



## **Asset Liability Management in DROP**

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# Asset Liability Matching Model

## Overview

1. Competing Goals of Individual Investors: An individual investor has two competing goals – principal protection and asset growth.
2. Model Addressing the Competing Goals: The objective of this chapter is to provide a model allowing an investor to precisely weight these factors and implementing a portfolio maximizing the potential of achieving their goals with a clear understanding of their downside risk.
3. Addressing the Income Generation Functionality: Income generation is a critical component for some investors. This factor is addressed at the end of the chapter.

## Example

1. Quantification of the Exposed Risk: The classic investor dilemma is to decide between principal protection and growth. The model in this chapter provides clarity to this choice by estimating how much the investors are risking in dollar terms as opposed to merely categorizing themselves as conservation, moderate, or aggressive.
2. Portfolios from Stock-Bond Mix: For example, a portfolio with 60% S&P and 40% Bloomberg Barclays Aggregate will have an expected return of 6% and 10% volatility. The initial investment needed to obtain \$1,000 in 10 years, with a 6% expected return, is \$560. The investor will know through a Monte Carlo simulation that there is a 25% likelihood that the final value in 10 years will be worth less than \$830. The \$1,000 target amount is not guaranteed, and the results will vary depending upon the market conditions.

3. Tweaking for Growth/Protection Balance: The investor can scale up or down between principal protection and asset growth, which will be measures by the dollar dispersion around the future liability.
4. Principal Protection/Growth Trade off: More growth means a lower initial investment, but a higher dollar dispersion. On the other hand, greater principal protection will reduce the potential loss over the investment horizon, but requires a higher initial investment.
5. Typical Extreme Growth/Protection Portfolios: For example, if the investor wants zero dispersion around the liability, the model will create a portfolio with a single Treasury Strip that matures on the date that the liability is due. If the investor wants to maximize their expected returns and minimize their initial investment, the model will create a portfolio with 100% equities.
6. Trade-off Based Estimation of Investment: The investor adjusting the model will incrementally determine the trade-off between the dispersion around the liability, and the initial investment required.
7. Construction of Optimal Component Portfolios: Once the investor determines their preferences, the portfolio will be created from an optimal blend of maturing assets – e.g., a single Treasury Strip held to maturity – and non-maturing assets – e.g., the Russell 1000 Index.
8. Controlling the Volatility of Returns: The vital component of the model is enabling the investor to incrementally adjust the volatility of the optimization, which will directly impact the Monte Carlo simulated expected dispersion around the liability.
9. Incorporating Liquidity and Component Default: The portfolio will have daily liquidity, but the mean-variance optimizer (MVO) that the risk of the maturing asset is the risk of the default, not its decreasing volatility over the period. For instance, insurance companies do not mark fixed income instruments' daily volatility on their balance sheet if it is held to maturity.
10. Impact of the Volatility of the Maturing Asset: The reason for this is that the volatility should not matter to an investor holding the security to maturity. A KMV model may be used to determine the risk of default. It is assumed here that a data set can be licensed that provides a KMV estimate for each bond issue, and that this estimate can be used in the MVO.

11. Portfolio Returns Monte Carlo Simulation: However, the Monte Carlo simulation needs to include the maturing asset actual declining volatility to inform the investor of the potential returns variation over the entire investment period.
12. Double Convex Portfolio Returns Pattern: The expectation is that the Monte Carlo simulation will forecast a double convex expected return pattern giving the investor confidence that they will achieve their objective. A double convex patterns converges on both ends, but is thicker across the middle.

## **Construction Objectives**

1. The Asset-Liability Matching Model: Create a dynamic asset-liability matching model that makes it possible to incrementally increase or decrease the dollar dispersion of expected returns around a future liability. The dollar dispersion represents the amount of money an individual investor can expect to make or lose at the end of the investment period. The dollar denominated risk profile is more precise than the standard conservative, moderate, and aggressive description. The investor will change the dispersion around the future liability based on their tolerance for accepting losses.
2. Returns Portfolio Monte Carlo Simulation: Create a Monte Carlo simulation that tracks the expected returns of the portfolio. A statistical illustration of all potential returns paths for an asset-liability matching model will mitigate negative performance anxiety and make assets stickier during downturns.
3. Optimizer to cover all Assets: Enable the optimizer to include both the maturing and the non-maturing assets. This capability will allow the investor to create a Monte-Carlo simulation with risk patterns ranging from double convexity – e.g., treasury strips – to wide dollar dispersion around the liability target – e.g., 100% equities.
4. Impact Analysis on the Target Metrics: The capabilities listed above will alter the following quantities:
  - a. Asset Matching Portfolio Holdings
  - b. Expected Risk and Returns
  - c. Initial investment required to match the Liability

d. Monte Carlo simulation

The investor adjusting the model will be able to see in real-time the impact on all these four factors.

## Details

1. Primary Components of the Model: There are three primary components to this model.
  - a. The mean variance optimizer (MVO) to determine the portfolio holdings and expected returns over each level of risk.
  - b. Monte Carlo simulation to project the expected returns *journey* over the investment period and the dispersion of expected returns around the liability.
  - c. Dynamic functionality to discount the liability back to its present value using the expected return derived from changes in dispersion.
2. Parameters Governing Non-maturing Assets: The MVO available assets can be sub-divided into two groups – maturing assets and non-maturing assets. The allocation between these two groups will vary as the risk levels change to reflect the dispersion around the target value. The non-maturing assets risk/return performance is based on historical performance. This data is expected to be included, along with the list of assets.
3. Parameters Governing the Maturing Assets: Maturing assets have verifiable results, but volatility that diminishes over time, given its decrease in duration. The only risk for the maturing asset that should be included in the MVO is the probability of default. A KMV model can calculate this likelihood. The maturing assets are assumed to be held to maturity, and daily market volatility is not factored into the long-term portfolio optimization.
4. Rationale behind the Portfolio Simulation: The Monte-Carlo projections need to reflect the bond volatility despite the effort to not overstate price instability within the MVO framework. There are two rationales behind this. First, the investor may have daily liquidity and will need to know the NAV. Second, a bond's volatility that decreases as it approaches maturity is favorable for a strategy looking to narrow its dispersion around its liability.

5. Investor's Control Function: The investor will have the ability to increase and decrease the dispersion around the liability by increasing or decreasing the MVO volatility.
6. Investors' Inputs:
  - a. Future liability
  - b. Date the liability is due
7. Model Outputs:
  - a. Portfolio expected returns
  - b. Monte Carlo simulation
  - c. Portfolio holdings
  - d. Initial investment
  - e. Monthly cash flow
8. Available MVO Outputs: There are two categories of assets – non-maturing and maturing assets. The non-maturing assets include expected risk/returns based on historical data. The maturing assets include bond ETF's with fixed terms between 1 and 10 years. Other maturing assets are fixed income categories where individual securities will be utilized in the portfolio. The yield curves for these securities will serve as proxies for individual securities that will be purchased at a later date and held to maturity unless the investor liquidates the portfolio.

## Non-Maturing Assets

<b>Ticker</b>	<b>ETF Description</b>	<b>Volatility (Annualized)</b>	<b>Arithmetic Mean (Annualized)</b>	<b>Geometric Mean (Annualized)</b>	
TIP	iShares Bond TIPS	5.69%	4.11%	3.95%	Jan 2004 – Jul 2019
BMOIX	iShares Blackrock Aggregate Bond Index	2.88%	2.60%	2.55%	Apr 2011 – Jul 2019
EMB	iShares JP Morgan Emerging Bond Index	11.50%	6.82%	6.11%	Jan 2008 – Jul 2019
IWB	iShares Russell 1000 Index ETF	14.63%	7.80%	6.65%	Jun 2000 – Jul 2019

<b>MASKX</b>	iShares Russell 2000 Small-Cap Index Fund	19.81%	9,40\$	7.27%	May 1997 – Jul 2019
<b>IXUS</b>	iShares MSCI Total International Stock ETF	11.86%	5.00%	4.28%	Nov 2012 – Jul 2019
<b>BIRDY</b>	iShares Developed Real Estate CL K	11.67%	7.48%	6.78%	Sep 2015 – Jul 2019

## Maturing ETF Assets

1. Invesco and Blackrock FI ETF: Invesco BulletShares and Blackrock iBond are fixed-term exchange-traded funds (ETFs) that provide defined maturity exposure. Each BulletShares of iBond ETF comprises a diversified portfolio of individual bonds that mature or are anticipated to be called in a specific year.
2. Operating Mechanism for BulletShares ETFs: BulletShares corporate bond ETFs begin moving to cash in the final six months of the maturity year. BulletShares high-yield corporate bonds and emerging markets ETFs start to move to cash in the final 12 months. Cash from these securities is re-invested in T-bills. The fund stops trading on the maturity date of the designated year. At this point, the ETF will de-list from the exchange and make a final distribution to the shareholders, similar to the principal re-payment of an individual bond at maturity.
3. Invesco BulletShares Corporate Bond ETFs:

<b>Ticker</b>	<b>Maturity Date</b>	<b>Yield To Maturity</b>	<b>Yield To Worst</b>	<b>Effective Duration (years)</b>	<b>30-Day SEC Yield</b>	<b>Distribution Rate</b>	<b>Number of Holdings</b>
BSCX	12/31/20	2.32%	2.24%	0.82	2.26%	2.57%	373
BSCY	12/31/21	2.38%	2.24%	1.69	2.26%	2.75%	399
BSCZ	12/31/22	2.35%	2.32%	2.64	2.32%	2.91%	380
BSCA	12/31/23	2.41%	2.38%	3.43	2.39%	3.06%	318
BSCB	12/31/24	2.56%	2.53%	4.28	2.53%	3.19%	240

BSCP	12/31/25	2.69%	2.66%	5.11	2.64%	3.34%	236
BSCQ	12/31/26	2.78%	2.77%	5.94	2.76%	3.29%	249
BSCR	12/31/27	2.91%	2.89%	6.66	2.84%	3.43%	214
BSCS	12/31/28	2.99%	2.97%	7.22	2.90%	3.47%	147

4. Invesco BulletShares High Yield Corporate Bond ETFs:

<b>Ticker</b>	<b>Maturity Date</b>	<b>Yield To Maturity</b>	<b>Yield To Worst</b>	<b>Effective Duration (years)</b>	<b>30-Day SEC Yield</b>	<b>Distribution Rate</b>	<b>Number of Holdings</b>
BSJK	12/31/20	4.56%	3.36%	0.64	3.89%	4.17%	79
BSJL	12/31/21	5.45%	4.80%	1.52	4.63%	5.19%	125
BSJM	12/31/22	5.90%	4.97%	1.72	4.82%	5.33%	177
BSJN	12/31/23	6.26%	5.49%	2.18	4.93%	5.65%	207
BSJO	12/31/24	5.76%	4.96%	2.43	4.90%	5.43%	190
BSJP	12/31/25	6.05%	5.74%	3.27	5.45%	5.82%	243
BSJQ	12/31/26	6.02%	5.73%	2.75	5.54%	5.63%	152

5. Invesco BulletShares Emerging Market Debt:

<b>Ticker</b>	<b>Maturity Date</b>	<b>Yield To Maturity</b>	<b>Yield To Worst</b>	<b>Effective Duration (years)</b>	<b>30-Day SEC Yield</b>	<b>Distribution Rate</b>	<b>Number of Holdings</b>
BSAE	12/31/21	2.95%	2.95%	1.72	2.65%	N/A	50
BSBE	12/31/22	3.32%	3.31%	2.58	2.89%	N/A	55
BSCE	12/31/23	3.48%	3.46%	3.31	2.96%	N/A	48
BSDE	12/31/24	3.69%	3.63%	3.97	3.27%	N/A	48

6. Blackrock iBond Corporate Term ETFs:



<b>Ticker</b>	<b>Maturity Date</b>	<b>Yield To Maturity</b>	<b>Weighted Avg. Mat (years)</b>	<b>Effective Duration (years)</b>
IBDL	12/15/20	2.32	0.86	0.84
IBDM	12/15/21	2.31	1.77	1.70
IBDN	12/15/22	2.35	2.74	2.62
IBDO	12/15/23	2.44	3.67	3.44
IBDP	12/15/24	2.58	4.68	4.29
IBDQ	12/15/25	2.71	5.62	5.08
IBDR	12/15/26	2.82	6.63	5.91
IBDS	12/15/27	2.95	7.58	6.63
IBDT	12/15/28	3.02	8.58	7.25

7. Blackrock iBond Term Muni Bond ETFs:

<b>Ticker</b>	<b>Maturity Date</b>	<b>Yield To Maturity</b>	<b>Weighted Avg. Mat (years)</b>	<b>Effective Duration (years)</b>
IBMI	9/1/20	0.97	0.92	0.91
IBMJ	9/1/21	0.99	1.92	1.83
IBMK	9/1/22	1.01	2.93	2.73
IBML	9/1/23	1.03	3.88	3.55
IBMM	9/1/24	1.06	4.90	4.41
IBMN	9/1/25	1.12	5.89	5.21
IBMO	9/1/26	1.75	6.64	5.82
IBMP	9/1/27	1.89	7.50	6.49
IBMQ	9/1/28	1.90	8.22	7.11

**Single Name Maturing Assets**

1. Long-Term Liability Matching Instruments: The objective is to empower the investors to create a liability matching portfolio that extends out as far as 30 years with intra-day liquidity. The fixed-term ETFs enable a portfolio to be implemented up to 10 years quiet easily. Beyond 10 years, it is uncertain at this time how to make purchases of single-name debt instruments, i.e., long corporate debt, intra-day, which will likely be in small amounts, i.e. \$50. It is assumed here that the issue will be addressable.
2. Maturity Matching Yield Curve Instruments: What follow are the single-name maturity asset categories that the optimizer would have access to initially when determining the portfolio. The most-straightforward approach is to use the yield curve for each category and designate the term that reflects the maturity date matching the liability. The idea is that the yield curve can serve as a substitute for a future single bond purchase.
3. Instruments:
  - a. US Treasury Strips => 1 – 30 years Yield Curve
  - b. US Corporate Investment Grade => 1 – 20 years Yield Curve
  - c. US High Yield => 1 – 20 years Yield Curve
  - d. Emerging Market Debt => 1 – 20 years Yield Curve

## **Running Income Prioritization**

1. Motivation for Running Income Prioritization: Income is the third factor investors consider beyond principal protection and asset growth. For some investors, maximizing monthly cash flows takes priority over choosing between capital preservation and asset growth.
2. Running Income Prioritization Preference Scheme: This preference requires:
  - a. An option for investors to prioritize monthly income
  - b. Categorization of assets by their cash flow potential as well as expected returns and risk
  - c. Restricting MVO to assets with highest potential income

- d. The investor can still scale up between capital preservation and growth. The only difference is that the MVO will prioritize expected cash flow over expected returns. It is expected that this will lower the returns throughout the different risk levels.