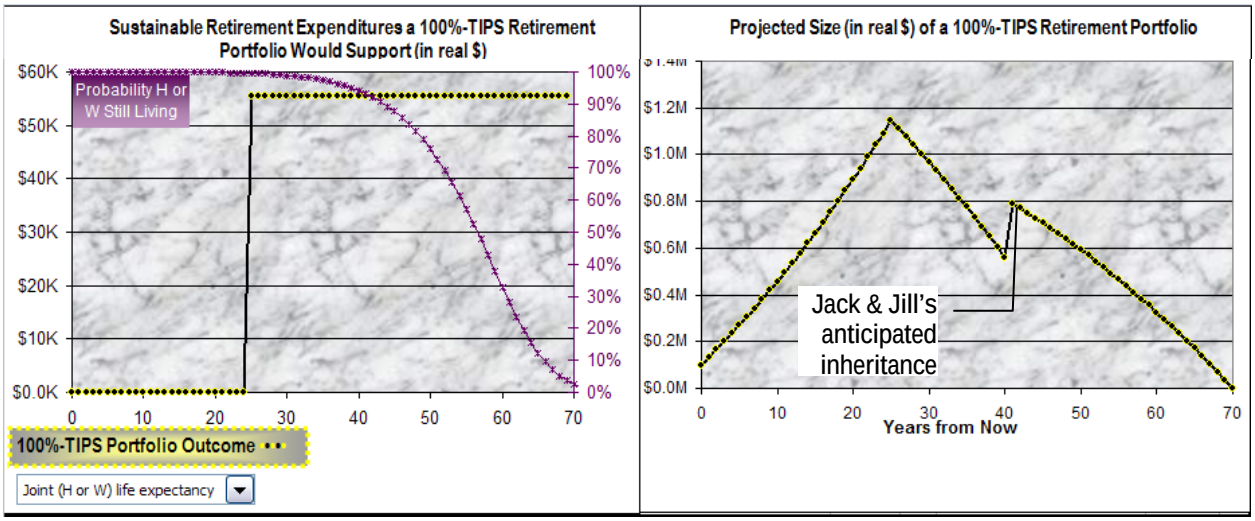


Figure 5: The chart to the left illustrates the expenditures – boosted somewhat by the anticipated inheritance – expected to be sustained by Jack & Jill's portfolio, should they invest it all in TIPS. The chart to the right illustrates the changing size of Jack & Jill's all-TIPS portfolio – now as also impacted at year 40 by the anticipated inheritance – over time.

(e) Reverse Mortgage

The "Additional Portfolio Inputs and Outputs" section allows you to specify the impact of an anticipated reverse mortgage on your retirement situation.

For example, imagine that Jack and Jill expect that by the time they are 80 years old, they will take out a reverse mortgage on their home that will provide an anticipated income stream of $25,000/year, in today's dollars. So Jack and Jill specify $25,000 in the "Amount" cell and "50" in the "Yrs 'till event" cell. They also specify "Until both H and W die" in the "Type" list box.

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
Reverse mortgage PV = $154,913	$ 25,000	50	Lump Sum Annually for n years Until both H and W die Until either H or W dies	20	0.0%

As Jack and Jill enter these additional inputs, TIP$TER® immediately recalculates the sustainable retirement budget an all-TIPS portfolio would support and modifies the graphs illustrated in Fig. 1 to look like the graphs illustrated in Fig. 6.

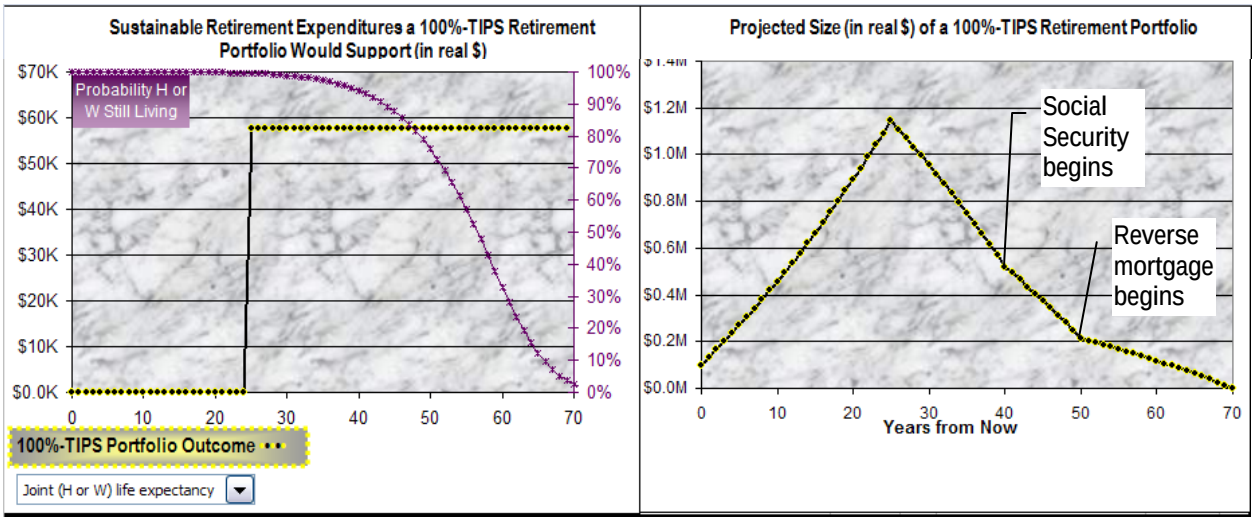


Figure 6: The chart to the left illustrates the expenditures – boosted somewhat by the anticipated reverse mortgage – expected to be sustained by Jack & Jill's portfolio, should they invest it all in TIPS. The chart to the right illustrates the changing size of Jack & Jill's all-TIPS portfolio – now as also impacted at year 50 by the anticipated reverse mortgage – over time.

(f) How Can We Model More Expenditures in Early Retirement Years?

Suppose that you expect to spend more in your early years of retirement – when you are still healthy enough to travel – than in the twilight years of your life. The "Additional Portfolio Inputs and Outputs" section allows you to model more expenditures in early retirement.

For example, imagine that Jack and Jill want the freedom to spend an extra $10,000/year in the first 10 years of retirement. So Jack and Jill enter -$10,000 in the "Amount" cell and "25" in the "Yrs 'till event" cell. In the "Type" list box, Jack and Jill select "Annually for n years." And in the "# of Years" cell, they select the appropriate spinners until it reads "10."

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
More fun in first 10 yrs of retirement PV = -$55,847	$ (10,000)	25	Lump Sum Annually for n years Until both H and W die Until either H or W dies	10	0.0%

As Jack and Jill enters these additional inputs, TIP$TER® immediately recalculates the sustainable retirement budget an all-TIPS portfolio would support and modifies the graphs illustrated in Fig. 1 to look like the graphs illustrated in Fig. 7.

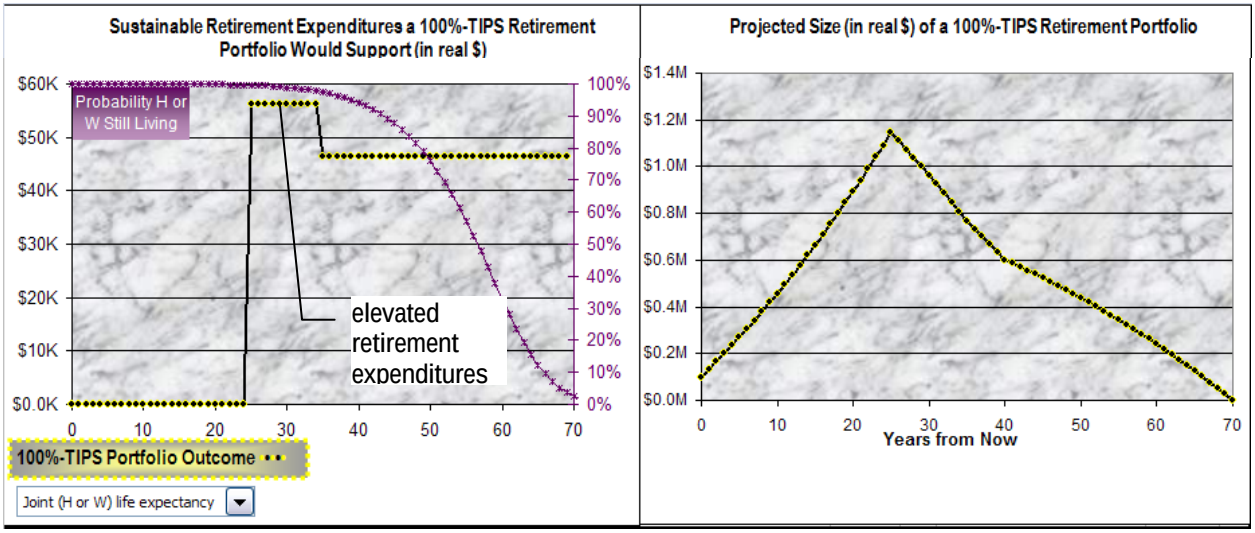


Figure 7: The chart to the left illustrates the expenditures – which include a $10,000 boost in the first 10 years of retirement – expected to be sustained by Jack & Jill's portfolio, should they invest it all in TIPS.

As an alternative example, imagine that Jack and Jill want to start with an extra $10,000/year in the first year of retirement, but reduce that amount by 10%/year until the very end. So Jack and Jill enter -$10,000 in the "Amount" cell and "25" in the "Yrs 'till event" cell. In the "Type" list box, Jack and Jill select "Until both H and W die." And in the "Increase/Decrease by real % per year" cell, they select the appropriate spinners until it reads "-10%."

Description	Amount	Yrs 'till event	Type	# of Years	Increase/Decrease by real % per year
More fun in first 10 yrs of retirement PV = -$51,625	$ (10,000)	25	Lump Sum Annually for n years Until both H and W die Until either H or W dies	45	-10.0%

As Jack and Jill enter these additional inputs, TIP$TER® immediately recalculates the sustainable retirement budget an all-TIPS portfolio would support and modifies the graphs illustrated in Fig. 1 to look like the graphs illustrated in Fig. 8.

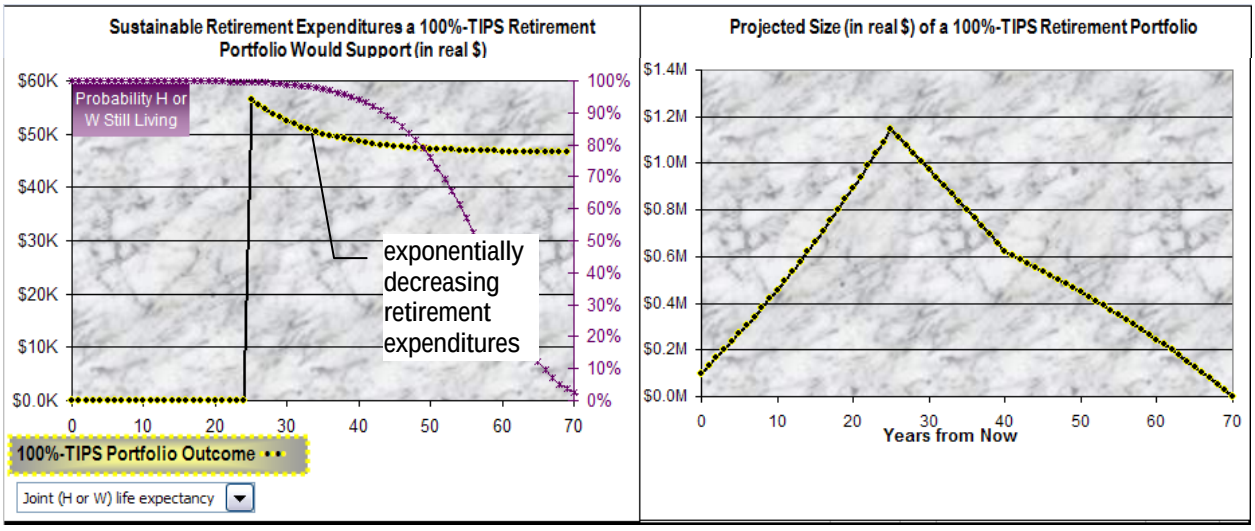


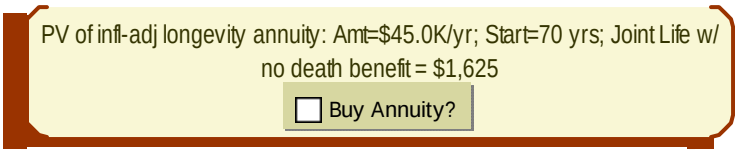
Figure 8: The chart to the left illustrates the exponentially decreasing expenditures expected to be sustained by Jack & Jill's portfolio, should they invest it all in TIPS.

(g) Conventional and Variable Annuity Income

The "Additional Portfolio Inputs and Outputs" section lets you also specify income from a conventional annuity. As with the Spousal Social Security benefit illustrated in subsection (b) above, a user may enter the income that they expect from a fixed or inflation-adjusted annuity. If it is an inflation-adjusted annuity, the user should leave the "Increase/Decrease by real $ per year" value at 0%. If it is a fixed-income annuity, the user should specify the negative of the expected long-term inflation rate in the "Increase/Decrease by real % per year" field.

Currently, TIP$TER® does not support stochastic modeling of variable annuities separate from the rest of the user's portfolio. A user can, however, estimate the future income stream they anticipate to get from the variable annuity as a fixed or inflation-adjusted stream of payments. A user can also treat an annuity as part of the user's overall existing savings and asset allocation, and adjust the expected extra yield on stocks downward to account for mortality and expense risk charges and administrative fees.

(h) Modeling the Purchase of an Inflation-Adjusted Longevity Annuity



What if insurance companies offered an inflation-adjusted "longevity annuities" to insure a person from outliving their savings? If so, a 65 year-old could purchase a longevity annuity that would begin paying out $40,000/year (inflation-adjusted) if and when he reaches 85 years old. A person could build a retirement nest egg, using TIPS and/or stocks, sufficient to fund his or her retirement needs through age 85, and also purchase a "longevity" annuity to cover expenses thereafter, in case he or she lives past 85.

TIP$TER® calculates the present value of a maximum-income, inflation-adjusted longevity annuity (with no death benefit) that would provide you and your spouse, if any, with income

security should you or your spouse, if any, live beyond the expiration of your targeted portfolio duration.

TIP$TER® calculates what the present value of such an *inflation-adjusted* longevity annuity would be, if it had the following characteristics: (1) its payouts would begin the year following the expiration of the user's targeted portfolio duration, if there were still any surviving spouse; (2) the annual benefit would be equal to the difference between the user's targeted annual retirement budget and all other lifetime retirement income sources (such as Social Security); and (3) its payouts would continue through the lifetime of the last surviving spouse. The present value is calculated using the TIPS real rate of return as the discount rate. In other words, the annuity payment, in combination with other income sources like Social Security, would enable the users to continue spending the targeted amount long after they exhausted their retirement savings.

WARNING:

The author is unaware of any *inflation-adjusted* longevity annuities offered by insurance companies. DO NOT CONFUSE the present value of an *inflation-adjusted* longevity annuity with the present value of a *fixed-income* longevity annuity. The present value of a *fixed-income* longevity annuity is considerably *less* than that of an *inflation-adjusted* longevity annuity.

"Buy Annuity?" Checkbox

TIP$TER® can also model the impact that the purchase of such a hypothetical inflation-adjusted "longevity annuity" would have on the user's retirement budget and shortfall risk. If a user checks the "Buy Annuity?" checkbox, TIP$TER® assumes that the user would purchase the annuity with a one-time premium payment, at a cost equal to the calculated present value of the annuity, and subtracts that one-time premium payment from the user's "Current Retirement Savings."

The purchase of an inflation-adjusted longevity annuity – if it existed – would allow you to plan a shorter targeted portfolio duration in order to boost your retirement lifestyle.

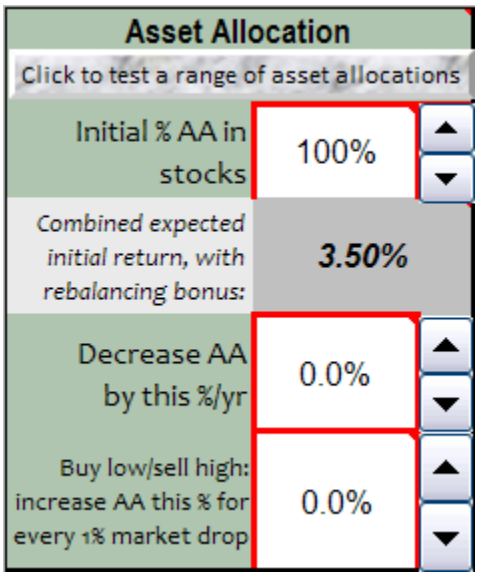
In recent years, some insurance companies have begun selling longevity annuities that would begin to make payouts if and when the annuitant reached an advanced age, like 80, 85, or 90. Because the payouts would be delayed for many years, and would be contingent on the annuitant living to that target age, the premiums for longevity annuities are significantly lower than the premiums for immediate annuities. But so far, none of the available products of which the author is aware provide fully-inflation-adjusted payouts.

WARNING:

Do not select the "Buy Annuity" checkbox if your current retirement savings are insufficient to cover the cost. If you do, TIP$TER® assumes that you will take out a loan, at the TIPS real rate of return, to fund the purchase. Moreover, the year-one value in TIP$TER's retirement budget chart will reflect the purchase price of the annuity, less your existing "current retirement savings."

E. Your Asset Allocation

1. Choosing an Initial % Asset Allocation



TIP$TER® asks that you specify the percentage of your hypothetical, about-to-be-simulated portfolio that – starting now – is to be invested in stocks and other risky assets. TIP$TER® refers to this percentage as your initial "Asset Allocation" (AA). TIP$TER® assumes that the remainder of your portfolio will be invested in TIPS, earning the "real return" amount you specify. When TIP$TER® simulates your portfolio, TIP$TER® will rebalance your portfolio every simulated year to maintain your specified AA.

So what initial asset allocation should you choose? Remember that the higher your AA, the greater the volatility your portfolio will experience. Use TIP$TER® to test any AA you want – but when it comes to implementation, choose an AA consistent with your tolerance for risk. In evaluating your tolerance for risk, consider the fact that within your lifetime, there are catastrophic risks that you cannot control, like war, depression, and hyperinflation.[14]

2. The Law of Diminishing Returns

The concave shape of the blue line in the outcome-vs.-AA chart of Fig. 3 illustrates that the "law of diminishing returns" is applicable to asset allocation decisions. To put it another way, the amount of reward you get per extra unit of risk decreases as you travel along the AA axis. This is an important reason why most people should hesitate to put all of their money into equities.

Why is this the case? The so-called "rebalancing bonus." The "rebalancing bonus," explained next, accounts for the concave "bulge" in the blue curve.

[14] *See* William J. Bernstein, "The Retirement Calculator from Hell, Part III: Eat, Drink and Be Merry," http://www.efficientfrontier.com/ef/901/hell3.htm.

3. *Understanding the Rebalancing Bonus*

Combined expected initial return, with rebalancing bonus:	3.16%

The expected return from a portfolio that is rebalanced between two or more uncorrelated asset classes is greater than the weighted sum of the expected returns of each of the asset classes.

To use a simple example, suppose Jack has a portfolio is weighted 50% between stocks and cash, which respectively have expected returns of 8% and 4%. The *average* expected return is ½ x 8% + ½ x 4% = 6%. But the stock half of Jack's portfolio is volatile. When stocks go down, Jack has to use some of his cash to buy more stocks, to maintain a 50% ratio. When stocks go up in value, Jack has to sell some of the stocks to restore that 50% ratio. The process of rebalancing forces Jack to buy low and sell high, boosting the overall return of his portfolio. In fact, the more volatile Jack's stocks, the greater the boost. That boost in performance is often called the "rebalancing bonus."

For those of you who are mathematically inclined, Professor Peter Ponzo has published a webpage (http://www.gummy-stuff.org/rebalancing-bonus-2.htm) in which he mathematically derives the following formula that quantifies the expected rebalancing bonus between two normally-distributed asset classes:

$$\text{Rebalancing Bonus} = X \bullet Y \bullet [\tfrac{1}{2}(Var_A + Var_B) - Covar_{A,B}]$$

where X and Y are the % of the portfolio in asset classes A and B, respectively, Var_A and Var_B are the variances of asset classes A and B, respectively, and $Covar_{A,B}$ is the covariance of the two asset classes.

4. *Reducing Your Asset Allocation As You Age*

TIP$TER® also allows you to specify an annual percentage decrease in your AA. One "rule of thumb" promoted by some financial advisors is to invest your "age in bonds," that is, decrease your AA by 1% per year. When TIP$TER® simulates your portfolio, TIP$TER® will rebalance your portfolio every simulated year to equal the previous year's starting AA minus the percentage decrease per year, if any, that you specify.

So should you reduce your AA as you age? Ask your financial advisor, or decide for yourself. Keep in mind that it is generally easier to adapt to a financial hardship when you are old. And many can afford to take more risk when they are young. In any event, TIP$TER® lets you test both fixed-AA and declining-AA strategies.

5. *Testing Tactical Asset Allocation Strategies*

Recommended values:
0.0% to 1.0%

Buy low/sell high: increase AA this % for every 1% market drop	0.0%

If you believe that overvalued and undervalued markets tend, over the very long term, to revert to the mean, you might also be inclined to invest a higher

percentage of your assets in stocks when the market is down, and less when the market is up. This type of investment behavior is sometimes referred to as "tactical asset allocation." Tactical asset allocation strategies are difficult to implement in any objective and disciplined sort of way. They are also disfavored by many proponents of the "efficient market hypothesis" (EMH). Nevertheless, it is rational to adjust one's asset allocation upward when the "expected risk premium" (ERP) on stocks goes up, and downward when the ERP goes down.

TIP$TER® allows you to model a "tactical asset allocation" strategy. TIP$TER® keeps track of the difference between the simulated return and the cumulative expected return of the stock portion of your portfolio. For every 1% that the cumulative simulated returns of the stock portion of your portfolio *underperforms* expectations, TIP$TER® will *increase* your asset allocation by the amount you specify. Likewise, for every 1% that the cumulative simulated returns of the stock portion of your portfolio *exceeds* expectations, TIP$TER® will *increase* your asset allocation by the amount you specify.

The graphs in Figs. 9 and 10 illustrate the effect of a tactical asset allocation strategy on TIP$TER's outcomes. Consider again Jack and Jill's portfolio described on page 5. Figs. 9 and 10 illustrate two "mean-reverting" Monte Carlo simulations (using a lognormally distributed return model) – one with a fixed 50%-stock/50%-TIPS asset allocation and another with a flexible asset allocation – of that portfolio. The graphs on the left were produced by the simulation of the fixed-AA portfolio. The graphs on the right were produced by the simulation of the same portfolio, but with a flexible asset allocation in which Jack and Jill increase their stock weighting by 0.5% for every 1% the stock market underperforms expectations. As shown in Figs. 17 and 18, the flexible-AA strategy produces even more attractive simulation results than the fixed-AA strategy.

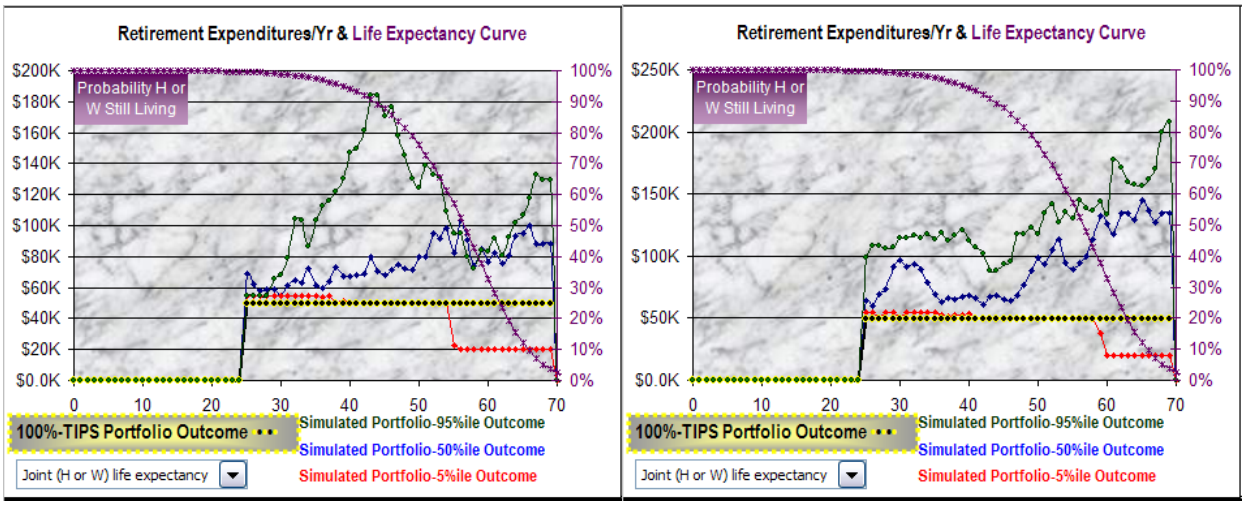


Figure 9: The graphs above illustrate the 5, 50, and 95-percentile simulated series of retirement budgets produced by two "mean-reverting" Monte Carlo simulations of Jack and Jill's portfolio. In the left graph, Jack and Jill's portfolio maintained a fixed asset allocation. In the right graph, Jack and Jill increased their asset allocation by 0.5% for every 1% that the simulated stock market underperformed expectations. Notice how Jack and Jill's outcomes *improved* by implementing a tactical asset allocation strategy. WARNING: a tactical asset allocation strategy, while attractive in theory, is very difficult for most people to implement in an objective and disciplined manner.

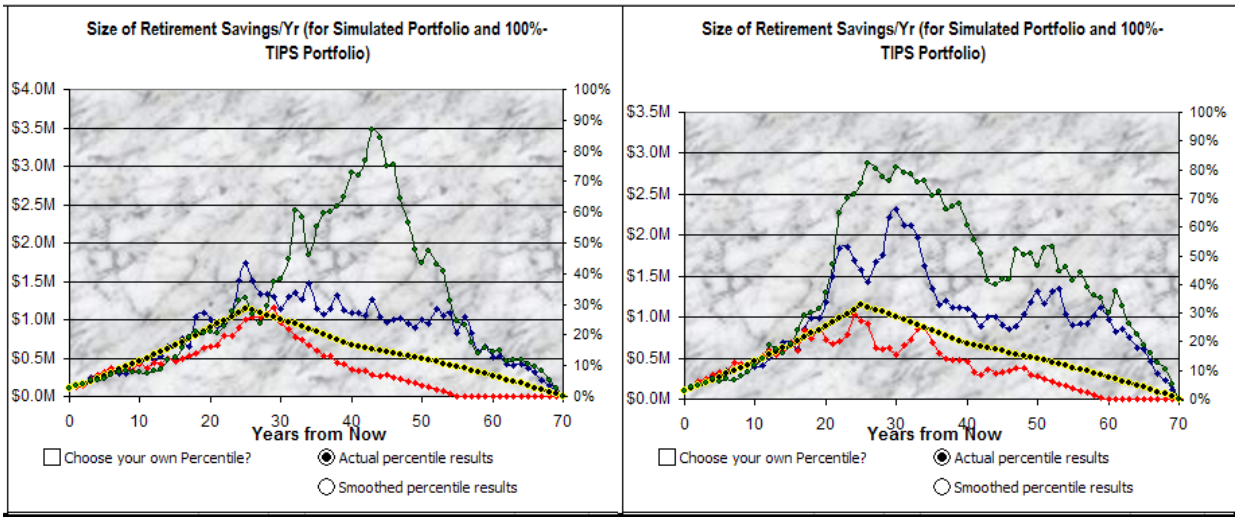
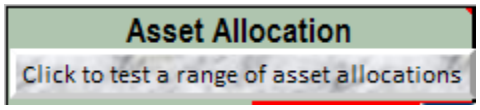


Figure 10: The graphs above illustrate the 5, 50, and 95-percentile simulated series of portfolio values produced by two "mean-reverting" Monte Carlo simulations of Jack and Jill's portfolio. In the left graph, Jack and Jill's portfolio maintained a fixed asset allocation. In the right graph, Jack and Jill increased their asset allocation by 0.5% for every 1% that the simulated stock market underperformed expectations. Once again, notice how Jack and Jill's outcomes *improved* by implementing a tactical asset allocation strategy.

6. Using the Asset Allocation Risk/Reward Spectrum Chart

You can direct TIP$TER® to simulate a portfolio with a particular AA and generate a set of charts like those seen in Fig. 2 (page 5). You could – if you wanted to – repeat this simulation process for several different AAs, each simulation process producing another set of charts. You could also print the results out for each simulation and compare them in an effort to assess the mix of projected risk and reward that you are most comfortable with.



But TIP$TER® provides an easier way to comparatively evaluate the projected risks and rewards of several different AAs: TIP$TER's Asset Allocation Risk/Reward Spectrum Chart.

Click on the "Click to test a range of asset allocations" button. In response, TIP$TER® opens up the chart depicted in Fig. 11 below. Now, click on the "Simulate Different Asset Allocations" button. In response, TIP$TER® simulates your portfolio – based on the inputs you entered in TIP$TER's input screen – ten different times using ten different asset allocations ranging from 10% to 100%. It takes a few minutes – but the results are worth the wait.

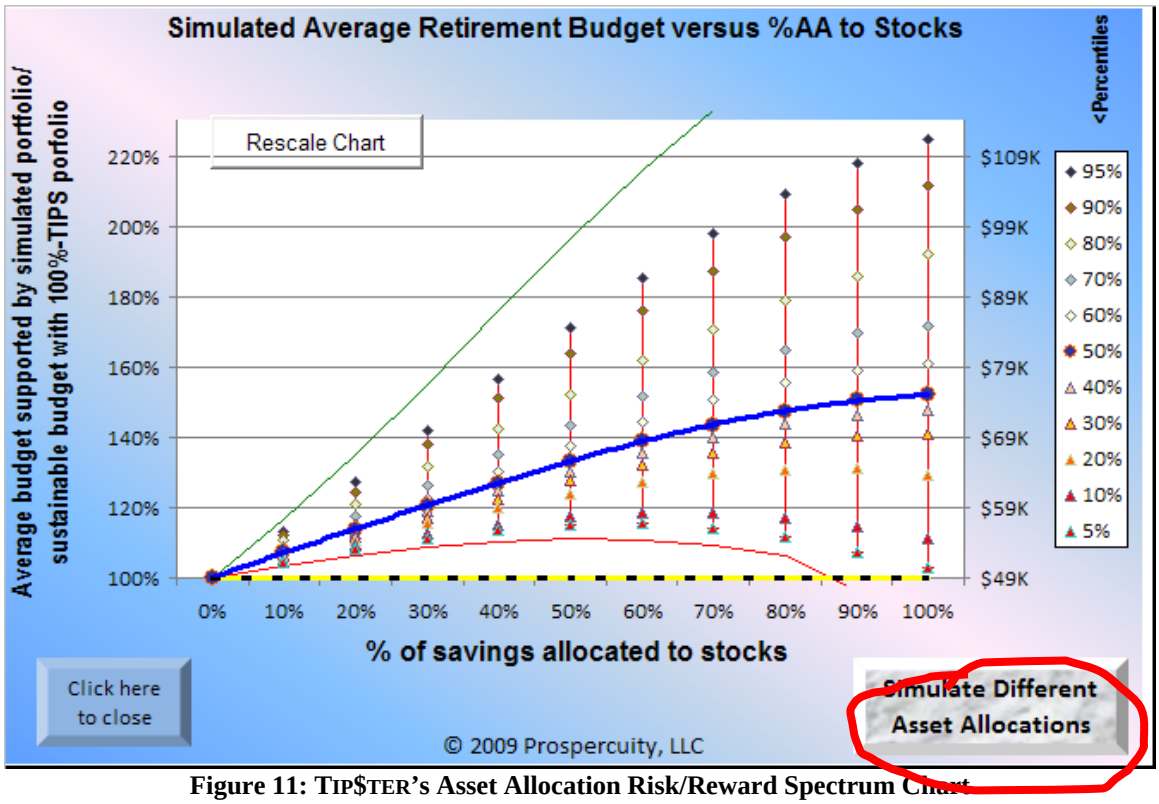


Figure 11: TIP$TER's Asset Allocation Risk/Reward Spectrum Chart

In this single chart, TIP$TER® simultaneously displays, as a function of asset allocation, the magnitude of the median expected benefit (the blue dots) *and* the large range and magnitude of other possible outcomes, along with their associated probabilities on either side of that blue line.

Moreover, TIP$TER's Asset Allocation Risk/Reward Spectrum Chart displays the outcomes both in the form of the anticipated annual retirement expenditures supported by the diversified portfolio and also as a percentage of the sustainable annual retirement expenditures supported by an all-TIPS portfolio.

By combining all of this information onto one chart, TIP$TER® helps you assess the different risk-reward tradeoffs associated with different asset allocations, and to select an asset allocation you are comfortable with.

F. Specifying Retirement Budget Goals in View of TIP$TER's "Retirement Feasibility Estimates."

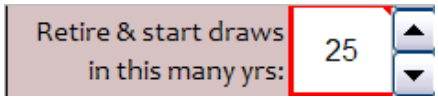
In the "Retirement Budget Plans" section, you specify the retirement spending rules that TIP$TER® will implement when simulating your diversified portfolio. How long do you want your portfolio to last? When do you plan to retire? What is your targeted annual retirement expenditure level? How

TIP$TER's Retirement Feasibility Estimates	
$ 47,794	Est. retirement budget a 100%-TIPS portfolio would support
$ 64,946	Est. median budget a 50%-stock portfolio would support
$ 69,296	Est. median budget a 100%-stock portfolio would support

would you change your spending habits in response to a bear or bull market? What is the absolute minimum amount per year you need during retirement?

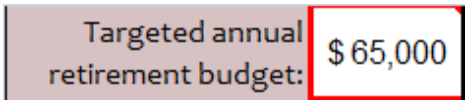
When specifying your retirement spending plans, be realistic. To help you frame your expectations, TIP$TER® provides several "Retirement Feasibility Estimates," which identify a range of annual retirement budgets that different asset-allocation mixes of portfolios are likely to be able to sustain. You should set your Retirement Budget Plans within the range of TIP$TER's "Retirement Feasibility Estimates."

1. Retirement Year



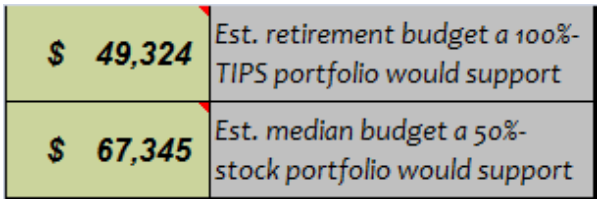
Here, specify how many years from now you plan to retire and start drawing down your portfolio.

2. Targeted Annual Retirement Budget



In the "Targeted Annual Retirement Budget" cell, specify the annual, inflation-adjusted expenditure amount that you would like to budget. These expenditures would be drawn from the combination of your portfolio and (when they became available) your other anticipated retirement income sources (like social security).

You should select a "target" value that is somewhere between the sustainable budget an all-TIPS portfolio would support and the estimated median retirement budget the diversified portfolio (that you plan to simulate) would support. TIP$TER® calculates and displays these two values, for your reference, in the "Retirement Feasibility Estimates" section.



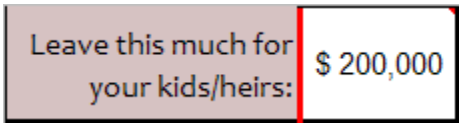
You Should Choose a Targeted Annual Draw That Falls Between The Two Values TIP$TER® Displays in These Cells

If your targeted retirement budget is greater than the estimated median retirement budget that your diversified portfolio would support, then you run an aggravated risk of experiencing a shortfall, due to the volatility in equity returns. This volatility should inspire a more conservative targeted retirement budget.

Interesting Note: According to the Bureau of Labor Statistic's 2006 Consumer Expenditure Survey, the middle 20% of American households, averaging 2.5 persons, "spent" an average of $41,431/year, which dropped to $35,198/year when you exclude mortgage interest and Social Security taxes/pension funding.

3. Planning a Bequest to Your Heirs

The "Retirement Budget Goals" section also allows you to specify a minimum "inheritance" amount that you want to bequest to your heirs.



Keep in mind that even if you don't plan to leave an inheritance, chances are you will. Your very effort to avoid outliving your portfolio will probably result in an inheritance for your heirs.

But imagine that Jack and Jill want to plan on leaving an inheritance of at least $200,000, even if they reach old age. To model that, Jack and Jill enter $200,000 in the box illustrated above.

As Jack and Jill enter these additional inputs, TIP$TER® immediately recalculates the sustainable retirement budget an all-TIPS portfolio would support and modifies the graphs illustrated in Fig. 1 to look like the graphs illustrated in Fig. 12.

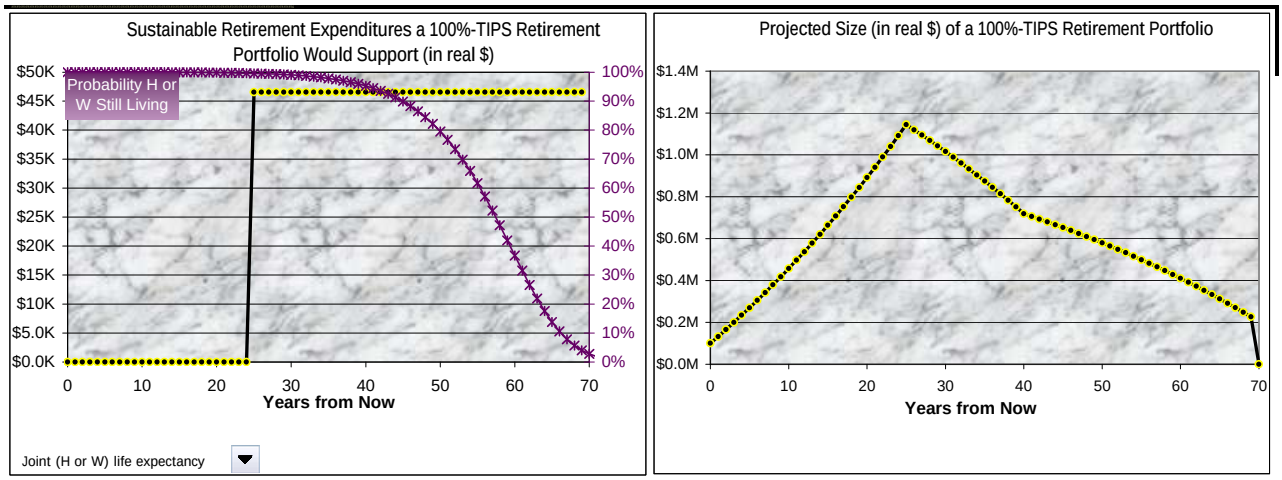
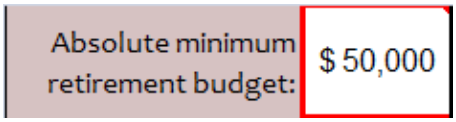


Figure 12: The chart to the right illustrates the size of Jack & Jill's portfolio, should they invest it all in TIPS, where Jack & Jill specify a certain bequest of $200,000 no later than 69 years from now.

G. Understanding TIP$TER's Retirement Budget Constraints

1. Absolute Minimum Retirement Budget



Here, you enter the absolute minimum amount you need each year from your portfolio, for purposes of TIP$TER's simulations.

Keep in mind that the higher your "absolute minimum retirement budget," the greater your "shortfall risk," that is, the risk of you or your spouse, if any, outliving your portfolio.

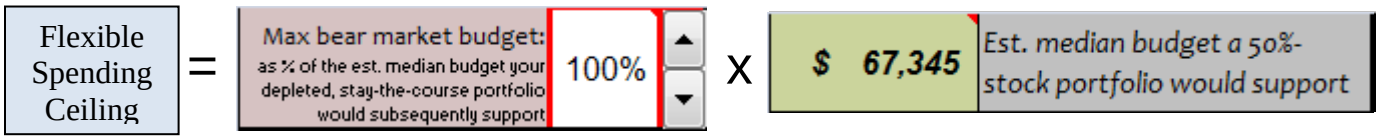
2. Be Thriftier If Market Leaves You Poorer (Max Bear Market Budget)

How would you change your spending habits in response to a bear market? Wouldn't you recalculate the retirement budget your depleted portfolio would be able to sustain, going forward, and adjust your lifestyle accordingly?

In any given simulation, TIP$TER® annually recalculates the median expected budget, going forward, that your simulated portfolio is likely to be able to sustain based upon your chosen asset allocation. You should be hesitant to budget any more than this amount, for it will significantly increase your "shortfall" risk.

Use the "Max bear market budget" cell to set a flexible, portfolio-performance-dependent *ceiling* (recommended value = 100%; minimum value = 80%; maximum value = 300%) on how much you will spend every year. TIP$TER® multiplies the "scaling" factor you enter by the annually recalculated median retirement budget that your portfolio is expected to sustain.

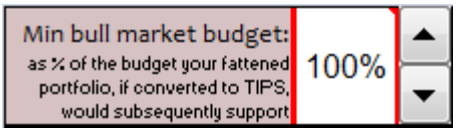
Provided that the *ceiling* amount is at least as great as your "Absolute Minimum Retirement Budget," TIP$TER® simulates your portfolio so that no more than the "ceiling" amount, annually recalculated, is spent every year. The diagram below illustrates the math:



(*Scaling Factor you enter*) (*Annually Recalculated*)

TIP$TER® will not, however, reduce your retirement budget below your "Absolute Minimum Retirement Budget."

3. Spend More If Market Makes You Richer (Min Budget after Bull Market)



How would you change your spending habits in response to a bull market? Wouldn't you calculate whether you could spend more?[15] After all, you could convert your entire bull-market-fattened portfolio to safe assets like TIPS and safely increase your budget to an amount equal to the "estimated retirement budget a 100%-TIPS portfolio would support" every year thereafter. TIP$TER® lets you specify a spending policy, for use in TIP$TER's simulations, that takes advantage of such good times.

Use the "Min bull market budget" cell to set a flexible, portfolio-performance-dependent *floor* on how much you will spend every year. In any given simulation, TIP$TER® annually recalculates what the "sustainable budget" for the simulated portfolio would be if it were entirely reinvested in TIPS. Then, TIP$TER® multiplies this number by a "scaling" factor that you enter in the "Min bull market budget" cell. TIP$TER simulates your portfolio so that at least this amount, annually recalculated, is budgeted every year. The diagram below illustrates the math:

[15] *See generally* http://www.gummy-stuff.org/sensible_withdrawals.htm.

Flexible Spending Floor	=	Min bull market budget: as % of the budget your fattened portfolio, if converted to TIPS, would subsequently support	100%	X	$ 49,324	Est. retirement budget a 100%-TIPS portfolio would support
		(Scaling Factor you enter)				*(Annually Recalculated)*

The suggested value for the "Min bull market budget" cell is 100%. The minimum and maximum values are 0% and 200%, respectively.

V. UNDERSTANDING TIP$TER'S RETIREMENT FEASIBILITY ESTIMATES

TIP$TER's "Retirement Feasibility Estimates" project the annual, inflation-adjusted retirement expenditures that your current and planned future savings and retirement income are likely to sustain, starting the first year you retire. The first estimate is based on the assumption that you put all of your current and future savings into TIPS. The second estimate is based on the assumption that you divide your current and future savings between stocks and TIPS in accordance with the asset allocation you specify, and annually rebalance your portfolio. The third estimate is based on the assumption that you put all of your current and future savings into stocks.

TIP$TER's Retirement Feasibility Estimates	
$ 47,794	Est. retirement budget a 100%-TIPS portfolio would support
$ 64,946	Est. median budget a 50%-stock portfolio would support
$ 69,296	Est. median budget a 100%-stock portfolio would support

TIP$TER® generates these "Retirement Feasibility Estimates" immediately, as you modify your inputs. These estimates help you assess how much you need to save, and for how long, to produce an adequate retirement nest egg. Also, by providing a quick comparison between the estimated annual budget that an all-TIPS portfolio, an annually-rebalanced-TIPS-and-stock portfolio, and an all-stock portfolio would sustain, these estimates provide you with insights on your asset allocation and your retirement spending plans.

TIP$TER's "Retirement Feasibility Estimates" are generated without the benefit of any simulations. As such, they provide an estimate of the expected benefits – but not the expected risks – of being invested in stocks. Therefore, you are encouraged to run TIP$TER's simulation on your portfolio and examine the shortfall risk and the range of potential outcomes your volatile portfolio is likely to produce.

TIP$TER's "Retirement Feasibility Estimates" are also generated without regard to your Targeted and Absolute Minimum Retirement Budget inputs. TIP$TER's "Retirement Feasibility Estimates" are also generated without regard to the potential impact of any "Tactical Asset Allocation" inputs, or annual decrease in asset allocation, you may have specified. Therefore, TIP$TER's simulation engine may produce summary statistics that differ significantly from its "Retirement Feasibility Estimates."

Accordingly, you should regard TIP$TER's simulation summary statistics as being more relevant than TIP$TER's "Retirement Feasibility Estimates." But, of course, TIP$TER's simulation summary statistics take longer to generate.

A. Estimated Retirement Budget a 100%-TIPS Portfolio Would Sustain

$ 49,324	Est. retirement budget a 100%-TIPS portfolio would support

TIP$TER's first estimate is the annual inflation-adjusted spending allowance that your current and future planned savings and retirement income would sustain, beginning the year you retired and extending through the end of your targeted portfolio duration, if all of it were invested in TIPS.

CAUTION: TIP$TER's estimate is based on the simplifying assumption that real interest rates on TIPS will remain constant and that TIPS would have no volatility. In the real world, TIPS prices and yields change with changing market conditions – although not nearly as much as most stocks.

TIP$TER's estimate is generated *net* of any additional expenditures that you indicate in the "Additional Portfolio Inputs and Outputs" section. For years in which you have designated additional expenditures, your total expenditures would be the sum of TIP$TER's estimate plus those additional expenditures.

TIP$TER's estimate is based on a complex derivation, set forth in a pending patent application, of the mortgage payment formula, using the "Real Return on TIPS" that you specify in the "Return Expectations" section.

B. Estimated Median Retirement Budget that Your Diversified Portfolio Would Sustain

$ 67,345	Est. median budget a 50%-stock portfolio would support

TIP$TER's second estimate is the *median* annual inflation-adjusted spending allowance that your current and future planned savings and retirement income would sustain, beginning the year you retired and extending through the end of your targeted portfolio duration, if you invest all of it in stocks and TIPS in accordance with the asset allocation you specify.

CAUTION: Because of the inherent volatility of the stocks, the spending allowance your diversified portfolio would sustain may vary from year to year and could be, on average, significantly <u>less</u> than the "median" expected value. Run TIP$TER's Monte Carlo simulator to illustrate a range of probable retirement draw values.

Again, TIP$TER's estimate is generated *net* of any additional expenditures that you indicate in the "Additional Portfolio Inputs and Outputs" section. For years in which you have designated additional expenditures, your total expenditures would be the sum of TIP$TER's estimate plus those additional expenditures.

TIP$TER's second estimate is also based on the same derivation of the mortgage payment formula used for the first estimate. But for the second estimate, TIP$TER® uses the "Combined expected initial return, with rebalancing bonus" as the interest rate.

For those of you who are mathematically inclined, the formula that TIP$TER® uses calculate the "Combined expected initial return, with rebalancing bonus," is as follows:

$$\mu_{composite} = \mu_{TIPS} + \alpha \times ERP_{stocks} + \alpha \times (1-\alpha) \times \frac{\sigma_{stocks}^{2}}{2}$$

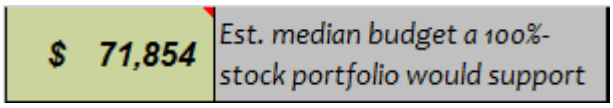
where μ_{TIPS} is your expected real return on TIPS, ERP_{stocks} is your extra expected return on stocks, σ is the expected standard deviation of stock returns, and α is your asset allocation.

To put it another way, TIP$TER's second estimate is what you could sustainably spend every year, beginning the year you retired and extending through the end of your targeted portfolio duration, if your diversified-TIPS-and-stocks portfolio got all of the benefits of the rebalancing bonus caused by the volatility of the risky assets, but without any of the associated risks.

As noted earlier, TIP$TER's second estimate also assumes that you have a fixed asset allocation.

Also as noted earlier, TIP$TER® regenerates this second estimate every year of a simulation and, in conjunction with the "Max Bear Market Budget" variable you specify, uses this second estimate to specify a portfolio-performance-based ceiling to your retirement draws. The theory behind this dynamic withdrawal ceiling is that you shouldn't withdraw more than what your portfolio could sustain if it regularly, year after year, achieved your portfolio's long-term composite expected return.

C. Estimated Median Retirement Budget that a 100%-Stock Portfolio Would Sustain



TIP$TER's third estimate is the *median* annual inflation-adjusted spending allowance that your current and future planned savings and retirement income would sustain, beginning the year you retired and extending through the end of your targeted portfolio duration, if you invested all of it in stocks.

CAUTION: Because of the inherent volatility of the stocks, the spending allowance an all-stock portfolio would sustain may vary from year to year and could be, on average, significantly <u>less</u> than the "median" expected value. Run TIP$TER's Monte Carlo simulator, using a 100% asset allocation, to illustrate the broad range of probable retirement draw values for an all-stock portfolio.

Again, TIP$TER's estimate is generated *net* of any additional expenditures that you indicate in the "Additional Portfolio Inputs and Outputs" section. For years in which you have designated additional expenditures, your total expenditures would be the sum of TIP$TER's estimate plus those additional expenditures.

TIP$TER's third estimate is also based on the same derivation of the mortgage payment formula used for the first estimate. But for the second estimate, TIP$TER® uses the sum of your "Real return on TIPS" and "Extra expected return on stocks" inputs as the interest rate.

D. TIP$TER'S *Pre-Simulation* Retirement Budget & Portfolio Size Charts

1. The Black-and-Yellow TIPS-based Baseline Curves

As you enter or modify TIP$TER's inputs, TIP$TER® also immediately generates pre-simulation retirement expenditure and portfolio size charts, like those depicted in Figs. 1 (again illustrated below) and 4-8. The retirement expenditure chart illustrates the annual expenditures, over the life of your portfolio, that your current and future savings and retirement income streams (including Social Security) are projected to be able to sustain, assuming that all of it is invested in TIPS yielding the real rate of return that you specify. The portfolio size chart illustrates the growth and depletion of your portfolio over the same time period.

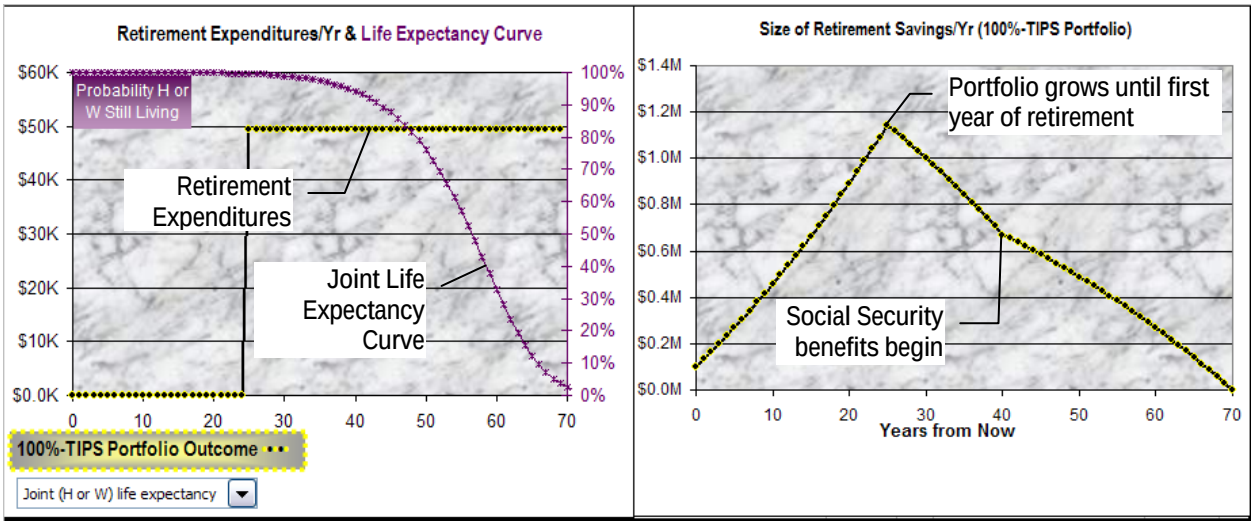
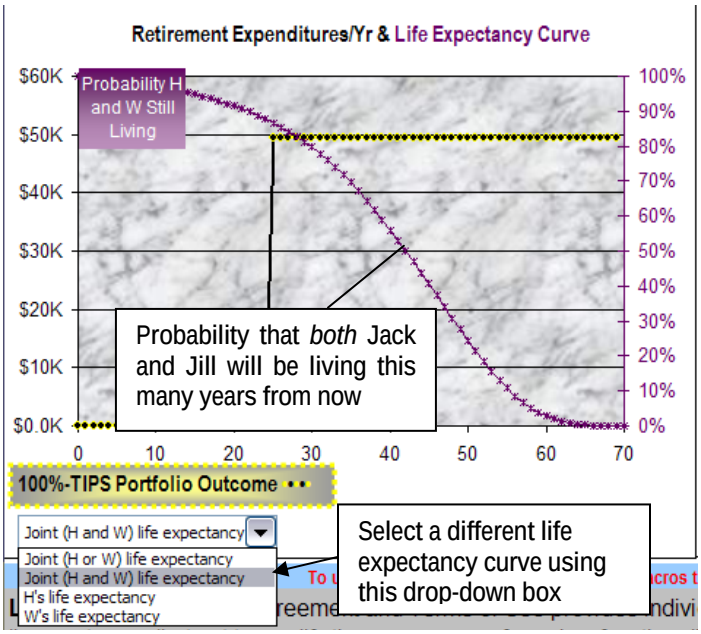


Figure 13: The chart to the left projects the annual retirement expenditures that Jack & Jill's portfolio, plus other retirement income sources (e.g., social security), could sustain if they put all their savings in TIPS. The chart to the right projects the growth and depletion of Jack & Jill's all-TIPS portfolio over the next 70 years.

In both charts, the x-axis represents the number of years from now. In the retirement expenditure chart, the y-axis represents the annual inflation-adjusted retirement expenditures that your portfolio, if completely invested in TIPS, is projected to sustain. In the portfolio size chart, the y-axis represents the total size of your portfolio at any given point in time.

The retirement expenditure and portfolio size charts illustrate these TIPS-based values using black and yellow symbols, signifying what is probably the most cautious approach you can make to retirement savings. TIP$TER® continues to display these black and yellow symbols after it runs a simulation of a diversified portfolio, so that you can compare and contrast the simulated outcomes of a diversified portfolio with the play-it-completely-safe, all-TIPS alternative.

2. *The Purple Life Expectancy Curves*



The retirement expenditure chart also illustrates a "Joint Life Expectancy Curve." This reflects the probability that either you, or your spouse (if any), will survive the indicated number of years from now. The retirement expenditure chart also provides a drop down box that allows you to view just your life expectancy, your spouse's life expectancy, or the probability that *both* of you will survive to some in time. The graph to the right depicts a life expectancy curve representing the probability that *both* Jack and Jill will be living so many years from now. The graph in Fig. 1, by contrast, depicts a life expectancy curve representing the probability that *either* Jack and Jill will be living so many years from now.

VI. USING TIP$TER'S SIMULATION ENGINE

TIP$TER® simulates your portfolio by modeling the stock portion of the portfolio as a volatile asset. TIP$TER® can model the stock behavior in numerous ways, ranging from exploratory simulation of mean-adjusted, but otherwise historical S&P 500 return data (see section VII(A)) to Monte Carlo simulation using a whole menu of different return distributions (see sections VII(B)-(G)).

TIP$TER® models the risk-free portion of the portfolio (e.g., the TIPS) as if it has a constant, steady real rate of return. This is a simplifying assumption. Long-term TIPS are mildly volatile assets, and they have a non-zero correlation with stocks.[16] It is an assumption that saves significant computational power[17] without significantly affecting TIP$TER's simulation results.

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[16] For a graph showing correlation over the past few years between TIPS and the S&P 500, go to http://www.assetcorrelation.com, click on the "Select 2 Assets" link, and specify the ticker symbols TIPS & SPY.

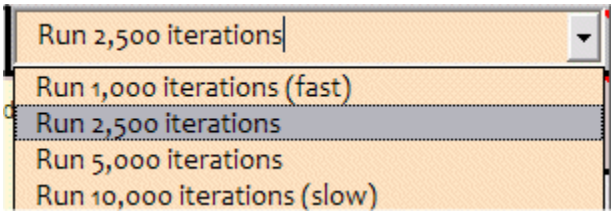
[17] It also enables immediate computation of a baseline "all-TIPS" value and avoids the occasion to ask the user to enter an assumed standard deviation and correlation for the TIPS portion of the portfolio.

TIP$TER® also assumes that you will rebalance the risk-free and risky portions of the portfolio at the beginning of each year.

A. Running TIP$TER's Simulation Engine

In order to run TIP$TER's simulation engine, click on the "Run Simulation" button. It will take several seconds to run. You can monitor the progress of the simulation on the taskbar.

When running any of the Monte Carlo simulation modes, TIP$TER® also provides a drop-down box to enable you to choose the number of times TIP$TER® simulates the life of your portfolio. For a fast but less statistically precise simulation, you can choose as few as 1,000 iterations. For a slow but more statistically precise simulation, you can choose as many as 10,000 iterations.



B. Understanding TIP$TER's Simulation Results

TIP$TER's simulation engine produces several summary statistics that are highly relevant to the evaluation of an investment portfolio strategy.

TIP$TER's Simulation Results:	
8.4%	*Cumulative shortfall risk*
95.6%	*Prob. that diversified portfolio will support a larger retirement budget than a 100%-TIPS portfolio*
$65,928	*Expected average annual retirement budget*
$563,928	*"Average" final estate size*

1. Shortfall Risk

First, TIP$TER's simulation engine projects the cumulative "shortfall risk" of your portfolio. This is the estimated probability that you or your spouse, if any, will outlive the portfolio. This estimate is based upon your inputs and TIP$TER's models for returns on your TIPS and stock investments.

Under **most circumstances**, TIP$TER's estimated shortfall risk is the *combination* of the risk of your portfolio running out *before* the targeted portfolio duration while you are still alive, plus the risk of you or your spouse outliving your targeted portfolio duration. If you choose a targeted portfolio duration that is simply equal to you and your spouse's combined life expectancy, the "shortfall risk" is likely to exceed 50%, because there is at least a 50% chance that you or your spouse would exceed that life expectancy.

NOTE: Most other Monte Carlo simulators give you the shortfall probability, or its opposite, the "survival" probability, over a fixed targeted portfolio duration (like 30 or 40 years) – but without taking into account the probability that you will be alive to suffer that shortfall. TIP$TER's shortfall risk estimate takes you and your spouse's life expectancies into account – which reduces the computed shortfall risk.

But TIP$TER's shortfall risk ***does not include*** the probability of outliving one's portfolio if at least one of two conditions are present:

- The "Buy Annuity" checkbox is selected (see § IV(D)(3)(h)); or
- The sum of expected social security benefits and "Additional Inputs" for which the "Until both H and W die" or "Until Death" options have been selected exceed the "Absolute minimum retirement budget"

2. Probability of Diversified Portfolio Outperforming All-TIPS Portfolio

Second, TIP$TER's simulation engine calculates the probability that your diversified, part-TIPS, part-stock portfolio will sustain a higher retirement draw than an all-TIPS portfolio. Conversely, 1 - the displayed value is the probability that your diversified portfolio will sustain (on average) a *lower* retirement draw than an all-TIPS portfolio. Accordingly, this statistic sheds further insight on the risks and rewards of investing a portion of your portfolio in risky assets like stocks.

3. Expected Average Annual Retirement Budget

Third, TIP$TER's simulation engine calculates the expected average annual retirement budget that your diversified portfolio would support. TIP$TER® simulates your portfolio thousands of times. Each simulation produces a series of annual retirement budgets over the life of your portfolio, based upon your "Retirement Spending Plans" inputs and the simulated performance of the stock portion of your portfolio. After completing these simulations, TIP$TER® identifies the median, or middle-ranked, retirement budget for each year of the life of the portfolio. TIP$TER® then calculates the "life-weighted" average of the median retirement budgets. That is, the median retirement budgets are each given a weight proportional to the probability that you or your spouse, if any, will be alive to spend it. TIP$TER® then displays the computed average as "Expected Average Annual Retirement Budget."

Put another way, the displayed value is the average, weighted by the probability of you or your spouse living, of the median retirement budget/year for each year of the simulation. Approximately 50% of the simulations produced a life-weighted average retirement budget greater than or equal to this value. Approximately 50% of the simulations produced a life-weighted average retirement budget less than or equal to this value.

NOTE: The displayed will often be slightly different from the life-weighted average of the median *series* of retirement budgets – which is a slightly different statistic. TIP$TER® displays the life-weighted average of the median series of retirement budgets on the "Draw" chart when you select "Choose your own Percentile" on the simulation charts, and select the 50 percentile series.

4. Average Final Estate Size

Fourth, TIP$TER's simulation engine calculates the average final estate size, again based upon you and your spouse's life expectancies. If you or your spouse exceed normal life expectancies, then your final estate size is likely to be lower than this estimate.

TIP$TER® calculates the average final estate size by (1) computing the average, across all of the thousands of simulations, of the simulated sizes of the portfolio for each year of the life of the portfolio, (2) multiplying each average by the incremental probability that both you and your spouse will have passed away by that year, (3) and summing these weighted averages together.

TIP$TER favors median statistics for retirement draws and average statistics for final estate sizes. With respect to retirement draws, risk is a key concern. The median is a better risk-adjusted statistic than the average. But risk is not a significant concern with respect to final estate sizes. There, the "average" is a better indicator than the "median" of the incentive to choose a portfolio strategy.

The "Average Final Estate Size" should not be confused with the "median" simulated final estate size. The "Average" is significantly skewed upward by the highly-ranked simulations.

C. Understanding TIP$TER'S *Post-Simulation* Retirement Budget & Portfolio Size Charts

After running a Monte Carlo simulation, TIP$TER® also displays a bounty of information, described in the following subsections, from the simulation on the retirement expenditure and retirement savings size charts.

1. The 95, 50, and 5 percentile outcomes are illustrated by green, blue, and bright red symbols, respectively.

TIP$TER® ranks the series of simulated retirement budgets and corresponding portfolio sizes produced by the thousands of simulations that TIP$TER® performs over the life of the portfolio. TIP$TER® also identifies the 95, 50, and 5 percentile series and displays them on the retirement expenditure and portfolio charts. A 95 percentile outcome is an outcome that is equal to or better than 95 percent of the simulations. A 5 percentile outcome is an outcome that is equal to or worse than 95 percent of the simulations. A 50 percentile outcome is the median outcome of the simulations.

In section II.C.2, this manual describes the information presented on the retirement expenditure and portfolio size charts of Fig. 2, which is reproduced below.

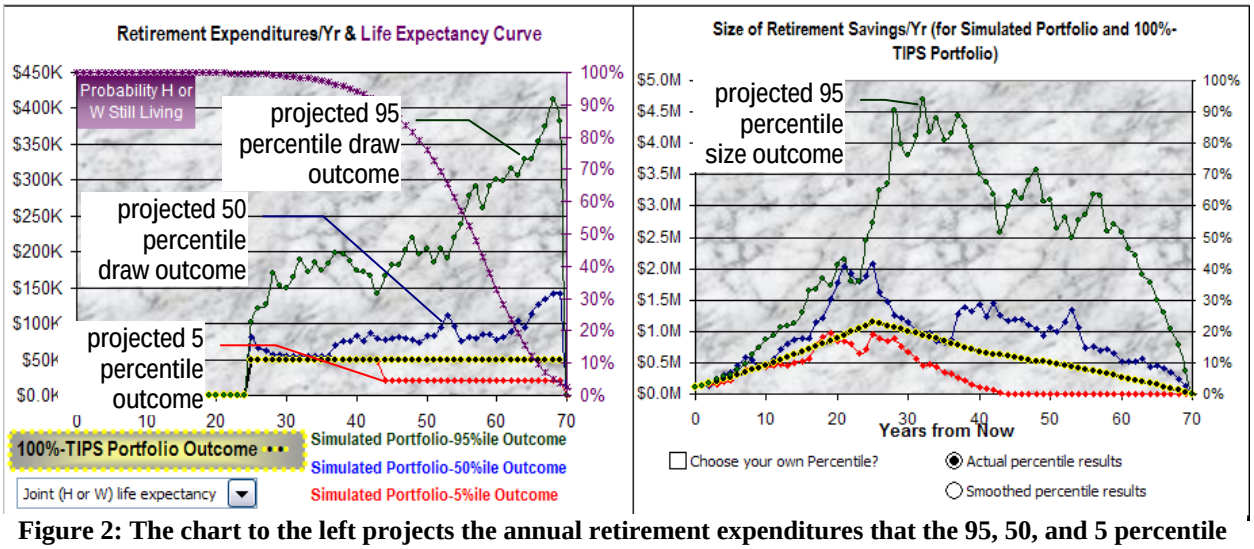


Figure 2: The chart to the left projects the annual retirement expenditures that the 95, 50, and 5 percentile simulated outcomes from Jack and Jill's 70%-stock/30%-TIPS portfolio, plus other retirement income sources (e.g., social security), would sustain. The chart to the right projects the corresponding 95, 50, and 5 percentile growth and depletion outcomes of the portfolio. The black and yellow lines represent the corresponding outcomes anticipated from a 100%-TIPS portfolio

The green lines represent the 95-percentile outcomes. The blue lines represent the 50-percentile outcomes. And the bright red lines represent the 5-percentile outcomes. TIP$TER® continues to display black and yellow symbols representing the outcomes of an all-TIPS portfolio, so that you can compare and contrast the simulated outcomes of a diversified portfolio with the play-it-completely-safe, all-TIPS alternative.

In both charts, the x-axis represents the number of years from now. In the retirement expenditure chart, the y-axis represents the inflation-adjusted retirement expenditures provided each year by the 95, 50, and 5 percentile outcomes of the simulated portfolio. In the portfolio size chart, the y-axis represents the size of the corresponding portfolio versus time for the 95, 50, and 5 percentile simulated outcomes.

2. What is the difference between the "Actual Percentile Results" and the "Smoothed Percentile Results"?

TIP$TER® provides you with an option to display either the "Actual Percentile" results or the "Smoothed Percentile" results. The "Actual Percentile" results show you the results of actual simulations, with all the volatility inherent in having a portion of your portfolio invested in stocks. The "Smoothed Percentile" results filter out the year-to-year volatility while still displaying a relatively wide dispersion between the different percentile outcomes. The difference between the two representations, again as applied to Jack and Jill's portfolio, is illustrated in Figs. 13 and 14.

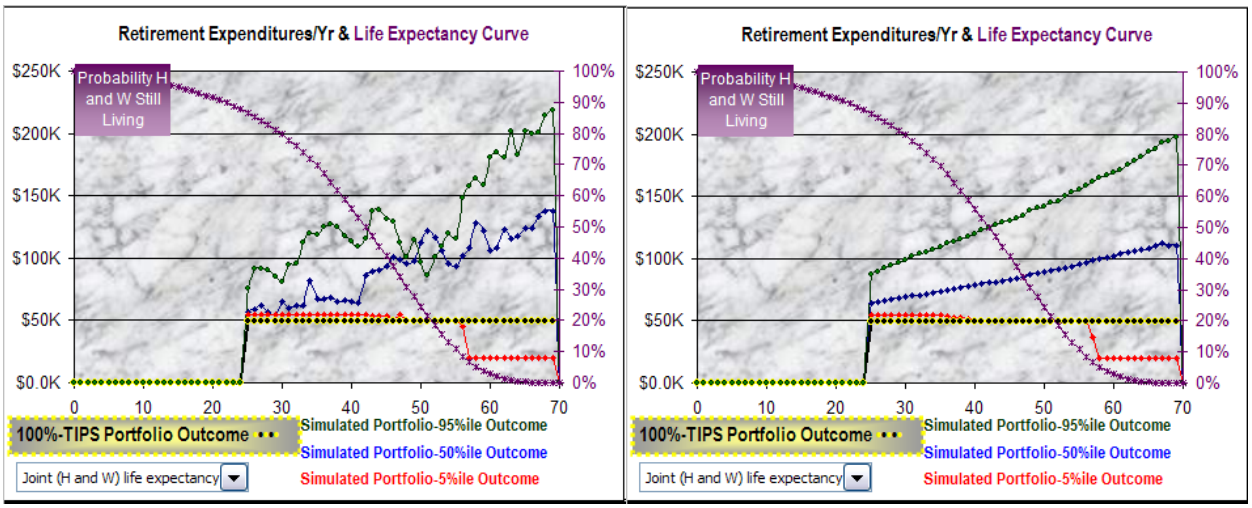


Figure 14: The left chart illustrates the annual retirement expenditures provided by the 95, 50, and 5 percentile, actual simulated outcomes of Jack and Jill's portfolio. The right chart illustrates the 95, 50, and 5 percentile budgets, produced over all of the simulations, for each year of the life of Jack and Jill's portfolio.

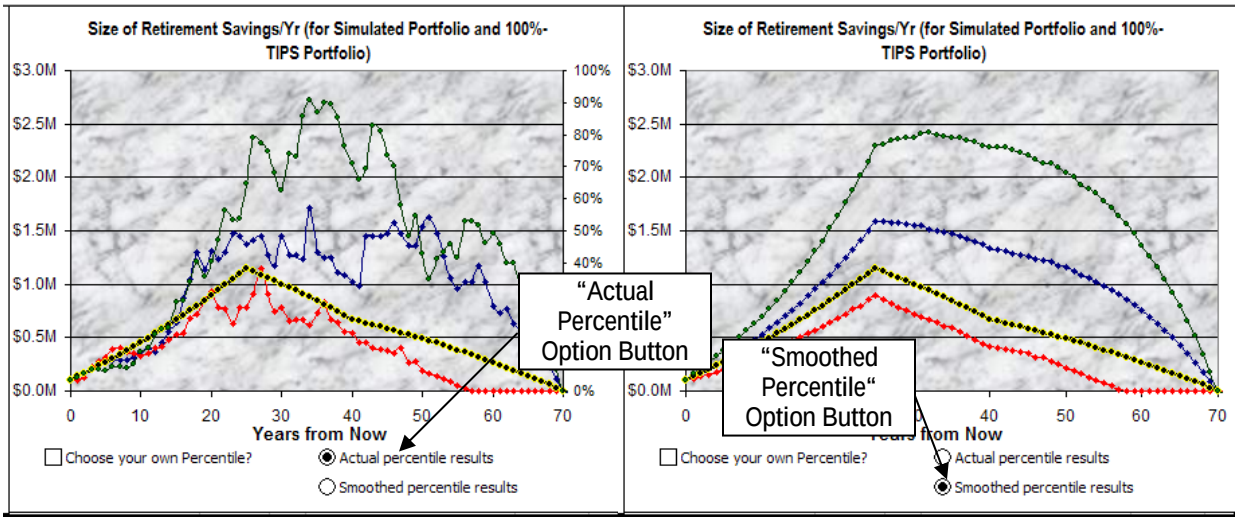


Figure 15: The left chart illustrates the portfolio sizes corresponding to the 95, 50, and 5 percentile, actual simulated outcomes of Jack and Jill's portfolio. The right chart illustrates the 95, 50, and 5 percentile portfolio sizes, produced over all of the simulations, for each year of the life of Jack and Jill's portfolio.

TIP$TER® generates the "actual percentile" results by ranking the thousands of series of simulated draws and corresponding portfolio sizes – but *without* blending the results of any of the simulations together. TIP$TER® generates the "smoothed percentile" results by identifying the 5, 50, and 95-percentile-ranked retirement expenditure and portfolio size for *each year* of the life of the portfolio – and then linking those similarly ranked draws and portfolio sizes together. TIP$TER's "smoothed percentile" results, unlike its "actual percentile results," blend the results of the simulations together.

3. Choosing Your Own Percentile

To give you a more comprehensive feel of the range of different outcomes your diversified portfolio could produce, TIP$TER® also lets you choose your own percentile. When you select the "Choose your own Pecentile?" checkbox in the portfolio size chart, TIP$TER® provides spin buttons (see Fig. 21) that let you selectively display the 5, 10, 15, etc., percentile simulated outcomes (actual or smoothed), in 5% increments. TIP$TER® also displays summary statistics associated with the selected percentile, and contrasts those statistics with the corresponding outcomes projected from an all-TIPS portfolio.

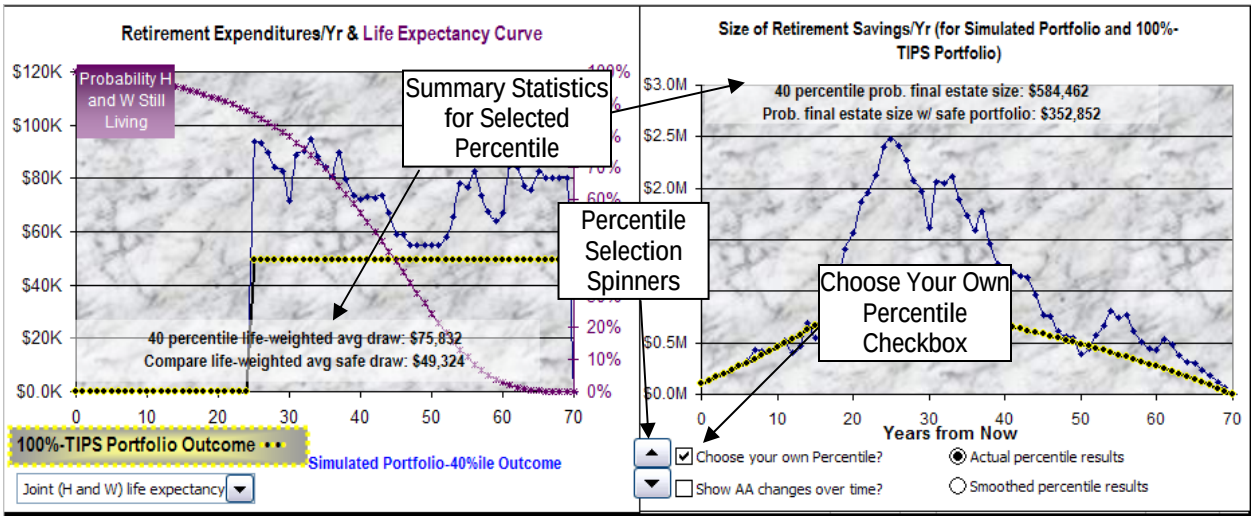


Figure 16: The charts above illustrate the 40-percentile outcomes of a simulation of Jack and Jill's portfolio. The charts also present summary statistics associated with the selected 40-percentile outcome. The charts allow you to display any percentile, in 5% increments, of your choosing.

4. Showing Asset Allocation Changes Over Time

As noted earlier, TIP$TER® lets you test asset allocation strategies. After doing so, it is useful to see the correspondence between a particular percentile outcome and the asset allocation pattern that the simulation implemented. So TIP$TER® lets you select a checkbox to reveal how the simulated asset allocation changed over time. When this checkbox is selected, TIP$TER® displays the asset allocation curve in an earth-toned red. Fig. 22 illustrates the asset allocation versus time for the 20-percentile outcome of a "mean-reverting" simulation, using a 25-year RTM time factor. Notice how, when Jack and Jill's portfolio experienced rapid growth, reflecting a bull market, Jack and Jill's asset allocation declined from an initial 70% almost to zero. And as Jack and Jill's portfolio experienced significant losses, reflecting a bear market, the simulation responded by increasing Jack and Jill's allocation.

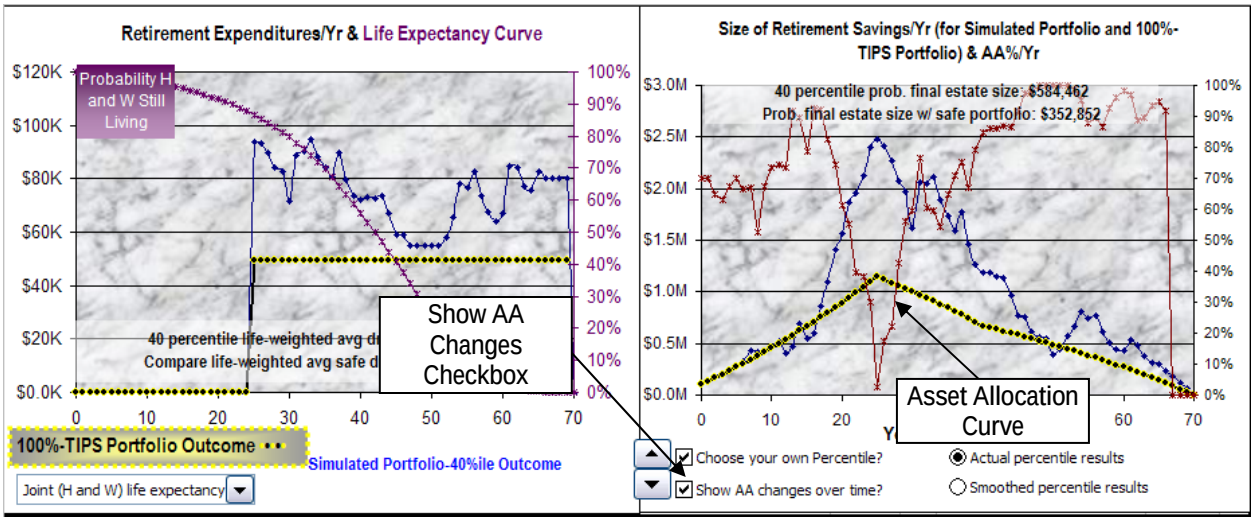
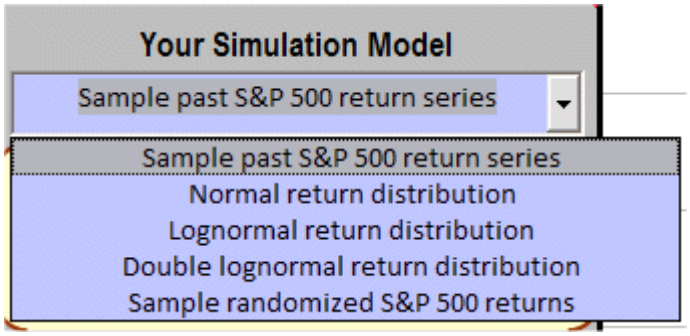


Figure 17: The charts above illustrate the 40-percentile outcomes of a "mean-reverting" simulation of Jack and Jill's portfolio, with a 25-year RTM time factor. The right chart also displays TIP$TER's implementation of Jack and Jill's tactical asset allocation strategy for the simulated 40-percentile outcome.

VII. UNDERSTANDING TIP$TER'S SIMULATION MODELS



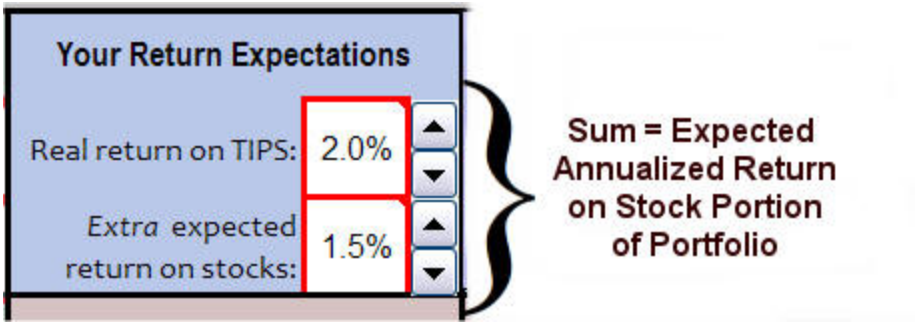
TIP$TER® provides five return models for simulating the stock portion of the portfolio.

The first, and preferred, option is an exploratory simulation of historical S&P 500 real return data.

The next three options enable Monte Carlo simulation by modeling returns as if they have a normal, lognormal, or double lognormal distribution.

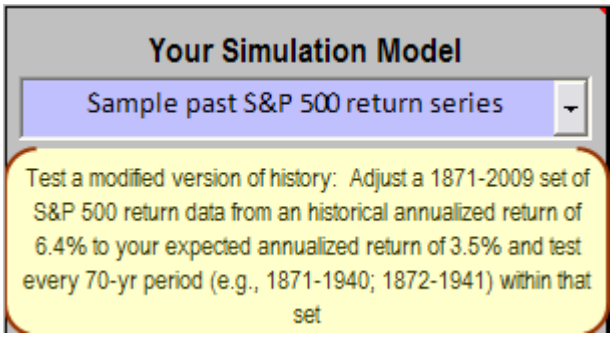
The fifth option enables Monte Carlo simulation by randomly sampling returns, with replacement, from the distribution of S&P 500 returns. Unlike the "exploratory simulation" model, the fifth option effectively scrambles the S&P 500 returns as if each return was entirely independent from every other.

In all five simulation options, TIP$TER® adjusts the distribution or exploratory series of stock returns to have an annualized return equal to the user-specified expected annualized return on stocks. The expected annualized return on stocks is equal to the sum of the risk-free rate (in TIP$TER's interface, the "Real return on TIPS") and the expected equity risk premium (in TIP$TER's interface, the "extra expected return for stocks").



If the user keeps TIP$TER's default inputs of 2% for TIPS plus an "extra" 1.5% for stocks, TIP$TER® either centers the arithmetic mean of the Monte Carlo distribution, or scales its set of historical S&P 500 return data, to yield an annualized return of 3.5%.

A. Exploratory Simulation: Sampling Past S&P 500 Return Series



TIP$TER's preferred method for modeling returns is through an "exploratory simulation" of mean-adjusted S&P 500 real returns.

Previous versions of TIP$TER® only supported Monte Carlo simulation and experimented with ever more complex Monte Carlo stock return models (such as the "double lognormal," discussed below) in an effort to better reflect the short-term fat-tails (leptokurtosis) and long-term mean-reverting behavior of stock markets.

Now TIP$TER® supports exploratory simulation. Exploratory simulation, in short, tests a person's financial plan against the past. It puts the investor back in time – for example, back to Jan. 1871, or July 1921, or August 1954 – and tests how that investor's portfolio would have performed from that point through the end of the investor's targeted portfolio duration. Such an exploratory simulation inherently incorporates all of the mean reverting behavior and serial return correlation in the market.

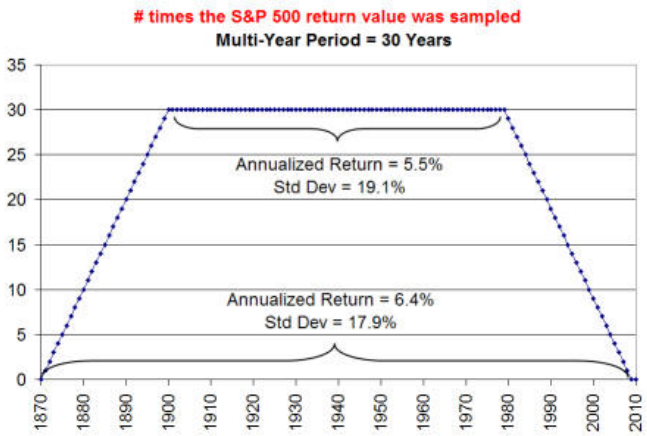
Exploratory simulation circumvents the need to develop ever more complex return distribution models, and for users to specify their ever more difficult-to-understand parameters. Instead of trying to design and parameterize a model that best fits the data, exploratory simulation uses the actual data itself.

But unless that historical return data set is modified for use in a simulation, exploratory simulation suffers from at least two significant defects: (1) exaggerated, unrepeatable return assumptions; and (2) unequal sampling of data points.

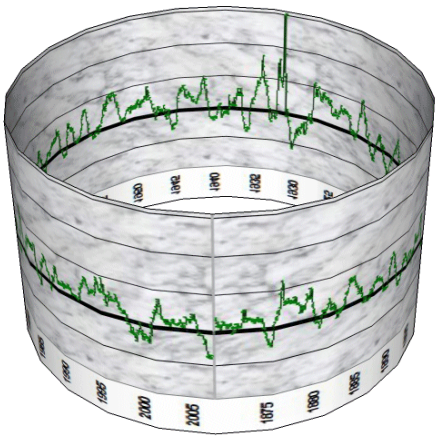
The use of historical returns, without any adjustment for present-day realities, is potentially misleading. Between 1871 and 2009, the S&P 500 experienced an annualized real

return (including reinvested dividends) of 6.4%. It is unrealistic to assume that future stock market returns will be anywhere nearly as generous. After all, in the infinitely long run, it is mathematically impossible for the stock market to return more than its dividend yield plus the long term growth rate of the economy it represents.

Typical exploratory simulations also results in unequal sampling of data points. For example, if one were to test a 30-year targeted portfolio duration against a real return data set spanning from 1871 to 2008, the returns in the 1901-1978 span would be tested more often than the returns on the tail ends of the data set.



Unlooped Data Set Results in Uneven Sampling



Solution: Looped Data Set

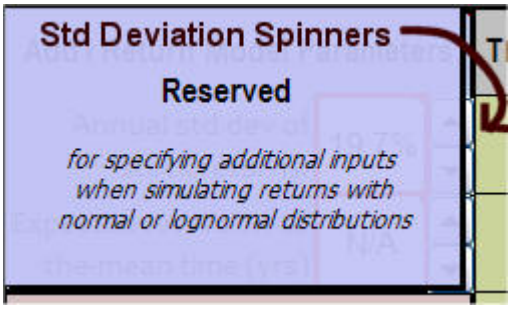
TIP$TER® addresses both of these problems. TIP$TER® stores the real monthly returns (including dividends) of the S&P 500 from January 1871 through March 2009 (at later, depending on the version). TIP$TER® then proportionally scales its set of historical S&P 500 return data to yield an annualized return equal to the user-specified expected stock return. TIP$TER® also "loops" its data set. The March 2009 return would be followed by the January 1871 return. Accordingly, all data points within the 1871-2009 data set are sampled the same number of times.

For every month of this mean-adjusted and looped 1600+ month historical data set, TIP$TER® calculates the subsequent 12-month return. (For the last 11 months of the data set, TIP$TER® wraps back to the beginning of its data set -- i.e., 1871 -- to calculate the 12-month return going forward).

To simulate a portfolio, TIP$TER® tests a user's portfolio against every available start date in the modified and looped data set. For example, one simulation iteration would test the user's portfolio against an interval of modified S&P 500 data starting with Jan. 1871. The next simulation iteration would test the user's porfolio against an interval that started with Feb. 1871. And so on. For intervals starting more recently, TIP$TER® wraps back to the beginning of its data set (1871) after simulating the last return in its historical data set. Every TIP$TER® exploratory simulation tests a user's financial plan against over 1600 intervals of modified historical data. Every TIP$TER® exploratory simulation also samples every modified historical data point equally.

Technical Notes:

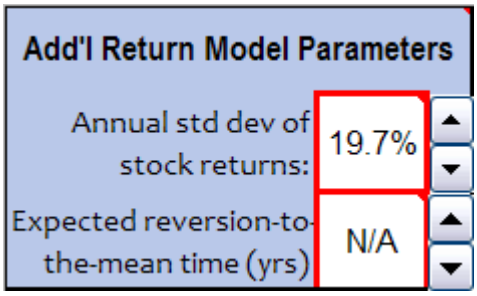
By default, TIP$TER's mean-adjusted historical data set has the same volatility as the original data set (i.e., 19.7% standard deviation for rolling annual returns from Jan. 1871-Mar. 2008). However, TIP$TER can scale its set of historical S&P 500 return data to have a volatility (standard deviation) equal to the user-specified volatility. *To keep the interface simple for most users, TIP$TER mostly conceals the "annualized standard deviation of returns" input behind a "Reserved" comment when the "exploratory simulation" option is selected.* Sophisticated users who wish to adjust the volatility of the data set, however, can still access the standard deviation input spinners (by zooming on this section of the spreadsheet or by unprotecting the spreadsheet and closing or moving the comment).



TIP$TER's exploratory simulation is insensitive to any changes a user makes to the "Expected reversion-to-the-mean time (yrs)" input spinners. Those spinners only affect simulations using a normal, lognormal, or double lognormal model of returns.

B. Monte Carlo Simulation Modes

TIP$TER® provides four different Monte Carlo simulation modes.



When you specify one of the Monte Carlo simulation modes, TIP$TER® asks you to specify at least one additional parameter: the standard deviation. TIP$TER® also provides the option of modeling a *non-stationary, mean-reverting* normal, log-normal, or double-lognormal distribution (see section VII(G)) by giving the "Expected reversion-to-the-mean time" input a positive number.

A Monte Carlo simulation is a mathematical model of a system that exhibits random behavior. A Monte Carlo simulation can be used to model something as simple as a coin flip or the toss of a die or something as complex as quantum behavior. TIP$TER® provide several Monte Carlo simulation options to model stock returns.

A Monte Carlo simulator uses a probability distribution (and there are several to choose from) to define the range of possible values for an uncertain variable. For something as simple

as a coin flip, the probability distribution would be defined by two values: 50% for heads, and 50% for tails.

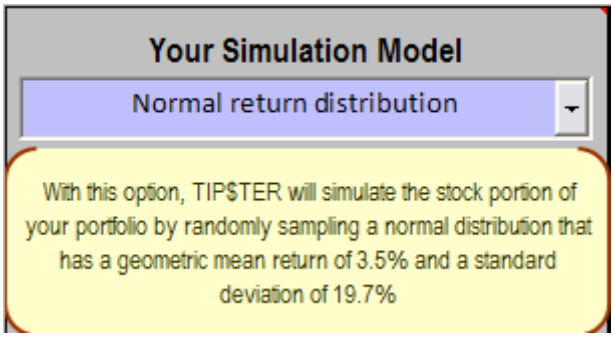
All Monte Carlo simulators, including TIP$TER®, rely on random-number or pseudo-random-number generator to generate numerous numbers that are randomly distributed in accordance with the probability distribution used in the model. Each year of a simulation, TIP$TER® takes a randomly distributed number and plugs it into a complex mathematical function (which is much too complex to discuss in this manual) in order to generate a simulated return on the stock portion of the portfolio.

Because TIP$TER® simulates the life of a portfolio thousands of times, TIP$TER's Monte Carlo simulator uses many tens of thousands of pseudo-random numbers. Each simulation generates a series of consecutive draws and corresponding portfolio sizes for each year of the targeted portfolio duration. Each simulation also generates, for visual analysis purposes, a series of asset-allocation percentages for each year of the targeted portfolio duration.

After the simulations are complete, TIP$TER® ranks the series of draws and corresponding draw sizes in order to identify selected percentile outcomes. TIP$TER® then graphs these selected percentile outcomes on the retirement expenditure and portfolio size charts, in order to illustrate the volatility and wide dispersion of potential outcomes of your diversified portfolio.

C. Simulating With a Normal Return Distribution

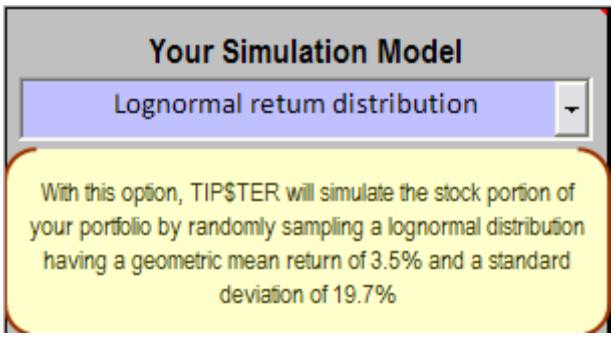
The Monte Carlo model most commonly used by alternative stock market simulators is the simple normal (aka gaussian) distribution. TIP$TER® provides the very same model as a simulation *option*.



Because there is a finite chance, with an unmodified normal distribution, of having a return event *worse* than -100%, TIP$TER's simulation engine truncates the low end of the tail of the normal distribution at -100%.

D. Simulating With a Lognormal Return Distribution

The second most common Monte Carlo simulation model is the lognormal distribution. TIP$TER® provides this model as yet another simulation *option*.



The lognormal distribution is widely used by academics to model stock returns and is sometimes preferred for its geometric symmetry. Whereas the normal distribution will give an equal chance to events 50% above and below the expected return, the lognormal distribution will give an equal chance to events that are 100% above (a doubling event) and 50% below (a halving event) the expected return.

The normal distribution, however, has a fatter tail on the negative return-side of the distribution than the log-normal distribution. Moreover, the normal distribution appears to fit the annual S&P 500 data just slightly better – although not in any statistically significant sense – than the log-normal distribution.

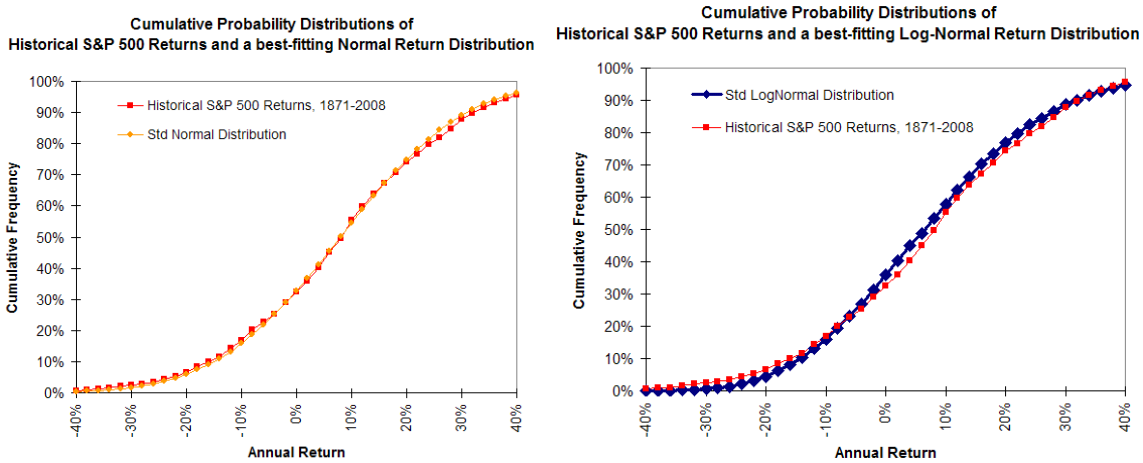


Figure 18: The normal distribution fits the historical data slightly better – but not in any statistically significant sense – than the lognormal distribution.

E. Simulating With a Double Lognormal Return Distribution

In the pursuit of an even better-fitting distribution, TIP$TER® introduced in version 1.5 a "double lognormal" distribution as yet another simulation *option*.

Note:

A technically complex discussion of TIP$TER's double lognormal distribution follows. The very difficulty of describing this option, along with the remaining limitations of this more-elaborate model, inspired the development of TIP$TER's easier-to-understand and generally superior exploratory simulation model.

The double lognormal distribution nevertheless remains one of TIP$TER's simulation options, for purposes of comparing models.

One interesting observation about stock returns is that they are often characterized by long periods of relative calm that are punctuated by periods of extreme volatility. This is starkly illustrated by the "Implied Volatility" of the S&P 500 based on options market prices. The following illustrates how the implied volatility index, or VIX, has varied between 1990 and 2009.

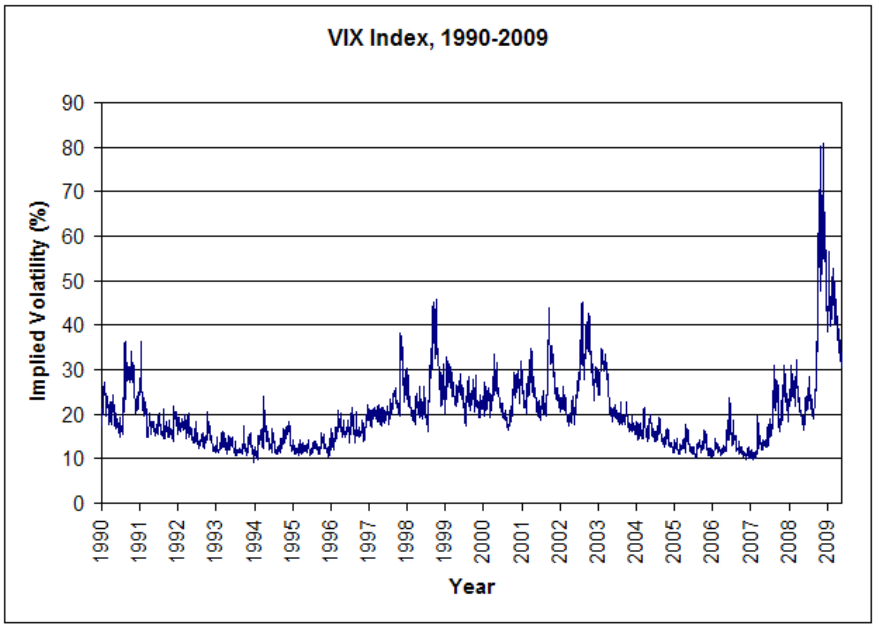


Figure 19: Chart illustrating the volatility of the index that implies the volatility of the S&P 500

The market was characterized by periods of high volatility from mid 1990 through mid 1991, from late 1997 through 200, and again, from mid-2007 to date. In between those periods, the market was predominantly characterized by relatively stable, low-volatility returns.

The long and short of it is that the volatility of stock returns is not constant. Rather, as Fig. 6 above shows, there is a *volatility to the volatility*.

The following chart presents a frequency distribution of the VIX index itself.

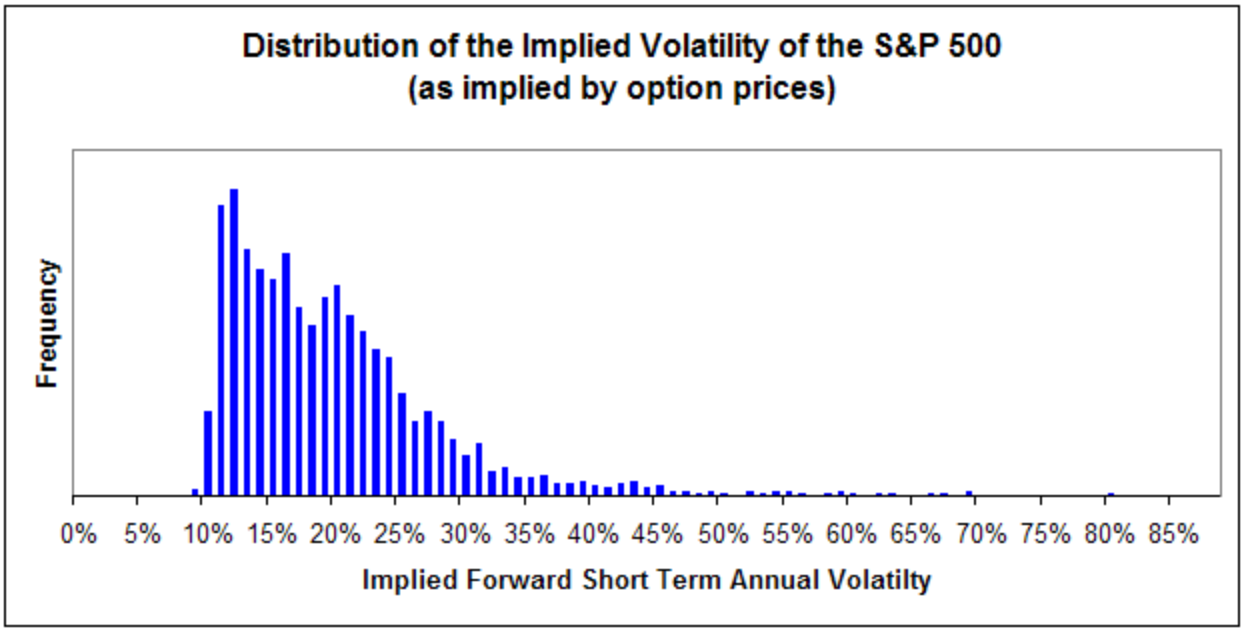


Figure 20: Frequency distribution of the VIX Index, 1990-2009.

Notability, the volatility of the VIX (i.e., the volatility *of* the implied volatility of the S&P 500) -- which covers a relatively short time range of 1990 to 2009 -- *itself* has a roughly lognormal shape, as shown by the graph above. Indeed, a best-fitting lognormal to the distribution shown above has a geometric mean of about 16.3% and a geometric standard deviation of about 7.3%.

These observations inspired the development, in TIP$TER® version 1.5, of the "double lognormal" return distribution model. This distribution model has three parameters – a geometric mean return, a first-order volatility parameter, and a second order volatility parameter – and uses two lognormal distributions. The first lognormal distribution is centered by the geometric mean parameter. But its volatility varies from year to year. The simulated value for the first lognormal distribution's standard deviation is randomly drawn from the second lognormal distribution. The second lognormal distribution is centered around the first-order volatility parameter and its width is defined by the second-order volatility parameter.

Interestingly, an experimental double lognormal distribution with a geometric mean of 6.4%, a first-order volatility parameter of 16.3%, and a second-order volatility parameter of 7.3% fits the historical S&P 500 data set pretty well.

The graph below compares both a lognormal and a double lognormal fit of 10000 simulated iterations of annualized S&P returns with the historical annual S&P returns.

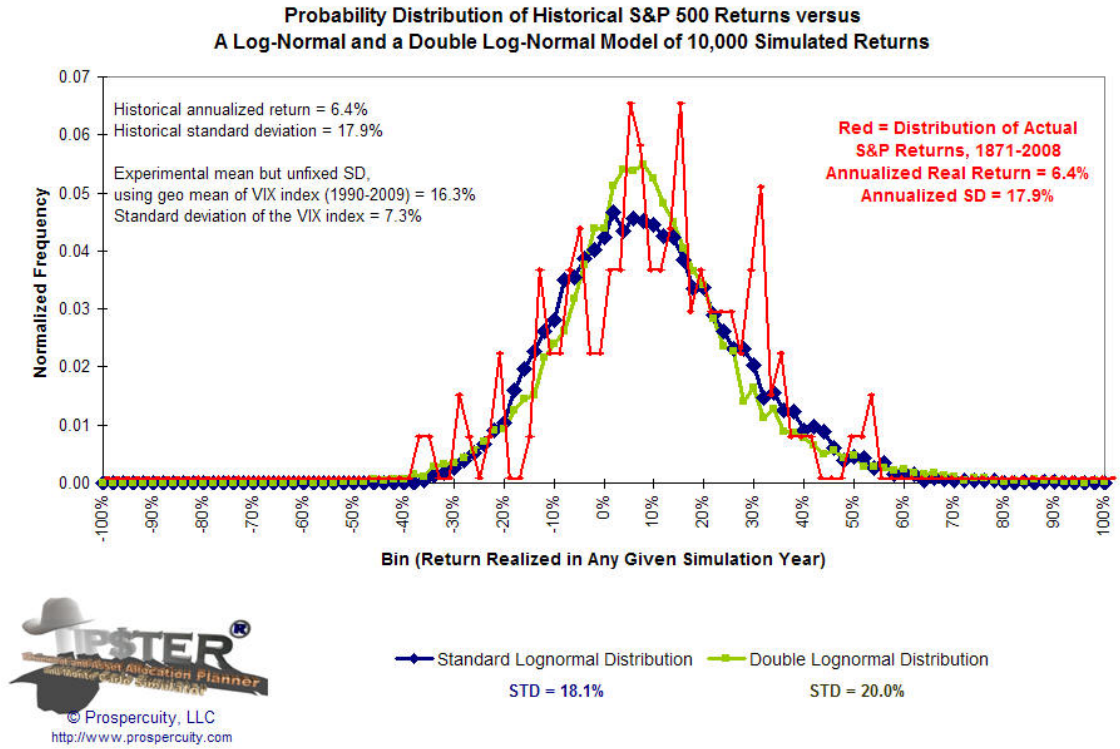


Figure 21: Simulated versus historical distribution of S&P annual returns, from the years 1871-2008.

Notably, the simulated sample of doubly-lognormal returns (depicted in light green) has a a sharper peak and fatter tails (i.e., it is more "leptokurtic") than the simulated sample of lognormally distributed returns.

The low end of the cumulative frequency distribution of the simulated versus historical S&P 500 annual return values (with overlapping 12 month series) demonstrates that this experimental double lognormal fits the low end of the historical distribution. At this low end, the double-lognormal curve, shown in green, provides a much better fit than the single lognormal curve, shown in blue, to the historical data, shown in red.

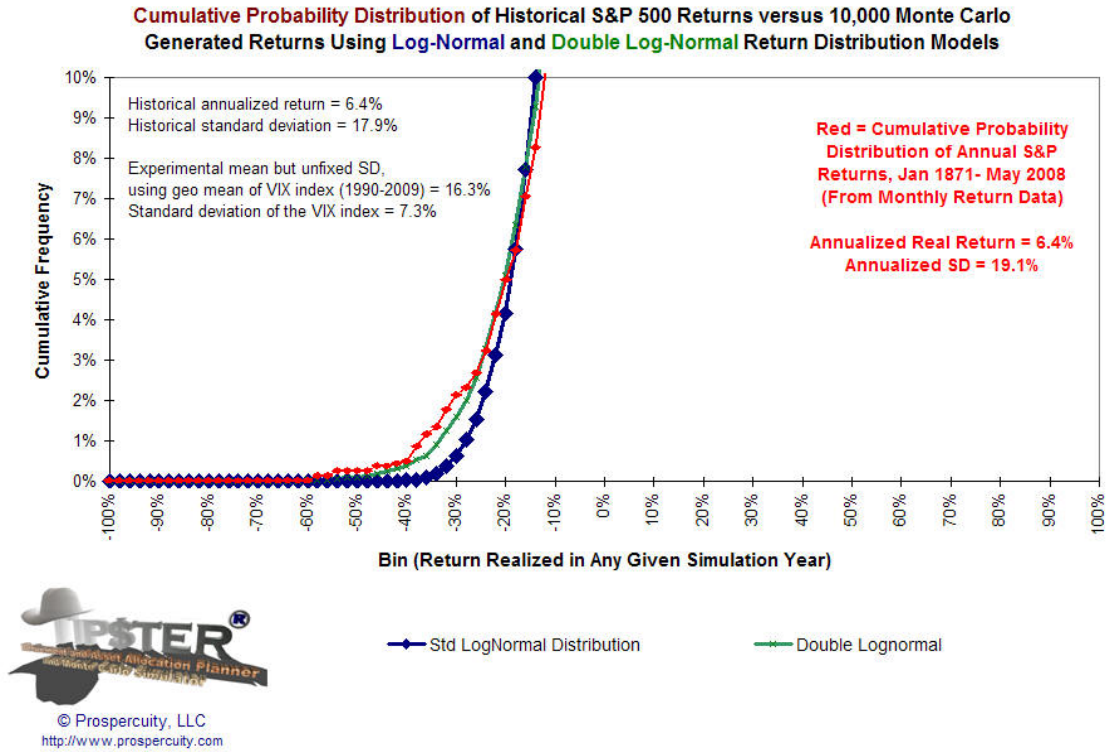
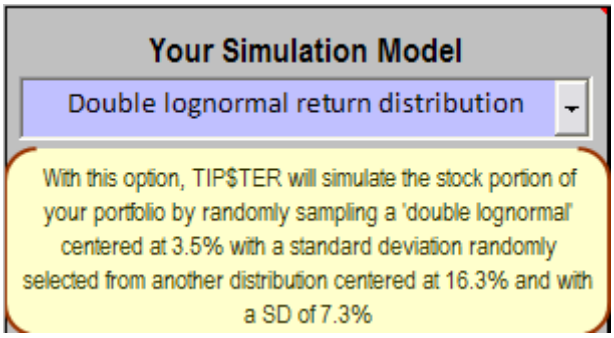


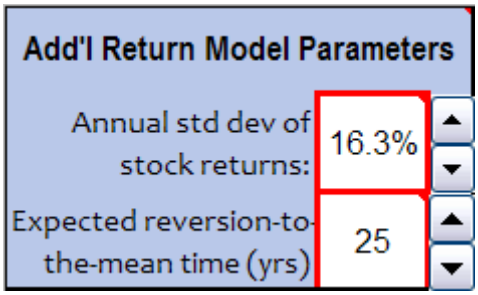
Figure 22: Cumulative probability distribution of lognormally and doubly-lognormally simulated returns versus historical S&P returns.

To select the "double lognormal" distribution model, a user selects the option depicted below:



When this option is selected, TIP$TER® changes the "standard deviation" – which TIP$TER® uses as a first-order volatility parameter – to a default value of 16.3%. The user may adjust this parameter before performing a simulation.

TIP$TER® changes also uses the value 7.3% as the second order volatility parameter, a hidden parameter for which is not intended to be user-adjusted. (However, anyone interested in modifying this parameter can contact Prospercuity, LLC for details.).



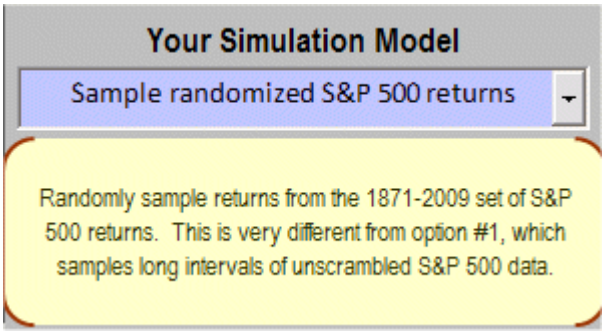
When the "double lognormal" option is selected, TIP$TER® also changes the default "reversion-to-the-mean time" to 25 years (see section VII(G) below for an explanation).

Statistical Trivia:

A distribution whose volatility varies over different time periods is referred to as a "heteroskedastic" distribution. And when there is no known periodicity to the volatility of the volatility, it is referred to as a "conditional heteroskedastic" distribution.

Many economic statisticians have observed that short term stock returns tend to be more concentrated near the mean and in the tails than a normal distribution would suggest. Distributions that exhibit this kind of behavior are referred to as "leptokurtic." In the very long term, however, stock returns tend to be more platykurtic, with thinner tails than a normal or lognormal distribution would suggest. That is, the distribution of stock returns tends from a leptokurtic distribution in the short term to a platykurtic distribution in the very long term.

F. Randomly Sampling the Distribution of Historical S&P 500 Returns



The fifth option enables Monte Carlo simulation by randomly sampling returns, with replacement, from the distribution of S&P 500 returns. Unlike the "exploratory simulation" model, the fifth option effectively scrambles the S&P 500 returns together as if each return was entirely independent from every other.

TIP$TER® also scales the values of this set to yield then annual expected real return and standard deviation you specify.

G. Simulating with Non-Stationary, Mean-Reverting Distributions

> "If stock price movements contain large [mean-reverting] transitory components then for long-horizon-investors the stock market may be much less risky than it appears when the variance of single-period returns is extrapolated using the random-walk model."
>
> *Poterba, James M. and Summers, Lawrence H., Mean Reversion in Stock Prices: Evidence and Implications (July 1989), NBER Working Paper Series, Vo. W2343, p. 1, 1989. Available at SSRN: http://ssrn.com/abstract=227278.*

1. The Problem with the IID Assumption

TIP$TER® enables the user to model both stationary and non-stationary normal, lognormal, double lognormal, and random S&P 500 distributions.

Conventional stock market models follow a random-walk model that assumes that returns are independent and identically distributed (IID). Each return is independent from all of the previous returns. And each return is drawn from exactly the same distribution. The distribution of probable returns never changes. Even after an extended bull or bear market, the distribution of probable returns remains "stationary," fixed as if it were in concrete. The probability of a given yield for any given year is always the same, regardless of cumulative past simulated performance. This is a necessary consequence of the assumption that all returns are IID.

The assumption that returns are IID is fundamentally at odds the dividend discount model. The dividend discount model states that the annualized return on a total stock market investment is – in the infinitely long run – equal to its dividend rate plus the long-term growth rate in those dividends. Also, the dividend yield cannot – in the infinitely long run – grow faster than the economy it represents.

According to the dividend discount model, if one expects the real (inflation-adjusted) dividend growth rate to be about 1%/year (which is close to the historic U.S. real dividend growth rate), and the current yield of the total stock market (after expenses) is 3%, then one should expect a long term real return on stocks of 1% + 3% = 4%. Therefore, the return distribution model should be centered about an annualized 4% real return.

But if, six months later, the stock market doubles without any corresponding increase in the amount of dividends distributed by the companies represented by the stock market, then one should expect a long term real return on stocks to drop down to 1% (growth rate) + 1.5% (new dividend rate) = 2.5%. The dividend discount model would *recenter* the distribution of potential returns around an expected annualized 2.5% real return.

Conventional Monte Carlo simulators do not *recenter* the distribution of potential returns as a simulation progresses. They do not shift the distribution of expected returns downward to account for cumulative simulated results that far exceed the originally expected return of the market. Nor do they shift that distribution back upwards when the cumulative simulated

performance lags the originally expected return of the market. Rather, conventional Monte Carlo simulators assume that stock returns are IID.

The hypothesis that all returns are independent and identically distributed is a difficult one to defend, not only on the basis of the dividend discount model, but also when viewed against the data we have.

In their famous, oft-cited 1987 NBER Working Paper, authors James Poterba and Lawrence Summers develop evidence that stock returns are positively serially correlated over short periods and negatively autocorrelated over long periods.[18]

The following graph illustrates the historical distribution of annualized returns ***over 30-year periods*** for the S&P 500, for the years 1901-2008, looking back for each of those years at the annualized return over the previous 30 years.

Normal distribution theory teaches that the distribution of annualized returns over an n-year period will approach the distribution of annualized returns divided by the square root of n. The distribution of annualized returns was about 18%. Therefore, one would expect – if returns are truly normally distributed – that the annualized returns over a 30-year period would be 18% / SQRT(30) = 3.2%. But over the period from 1901-2008, the annualized return over the trailing 30-year period had a standard deviation of only 1.7%.

[18] Poterba, James M. and Summers, Lawrence H., Mean Reversion in Stock Prices: Evidence and Implications (July 1989), NBER Working Paper Series, Vo. W2343, p. 32, 1989. Available at SSRN: http://ssrn.com/abstract=227278.

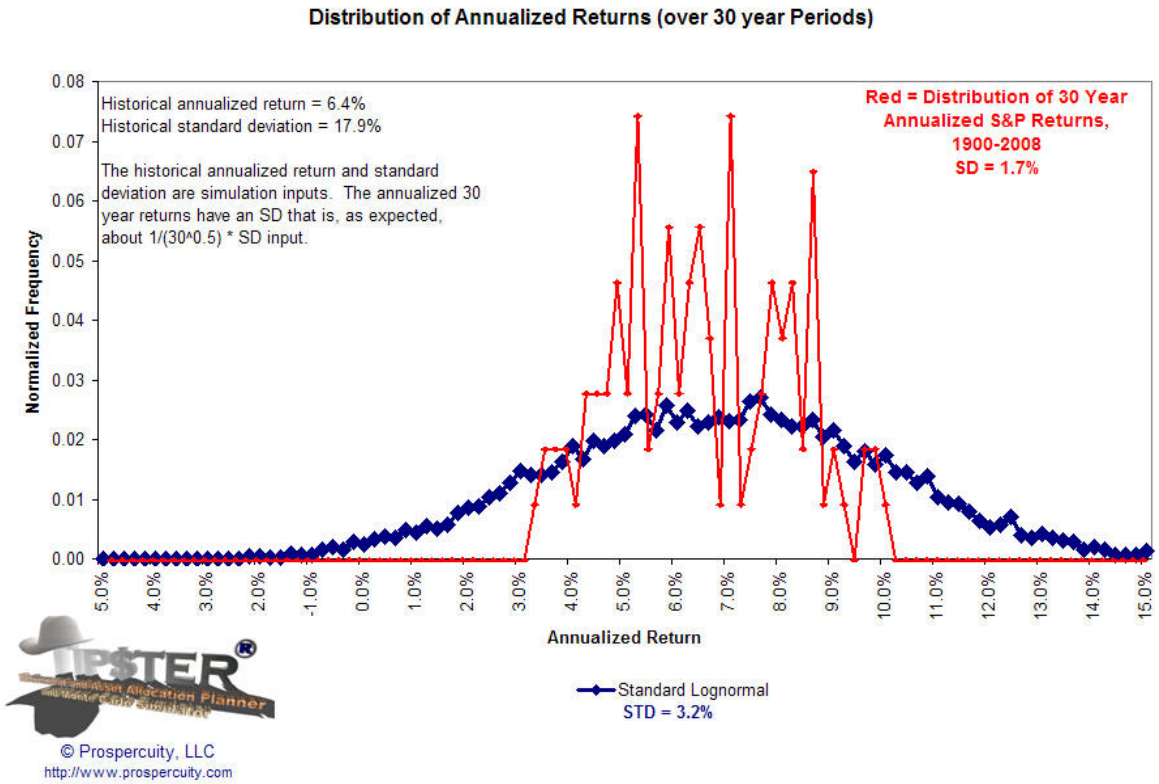


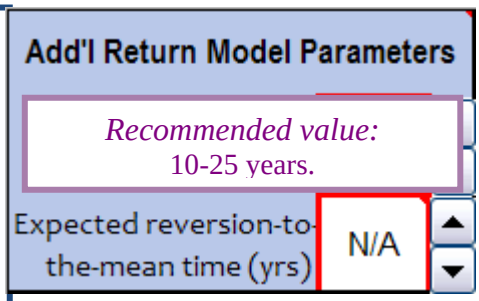
Figure 23: Simulated versus historical distribution of annualized S&P returns over previous 30 years, from the years 1901-2008.

The blue line in the graph above illustrates the distribution of 30-year averages of a 10,000-iteration simulation of a normally-distributed set of returns, each of which had an annualized return of 6.4% and a standard deviation of 18%. As normal distribution theory predicts, the standard deviation of the simulated distribution is 3.2%, pretty close to the 3.3% that normal distribution theory would predict.

The red line in the graph above illustrates the annualized returns over overlapping, rolling 30-year periods of actual historical S&P 500 return data between 1871 and 2008. Even though are working with an extremely very small data set relative to a 30-year time frame, permutation tests of the 1871-2008 return data set indicates only a 5-7% probability of the IID hypothesis being true.

2. *Introducing Mean-Reverting Behavior into TIP$TER's Stock Return Model*

SUMMARY: To introduce mean-reverting behavior into TIP$TER's stock return model, specify the average number of years it would that you think it would take for a "bear-mauled" or "bull-riding" stock market to "revert to the mean," and deliver the *cumulative* performance you had originally expected. The shorter the RTM time factor you specify (except for the value zero), the stronger the mean-reverting behavior that TIP$TER simulates. If you don't want TIP$TER to model mean-reverting behavior, lower the value toward zero (0), at which point TIP$TER displays "NA."



When you enter a non-zero value for the "reversion-to-the-mean time" factor, TIP$TER® *nudges* the expected return distribution upward or downward (see Fig. 24) each year of the simulation to respond to departures from your originally expected cumulative return. The farther away cumulative simulated results stray from the cumulative results that would have been generated by compounding the geometric mean expected return, the more the distribution is shifted.

The extent to which TIP$TER® nudges each year's simulated return depends on a reversion-to-the-mean (RTM) time factor that you specify. Essentially, TIP$TER® asks you to specify the average number of years you think that it would take for stock portion of your portfolio to "revert to the mean," and deliver the performance you originally expected. The shorter the RTM time you specify, the stronger the mean-revering behavior that TIP$TER® simulates. If you don't want to specify a RTM time factor, simply reduce the RTM factor to "N/A" – and TIP$TER® will not model your stock returns with mean-reverting behavior.

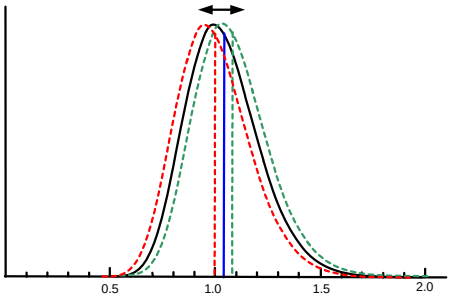


Figure 24: TIP$TER models mean-reverting behavior – if you choose – by "nudging" the expected return up or down to correct for large disparities from cumulative expected returns.

When you specify an RTM time factor, TIP$TER® keeps track of the difference between the simulated return and the cumulative expected return of the stock portion of your portfolio. Every year of any given simulation, TIP$TER® calculates the ratio between the cumulative simulated return and the cumulatiave expected return. Then, based on this difference, TIP$TER® calculates an adjusted short-term expected annualized rate of return (Fig. 13) that would be needed, over the next "RTM" years, to nudge the long-term stock returns back up, or back down, to the annualized return that you originally expected.

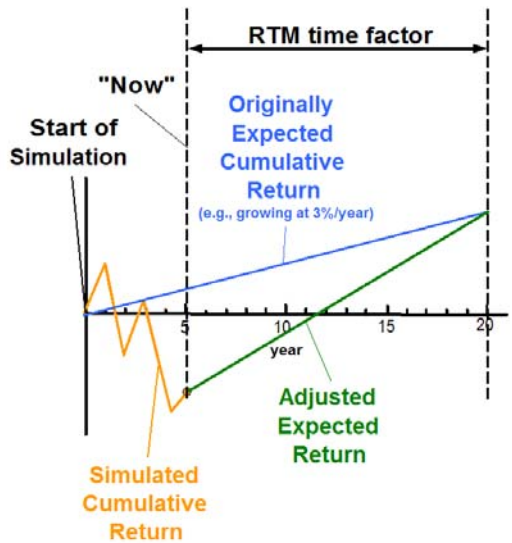


Figure 25: The blue line illustrates an elevated expected return computed to help TIP$TER's future simulated stock returns "catch up," over a 15-year RTM period, to expectations

To illustrate, assume that you specified an expected real return for stocks of 3%. In the first year of the simulation, TIP$TER® simulates a negative 20% return on your stock investments. What adjusted annualized rate of return, over the next 9 years (i.e., RTM = 9 years) would the stock portion of your portfolio need to obtain to cause the average real return over the entire 10-year span to "revert" to 3%/year? The answer is 5.32%. What adjusted annualized rate of return, over the next 25 years (i.e., RTM = 25 years) would the stock portion of your portfolio need to obtain to cause the average real return over the entire 26-year span to "revert" to 3%/year? The answer is 4.05%. Say you specified a RTM time factor of 50 years, instead of 25 years. Then the answer would be 3.52%.

There's a pattern here: the longer the RTM time factor you specify, the less difference between the original 3% rate of return and the adjusted rate of return. To put it another way, the longer the RTM time factor you specify, the weaker the mean-reverting behavior.

Let's consider one more illustration. Suppose that instead of a negative 20% return, TIP$TER® simulated a positive 30% return on your stock investments after the first year. The adjusted rate of return the stock portfolio of your portfolio would need to obtain, over the next 25 years, to cause the average real return to achieve 3% would be 2.05%.

For those of you who are mathematically inclined, the formula that TIP$TER® uses calculate an *adjusted* expected annualized rate of return μ on the stock portion is as follows:

$$\mu_{adj}(t) = \left(\frac{(1+\mu_{orig})^{RTM}}{\prod_{j=0}^{t} \left((1+r_j)/(1+\mu_{orig}) \right)} \right)^{1/RTM} - 1$$

where μ_{orig} is the original expected return, $\mu_{adj}(t)$ is the adjusted expected return at year t, RTM is the time factor, and r_j is the randomly simulated return that occurred in simulated year j.

So what's the effect of introducing RTM behavior into TIP$TER's model for stock returns? Consider Jack and Jill's portfolio described on pages 4-6. The graphs in Figs. 26 and 27 below illustrate two Monte Carlo simulations – one a "random-walk" lognormal simulation and the other a "mean-reverting" lognormal simulation – of that portfolio, assuming a fixed asset allocation of 70%-stock/30%-TIPS. The graphs on the left were produced by the random-walk simulation. The graphs on the right were produced by a mean-reverting simulation, using a 25-year RTM time factor, on the same portfolio. Although both simulations exhibited a significant amount of short-term volatility, there was far less dispersion between the 5 and 95 percentile outcomes of the mean-reverting simulation than there were for the random-walk simulation. Moreover, the mean-reverting simulation yielded a smaller shortfall risk than the random-walk simulation.

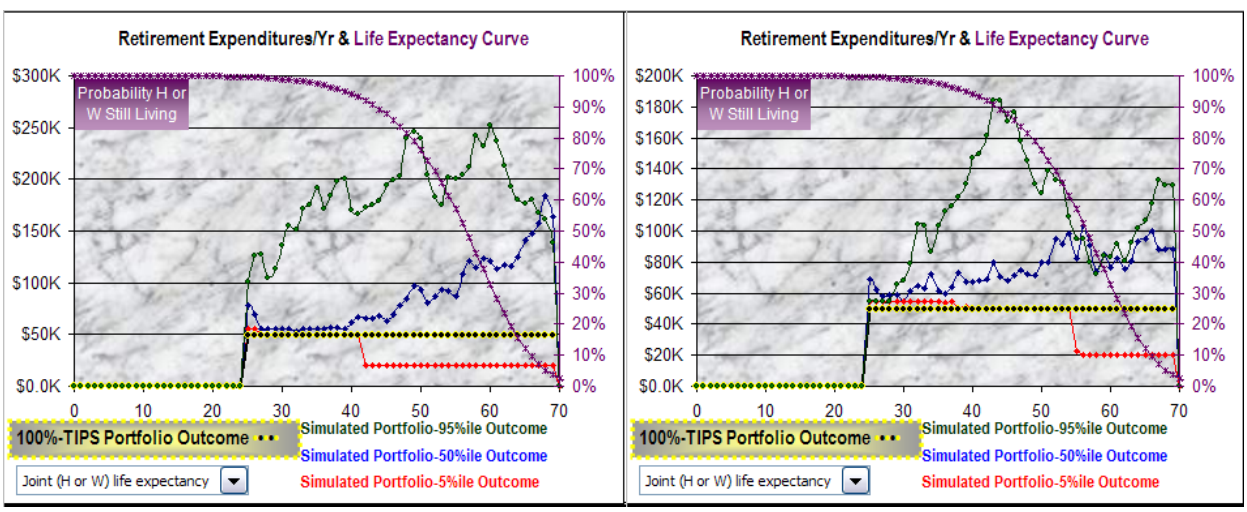


Figure 26: The graphs above illustrate the 5, 50, and 95-percentile simulated series of retirement budgets produced by Monte Carlo simulations of Jack and Jill's portfolio. A "random-walk" simulation produced the left graph. A "mean-reverting" simulation produced the right graph. Notice the $0K-$300K scale of the left graph, versus the $0-$200K scale of the right graph. There is less dispersion between the 5 and 95 percentile results in the right graph than in the left graph.

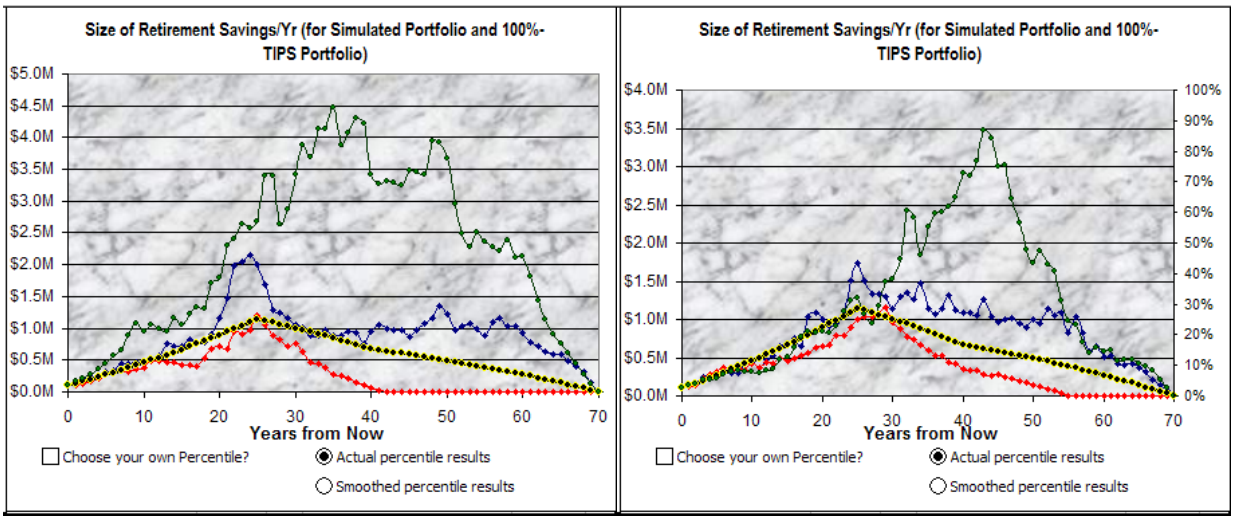


Figure 27: The graphs above illustrate the 5, 50, and 95-percentile simulated series of portfolio values produced by Monte Carlo simulations of Jack and Jill's portfolio. A "random-walk" simulation produced the left graph. A "mean-reverting" simulation produced the right graph. Notice the $0M-$5M scale of the left graph, versus the $0M-$4M scale of the right graph. Again, there is less dispersion between the 5 and 95 percentile results in the right graph than in the left graph.

Perhaps the very best illustration of the difference between a random-walk simulation and a mean-reverting simulation is illustrated in the Asset Allocation Risk/Reward Spectrum Charts of Fig. 28.

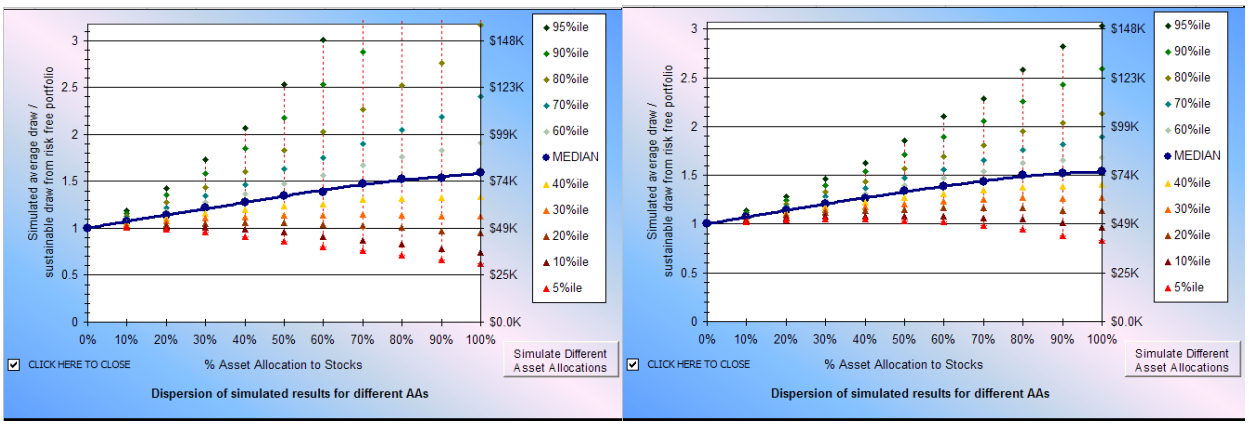


Figure 28: The Asset Allocation Risk/Reward Spectrum chart on the left was based on a random-walk simulation. The Asset Allocation Risk/Reward Spectrum chart on the right was based on a mean-reverting simulation. Once again, the mean-reverting simulation exhibited far less dispersion between extreme results than the random-walk simulation.

3. What RTM time factor would best fit the historical S&P 500 return data set?

Prospercuity, LLC tested several different RMT time factors for a double lognormal distribution model in an effort to find a value that would result. We found that an 8-year time factor produced a close fit to the annualized returns from rolling 30-year periods of S&P 500 data.

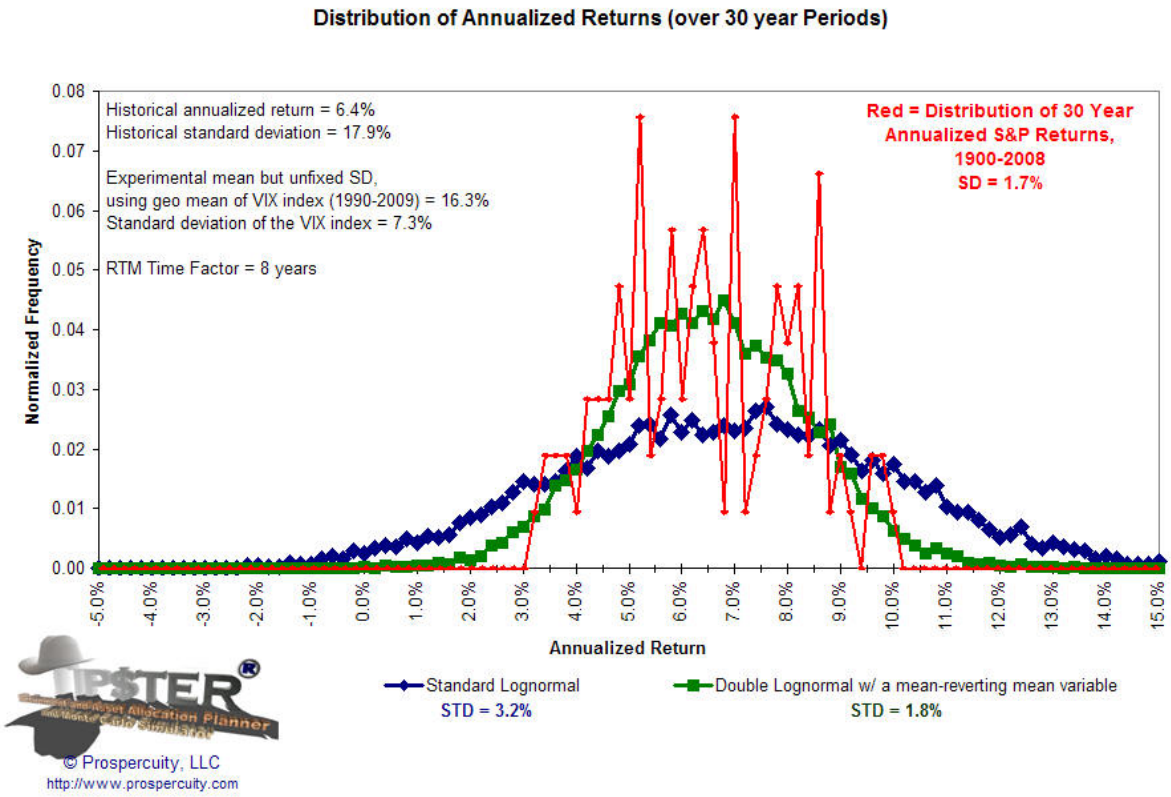


Figure 29: Historical distribution of S&P annualized returns over 30-year periods versus simulated annualized returns over 30-year periods generated by lognormal and double-lognormal/mean-reverting return distribution models

The fact that such a low RTM time factor fits the data better than a bigger RTM time factor may be nothing more than a statistical anomaly. We simply do not have enough data to know. Furthermore, given the dismal returns of the S&P 500 since 2000, it is likely that future data points will broaden the distribution, falling well below the worst-performing (3% annualized real return) data point currently in our limited data set. Consequently, Prospercuity LLC recommends that portfolios be tested with a bigger RTM factor, perhaps as large as 25 years.

VIII. ABOUT PROSPERCUITY, LLC

Prospercuity, LLC, was formed to develop a publicly-accessible, user-friendly version of TIP$TER®, and make it available to licensed users. Prospercuity is a play on the words *prosper* (from the Latin *pro spere*, meaning "according to expectation") and *acuity* (meaning "sharpness of vision or perception").

IX. ABOUT THE AUTHOR

Greetings. I am Eric Cernyar. As a self-employed intellectual property attorney (see http://www.cernyar.com), I have to save and plan for my own retirement.

Like me, you probably don't find making investment and asset allocation decisions easy – particularly given the wild gyrations of the stock market. You want to base those decisions on good information and robust analysis. You want to know what you can *reasonably* expect from a well-diversified portfolio of stocks going forward, regardless of the market's past performance. You would like a robust, rational justification for those expectations. You also want to understand the relative risks and rewards of stocks to a safer alternative, like Treasury Inflation Protected Treasuries ("TIPS").

Not only that, how much do you need to accumulate to retire? And when you do retire, how much can you plan on withdrawing from your diversified portfolio – whose value will fluctuate with the gyrations of the stock market – without outliving it? Of course, the answer to the latter question significantly affects the answer to the former.

I created TIP$TER® to project how much to save, the level of retirement expenditures my present and future savings should be able to sustain, and the potential risks and rewards of a diversified, passively managed portfolio as compared to a super-safe, all-TIPS portfolio.

I also created TIP$TER® because developing and coding the program was a fun, mathematically-intensive challenge. I drew upon my earlier engineering experience, at the National Institute of Standards and Technology, developing Monte Carlo simulations to model high-voltage electrical breakdown discharge patterns.

Finally, I created TIP$TER®, along with this user manual, to illustrate the technical, communication and legal skills with which I serve my intellectual property clients. I not only developed TIP$TER®, but also prepared and filed a pending patent application to cover TIP$TER's patentable subject matter, secured a registered federal trademark to cover the TIP$TER trademark, and secured a copyright registration to cover the expressive aspects of the program. I also prepared the License Agreement at the back of this manual. If you are ever in need of such services, I would be happy to serve you. I am licensed to draft and prosecute patent applications for anyone in the United States. I also have over ten years of legal experience and am licensed to practice law in Texas and Colorado. Finally, my fees are very reasonable. Learn about my qualifications at http://www.cernyar.com. Feel free to contact me at:

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X. APPENDIX

A. What are TIPS?

TIPS are inflation-adjusted bonds issued by the United States Treasury. Because they are backed by the full faith and credit of the United States, and protect their holders from the ravages of inflation, many economists regard TIPS to be one of the best available "proxies" for a "risk-free" rate of return.

The Treasury issues TIPS bonds, which have maturities of 5, 10, or 20 years, at an auction with a stated real, inflation-adjusted interest rate applied to a par amount. The actual price a bidder pays at the auction will be at a market-determined discount or premium to the par amount. The principal, or par-amount, of a TIPS bond increases with inflation as measured by the Consumer Price Index. The Treasury pays interest semi-annually on a TIPS bond, at the stated rate divided by two times the inflation-adjusted par amount. Finally, at maturity, the Treasury redeems a TIPS bond at its inflation-adjusted par amount.

TIPS are readily available on the secondary market. There are several mutual funds and exchange-traded funds (ETF) that are invested solely in TIPS. The Vanguard Inflation-Protected Securities Fund (ticker: VIPSX) invests in TIPS and charges an annual expense ratio of 0.20%. Barclay's iShares ETF Lehman U.S. Treasury Inflation Protected Securities Bond Fund (ticker: TIP) also invests in TIPS and, like VIPSX, charges an annual expense ratio of 0.20%. Some discount brokers – including Fidelity, Vanguard, and TDAmeritrade – enable their customers to buy specific TIPS on the secondary market.

Like any other bond, the price of a TIPS bond fluctuates as real interest rates change. And like any other bond, changes in the price of a TIPS bond changes the *effective* inflation-adjusted (real) return you would realize on the bond if you held it to maturity.

There are several websites that disclose the *effective* inflation-adjusted (real) return on TIPS. Vanguard's website reveals the effective rate on its VIPSX fund.[19] Barclay's website reveals the effective rate on its TIP ETF.[20] Bloomberg's website provides the real yields on TIPS with approximately 5, 10, and 20 year maturities.[21] The Wall Street Journal's website gives the real yields on specific TIPS coupons of various maturities.[22] Finally, the Federal Reserve's website reports the historical real yields on TIPS of various maturities.[23]

For more information about TIPS, see http://www.savingsbond.gov/indiv/products/prod_tips_glance.htm.

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[19] *See* https://personal.vanguard.com/us/JSP/Funds/Profile/VGIFundProfile0119Content.jsf?tab=0&FundId=0119.

[20] *See* http://us.ishares.com/product_info/fund/overview/TIP.htm.

[21] *See* http://www.bloomberg.com/markets/rates/index.html.

[22] *See* http://online.wsj.com/mdc/public/page/2_3020-tips.html?mod=topnav_2_3010.

[23] *See* http://www.federalreserve.gov/releases/h15/data.htm.

B. How can I construct a well-diversified, passively-managed portfolio?

You can construct a well-diversified, passively-managed portfolio by investing the non-TIPS portion of your portfolio in index funds and index-based exchange traded funds (ETFs). Index funds are passively managed. They contain hundreds of stocks that are weighted in accordance with their market capitalization or some other mathematical metric. Because they are passively managed, it costs little for operators to manage them. The stocks also turn over less often, resulting in fewer transaction costs. Many index fund providers, for example, Vanguard, pass on these savings to you. For this reason, index funds have historically outperformed their actively managed peers over long periods of time.

For information on index funds and exchange traded funds, see http://www.indexuniverse.com. For basic information on the benefits of passive investing, go to http://www.bogleheads.org. Finally, if you are not comfortable making your own investment decisions and evaluations, and assuming all the risks thereof, contact a professional financial advisor.