WealthDefender ™

WHITE PAPER

www.wealth-defender.com

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Overview

Many existing retirement planning practices are simply faulty. Financial planners too often emphasize meeting or beating an investment benchmark as a retirement goal. This is similar to Roy's safety-first criterion, an early risk management technique that allows an investor to select one portfolio rather than another based on minimization of the probability of the portfolio's return falling below a minimum desired threshold. Yet this investment-oriented approach does not guarantee that sufficient funds will be available to meet the individual's needs and wants.

Some advisers recommend planning on a fixed retirement spending budget, but this budget might not be sustainable if the individual outlives their money. Others suggest spending a fixed fraction of savings each period. A person who spends x% of savings each year is unlikely to ever run out of money because a sudden decline in savings would be accompanied by a proportional decline in spending. However, this individual's standard of living could be subject to wide swings as the savings / investment balance swings with the market. Should the individual enjoy a long life, spending would fall to a very low level in response.

Still other planners suggest a funding ratio – based hedge strategy. A client's funding ratio is an actuarial calculation that evaluates the over- or under-funding of projected liabilities representing that client's consumption objectives over time. Risk is defined in terms of the funding ratio dispersion projected for a given investment strategy and financial plan. The client's tolerance for risk taking is captured by the willingness to accept the expected rewards as well as the downside risk of aggressive investment strategies in funding long-term, multi-period cash-flow budgets. But the success of such an approach depends greatly its implementation within a holistic framework of client finances. Even so, it is a liability-driven planning tool that may not adequately consider client goals when optimizing finances.

Let us understand this better from a brief survey of the literature. Most financial advisers employ static Markowitz mean-variance portfolio allocations (setting asset or asset class weights within a portfolio based on a mean-variance risk-return tradeoff) based on current market views, market projections, and / or historical data to simulate and calculate the probabilities of achieving various goals. Similar portfolio allocations are applied to separate portfolios for each investment goal such as retirement, elder care, children's' private education, etc. Rarely is a holistic view of a household's financial requirements in terms of income, asset and liability cash flows is given. Hoevengars et al. (2009) and Amenc et al. (2009) try to take account of forward household liabilities by applying the funding ratio discussed above, but even in the institutional pension fund setting from which it comes this problem might be better suited to explicit cash flow matching (Dempster et al., 2009). See also Wilcox & Fabozzi (2009) which attempts to account for the present value of individual liabilities in a best practice Markowitz approach. Semi-variance methods (also referred to as downside risk or lower partial moment) of determining asset allocations have been proposed but remain difficult to implement.

WealthDefender ™ progresses the optimization of asset allocation and product selection beyond mean-variance and discounted cash flow techniques by introducing a goal-based model that considers life cycle objectives as well as current and projected cash flows and net worth. We extend Markowitz's traditional quadratic programming equations to solve for the optimal asset allocation and even product selection for a given portfolio by maximizing the probability of meeting goals (or minimizing Cash Flow at Risk, defined below) given a statistical confidence interval and subject to constraints representing investor risk measures and guidelines including a minimum amount of portfolio liquidity. Cash inflows, outflows, account balance evolution, and risk factor movements (also including inflation, taxes, FX movements, and investment fees) are subject to stochastic treatment, simulation, stress testing, and subsequent revaluation along the simulation path to work out the probability of goal success or Cash Flow at Risk over the goal time lines.

WealthDefender ™ is a financial planning software application that measures short-term and long-term financial risks and, more specifically, how much can be lost and what are the chances of achieving long-term goals. WealthDefender ™ provides a highly sophisticated Value at Risk and Cash Flow at Risk model to a retail base including wealthy individuals, family offices, and their financial advisers. This white paper briefly outlines the WealthDefender ™ model for measuring short- to long-term risk of an investor's finances given the portfolio today, the investor's financial goals and projected cashflows, and assumptions about underlying market processes and future economic environments. Both short and long term measures of risk are applied across the user's balance sheet (not just to traded investments) and across a full set of cashflows and lifecycle events; WealthDefender ™ recognizes that only looking at a subset of net worth or cashflows (as do most risk management software offerings for the individual) provides a grossly misleading picture of risk.

Investment Risk Measurement and Optimization

The Value at Risk (VaR) framework has been used to assess market risks, and more recently credit and even operational risks. One might wonder whether such a model could be easily implemented by the individual investor and their financial advisors since there is little risk management software geared to that market. Individuals tend to hold dissimilar types of investment portfolios to large organizations for many reasons, including access to different financial instruments, divergent investment objectives and constraints, different sets of risk drivers (albeit with a fair degree of overlap) dissimilar time horizons, and distinct sets of tax liabilities. And whereas the organization often measures risk in shorter, discrete slots of time often corresponding with financial statement reporting, individuals need to assess risk across various lifecycle stages – each carrying its own goals and constraints.

WealthDefender ™ is based on the concept of adapting short, medium, and long term portfolio risk management measures to the needs of the individual and their advisors in terms and formats that they can easily understand. Because investors may ring-fence different portfolios for different purposes (retirement, trusts, gifts to children, college savings, major purchases, etc.) and because such

portfolios may face very different tax liabilities, they often fall into the trap of looking at risk only at the investment or account level. But taking a portfolio-wide view of risk also requires looking at the contents of these different accounts together. The reason for this was explained by modern portfolio theory – individual positions in assets or asset classes or funds may have a certain measure of risk in themselves, but when combined with a portfolio of other assets, the total risk is typically less than the sum of each asset's risk due to different correlations between asset returns / hedging effects. This is why it is important for individuals to take a portfolio view of risk as well as return, across their various account holdings.

WealthDefender ™ uses a Value at Risk measure (and its corollary Conditional Value at Risk), and other measures of credit, issuer, concentration, and liquidity risk to assess investment over the short to medium term.

VaR is a powerful measure of risk across the portfolio, as it takes into account not just the risks of individual assets but of how these assets are correlated. VaR provides a consistent measure of risk across the portfolio and its component assets, including less liquid assets (where we set the holding period t to a greater value to reflect illiquidity.) The WealthDefender ™ VaR calculation does not assume an often unrealistic normal distribution of returns, and it does leverage powerful measures of asset dependence to provide highly accurate measures that can be backtested against historical returns.

Other dimensions of investment risk (credit, liquidity, currency, and issuer) are presented by WealthDefender ™ as well. Both portfolio and cashflow simulation and stress testing across multivariate inputs and parameters are integral components of the WealthDefender ™ model across all measures of risk, allowing us to avoid the pitfalls present in many simplistic financial planning calculators by way of unrealistic or overly simplistic assumptions. Another capability of this model that differentiates WealthDefender ™ from commonly-available financial planning software (if not enterprise risk software) is the calculation of multiple aggregation dimensions along the multiple risk measures, allowing a more nuanced and comprehensive view of risk.

Goal Risk Measurement and Optimization

But Value at Risk is less useful for the longer term mainly due to problems forecasting volatility and dependence over longer time periods, problems owing to longer holding periods themselves, and the fact that portfolio composition can change significantly over time (a buy-and-hold assumption becomes less realistic over time.) Therefore, WealthDefender ™ introduces a Cash Flow at Risk (CFaR) measure for longer-term personal financial risk measurement based on simulation of a data-rich set of cashflows, goals, assumptions, constraints, forecasts, and parameters (including return and residuals distributions.)

CFaR is defined for one particular scenario of goals, cashflows, assumptions, and forecasts as follows. CFaR is a measure of the width of a distribution and is dimensioned in monetary units. Let C be the net future value of all cash flows for a random future scenario, expressed as a random varia-

ble. The Cash Flow at Risk for a probability p, $CFaR_p$, is the positive value C_0 such that the probability that C is greater than its expected value minus C_0 is p (expressed in decimal terms):

$$CFAR_p = \{C_0 : Prob\ (\tilde{C} > E\tilde{C} - C_0) = p\}$$

Note that C and $CFaR_p$ are measured in dollars.

While CFaR a measure of risk of net future value of cashflows with respect to the expected goal value, probability of failure expresses the probability of not meeting a defined goal; probability of failure is expressed in percentage not dollar terms. The probability of success that C is greater than a certain goal is:

$$ProbOfSuccess = P_{success} = Prob(\tilde{C} >= C_{goal}).$$

And similarly for probability of failure

$$ProbOfFailure = P_{failure} = Prob(\tilde{C} < C_{goal}).$$

Both CFaR and Probability of Failure are presented for the goal's future evaluation period (the date the goal starts and ends.) The CFaR distribution is also presented for the period of time between the current / start date and the evaluation period; this will allow the user to determine whether wealth falls below a certain target (or indeed below zero) during that time period.

What this means is that p is the probability of expected inflow and outflow cashflows being sufficient to meet one or more goal cashflows' C_{goal}. The CFaR measure allows statements such as "It is expected that 100*p % of the time the cash flow will be larger than C_{goal}." Cash Flow at Risk enables modeling of the complete set of expected cashflows that an individual or family will face, and can also be used to model the effects of lifecycle events (marriage, childbirth, divorce, retirements, etc.) and even to a degree unexpected events (using stochastic modeling.) Changes in portfolio composition over time with CFaR will be reflected by an age-based target asset allocation. These changes will be applied due to new cashflows coming in, or alternatively net cash out the door (outflows.)

In sum, WealthDefender [TM] provides the following measures of goal risk:

1. Probability of Failure - The number of simulated outcomes weighted with survival probability where wealth (after meeting goals) was below or equal to zero – this is equivalent to saying that all defined goals have not been met

2. Probability of Success - The number of simulated outcomes weighted with survival probability where wealth (after meeting goals) was above zero – this is equivalent to saying that all defined goals have been met

3. Expected Legacy - The average wealth at the date of mortality conditional on wealth being positive

4. Expected Shortfall - The average wealth at the date of mortality conditional on that wealth being negative

Product Support

WealthDefender ™ measures and manages risk for the following asset classes (for which valuations and other information are sourced externally):

- Alternative Investments (Hedge Funds, Managed Futures, Private Equity, Structured Credit)
- Annuities (Fixed, Variable, Proprietary, Non-Proprietary)
- Cash and Money Market Products, including Foreign Exchange Holdings
- Collectibles
- Commodities and Precious Metals
- Concentrated Stock Services (Funds, Equity Derivatives, Block Trading, Other)
- Education and Health Savings Accounts
- Equities (Single, Blocks, ETFs, Other Funds)
- Equity Derivatives, Convertibles, Unit Investment Trusts, Limited Partnerships
- Fixed Income (Bonds, Treasuries, Agencies, Asset Backed Securities, CDs, Funds)
- Options and Futures
- Real Estate (Primary Use, Secondary Use, Investment)
- Structured Investments (Warrants, CLNs, Currency Basket Notes, Long-Short Notes, Other)
- Trusts, Custodial Accounts, Retirement Accounts

Methodology

Value at Risk Calculation

Value at Risk is computed utilizing Monte Carlo simulation using historical returns and modeled volatility (GARCH-based), dependence (copula-based), drift, and return approaches. This method involves developing a model for future asset price returns and running multiple hypothetical scenarios through the model using Monte Carlo simulation. Asset returns, following the efficient markets theory, are understood to incorporate risk due to movements in prices, volatility, FX rates, credit spreads, and higher order risk drivers like convexity. Basically, this is a method that randomly generates trials and calculates outcomes for each scenario. With proper modeling of underlying

risk factor movements, sufficient asset return history to construct mean return and volatility estimates, and with a large number of scenarios, a fairly accurate simulated VaR can be achieved and this is the method WealthDefender ™ uses.

Conditional Value at Risk Calculation

Conditional Value at Risk, or CVaR, is an important supplementary risk measure to VaR. VaR is a measure of the maximum loss for a given confidence interval for a specified number of days. CVaR Conditional VaR is a measure of how large the losses are, on average, when the losses are greater or equal to the VaR level. The CVaR reported by WealthDefender ™ (also called Expected Shortfall and Expected Tail Loss) is the expected loss conditional on the loss being equal to or greater than the VaR level.

Liquidity Risk

Liquidity risk is the risk that a given security or asset cannot be traded quickly enough in the market to prevent a loss, or to meet cash flow goals. More broadly, liquidity risk is the risk that liabilities cannot be met when they fall due given the asset / investment position.

To assess the latter, we provide traditional funding gap metrics. We also measure the liquidity gap, defined as the net liquid assets of the user or the excess value of liquid assets over its volatile liabilities. A negative liquidity gap would indicate the need to shore up liquid assets. We do this with our patent-pending algorithms to stress test CFaR at various points along the distribution.

Similarly, we assess investment liquidity risk by increasing the close-out period assumption for an individual security, or for an entire asset class. The close-out period is a key part of the VaR calculation.

Credit Risk

Credit risk is the risk of loss due to one party to a transaction not living up to their agreements to the transaction – this can include non-payment of a loan or other line of credit, non-payment of a coupon or principal, or not honoring other aspects of the agreed payment schedule. Investors face credit risk to the brokers, custodians, and counterparties to their investment transactions in that if these do not honor their obligations to the investor the investor could lose part of all of their investment. Individuals also face credit risk to their banks, insurance providers, and business partners.

To measure credit risk, a simple replacement value (market value) approach can be used. Exchange-traded instruments and any other instrument that is subject to daily marking and margining will be taken to have minimal credit risk. Replacement value is recognized as both a simple and conservative measure of credit risk – in reality, losses might be less than the market value amount (i.e., recovery rate might be positive.) The key is to aggregate risk at the account / broker level,

since this is where credit losses can occur. The approach will also take into account any insurance provided by regulators etc. for certain banking or investment accounts.

Currency Risk

Besides the currency risk factors playing an important role in risk measures (along with other risk factors like interest rates, commodity prices, equity prices, etc.), the "translation risks" of the portfolio will be measured by presenting the portfolio in a base currency but allowing translation into other currencies. By also allowing stress testing of foreign exchange sensitivities (including the FX delta), the investor can see the effects of currency appreciation / depreciation / devaluation.

Issuer Risk

Issuer risk is the risk of loss on securities and other traded products, arising from credit / default – related events. Measures of issuer risk exposure are generally based on the loss expectation following an event; as such this measure may involve more than a simple calculation of market value, also taking into account the seniority of the obligation in case of a credit event, the type of asset, and whether obligations are secured or unsecured. WealthDefender ™ uses a simple replacement value approach to quantify issuer risk.

Cash Flow at Risk Calculation

The basic steps in calculating CFaR and Probability of Success / Failure using the patent-pending WealthDefender ™ simulation model are:

- Setting one or more goals, time horizons, and confidence interval
- Describing current net worth and investments including the current asset allocation
- Inputting or uploading asset returns, volatilities and correlations (the latter can be calculated from return history)
- Describing current and projected cash flows
- Defining assumptions and constraints
- Mapping cashflows
- Identifying risk factors
- Simulating risk factors
- Modeling mortality and inflation
- Simulating and revaluing cash flows and account balances at each simulation step, processing flows set up by the user as well as those generated from the user's investments including account fees and those arising from application of appropriate tax rates
- Adding investment gains or losses and net cashflows to appropriate account balances
- Constructing the probability distribution of cash flows
- Determining the probability of hitting or missing the goal

Over the longer term financial planning horizon it would be misleading not to include the effect of taxes on cashflows and the growth and size of investments. To handle this, each account that is set up in WealthDefender ™ is flagged as taxable, tax-qualified, or tax-free and each account can be set up with state / local and Federal income taxes and capital gains taxes. Tax can be treated deterministically or modeled as a stochastic process.

Different inflation datasets can be used to present the user with the choice of a scalar deterministic inflation rate, inflation based upon a dataset specific to the type of cash flow modeled (consumables, health care, education, etc.), or stochastic inflation.

A key point is that there is no single CFaR value, even for a given goal. CFaR can change as other inputs change. The system will store a matrix of CFaR values for given sets of inputs so that users can (a) see the range of CFaR values, and (b) see how sensitive these are to the respective inputs, via simple and understandable delta sensitivities.

Goal-Based Asset Allocation

Optimizing asset allocation is defined as the process of setting asset or asset class weights within a portfolio subject to an investor's capital constraints in order to yield the most favorable risk-return trade-off. For typical risk-averse investors, an optimal combination of investment assets that provides a lower risk and higher return is always preferred (Markowitz, 1959). Mean-variance techniques have been used to determine efficient asset allocations, but these suffer from an assumption of normally distributed returns and from ignoring investor risk aversion. Semi-variance methods (also referred to as downside risk or lower partial moment) have been proposed but remain difficult to implement.

WealthDefender ™ extends Markowitz's traditional quadratic programming equations to solve for the optimal asset allocation of a given portfolio within a specified confidential interval of meeting goals by including constraints representing investor risk measures including a minimum amount of portfolio liquidity and other assumptions and investment policies including strategy bucketing, concentration limits, and more. WealthDefender ™ can utilize this patent-pending optimization algorithm to also make product selection decisions, given an investment universe of product alternatives available for each asset class. Along with product selection, WealthDefender ™ will make a product location decision to determine in which account to place the product to minimize the tax liability. WealthDefender ™ alternatively can suggest to the investor how much his or her starting invested balances would need to be increased in order to meet goals within the specified confidence.

WealthDefender ™ supports optimization beyond that of asset allocation and product selection. Sometimes there is only so much that can be done via these methods and it simply may not be possible for the investor to increase their invested balances by tapping home equity or selling hard assets. For these cases, cash flow optimization can give the investor specific recommendations on how to adjust the amount and / or timing of discretionary cash inflows or outflows to increase the

probability of goal success. This might mean reducing certain discretionary expenses, trimming down goals, or providing an increased income target.

Risk-Based Performance Measurement

The Sharpe ratio is an industry standard measure of risk-adjusted performance. It is calculated by using standard deviation and excess return to determine the reward per unit of risk. The higher the Sharpe ratio, the better the risk-adjusted performance. The Sharpe ratio is calculated for a period of time by dividing annualized excess returns over the risk-free rate by its annualized standard deviation. WealthDefender ™ calculates a similar risk-adjusted performance ratio for each asset by using this method but with the asset's VaR instead of its standard deviation. Unlike the Sharpe ratio, this provides a portfolio-based measure of risk-adjusted performance.

Multi-Period Optimization

The traditional Markowitz optimization approach is a single period approach to asset allocation in that it assumes that forecasts of future returns, risks, and asset dependencies are correct and unchanging. Risk tolerance and investment objectives are also assumed to stay constant. How is it possible to account for changing goals and objectives, a changing financial picture, and dynamic market conditions – not to mention changing investor risk tolerance over time? Only be adjusting the variables used in the optimization and re-optimizing / re-balancing over multiple time periods. This is known as multi-period optimization.

The most basic approach to multi-period optimization is to simply re-balance the portfolio to a static allocation at the end of each time period. A common approach is to implement age-based asset allocations, which the portfolio is rebalanced to when that target age is met (holding other factors constant.) Some more sophisticated approaches also build correlation matrices for each time step based upon the results of the simulation for the previous time step.

WealthDefender ™ takes these approaches even further by time-subscripting not just target allocations and dependence, but a host of other factors:

- Goals and cash inflows and outflows are time-dependent into the future as is asset dependence and investment constraints;
- Product structures that are time-dependent (options, account lock-ups, etc.) are reflected accurately in simulation;
- Tax status and rates reflect minimum withdrawal ages and also required maximum distribution (RMD) ages, and are time subscripted incorporating a stochastic element for future tax rates, and thus reflect the time element;
- We then take in a client's age-based asset allocation mix (which can change over the lifecycle to reflect changing risk tolerance and lifecycle phases) to reflect a starting point allocation for each time period;
- For each time period, projected returns, volatilities, and correlations can be entered; Principal Components Analysis and copulas are used to reflect dependence;

- VaR and CFaR – based optimization is then run - the goal is to maximize the true multi-period (geometric mean) return for a given level of fluctuation within the broader objective of maximizing the client's probability of success of meeting their goals;
- Simulations account for the changing nature of risk and return drivers like interest and currency rates, equity prices, and others.

Stress Testing

There is always a chance that the market losses extend beyond VaR or that extreme events in the tail of the CFaR confidence interval would cause goals to be missed. Here we enable the investor to apply canned or custom stress scenarios to attempt to measure the worst that can happen to the performance of their portfolio or their probability of goal success. The output of the stress test scenarios is a maximum loss or worst loss figure, to supplement the VaR and CFaR loss expectation figures.

Aggregation Points

Aggregation is the roll-up of risk from granular risk measures to higher-level, summarized risk measures. We will aggregate VaR, stress, and marginal contribution to risk by asset class, issuer, issuer type, country, risk driver, tax status of the asset / account, degree of liquidity, asset distribution needs / constraints, account, and at the overall portfolio level. This will typically be done at the level of the investor's tax filing status – the system is designed for flexibility in considering marital status, dependents, non-marital domestic partnerships, and aggregation of individual sets of tax filers into a "family" account to assess risk at the family level (as wealthy families with adult children and multiple business and investment interests might wish to do.)

This will allow the user to see their risk, including concentrations of risk, at each of these aggregation points. Besides being able to see measures like VaR, stress, and marginal contribution to risk at these aggregation points, it is important to also show a raw market value at these points as well.

Marginal Contribution to Risk

It is important to factor in the marginal contribution to portfolio risk that an individual position, risk factor, or an asset class, contributes. Investors will want to know this prior to taking on a new investment position, or when evaluating an existing position. We will do this by simulating the portfolio without that position / risk factor / asset class, and comparing the VaR before and after this removal using an Incremental VaR calculation.

Summary

When considering risk it is important to look at the short to medium term, yet not to lose sight of the long term. Just as a microscope is an appropriate tool to examine objects very close up and a telescope the right tool for looking into the distance, we need different tools to measure risk and

optimize finances along different dimensions of time, etc. The proven Value at Risk methodology, enhanced with more sophisticated modeling of volatility, returns, and residuals, is appropriate as a short term measure of investment portfolio risk. Supplemented by stress testing and by the ability to see these measures and market valuation at different levels of portfolio aggregation, the investor will have powerful tools to manage investment risk. For longer term financial planning, the Cash Flow at Risk measure can cater to these longer holding periods, investor goals (primarily, the goal of making it through their lifetimes meeting their spending goals with enough money to last until death or even afterwards), tax assumptions, and inflation assumptions. Goal-based optimization that uses these measures of risk as constraints in an asset allocation, product selection / location, and cash flow tuning process means that we can take these measures of risk and turn them into actionable financial planning decision. Use of these methods at appropriate frequencies along the investor's lifecycle can go a long way towards better management of personal financial risk.

For more information, please visit www.wealth-defender.com.

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